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Force distribution within spinal tissues during posterior to anterior spinal manipulative therapy: a secondary analysis

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Introduction: It is well known that spinal manipulative therapy (SMT) transfers forces to different spinal tissues. Previous studies have shown that the intervertebral disc experiences the greatest forces during SMT and that the distribution of SMT forces among spinal tissues change as a function of the applied SMT parameters. However, a more comprehensive description of SMT force distribution contextualizing the forces experienced by spinal structures relative to the ones applied and experienced by the whole functional spinal unit is still needed to understand the underlying mechanisms of this common conservative therapy. Therefore, this study aimed to describe the percentage force distribution between spinal tissues relative to the applied SMT forces and total force experienced by the functional unit.

Methods: A secondary analysis of forces experienced by spinal structures during a posterior-to-anterior SMT application was conducted. Thirty-five fresh porcine cadavers were exposed to a simulated 300N SMT thrust to the skin overlying the left L3/L4 facet joint via servo-controlled linear motor actuator. Vertebral kinematics were tracked optically using indwelling bone pins. The functional spinal unit was then removed and mounted on a parallel robotic platform equipped with a 6-axis load cell. The kinematics of the spine during SMT were replayed by the robotic platform. By using serial dissection, peak (maximun force during thrust) and mean (average force during preload and thrust) forces induced by the simulated SMT experienced by spinal structures in all three axes of motion were recorded by the load cell. Forces experienced by spinal structures were analyzed descriptively and the resultant force magnitude was calculated.

Results: During SMT, the intact functional spinal unit experienced a median peak resultant force magnitude of 36.4N (IQR: 14.1N) and a mean resultant force magnitude of 25.4N (IQR: 11.9N). Peak resultant magnitude experienced by the spinal segment corresponded to 12.1% of the total force that was applied during SMT thrust (300N). The resultant force magnitude experienced by the intact functional spinal unit was then considered to be 100%. Relative to this, the supra and interspinous ligaments experienced 0.3% of the peak forces and 0.5% of the mean forces. Facet joints and ligamentum flavum experienced 0.7% of the peak forces and 3% of the mean forces, while intervertebral disc and longitudinal ligaments experienced 99% of the peak and 96.5% of the mean forces.

Discussion: In this animal model, a small percentage of the forces applied during a posterior-to-anterior SMT reach spinal structures in the lumbar spine. Most SMT forces (over 96%) are experienced by the intervertebral disc. This study provides a novel perspective on SMT force distribution within spinal tissues.

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In vivo evaluation of lumbar intervertebral disc structure and deformation utilizing MRI deformation-field magnetic resonance imaging

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Introduction

The detailed response of the intervertebral disc (IVD) to mechanical loading, *in vivo*, remains largely undocumented. *Ex vivo* experiments are not adequate surrogates for *in vivo* studies as they cannot capture the IVD's biomechanics during loading conditions. Methods for evaluation of the biomechanical properties of the IVD *in vivo* may yield greater insight into the pathophysiology of the IVD and assist in treatment planning Magnetic resonance imaging (MRI), a non-ionizing and *non-invasive* tool, may reveal important intradiscal deformation patterns when performed during spinal loading.
The purpose was to investigate how the lumbar IVD structure deforms *in vivo* during spinal loading, quantified with a novel non-invasive method utilizing MRI and image registration.

Methods

T2-weighted lumbar spine images (L1-S1) of 24 low back pain patients and 12 matched controls, acquired during axial loading, were compared with the corresponding unloaded T2-weighted MR images. To display the intradiscal deformation of the IVDs pixel by pixel, the Jacobian determinant matrix was retrieved from the deformation field of the image registration. The mean deformation over the whole IVD and in different sub-regions of the IVD was automatically determined using in-house softwares. With these softwares, also the center of mass of the deformation for each IVD was determined. The IVDs were grouped according to degeneration (Pfirrmann grade). Mann-Whitney's U and Kruskal-Wallis H tests were used to compare global as well as regional deformation measures between groups.

Results

The degeneration distribution of the IVD cohort was; Pfirrmann 1:10%, 2:50%, 3:21%, 4:16%, 5:2%. Differences in deformation for IVDs at different spine levels were found, where IVDs at the lower lumbar levels displayed more compressive deformation with axial loading ($p<0.001$; Fig.1), even when correcting for degeneration. With the novel imaging method, the regional variation in the deformation over the IVD was displayed, with generally more compression at the nucleus pulposus and a slightly left asymmetric pattern (Fig.2). IVDs with advanced degeneration displayed more compressive deformation at the posterior region ($p=0.035$-0.045), also when correcting for spine level. No difference between patients and controls was found.

Discussion

The present method reflected the loss in stiffness with more compression for IVDs with pronounced degeneration [1]. Also, the dependence of the intradiscal deformation on the IVD degeneration demonstrates the potential with new diagnostic tools for evaluation of the biomechanical properties of the IVD *in vivo*. Another interesting finding was the presence of asymmetries in the deformation pattern over the IVDs, most probably caused by varying disc height over the IVDs [2]. The proposed method offers the possibility to depict and track biomechanical changes *non-invasively* while characterizing disc structures in detail.

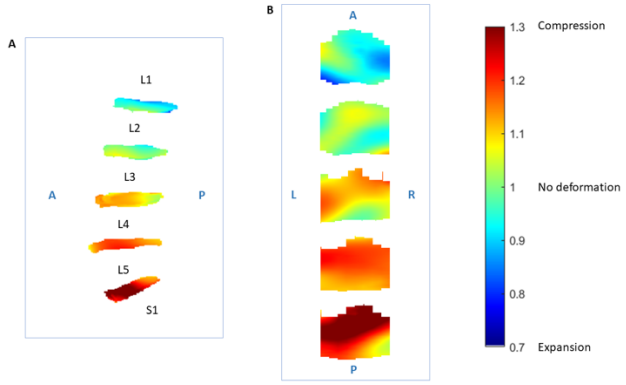

Figure 1. Deformation heat map where Jacobian determinant <1 = expansion and >1 = compression. Where more compression can be seen in the lower lumbar spine in the (A) sagittal projection and in the (B) projection from head to feet.

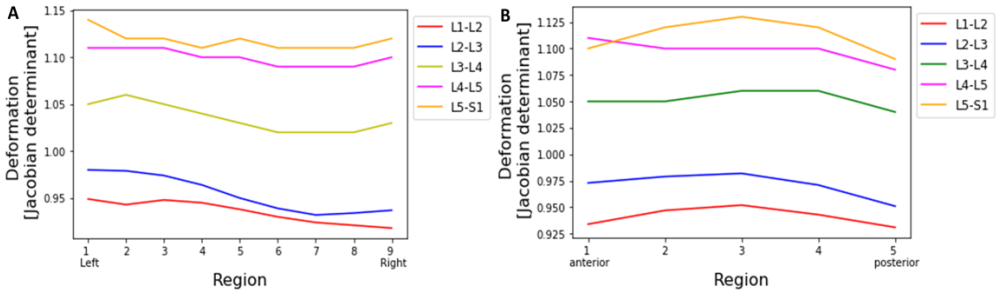

Figure 2. Mean deformation (<1 = expansion, >1 = compression) of the different spine levels for (A) the nine mid slices (B) the five anterior to posterior regions for IVDs.

1. O'Connell, G.D., E.J. Vresilovic, and D.M. Elliott, Human intervertebral disc internal strain in compression: the effect of disc region, loading position, and degeneration. J Orthop Res, 2011. 29(4): p. 547-55.
2. Byrne, R.M., A.K. Aiyangar, and X. Zhang, A Dynamic Radiographic Imaging Study of Lumbar Intervertebral Disc Morphometry and Deformation In Vivo. Sci Rep, 2019. 9(1): p. 15490.

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Using Lumbar Spine Intervertebral Motion Sharing as a Kinematics Biomarker for Classifying Individuals With Chronic Low Back Pain

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INTRODUCTION: Dynamic assessment of lumbar spine intervertebral kinematics may help identify subgroups of patients with chronic low back pain (cLBP) who may preferentially benefit from specific interventions[1]. One kinematics biomarker that may help classify individuals with cLBP is motion sharing among intervertebral motion segments[2], *i.e.* how the overall movement of the lumbar spine is distributed among the individual motion segments. A recent systematic review concluded that little or no data is available describing dynamic motion sharing in individuals with cLBP during flexion/extension or lateral bending[3]. This interim analysis from an ongoing study evaluates the potential for classifying individuals with cLBP based upon dynamic motion sharing among lumbar motion segments.

METHODS: Individuals having cLBP, defined as low back pain for more than 3 months with pain persistence greater than 50% of the time in the last six months, BMI <35 kg/m^2, not pregnant, and able to perform the required lumbar motions were enrolled. After obtaining written informed consent, participants performed two to three trials of maximal lateral bending to both sides and two to three trials of flexion/extension (Figure 1). Synchronized biplane radiographs of the lumbar spine were captured at 20 images per second over the 3 second duration of each movement trial. Bone tissues of L1 through S1 were segmented from CT scans and used to create subject-specific 3D bone models. Vertebral motion was tracked in the biplane radiographs using a validated tracking process that matched digitally reconstructed radiographs created from the CT-based bones to the biplane radiographs with an accuracy of better than 1mm in translation and 1° in rotation[4]. The percent contribution of each motion segment to the change in L1-S1 angle was computed at each 1° increment of L1-S1 rotation and averaged over the two to three corresponding movement trials for each participant. Segmental contributions to L1-S1 rotation were clustered using MATLAB's built-in k-means clustering algorithm. Silhouette coefficients were calculated to determine the appropriate number of clusters, with silhouette scores closer to 1.0 indicating more accurate clustering.

RESULTS: Data processing has been completed for 20 out of the 85 participants who have completed motion testing (9 M, 11 F; average age: 46±17yrs.; BMI: 25.5±4.2kg/m^2). Segmental contributions to L1-S1 rotation were used to group participants into 3 to 4 clusters at each motion segment for flexion (Figure 2), 2 to 5 clusters at each motion segment for extension, and 2 to 3 clusters at each motion segment for lateral bending, with silhouette scores ranging from 0.49 to 0.55 for flexion, 0.48 to 0.54 for extension, and from 0.59 to 0.71 for lateral bending (Table 1).

DISCUSSION: This interim analysis suggests that lumbar spine intervertebral motion sharing may be a promising kinematics biomarker for classifying individuals with cLBP, with lateral bending providing more accurate clusters than flexion or extension. These findings need to be confirmed after processing the entire dataset. Future work will identify which movements and motion segments produce the most accurate clustering of individuals with cLBP and explore how kinematics clusters can improve diagnostics and/or treatment.

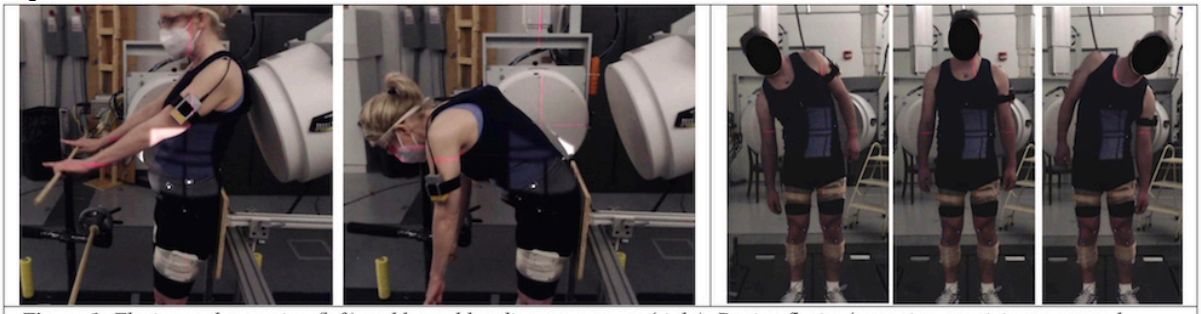

Figure 1: *Flexion and extension (left) and lateral bending movements (right). During flexion/extension, participants started upright and flexed forward to touch a target at the height of their tibial tuberosities (flexion), then they returned to their upright position (extension). Lateral bending was performed by sliding the arm down the leg as far as possible to the right and left without moving the hips.*

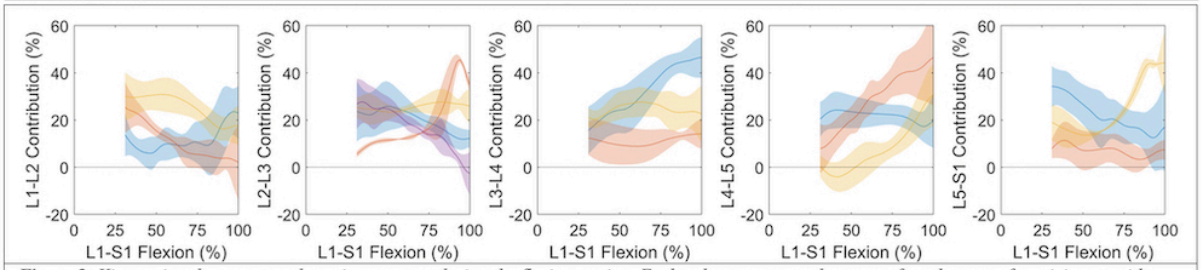

Figure 2: *Kinematics clusters at each motion segment during the flexion motion. Each color represents the mean of a subgroup of participants with similar kinematics for that specific motion segment (a cluster). Participants are not necessarily in the same cluster for all motion segments. The mean of each cluster (solid line) and standard deviation within the cluster (shaded region) is shown. Data from all subjects were available from 30% of the L1-S1 flexion motion to full flexion (100%).*

Table 1: *Optimal number of clusters and corresponding silhouette scores (in parentheses) for each movement.*

	L1-L2	L2-L3	L3-L4	L4-L5	L5-S1
Flexion	3 (0.52)	4 (0.55)	3 (0.50)	3 (0.54)	3 (0.49)
Extension	5 (0.50)	2 (0.52)	5 (0.54)	2 (0.53)	5 (0.48)
Lateral Bending	3 (0.63)	3 (0.63)	2 (0.71)	2 (0.66)	2 (0.59)

1) Teyhen, et al., Spine, 2007. 2) Breen and Breen, J. Biomechanics, 2020. 3) Widmer, et al., Ann. Biomed.Eng., 2019. 4) Dombrowski, et al., Euro. Spine J., 2018.

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Development of a High Throughput Bioreactor for testing Rodent Functional Spinal Units under Compressive Loading

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Introduction

Intervertebral disc degeneration is a common reason for low back pain and is attributed in part to abnormal mechanical loading experienced by the spine. Our prior work (1) has demonstrated that prolonged excessive mechanical compression increased catabolic and inflammatory gene expression in a rabbit disc cell culture model. To study the mechanobiological processes involved in disc degeneration, ex-vivo small animal functional spinal units (FSU) are tested under different mechanical loading conditions to observe changes in the biological outcomes. In this project we developed a compression testing device that can mechanically load and sustain physiological conditions for rodent FSUs and allow for a higher throughput by testing four samples in parallel simultaneously.

Methods

The testing device that was developed uses a standard 12 well cell culture plate, with the sample specimens placed in the 4 corner wells. The FSUs were isolated from Sprague Dawley rats and consisted of lumbar intervertebral discs and the superior and inferior vertebral bodies. The samples are supported in each well by placing the inferior vertebra in the center hole of a custom thermoplastic washer. The samples are cultured in 1ml F12 media.

The samples are loaded through four independent linear actuators (Physik Instrumente M-229.26S). Each test assembly has a load cell (Sentran PC3-50-000) in series between the actuator and the sample to provide force feedback to the control loop. The four stepper motors of the actuators are controlled through a custom Matlab program. The control program can apply load to the samples by either ramping up to and holding a prescribed load for a given time, or by cycling the load between prescribed values at a rate up to 1 Hz. The control program also allows for a period of preconditioning at the beginning of the test.

Additionally, the samples must be maintained at physiological conditions of 37℃ and 5% CO2/O2. The entire bioreactor assembly was designed to fit within a Heracell 150i incubator. A picture of the completed unit is shown in Figure 1.

Results

The results of a test run are shown in Figure 2. The target force was calculated to be 7.9 N from the cross-sectional area of the superior vertebra and a target pressure of 1MPa. The loading profile consists of a period cyclical loading for preconditioning, a rest period, and a ramp up to and hold at the target load. The mean and standard deviation of the load of each actuator during the hold portion of the test was found to be 7.89±0.06 N, 7.90±0.09, 7.92±0.15 N, and 7.92±0.14 N respectively.

Discussion

The design of the bioreactor satisfied all of the design constraints. The controller and actuator place loads on the specimen within the required parameters. In the future we will do biological tests to assess cell function (RT-PCR for expression of genes regulating matrix homeostasis) and cell viability (MTT assays, TUNEL assays) on nucleus pulposus cells or annulus fibrosus cells of the intervertebral disc post loading in our bioreactor system.

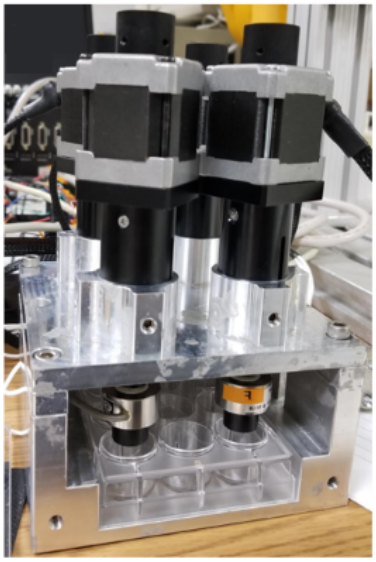

Figure 1 – High throughput bioreactor

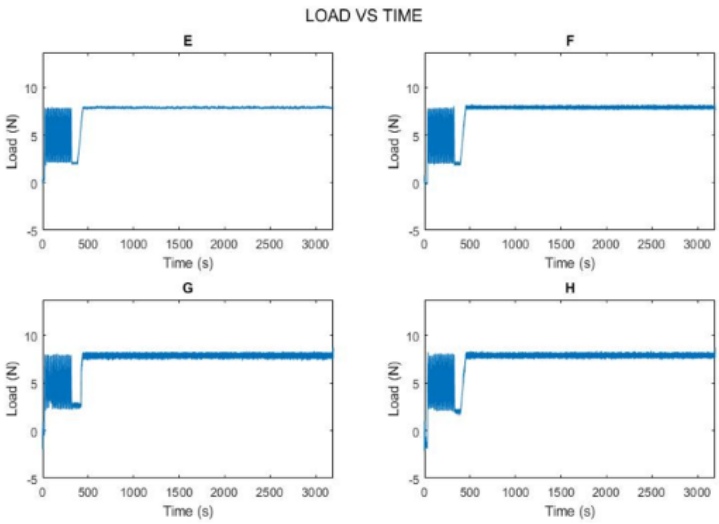

Figure 2 - Bioreactor test results with cyclic preloading and ramp and hold at 7.9N

1. (1) Sowa GA, Coelho JP, Bell KM, et al. Alterations in gene expression in response to compression of nucleus pulposus cells. Spine J. 2011;11(1):36-43. doi:10.1016/j.spinee.2010.09.019

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Next generation antibacterial nanostructured osseointegrated coatings for 3D printed customized prosthesis for vertebral replacement

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INTRODUCTION

Vertebral body replacement represents one of the most challenging, complex and invasive spinal procedures. Even though modern surgical techniques for en bloc resection of vertebral body are consolidating, this procedure is burdened by complication rates as high as 45.5%. Among the complications, surgical site infections are particularly critical and difficult to treat. Poor bone regeneration and mechanical instability are further issues, also correlated with infections. The project proposes to implement personalized vertebral prosthesis optimizing implant architecture by 3D modeling and additive manufacturing technologies and combining a nanostructured antibacterial coatings of silver to prevent infections combined with hydroxyapatite or bone apatite to promote fast and effective bone regeneration.

METHODS

In order to develop a 3D-printed customized vertebra prosthesis an optimization of the design and manufacturing has been performed. Nanostructured and biomimetic coatings with antibacterial activity have been realized exploring and comparing different deposition techniques (Ionized Jet Deposition and Magnetron Sputtering). Chemical-physical investigations (i.e. FT-IR, EDS, SEM, scratch and wettability tests) and microbiological assays with representative bacterial strains (S. Aureus and E.Coli) have been performed as well as preclinical in vitro and in vivo biocompatibility test to investigate the efficacy of the proposed approach.

RESULTS

The work on device optimization lead to the selection of giroyd deformed structure with porosity of 90% and pore size in principal of 1.3 x 2.6 mm. The results from physic-chemical investigations showed that both investigated techniques ensured good transfer in composition from target to the coatings which possessed nanostructured surface morphology and homogeneous distribution of the elements concentration. Coatings were no cytotoxic (UNI EN ISO 10993-5 rules) and the selected coatings exerted an inhibitory activity against bacterial growth. In vitro bioactivity of the selected nanostructured coatings showed primary human osteoblast viability, proliferation, adhesion and differentiation. In vivo macroscopic and microscopic analysis indicated that nanostructured coating did not cause inflammatory or adverse tissue reactions but they were able to promote osteointegration process.

DISCUSSION

The implementation of a personalized custom device by combining nanostructured antibacterial and biomimetic coatings with the simultaneous optimization of implant architecture by 3D modeling and additive manufacturing can represent an exploitable approach to increase patients' surgical options after spine resection.

ACKNOWLEDGEMENTS: These activities were funded by National Funding Organisations (Ministero della Salute – IMH, Italy) under the frame of EuroNanoMed III Project "Next generation antibacterial nanostructured osseointegrated customized vertebral replacement – NANOVERTEBRA" Joint Transnational call for proposals (JTC 2018).

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The effect neuromuscular electrical stimulation using the StimaWELL 120MTRS system on pain, disability, and function in patients with chronic low back pain: A pilot study

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Background: Individuals with chronic low back pain (CLBP) present with deficits in the paraspinal musculature, including smaller cross-sectional areas (CSA) and decreased activation during loading tasks, compared with healthy controls. Neuromuscular electrical stimulation (NMES) is used during rehabilitation to improve muscle activation and strength, but research into the efficacy of NMES on individuals with CLBP is limited. Although evidence suggests that deficits in the paraspinal musculature are associated with subjective reports of pain and disability in CLBP patients, it is unknown if treatment with NMES can help reverse these deficits. The aim of this preliminary study was to compare the effects of a novel medium-frequency electrotherapy device (the StimaWELL 120MTRS system) on subjective reports of pain intensity, pain interference, disability, and catastrophizing in CLBP patients.

Methods: A pilot study was designed to assess the effect of a progressive NMES treatment using the StimaWELL 120MTRS system (Figure 1). This study is part of a larger project investigating the effect of NMES on paraspinal muscle morphology and function for CLBP. Four patients with CLBP received 20 supervised electrotherapy treatments, 2x/week, over a 10-week period. Treatments began at 20 minutes, and were increased by 5 minutes every 6 sessions, up to a maximum of 30 minutes. Outcomes measures were obtained at 3 time points (baseline, 6-week and 11-week) and included pain intensity (Numerical Pain Rating Scale), pain interference (Brief Pain Inventory), disability (Oswestry Disability Index), and catastrophizing (Pain Catastrophizing Scale). The change in each outcome over time was assessed for each participant.

Results: Four participants (3 women, 1 man – 34±12.6 yrs old) with CLBP completed the intervention. Average time since onset of pain was 8.9 ± 14.1 years. By week 11, mean LBP improved from 4.25±0.96 to 2.25±1.5, a change of 2±1.42. Disability improved from 21%± 6.61% to 8%±5.74%, a change of 13%±4.16%. Pain interference improved from 3.54±2.94 to 0.75±0.64, a change of 2.79±3.17. Pain catastrophizing improved from 21.25±17.23 to 8.75±7.5, a change of 12.5±15.72. No long-term adverse effects were reported. One participant reported transient numbness at the application site twice post-treatment.

Discussion: This study provides preliminary evidence that a NMES intervention using the StimaWELL 120MTRS system is safe and feasible for clinical use. Of note was participants' improved pain and disability, along with other pain and psychosocial variables, following the intervention. We aim to conduct a larger scale investigation to expand our findings and evaluate whether this intervention can lead to improvements in paraspinal muscle morphology and function.

Table 1. Changes in outcome measures

Δ from Baseline to 11-weeks	NPRS	ODI	BPI - Interference	PCS
Patient 1	2	14%	0.578	3
Patient 2	1	8%	0.29	5
Patient 3	4	12%	7.14	6
Patient 4	1	18%	3.14	36
Δ Average	2 (1.41)	13% (4.16%)	2.79 (3.17)	12.5 (15.72)

* NPRS – Numerical Pain Rating Scale. ODI – Oswestry Disability Index. BPI – Brief Pain Inventory. PCS – Pain Catastrophizing Scale.

Figure 1. StimaWELL 120MTRS system

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The use of Motion Metrics parameters to predict Post-Operative Patient Reported Outcomes in Patients with Lumbar Stenosis and Spondylolisthesis

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Introduction: Lumbar stenosis is a common spinal pathology and studies have shown that surgical treatment is often more effective than non-operative management. Surgical options for the treatment of lumbar stenosis include decompression alone or decompression with fusion. Patients are often chosen for decompression with fusion when there is perceived instability; however, it is often unclear which radiographic parameters indicate instability requiring fusion. The aim of the current study was to evaluate the changes in radiographic motion metrics as well as pain NRS scores in patients with lumbar stenosis and spondylolisthesis undergoing decompression and fusion. We hypothesize that patients will improve in various intersegmental motion metrics and some will relate to improved post-operative pain NRS scores following decompression and fusion.

Methods: This was a retrospective single center cohort study. Patients treated for single level lumbar stenosis with spondylolisthesis by decompression plus fusion were included. preliminary analysis includes 23 patients. Pre-op and 1-year post-op flexion/extension X-ray images were analyzed with previously validated motion analysis software. Since the mechanical integrity of soft-tissues cannot be assessed unless the soft-tissues are sufficiently stressed, patients with <3 deg of pre-op intervertebral rotation between flexion and extension were excluded. Demographic data were obtained from medical records, including age, gender, length of stay, comorbidities and pain NRS scores. Outcome measures included Pain NRS scores, Angular Motion, Intervertebral Translation, Sagittal Plane Shear Index (SPSI), Spondylolisthesis Index, Anterior and Posterior Disc Integrity Index, Global ROM.

Results: Of the 23 patients, 14 (61%) were female and 9 (39%) were male. Ages ranged from 28 to 77 years old with an average of 61 at the time of surgery. Three patients had surgery at L3-L4 (13%), 19 had surgery at L4-L5 (83%), and one had surgery at L5-S1 (4%). All 23 patients received decompression with fusion. The 95% confidence interval of a dataset that includes 384 radiographically normal asymptomatic volunteers was used to define normal limits of motion. SPSI > 2 indicates that the translation per degree of rotation was beyond the upper limit of normal. The mean pre-op SPSI at the treatment level was 1.4±2.2 [-3 to 6.4] with 13 subjects having <2 and 9 subjects having >2. Patients with a normal pre-operative SPSI had a statistically significant improvement in pain NRS scores (6.7±1.7 to 1.8±2.3; $p < 0.001$) while patients with abnormal pre-op SPSI did not have a statistically significant improvement in pain NRS scores (5.1±2.0 to 3.5±2.5; $p = 0.160$)

Discussion: SPSI is an objective measure of sagittal plane instability that may inform physicians of the need for fusion in patients undergoing fusion for spondylolisthesis with spinal stenosis. A normal pre-operative SPSI was associated with a clinically significant improvement in post-op pain NRS scores at one year while patients with an abnormal SPSI did not have statistically significant improvements.

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Wearable IMU Sensor Clinical Repeatability of Participants with and without Chronic Low Back Pain

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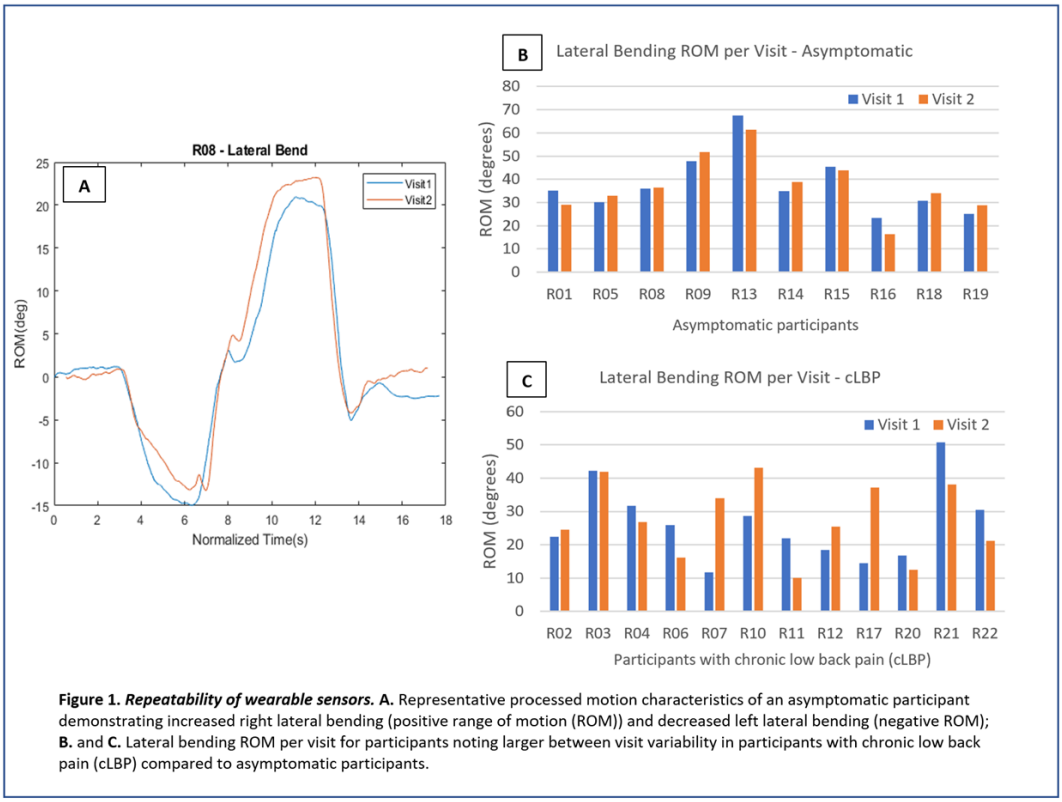

Figure 1. ***Repeatability of wearable sensors.*** **A.** Representative processed motion characteristics of an asymptomatic participant demonstrating increased right lateral bending (positive range of motion (ROM)) and decreased left lateral bending (negative ROM); **B.** and **C.** Lateral bending ROM per visit for participants noting larger between visit variability in participants with chronic low back pain (cLBP) compared to asymptomatic participants.

Introduction: Pain-influenced and adapted aberrant lumbar motions contain valuable information for clinicians treating patients with chronic low back pain (cLBP). However, objective clinical measurement techniques, like visually recalling multiple simultaneous mechanisms and/or clinical tools (i.e., goniometers, inclinometers, or measurement tape)[1], permit bias and errors to creep in between clinicians and visits. Additionally, valuable multiplanar motions and speed cannot be captured with these techniques. Wearable sensors with inertial measurement units (IMUs) applied to the body have objective and precise biomechanical assessment capabilities of lumbar motions needed for aberrant motion discrimination.[2,3] This current study used portable wireless wearable IMUs to capture test-retest reliability in lumbar ranges of motion (ROM) from participants without cLBP and participants with cLBP on two test days one week apart.

Methods: Participants 18-70 years old were recruited. Asymptomatic inclusion criteria: 1)no LBP history, or 2)most recent LBP episode was two years ago without any symptom return. Chronic LBP inclusion criterion: 1)persistent LBP >3 months. Overall exclusion criteria: 1)cancer history, 2)spinal cord compression, 3)discitis, 4)exercise intolerance, 5)lumbar motion activity restrictions, 6)positional vertigo, or 7)inability to travel to testing facility. Test visits were one week apart. At each visit, participants completed the PROMIS-29+2 patient-reported outcome and were fit with four wearable sensors (Lifeware Labs, Pittsburgh, PA) using double-sided skin adhesive (T1-T2, T12-L1, L5-S1, and on the right lateral thigh approximately 10 cm below the greater trochanter). Participants performed standing flexion, extension, lateral bending, and axial rotation. Triaxial accelerometer, gyroscope, and magnetometer readings were recorded. Post-processing used MATLAB, (The Mathworks, Inc., Natick, MA) and statistical analyses used Minitab v19 (State College, PA), and SPSS v26 (IBM Inc., Armonk, NY).

Results: Twenty-two participants completed all testing. Kolmogorov-Smirnov testing confirmed continuous data were normally distributed. Asymptomatic participants (F6M4, age_{ave}=43.9yrs(±17.8), 22-67yrs) demonstrated high repeatability on all lumbar ROM and velocity testing (ICC(3,1)=0.73-0.94) and no significant differences between visits (OWANOVA p=.471-.966) (Figure 1-A, B). Participants with cLBP (F10M2, age_{ave}=41.8yrs(±16.9), 21-69yrs) demonstrated no significant differences between visits (OWANOVA p=.430-.994). PROMIS 29+2 pain intensity ratings (from 0="no pain" to 10="worst pain imaginable") from Visit 1 ($Pain_{ave1}$=3.6 (±1.4)) to Visit 2($Pain_{ave2}$=3.3(1.2)) were not significant (Mann-Whitney p=.686). Participants with cLBP showed moderate correlation (ICC(3,1) 0.41-0.67) for axial rotation, lateral bending (Figure 1-C), and extension ROM, and axial rotation velocity with high repeatability with lateral bending and flexion velocities (ICC(3,1)=0.84 and 0.71, respectively).

Discussion: We captured highly repeatable IMU data for lumbar ROM from asymptomatic participants demonstrating the IMU sensors are reliable objective tools for measuring lumbar ROM. Additionally, we captured moderate to high ROM repeatability from participants with cLBP. While between-visit pain intensity was insignificant, other outcomes (i.e., pain interference or poor neuromuscular control) may be influencing between-visit variability for those with cLBP. Variables such as motion and speed patterns unique to individuals with cLBP may introduce variability also. Wireless IMUs uniquely capture nuanced motion details unique to individuals. Future goals will capture kinematic data on 1,000 participants with cLBP to characterize lumbar motion patterns coupled with behavioral and biologic data to encompass unique profiles for personalized cLBP treatments.

1009

CyroMilled Nucleus Pulposus Allograft – Sustaining Mechanical Property to Native Nucleus Pulposus

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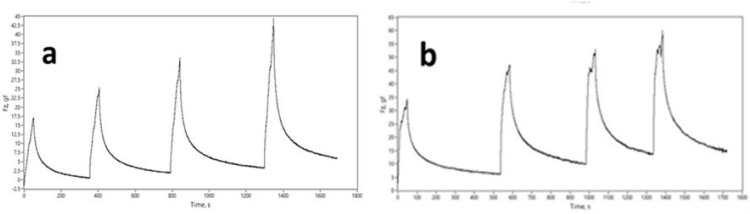
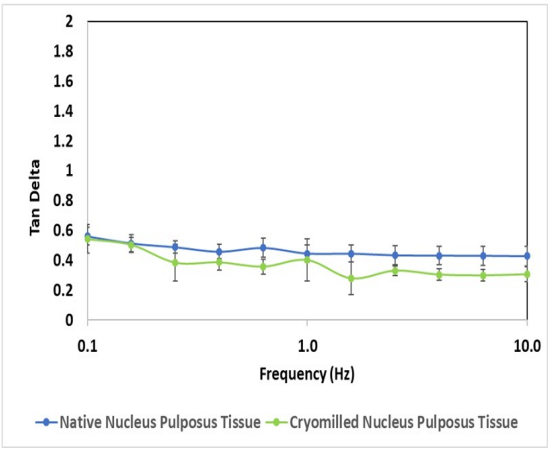
INTRODUCTION:
The intervertebral disc remains an enigmatic anatomy; offering both constrained and unconstrained properties as well as viscoelastic deformation. Although the nucleus pulposus does not completely behave physiologically as confined or unconfined, experimental setups have been performed to investigate and compare the mechanical properties of native nucleus pulposus to a cryomilled nucleus pulposus for cushioning metrics.

METHODS: Extracted nucleus pulposus tissue was dehydrated and subjected to a cryomilling process. The nucleus pulposus was pulverized with a cryomill to attain a target size (≤250 µm), and then lyophilized to create a particulate. Benchmark testing for cushioning properties of the nucleus pulposus commonly includes assessment of swelling pressure and hydraulic permeability in confined compression, and complex shear modulus with dynamic mechanical analysis (DMA).[1] Inherent to the evaluation is water binding as a correlate of proteoglycan composition.

RESULTS: Water content for the cryomilled tissue was 87.1% ± 1.0%, and similarly it was 87.8% ± 2.1% for the native tissue ($p > .05$; t-test). The hydraulic permeability was the same between both groups as 0.005×10^{-12} m^4/Ns ($p > .05$; t-test). Also, the swelling pressure for the cryomilled tissue was 5.4 ± 0.8 kPa and similar to the native tissue at 7.9 ± 2.4 kPa ($p > .05$; t-test). Both the cryomilled nucleus pulposus tissue and the native nucleus pulposus tissue retained a similar overall shape and consistency post-incubation following testing. Representative examples of stress-relaxation curves were similar for native nucleus pulposus tissue and cryomilled nucleus pulposus tissue (Figure 1). In addition to confined compression, cryomilled and native nucleus pulposus tissue underwent dynamic mechanical analysis in shear. The complex modulus, loss modulus, storage modulus and tan delta were similar for the native nucleus pulposus tissue and the cryomilled nucleus pulposus tissue, indicating that the viscous and elastic properties were similar to that existing for the native tissue (Figure 2).
DISCUSSION: Cryomilled nucleus pulposus tissue might provide a suitable replacement for nucleus pulposus tissue lost due to degradation, In this evaluation, native tissue was sized to support delivery through a 22-gauge cannula. Supplemented nucleus pulposus tissue seems to perform the same basic function with regard to maintaining matrix-water binding, providing a functional benefit of mechanical cushioning.



Representative stress-relaxation curves; (a) native nucleus pulposus tissue, and (b) cryomilled nucleus pulposus tissue. Similar viscoelastic stress-relaxation curves were observed after the cryomilling process.



Tan delta performed with dynamic mechanical analysis; both native nucleus pulposus tissue (blue) and the cryomilled nucleus pulposus tissue (green) indicate more elastic deformation than viscous behavior.

[1] Nerurkar et al. Mechanical design criteria for intervertebral disc tissue engineering. J Biomech 2010;43(6):1017-1030.

1010

Can We Quantify Patient's Cone of Economy from Home? The Future of Functional Outcome Measurements for Spine Patients

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2. Shaare Zedek Medical Center, Jerusalem, Israel

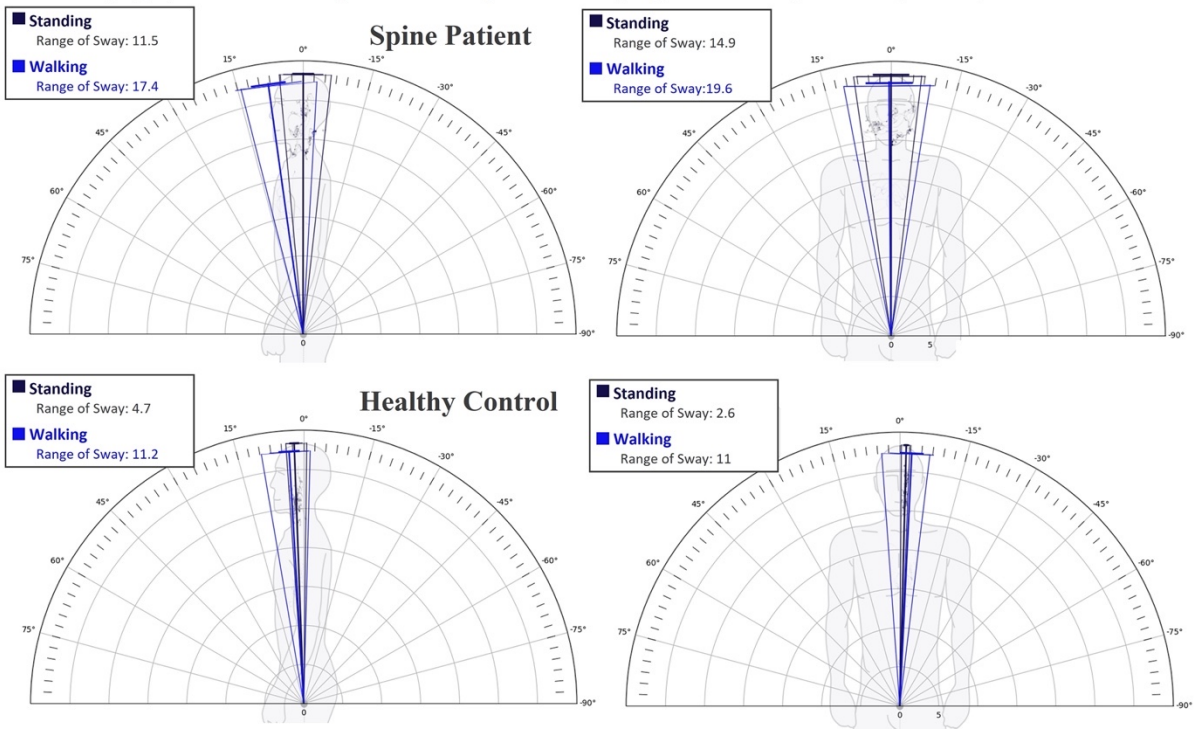
Introduction: Dubousset first introduced the concept of the cone of economy (CoE) as a reference to the area of standing posture that minimizes energy expenditure. Two decades later, Haddas et al. developed a method to quantify the CoE. This concept has been quickly adopted and has made a significant impact on our understanding of concepts such as sagittal balance and restoration of alignment to decrease the physiologic burden of gait and balance. As imbalance increases, the patient deviates from the center of the cone, resulting in a larger CoE. The resources currently required to collect CoE data are substantial as it requires a full array of motion capture sensors in a gait lab run with highly-trained staff. This is a significant hurdle to the widespread clinical use of CoE measurements. Haddas et al established a cheaper way, although still limited to a lab or clinical setting, to quantify the CoE using a force platform. Therefore, there will be a need for simple, objective measures to summarize the complexity of modern motion tracking data sets to simple, clinically meaningful, and interpretable terms. Therefore, the purpose of this study was to compare CoE between spine patients and controls in their home-based environment.

Methods: Twelves Lumbar Degenerative surgical candidates (LD; Age: 59.6, Height: 1.68 m, Weight: 71.5 kg) and 12 healthy controls (C; Age: 46.1, Height: 1.74 m, Weight: 80.1 kg) wore a small sensor (30 x 44 x 8mm, weight: 12 grams) with a patch on T1 for 24 hours. The sensor detected trunk sway and range of motion (RoM) for different types of activities during the day and also captured the patient's level of activity in the patient's home.

Results: Balance effort and CoE dimensions were found to be significantly greater in degenerative lumbar spinal pathologies patients compared to controls. Standing and walking Range of Sway (RoS) found to be significantly larger in both sagittal (Standing: LD: 7.9° vs C: 5.8°, $p<0.050$) and coronal (Standing: LD: 7.2° vs C: 3.2°, $p<0.050$; Walking: LD: 18.4° vs C: 13.1°, $p<0.001$) planes in spine patients in comparison to controls (Figure 1). Moreover, patients with degenerative lumbar spinal pathologies presented with a lower level of activity (Walking:4.7%, Standing: 11.6%, Sitting: 25.3%) in comparison to controls (Walking:7.9%, Standing: 21.7%, Sitting: 17.1%).

Discussion: The overall goal of this study was achieved by providing surgeons with a practical method for producing home-based objective global balance data via CoE measurements from a wearable device. Several benefits are anticipated from this quantitative tool to assist with preoperative planning for patient-specific alignment objectives and also prognostic information, recovery monitoring, and treatment data. More physicians may consider incorporating this technology into their clinical practice as wearable devices are relatively affordable, portable, and straightforward to use. Moreover, using this data with the Haddas' CoE classification system will help to identify patients that may benefit from surgery and guide their postoperative prognosis.

Figure 1. Standing and Walking Cone of Economy Dimension and Balance Effort in the Sagittal (Left) and Coronal (Right) Planes for a Representative Spine Patient (Top) and Healthy Control (Bottom).



1011

Calcification in Human Lumbar Cartilaginous Endplate and Disc Degeneration

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INTRODUCTION: Understanding structure-function relationships in the human endplate morphology has key implications when related to diagnosing and treating degenerative disc disease. Our previous unpublished data has shown concentrations of potential mineralized particles present in the cartilaginous tissue on micro-Computed Tomography of the cartilaginous endplate (CEP) of lumbar human spines of varied degeneration grades. We hypothesize that discs with higher degeneration grades will exhibit larger presence of calcification. The purpose of this study is to develop an approach to quantify the degree of calcification of the human lumbar spine CEP with disc degeneration and report the preliminary results.

METHODS: Lumbar spines were harvested from two donors (61M/76F). Clinical 1.5T MRI with T2-weighted sequences was used to evaluate the disc quality according to the Pfirrmann grading system. Six 4 mm diameter cylindrical core endplate samples were collected with a biopsy punch from either the superior or inferior surface of different lumbar vertebral levels, on the central region of the disc (within the footprint of the nucleus pulposus). These endplate core samples were embedded in polymethylmethacrylate mold, sectioned, ground and polished to a mirror finish before being stained using a combination of toluidine blue and basic fuchsin. Microscopic evaluation of each slide was done to create a 10x magnification mosaic image representation of each CEP, as shown in **Figure 1**. Based on these images, the ratio of all individual calcification surface areas to the entire CEP surface area for each sample was calculated and named *calcification area ratio* (**Figure 2**). A Spearman Rho analysis between area ratio and disc grade provided correlation data between these two variables.

RESULTS: The grades of the six discs ranged from 1 to 5 on the Pfirrmann classification system, lacking a grade 4 disc. The ratio of calcification surface areas to the CEP surface area increased with advancing disc degeneration grades. For example, **Figure 2** shows that a grade 2 disc will have a ratio of 0.011 compared to a grade 5 disc that shows a ratio of 0.015. The Grade 1 endplate in **Figure 1** shows a total calcification surface area of 25,768.2 μm^2 to a total CEP surface area of 2,728,418.3 μm^2 resulting in a ratio of 0.009. The calcification area ratio showed a positive correlation with disc grade as the Spearman Rho correlation produced an R-value of 0.971, with a p-value of $p < 0.001$, which shows its significance.

DISCUSSION: The data supports our hypothesis in human endplates: as the disc degeneration grade increased, the level of calcification in the CEP also increased. Some limitations exist: a) as this was a pilot study, there was a relatively small sample size. b) The technique of preparation also limits the available size of the region of interest contained in each slice. In the end, this work was able to reproduce preliminary evidence of increased calcification on the human lumbar spine cartilaginous endplate, implying a higher disc degeneration status. Further work to explore this topic further on a larger scale with a larger sample size is warranted.

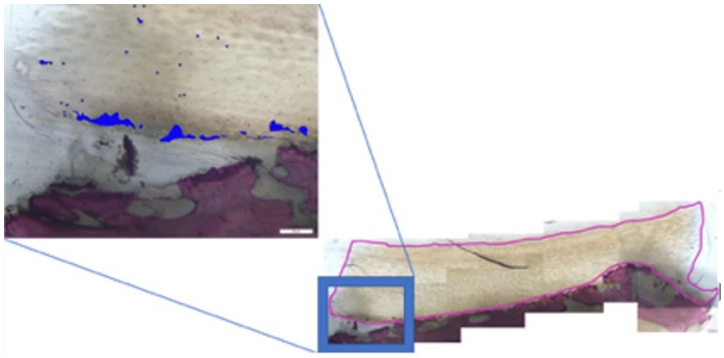
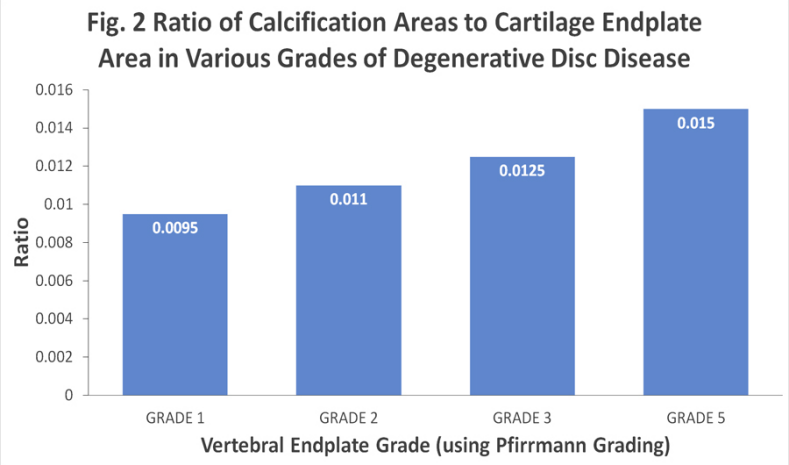


Fig. 1 Composite-mosaic histological slide of a representative Grade 1 cartilaginous endplate – outlined by the purple contour. Scale bar (lower right of the excerpted image) represents 100 micrometers. The regions highlighted in blue constitute the calcification areas within the CEP.



1012

Wearable Sensor Assessment of Neuropathic Physiological Impairments and Sensory Reweighting Caused by Lumbar Spinal Stenosis and Diabetic Peripheral Neuropathy: An Observational Pilot Study

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Introduction

Peripheral neuropathy can arise from many different underlying medical conditions and can lead to serious functional limitations and significant long-term healthcare costs. Misdiagnoses of neuropathies are common due to similarities in patient-reported symptoms and pathologies. Instrumented assessments of motor control disruptions have shown promise as sensitive tools for the assessment of multi-system impairments arising from a wide range of medical conditions. Lumbar spinal stenosis (LSS) and diabetic peripheral neuropathy (DPN) often present similarly, so the ability to classify these impairments non-invasively and with high specificity at a low cost would be beneficial. Head-mounted, triaxial inertial measurement unit-based sensors offer a unique, non-invasive method to identify various features in physiological vibration acceleration ("phybrata") signals [1-3] following sensory reweighting to classify various pathologies. This classification has not been examined in differing neuropathies to date. The aim of this observational pilot study is to investigate the application of phybrata sensing to differentially classify LSS from DPN and controls.

Methods

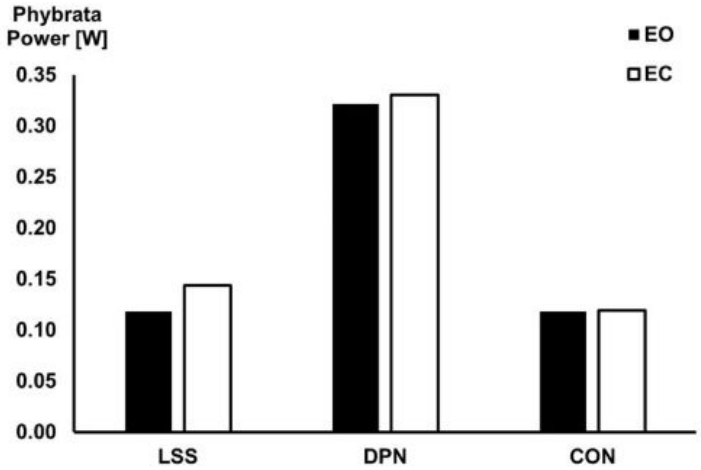
One male DPN patient (67 years, 170 cm, 75 kg), one female LSS patient (33 years, 75 kg, 165 cm), and one healthy control (CON) who presented without symptoms (age 42 years, 176 cm, 74 kg) participated in this pilot study. The phybrata sensor was attached to each participant's right mastoid using a disposable medical adhesive. Participants were instructed to stand upright in a relaxed position with feet together and their arms at their sides during testing. Patients maintained this position twice for 20 s each test: once with eyes open (EO) and once with their eyes closed (EC). During EO, patients maintained their gaze on a marker placed at eye-level, 1.5 m in front of them. EO was always performed first. The filtered phybrata data were collected at 100 Hz. EO and EC phybrata powers, EC:EO power ratio, left-right asymmetry, time-resolved power spectral density (PSD) distributions (0-50 Hz), and sensory reweighting profiles were compared between the three participants. Spectral shifts during each test were quantified using the mean frequency of a rolling 500 ms (250 ms overlap) analysis window.

Results

EO and EC phybrata powers were similar for LSS and the age-matched control but were both meaningfully elevated for DPN (Figure 1). The EC:EC ratio was higher in LSS compared to either DPN or CON. Left-right asymmetry was highest in the control during EO but was highest in DPN during EC. PSD distributions showed greater power at higher frequencies (12 to 15 Hz) for LSS, compared to either DPN or control. This behaviour did not change significantly for LSS during sensory reweighting.

Discussion

Changes to PSD frequencies reveal a shift to a more conservative postural control strategy triggered by LSS disruption of peripheral motor control. These preliminary data suggest that unique phybrata signatures for DPN and LSS may enable classification of different patient pathologies without the need for more costly and time-consuming diagnostic tests. Phybrata signals may also be used as a quantitative tool to longitudinally track patient responses to treatment and rehabilitation based on each patient's unique phybrata signature.



1. [1] Ralston JD, Raina A, Benson BW, Peters RM, Roper JM, Ralston AB. Physiological Vibration Acceleration (Phybrata) Sensor Assessment of Multi-System Physiological Impairments and Sensory Reweighting Following Concussion. Medical Devices: Evidence and Research. 2020; 13: 411–438.
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1013

Effects of Adiponectin receptor agonist AdipoRon on human intervertebral disc cell in a three-dimensional cell culture system and rat tail puncture model

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Introduction:

Adiponectin, a hormone secreted by adipocytes, is known to have anti-inflammatory and insulin resistance effects. Previous reports have shown that adiponectin decreased TNF-α expression in nucleus pulposus (NP) cells, and TNF-α was a pivotal contributor to Intervertebral disc (IVD) degeneration contributed to low back pain. The purpose of this study is to investigate the therapeutic value and the molecular mechanism of AdipoRon, an orally active adiponectin receptor agonist, on IVD degeneration through an in vitro study using a three-dimensional cell culture device and an in vivo study using a rat tail puncture model.

METHODS:

In vitro: Eighteen human NP cells were obtained from consented patients (nine males and nine females, mean age: 47.1 year-old) during surgical procedures for lumbar degenerative disc disease. NP cells were pre-cultured in a Tapered Stencil for Cluster Culture device for three-dimensional cell culture. After pre-culture, these cells were assigned to the following four groups: Group C; cells cultured without treatment, Group A; cells cultured with AdipoRon treatment, Group I; cells cultured with IL-1β treatment, Group A+I; cells cultured with both AdipoRon and IL-1β treatment. Extracellular matrix (ECM) metabolism, proinflammatory cytokines, and inflammation pathway levels were assessed by western blotting in each Group.

In vivo: We established a model of IVD degeneration by needle puncture of rat tail and compared the disc height and histology across the following three groups. Group C; the control group, Group P; rats with needle puncture only, Group P+A; rats with AdipoRon injection after the puncture. IVD height on X-ray was expressed as disc height index (%DHI). Histological analysis of IVD was performed according to the histological degeneration scale.

RESULTS:

In vitro: Western blotting results showed that expression levels of proinflammatory cytokines (TNF-α and IL-6) and ECM catabolic factors (MMP-13 and ADAMTS-4) were significantly upregulated by IL-1β treatment ($p<0.01$). Moreover, Group A+I showed significantly decreased expression levels compared to Group I ($p<0.01$). In the AMPK pathway, Group A and A+I showed increased expression of p-AMPK compared to Group I ($p<0.01$), and Group A+I showed decreased expression of p-NFkB compared to Group I ($p<0.01$).

In vivo findings: Group P showed a significant decrease in %DHI upon measurement at 14 and 28 days post puncture compared to group C ($p<0.01$). Group P+A showed a significantly smaller decrease in %DHI compared to group P ($p<0.01$). Histological analysis showed a significant degenerative change of IVD in Group P and P+A compared with Group C at 14 and 28 days post puncture ($p<0.01$). However, Group P+A showed significant suppression of the progression of IVD degeneration compared with Group P.

DISCUSSION:

This study demonstrated that the AdipoRon treatment resulted in decreased proinflammatory cytokines and ECM catabolic factors in human NP cells via the AMPK pathway. Additionally, the treatment with AdipoRon prevented the IVD degeneration in the rat IVD degeneration model. Our results suggest that AdipoRon might potentially lead to the reduction of IVD degeneration and might even LBP.

1014

C-reactive protein as biomarkers for Modic type 1 changes

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2. Department of Radiology, Balgrist University Hospital, Zurich, Switzerland
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4. Department of Orthopedic Surgery, Balgrist University Hospital, Zurich, Switzerland

INTRODUCTION

Modic type 1 changes (MC1) are inflammatory vertebral bone marrow lesions and associate with chronic low back pain (CLBP). Patients with MC1 profit from intraosseous basivertebral nerve ablation. However, MC1 are often not detected because MRI are not done due to the risk of patient catastrophizing and cost reasons. Therefore, MC1 biomarkers are needed. Increased serum C-reactive protein (CRP) has inconsistently been associated with MC1. It remains unclear if CRP is linked to local inflammation in MC1. The aim of this study was to show face-validity of CRP as a potential biomarker for MC1. We hypothesized that CRP is locally increased in MC1 bone marrow and correlates to blood CRP.

METHODS

This study was approved by the local Ethics Commission and performed in accordance with the Declaration of Helsinki. Thirteen MC1 patients undergoing lumbar spinal fusion at MC1 levels were included. Exclusion: infections, tumors, prior spinal fusion. Patients reported back and leg pain on a 10-point Visual-Analogue-Score (VAS.back,VAS.leg) and completed a Oswestry-Disability-Index (ODI). Two radiologists independently scored MC1 lesion size (0-4), Pfirmann grade of disc degeneration (0-5), and endplate degeneration score (0-6). Bone marrow aspirates from MC1 and control bone marrow were taken intraoperatively through pedicle screw trajectories before screw insertion (Fig. 1). Bone marrow plasma and cells were collected by centrifugation. Bone marrow plasma CRP was measured with ELISA. Blood CRP was measured as routine pre-operative clinical examination. CRP in MC1 was compared to intra-patient control bone marrow with t-tests. Blood CRP was correlated to MC1 CRP and to the difference of MC1 to intra-patient control bone marrow CRP (Spearman correlation). Expression of CRP by bone marrow cells was analyzed with quantitative real-time PCR (TaqMan).

RESULTS

Median blood CRP was 4 mg/L (0.2-52.9 mg/L). All values were below 8.0 mg/L except one patient, which was HLA-B27 positive. Mean bone marrow plasma CRP was higher in MC1 compared to intra-patient control (p=0.076; MC1: 49.7±52.6 mg/L; control 36.8±35.2 mg/L) (Fig.2). Blood CRP correlated with MC1 bone marrow CRP (rho=0.90, p<0.0001) and with the difference MC1-control bone marrow CRP (rho=0.82, p=0.002) (Fig.3). A blood CRP threshold between 3.1-4.1 mg/L detected with 100% accuracy increased CRP concentrations in MC1 bone marrow. Exclusion of the HLA-B27 patient did not affect correlation (rho=0.77, p=0.005). Patient demographic (age, sex, weight, height, BMI, smoker, VAS.back, VAS.leg, ODI) and radiologic data (MC1 size, disc degeneration, endplate score) did not correlated with blood or bone marrow CRP. Bone marrow cells did not express CRP.

DISCUSSION

Blood CRP correlated to increased CRP in MC1 bone marrow suggesting specific accumulation of CRP in MC1 as a result of local inflammation. Therefore, blood CRP in CLBP patients might be a MC1 biomarker with high face-validity to support physicans' decision on lumbar spine MRI for CLBP patients. Limitations: blood CRP does not correlate with MC1 size, pain, and disability and hence does not reflect clinical severity of MC1. Robustness of CRP with respect to comorbidities (e.g. osteoarthritis) should be tested in larger studies to substantiate validity of CRP as MC1 biomarker.

Fig.1

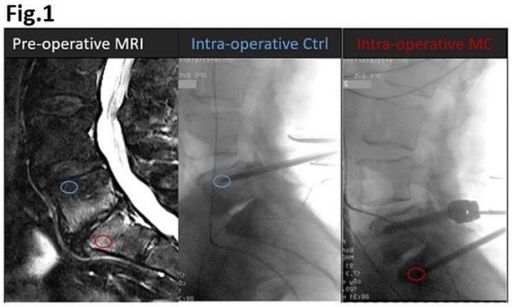


Fig.2

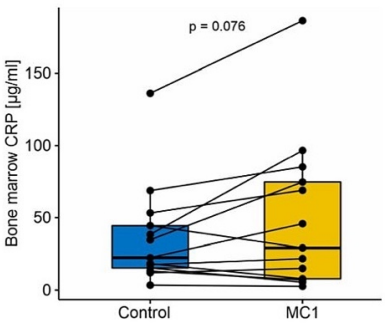
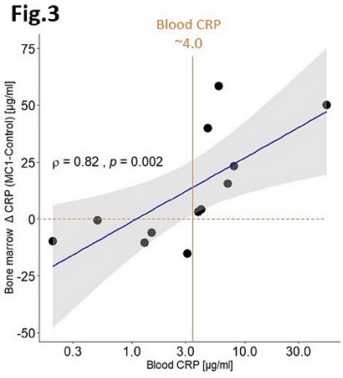


Fig.3



1015

Advanced Disc Degeneration, Bi-Planar Instability and Pathways of Peri-discal Gas Suffusion Contribute to Pathogenesis of Intradiscal Vacuum Phenomenon

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Purpose:

Intradiscal vacuum phenomenon (IDVP), despite being ubiquitous, is poorly understood. The dynamic passage of peri-discal gases into the degenerated disc is a commonly accepted theory. But the reasons behind its selective appearance in some discs is unevaluated.

Methods:

721 patients with chronic low back pain ± radiculopathy, were evaluated with AP and flexion-extension lateral radiographs and MRI. IDVP was classified based on its morphology and location. Radiographic parameters including sagittal translation, sagittal angulation, lateral listhesis, eccentric disc collapse, Pfirrmann's grade, disc height, Modic changes, anterior longitudinal ligament status and primary spinal disease at the level of IDVP was analyzed.

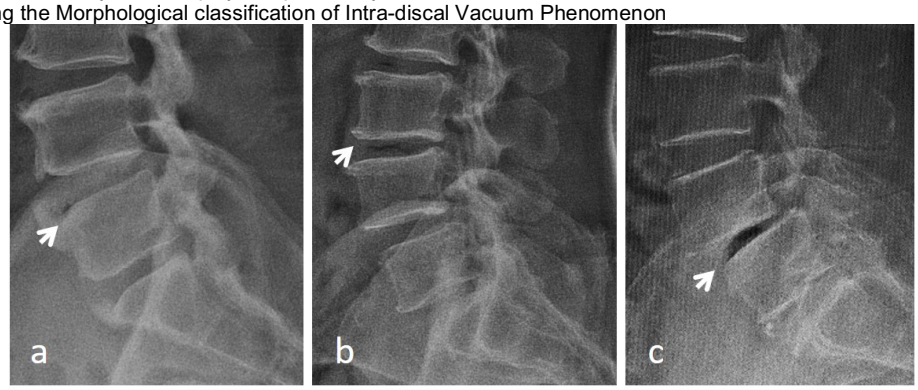
Results:

342 patients had IDVP, and had a higher mean age (57.2±12.5 years) than controls ($p < 0.001$). Eccentric disc space narrowing (26.5% vs 1.3%, $p<0.01$), coronal listhesis (7.83% vs 1.1%, $p < 0.001$), sagittal angular motion difference (11.3±4.6°, $p<0.001$), higher mean disc degeneration (4.36±0.69, $p<0.001$), ALL disruption (30.3% vs 2.2%, $p<0.001$) and Modic changes (88.6% vs 17.5%, $p<0.001$) were significantly higher in IDVP discs (vs non-IDVP). Binary logistic regression analysis indicated sagittal angular motion difference was the most predictive factor. IDVP was classified into three types - dense type (47.5%), linear (29.5%), dot type (23%). Dense type matched radiological correlations of IDVP while dot types behaved like non-IDVP discs.

Conclusion:

Modic disc-endplate contacts, ALL disruption and coronal translation could be pathways for passage of peri-discal gases into the degenerated disc. In the pathogenesis of IDVP, advanced disc degeneration, presence of pathways of gas transfer and angular/coronal instability seem to play complimentary roles.

Figure showing the Morphological classification of Intra-discal Vacuum Phenomenon



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Impact of glucose depletion on the nucleus pulposus homeostasis

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Introduction

Chronic low back pain is commonly associated with intervertebral disc (IVD) degeneration and new therapies aiming to cure the physiopathology behind it are necessary. The avascular nature of the IVD creates a physiological acidic pH and low concentrations of oxygen and glucose in its core (the nucleus pulposus-NP). The effect of degenerated IVD levels of glucose on isolated NP cell viability is divergent in the literature and the impact on NP cell phenotype isn't known. In our study, we used a bovine NP explant model (keeping intact the extracellular matrix (ECM) which plays a key role in cells' behavior) and physiological oxygen, osmolarity, pH and glucose levels found in IVD which makes it a more complete and truthful model than those used before. Comparing two glucose conditions, considered as physiological healthy and degenerated levels, the aim of this study is to determine if glucose depletion is one of the main actor of the loss of NP homeostasis.

Methods

NP bovine explants were cultivated into 2 different conditions representative of healthy (2 mM) and degenerated (0.3 mM) glucose levels. Osmolarity (430 mOsm/kg H_2O), pH (7.1) and pO_2 (4.4%) were all set at physiological healthy values to only evaluate the effects of the glucose variation. The effects of glucose depletion were assessed at 1, 5, 12 and 21 days of culture (n=5/8) using: viability staining (cell viability-CV), RT-qPCR (senescence, NP cell phenotype, anabolic and catabolic phenotype), immunohistochemistry (apoptosis), biochemical assays (ECM characterization), and ELISA (release of inflammatory mediators).

Results

CV showed a significant decrease for the degenerated glucose condition, starting at D8 (46%), when compared to healthy glucose condition (80%), while there was no significant decrease in the healthy glucose condition up to D21 (Fig1). Histological assessment of apoptosis is still ongoing. No increase in the gene expression of the $p21^{WAF1}$ senescent marker was observed. For both glucose conditions, glucose was still present in the conditioned cell culture media at every medium change, suggesting that cell death is not caused by a complete lack of glucose. Regarding ECM characterization, no effect on proteoglycan and collagen contents was observed with the biochemical assays and histology. As for gene expression of the catabolic (*MMP3* and *13*, *ADAMTS4* and *5*, *TIMP1* and *2*) and anabolic (*ACAN*, *COL1* and *2*) phenotype, there was no difference between both glucose conditions. NP cell phenotype genes (*T*, *KRT8*, *18* and *19*) showed no difference between both glucose conditions. IL-1β, IL-6 and TNF-α concentrations were below the detection limit for both glucose conditions at each time point of analysis.

Discussion

The results showed that a degenerated IVD glucose level has a significant impact on the NP CV in a 3D bovine NP explant model while it had no significant effect on NP cell phenotype and ECM maintenance. These results reveal that glucose is probably not the only player in phenotype and matrix changes in IVD degeneration on a short term, but prove glucose has a clear impact on one of the disc degeneration trait, that is cell death.

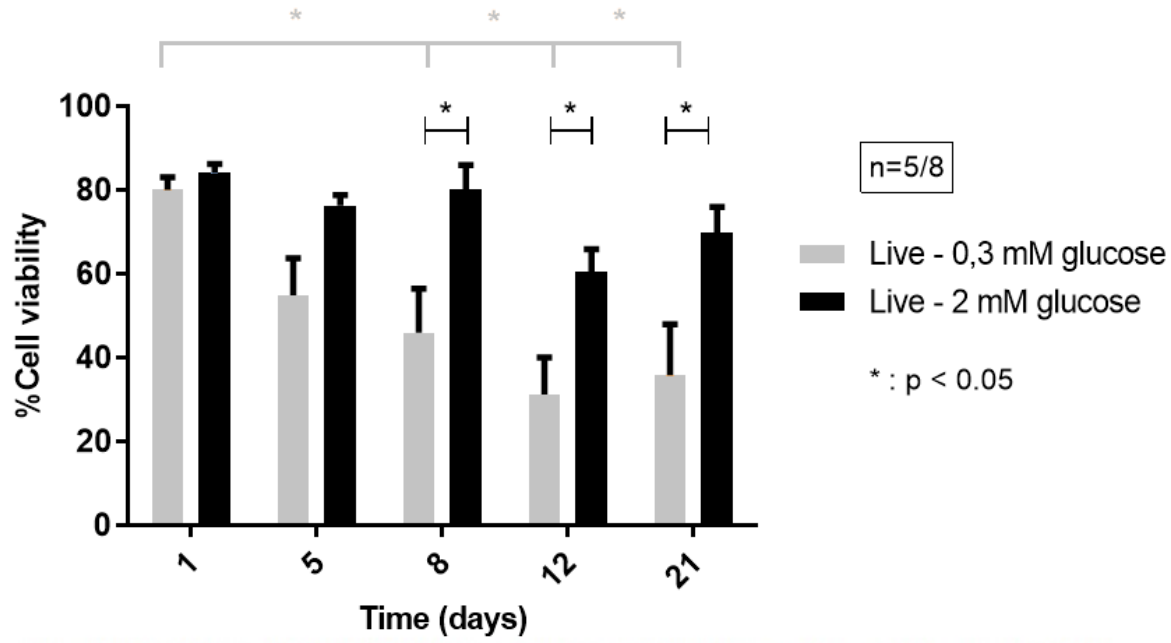

Fig.1: Evolution of cell viability percentage on bovine nucleus pulposus explants cultured for 21 days (mean + SEM)

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A novel rat model of intervertebral disc degeneration induced by spinal destabilization leading to increased mechanical stress

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INTRODUCTION

Intervertebral disc (IVD) degeneration, a common condition that often results in debilitating symptoms and functional disability, has a highly varied and complex pathophysiology. The most prevalent IVD degeneration model created by needle puncturing while effective, is unable to simulate disc degeneration process which result due to increased mechanical stress. In this study, we introduce a novel rat disc degeneration model generated by spinal destabilization surgery (SDS).

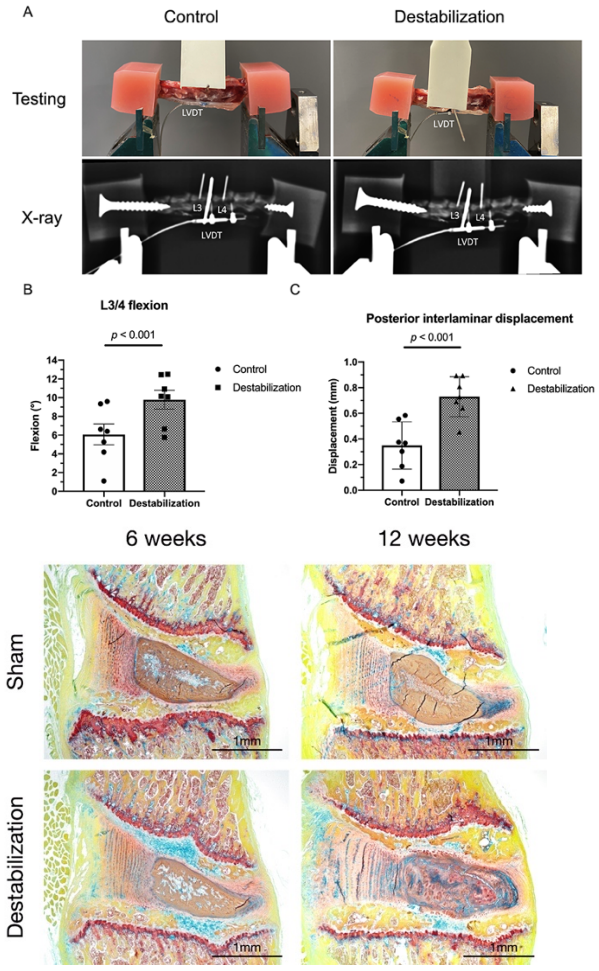
METHODS

Seven deep-frozen male rat lumbar spines were thawed and subjected to a physiological bending moment of 12.8 Nmm to test for L3/4 segmental instability. These spines were then surgically destabilized at L3/4 with L1-3 and L4-6 spinous process fixation, L3/4 supraspinous and interspinous ligaments resection, and retested for L3/4 segmental instability. During the test, the degree of flexion and the extent of posterior displacement of L3/4 were assessed.

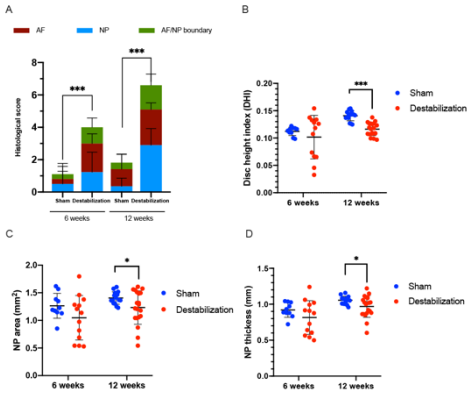
Fifty-eight male Sprague Dawley rat (450-500g) were divided into 2 groups – sham surgery and destabilization surgery, used for *in vivo* study (sham 6 weeks, n = 10; destabilization 6 weeks, n = 13; sham 12 weeks, n = 15; destabilization 12 weeks, n = 20). Rats were euthanized 6 and 12 weeks after surgery for X-ray examination to calculate disc height index (DHI). The L3/4 disc-endplate segments was harvested for histopathological evaluation under FAST staining to calculate disc scores. The area and thickness of nucleus pulposus (NP) were also measured.

RESULTS

Following L3/4 destabilization, the degree of spinal flexion increased at this level (destabilization 9.79°±2.65° vs sham 6.08°±2.95°, $p < 0.001$). Correspondingly, posterior interlaminar displacement at this level also increased (destabilization 0.73±0.16 mm vs sham 0.35±0.18 mm, $p < 0.001$).



The histological examination of L3/4 disc in the destabilization groups demonstrated increased matrix in NP compartment associated with little NP cell mass, rounded lamellae cells and annular fissures. Disc scores revealed greater degeneration in the destabilization groups at both 6 weeks (destabilization 4.00±1.92 vs sham 1.10±1.91, p = 0.002) and 12 weeks (destabilization 6.60±1.35 vs sham 1.80±1.32, p < 0.001) compared to sham groups respectively. These findings corroborated with greater reduction of DHI observed at L3/4 level in destabilization group compared to sham group at 12 weeks (destabilization 0.14±0.01 vs sham 0.12±0.01, p < 0.001), as well as reduction in NP area and thickness in destabilization group at 12 weeks by 12.3% (destabilization1.23±0.30 vs sham 1.41±0.11, p < 0.05) and 8.1% (destabilization 0.97±0.15 vs sham 1.06±0.06, p < 0.05), respectively.



DISCUSSION

This study has successfully established a novel rat IVD degeneration model by spinal destabilization surgery, substantiated by findings of reduced DHI, disc scores and decreased NP area and thickness. It provides an alternative to existing IVD degeneration models and is most suitable for application in conditions with accelerated IVD degeneration secondary to spinal instability.

1. Tam V, Chan WCW, Leung VYL, et al. Histological and reference system for the analysis of mouse intervertebral disc. J Orthop Res. 2018;36(1):233-243. doi:10.1002/jor.23637

Lumbar spine Modic changes are associated with abdominal aorta calcification

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Introduction:

Modic Changes (MC) in the lumbar spine are regularly associated with clinical and histo-immunological parameters. The etiology of MC is however only minimally studied, and a causal relation is thus difficult to establish. Insufficient vascularization of the endplate is proposed as a contributor to the appearance of MC on MRI. In this study, we chose to study aorta calcification as a representation of vascularization status. The presence of aorta calcification can lead to an explanation in two ways. On the one hand, it is conceivable that calcification of this large blood vessel is a (direct) indicator of reduced blood supply in the exiting vessels (which supply the endplates). On the other hand, it is possible that the aortic calcification is representative of the patient's overall vascular condition (indirect indicator).

Methods:

We reviewed the radiological imaging results of patients operated between November 2005 and November 2013, who received instrumented surgery for lumbar degenerative disc disease. Type and severity of Modic changes were assessed by MRI, and AAC was assessed by CT or, if CT was not available, fluoroscopy of the lumbar spine. The severity of MC and AAC were scored according to the proportion of abnormal signal range in the vertebral body (MC) and the grade of arterial calcification (AAC) (0-3 points indicated increasing severity in sequence). In addition, scores were dichotomized as well and graded as minimal (0,1) or relevant (2,3). Subsequently, the correlation between MC and AAC was studied by Pearson statistical analysis of the data, in which the influence of age on both parameters was studied as well (partial correlation).

Results:

130 patients met the inclusion criteria. The mean age of patients was 59±12 years, men and women equally represented. 113 (87%) patients demonstrated MC, of which 71 had Modic type 2. The majority of patients had relevant MC (55%). Eighty-eight (68%) of the 130 patients had abdominal aorta calcification. Almost half of the patients (43%) demonstrated relevant AAC. Pearson statistical analysis showed that AAC was correlated with age (coefficient=0.544, P=0.00), but that there was no correlation between age and the presence of MC (coefficient=0.129, P=0.142). The severity of AAC was significantly correlated with the severity of MC (P=0.002), which remained significant after adjusting for age (P=0.040).

Discussion:

This study showed that the AAC and MC are associated and that it is reasonable to speculate on the causal relation. Reduced blood flow due to atherosclerotic disease may indeed play a role in the formation of endplate degeneration, represented on MRI as MC, and induce low back pathology. Future research should focus on the specific elements contributing to AAC (obesity, smoking, abnormal serum lipid levels, immobility) and their influence on low back pathology parameters.

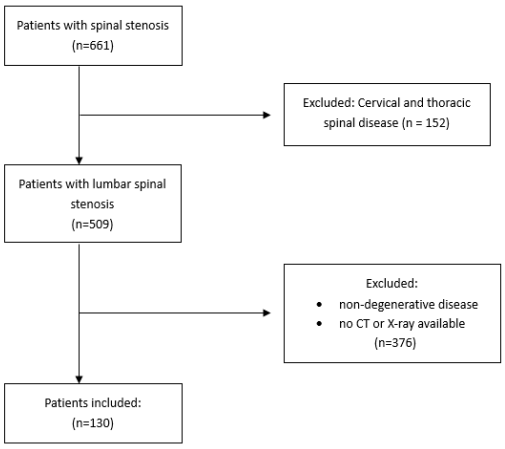

Figure 1. This flow chart illustrates how patient data were selected for inclusion in the study.

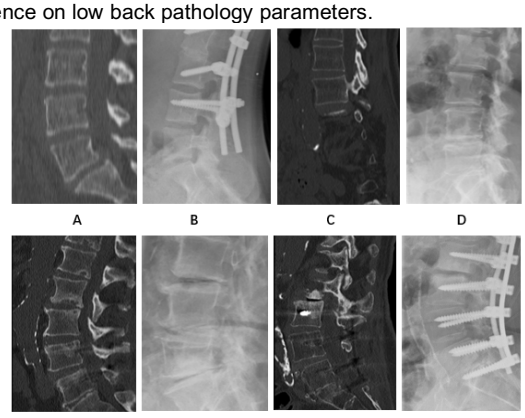

Figure 2: The grade of AAC was assessed by CT or X-ray. A/B, No calcification in the abdominal aorta, Grade 0; C/D, Few scattered calcific deposits filling the aorta in front of the vertebra, Grade 1; E/F, Moderate scattered calcific deposits filling the aorta in front of the vertebra, Grade 2; G/H, Massive nubby calcific deposits filling the aorta in front of the vertebra (pipe shape), Grade 3.

Table 1. Descriptive characteristics of the study population. (n=130)

Characteristics	N (%) or mean (SD)
Age (y)	59±12
<60	63 (48%)
≥60	67 (52%)
Gender	
Male	65 (50%)
Female	65 (50%)
Modic (all types)	113 (87%)
No Modic	17 (13%)
Type 1	35 (31%)
Type 2	71 (63%)
Type 3	7 (6%)
Severity of Modic	
0	17 (15%)
1	41 (36%)
Minimal (0+1)	58 (45%)
2	52 (46%)
3	20 (18%)
Relevant (2+3)	72 (55%)
AAC (all grades)	88 (68%)
Severity of AAC	
0	43 (33%)
1	31 (35%)
Minimal (0+1)	74 (57%)
2	38 (43%)
3	19 (22%)
Relevant (2+3)	57 (43%)

SD, standard deviation; AAC, abdominal aorta calcification

Table 2. Presence of MC and AAC in age groups.

Age	MC		AAC	
	Absence	Presence	Absence	Presence
	17 (13%)	113 (87%)	42 (32%)	88 (68%)
<60	8	55	32	31
≥60	9	58	10	57

Table 3. Severity(dichotomy) of MC and AAC in age groups.

Age	MC		AAC	
	Minimal	Relevant	Minimal	Distinct
	59 (45%)	71 (51%)	73 (56%)	57 (44%)
<60	31	32	49	14
≥60	28	39	24	43

Table 4 Correlation between MC, AAC and age

	MC		AAC	
	Correlation	P	Correlation	P
Age	0.129	0.142	0.544	0.000

Table 5 Correlation between MC and AAC

MC	AAC	Pearson correlation		Partial correlation adjusting for age	
		Coefficient	P	Coefficient	P
Yes/No	Yes/No	0.171	0.052	0.154	0.080
Minimal/Relevant	Yes/No	0.295	0.001	0.280	0.001
0,1,2,3	Yes/No	0.308	0.000	0.286	0.001
Minimal/Relevant	Minimal/Distinct	0.214	0.015	0.181	0.040
0,1,2,3	Minimal/Distinct	0.216	0.014	0.175	0.048
Minimal/Relevant	0,1,2,3	0.268	0.002	0.246	0.005
0,1,2,3	0,1,2,3	0.270	0.002	0.239	0.006

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Preventive effects on intervertebral disc degeneration of growth differentiation factor-6 in a Rat Tail Puncture Model

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INTRODUCTION:
Intervertebral disc (IVD) degeneration can cause chronic back pain and disability and has no available drug treatment till date. Growth differentiation factor (GDF) regulates IVD homeostasis and upregulates the production of healthy nucleus pulposus (NP) cells in degenerated tissues during the repair of disc injury. Moreover, atelocollagen gel (AC) is a cell-supportive scaffold for sustained drug release. Therefore, we hypothesized that GDF6 predominantly inhibits NP cell catabolites in vivo and examined its efficacy, using AC as a carrier, on the structural integrity of the body surface in a rat tail puncture model.
METHODS:
A previously established rat tail annular puncture model for IVD degeneration was used. Continuous disc histological degeneration scale and levels of extracellular matrix components in the rat tails (Co8-11, random order) were compared across the four experimental groups. Group C was the control group, and Groups P, A, and G comprised rats whose tail discs were punctured to a depth of 5 mm using a 20G needle with a handmade stopper, based on the approximate vertical distance from the skin to the center of the NP. The needle was rotated 360° and held in position for 30 s. After puncture, the tail discs of rats in Group A and G were injected with 2 µl AC and 20 µg GDF6, respectively. Catabolic factors, such as tumor necrosis factor-α(TNF-α) and interleukin-6 (IL-6), were evaluated using immunofluorescence on days 14 and 28 after the puncture. Two-way analysis of variance and Tukey post-hoc test were used to compare the degree of alteration between the groups. Statistical significance was set at $p<0.05$.
RESULTS:
In the control group, TNF-α-positive cells were rarely observed at both time points (C: day 14, 16.2±3.4%; day 28, 16.3±2.9%), and IL-6-positive cells were abundant at both time points (C: day 14, 15.0±4.8%; day 28, 16.7±3.4%). There was a significant increase in the number of TNF-α-positive cells in Groups P and A on day 14 after the puncture, with no significant difference in the count between Groups G and C (P: 28.0±6.0%, p=0.016; A: 27.2±7.0%, p=0.021; G: 23.5±5.3%, p=0.196). IL-6-positive cells showed a similar trend (P: 27.9±7.0%, p=0.02; A: 27.9±7.8%, p=0.02; G: 22.6 ± 5.1%, p=0.256). On day 28 after the puncture, TNF-α-positive cells (P: 71.8±7.4%, p<0.001; A: 71.4±7.9%, p<0.001; G: 33.3±10.5%, p=0. 017) and collagen IL-6-positive cells (P: 68.0±7.7%, p<0.001; A: 67.3±9.6%, p<0. 001, G: 35.7±10.3%, p=0.022) were significantly more in Groups P, A, and G than in Group C. However, this increase was less in Group G than in Groups P (TNF-α: p<0.001, IL-6: p=0.001) and A (TNF-α: p=0.004, IL-6: p=0.003).
DISCUSSION:
A disc degeneration model was created by percutaneously inserting a needle into the middle of the rat tail; however, administration of GDF6 using AC as a carrier prevented the progression of IVD degeneration. Therefore, the protective effect of GDF6 administered through AC on disc NP cells may inhibit IVD degeneration.

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Reconsideration of Pfirmann classification for Disc degeneration : possible subtypes in collapse disc

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[Purpose] In MRI findings, the Pfirrmanns's classification is widely applied to evaluate the degeneration of intervertebral discs. In this classification, the disc brightness decreases as grade progress. In grade 4, disc brightness becomes more low, in grade 5, the intervertebral discs proceed to collapse with low signal intensity. On the other hand, we sometimes observe the high signal intensity in collapsed disc. In this study, we investigate the prevalence of the collapsed disc with high signal intensity in MRI findings and considered about the mechanism of high signal intensity.

[Method] Among 2470 intervertebral discs of 494 patients who underwent lumbar spine MRI from July 2019 to June 2020 were evaluated. We defined intervertebral disc height of 5 mm or less as having collapse in MRI. The evaluation item was STIR of the intervertebral disc brightness (high (H group) or low (L group)), Modic degeneration of the upper and lower vertebral discs to be evaluated (None, type I, II, III).

[Results] Collapse was found in 138 of 494 patients (28%), and in 213 of 2470 discs (9%) . Mean age was 73.4 years (37-93 years), 60 males, 78 females. Group H which were suggested inflammation by STIR were found in 45 discs (21%). That is, we could find inflammation in the collapsed disc. Group L had the remaining 168 discs (79%). Modic change were 30 discs (14%) without MC, 20 discs (9%) for type I, 109 discs (51%) for type II, and 54 discs for type III (25%). There were no significant differences in MC types when classified into H and L groups. However only one intervertebral disc collapse was found in 89 (14 in H group, 75 in L group), and two or more intervertebral discs were found in 49 (16 in H group, 33 in L group). The number of patients which have many intervertebral collapse discs were significantly higher in the H group ($p = 0.02$).

[Discussion] In this study, we evaluated the inflammation of grade 5 by STIR, in which the intervertebral disc collapses at T2. A high signal was observed inside the intervertebral disc in 21%. Conventionally, it is said that the collapse discs becomes hypomobile and stabilizes and reduces low back pain, but it has become clear that, in a certain rate, inflammation is seen in the intervertebral disc and the end plate. Pfirmann classification Grade V is divided into subtypes depending on the disc inflammation.

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Metabolic characteristics in inner and outer annulus fibrosus cells in response to hydrostatic pressure and high osmotic pressure

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Introduction: We recently demonstrated that bovine nucleus pulposus (bNP) cells produced more cartilaginous extracellular matrices (ECMs) under repetitive cyclic hydrostatic pressure (HP) followed by constant HP in high-osmolality culture medium compared to no HP.# These findings indicate that NP cells need to be under intradiscal pressure, which must be held by the annulus fibrosus (AF) to maintain homeostasis and to promote intervertebral disc regeneration. We hypothesized that anabolic turnover in AF cells is maintained by HP as seen in NP cells. We assessed the effects of HP on production of ECMs by AF cells with qPCR using bAF cells. Since AF is exposed to compressive and tensile stresses, we evaluated the effects of HP in bAF cells isolated from inner or outer AF.

Methods: Fresh bovine tails were purchased from a local slaughterhouse (USDA certified). Inner AF and outer AF were harvested from the caudal IVDs (Fig. 1A), followed by digestion in 0.15% collagenase. The AF cells were rinsed, and 5 x 10^5 cells/25 µl were enclosed in a semipermeable membrane pouch (1 x 35 mm hollow fiber, 500 kD molecular cut-off)(Fig. 1B). The pouches were incubated with cyclic HP at 0.2 to 0.7 MPa, 0.5 Hz for 2 days followed by constant HP at 0.3 MPa for 1 day at 3% O_2 and 5% CO_2 repeated twice over 6 days using a pressure culture system (Fig. 2). For the no-HP control, pouches were suspended in culture medium with a stirrer. These pouches were incubated in Dulbecco minimum essential medium/Ham's F12 media with 10% fetal bovine serum and antibiotics at high osmolality (450 mOsm/kg H_2O) adjusted with NaCl. The cells were harvested on days 3 and 6, and gene expression of typical ECM molecules: *Acan*, *Col-1*, *Col-2*, *Eln,* and the catabolic molecule *Mmmp13* were evaluated with RT-PCR (n=3).

Results: In inner AF cells, the expression of *Acan* and *Col-2* were higher under HP and high OP conditions compared to no HP (Fig. 3A). On the other hand, in outer AF cells, the expression of *Acan*, *Col-1*, and *Col-2* were downregulated with HP compared to no HP (Fig. 3B). In inner and outer AF cells, *Eln* expression was suppressed with HP, and the expression of *Mmp13* was higher with HP than no HP on day 3.

Discussion: Inner and outer AF cells showed opposite gene expression profiles on ECM molecules in response to HP. Since inner AF connects to NP, inner AF may contain more NP-like cells compared to outer AF. On the other hand, outer AF expressed more fibrous molecules e.g., *Col-1, Eln* compared to inner AF cells. Physicochemical stresses in this study did not include deviatoric stress, which alters cell shape. Since outer AF cells are exposed mainly to deviatoric stress due to less hydration, we expect that combined HP and deviatoric stress will modify profiles obtained from current regimen of HP and high OP. Opposite characteristics in ECM production by inner and outer AF cells suggest multiple approaches (combined or steps) to repair the wound/incision.

Fig 1. Isolated inner and outer AF tissues and a semipermeable membrane pouch.
A) Isolation of Inner and Outer AF. B) A semipermeable membrane pouch for enclosing AF cells.

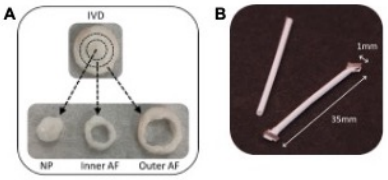


Fig 2. A HP/perfusion culture system and HP culture condition.
A) A HP/perfusion culture system. B) Regimen of HP culture condition for HP and no HP.

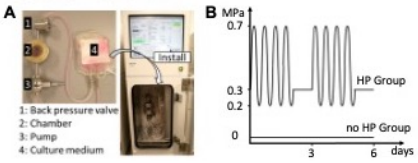
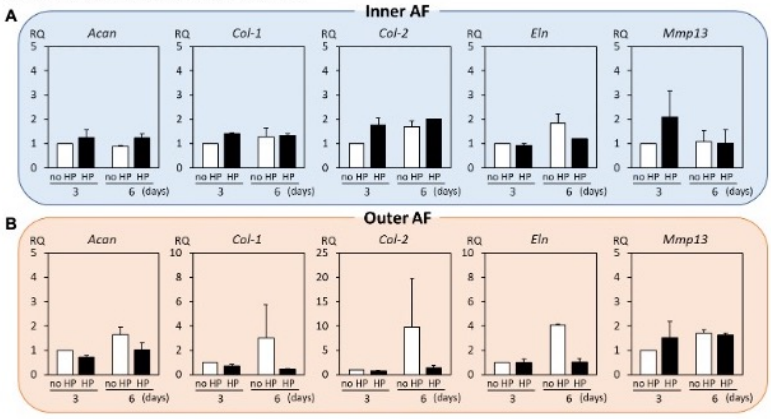


Fig 3. Gene expression profiles of inner and outer AF cells.
A) Gene expression in inner AF cells. B) Gene expression in outer AF cells.
Aggrecan core protein; *Acan,* collagen type-I; *Col-1,* Collagen type-II; *Col-2*, elastin; *Eln*, matrix metallopeptidase-13; *Mmp13*. RQ; relative quantity. Mean ± SD (n=3)



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Histology of the lumbar intervertebral disc in degenerative disc disease and its correlation with clinical and radiological findings

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Introduction:

Degenerative disc disease (DDD) of the lumbar spine is a common cause of significant morbidity in individuals of productive age group. Despite advancements in surgical techniques, there remain critical knowledge gaps with regards to understanding the causes of occurrence and progression of disease in individuals, the variability of symptoms in patients with an identical radiological picture, the indications of surgery and its bearing on eventual outcomes of non-surgical or surgical management. Correlation of the histological changes in the intervertebral disc with the clinical and radiological findings can provide valuable insights into the etiopathogenesis of lumbar DDD. In this study, we examined the histology of surgically procured disc specimens in patients with lumbar DDD and correlated it with clinical and radiological findings.

Methods

Specimens of the diseased disc were procured during the course of surgery for lumbar degenerative disorders in prospectively recruited adult patients at a single centre. All patients underwent single-level lumbar decompression with or without instrumented fusion. After adequate tissue processing, the disc specimens underwent histopathological evaluation according to a previously validated quantitative Histopathological Degeneration Score (HDS; a scoring system of cumulative 15 points over 4 criteria - cell density, structural alteration, granular changes and mucous degeneration). Clinical (visual analog scale and revised Oswestry Disability Index; VAS and r-ODI) and radiological (mean disc space height on plain radiographs; Modic changes and modified Pfirmann grade on MRI) evaluation was performed both preoperatively and postoperatively (at 6 months follow-up). An association was sought between the cumulative HDS scoring and the clinicoradiological parameters.

Results

A total of 102 patients (42 males and 60 females, median age of 40.2 years) with a clinicoradiological diagnosis of lumbar DDD were included in our study. The median HDS scores for male and female patients were 9.357 and 10.13, respectively. Univariate analysis revealed that none of the preoperative radiological findings (disc space height, Pfirmann grade, Modic changes) correlated with the cumulative HDS. However, both preoperative VAS and r-ODI scores showed a statistically significant correlation with HDS ($p = 0.03$ and 0.045, respectively). Postoperative VAS score and r-ODI scores did not show a significant correlation with the HDS.

Discussion

The results of this study point towards a possible correlation of histological changes in the intervertebral discs in patients with DDD, with their clinical symptoms. If validated by multi-centric and multi-ethnic studies with a larger sample size, these can be the focus of novel diagnostic and therapeutic strategies to treat lumbar degenerative disc disease.

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Transient Receptor Potential Vanilloid 4 (TRPV4) knockdown suppresses autophagy in rat intervertebral disc cells

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INTRODUCTION:

The intervertebral disc is the largest avascular, low nutrient organ in the human body. Autophagy is an important cell survival mechanism by self-digestion and recycling damaged components under stress conditions, primarily nutrient deprivation. Biologically, disc cells and their extracellular matrix are stimulated by physiological range of mechanical loading, and abnormal loading can result in disc degeneration. Therefore, the mechanobiological mechanisms that govern intradiscal homeostasis need to be clarified to understand the process of disc degeneration and to develop a therapeutic strategy for disc degenerative diseases. One possible mechanosensitive regulator in disc homeostasis is Transient Receptor Potential Vanilloid 4 (TRPV4). The TRPV4 has been identified as a critical mechanosensor in cartilage, and modulating TRPV4 in cartilage has protective effects against osteoarthritis. The TRPV4 has been also reported to be activated under a physiological mechanical stimulation in disc cells *in vitro*. We hypothesized that TRPV4 is involved in the maintenance of intradiscal autophagy. Our objective is to elucidate the role of TRPV4 in rat intervertebral disc autophagy and extracellular matrix metabolism through loss-of-function study with the RNA interference (RNAi) technique.

METHODS:

Disc nucleus pulposus (NP) and annulus fibrosus (AF) cells harvested from 12-week-old male Sprague-Dawley rats were used. Small interfering RNA (siRNA) was applied to knockdown TRPV4 by the reverse transfection method. Three different TRPV4-siRNA sequences were used to exclude the off-target effect. Cells after transfection were cultured in DMEM with or without 10% FBS for 24 h to simulate nutrient deprivation. Expression of AMPK, mTOR, p70/S6K, LC3-II, and a substrate p62/SQSTM1 as well as TRPV4 was measured by Western blotting. Next, cells after the transfection were cultured in serum-free DMEM with 10-ng/ml interleukin-1 beta (IL-1β) for 24 h. Autophagy markers and catabolic matrix metalloproteinases (MMPs) were assessed by Western blotting. To control for protein loaded, membranes were re-probed using anti-alpha-Tubulin. The intensities of the bands were quantified using ImageJ software. Multi-way ANOVA with Tukey–Kramer post-hoc test was used to analyze the data in immunoblotting. The *P*-values of < 0.05 were regarded as statistically significant.

RESULTS:

In rat disc NP and AF cells, TRPV4 expression significantly decreased by TRPV4 RNAi, which proved to silence the target proteins by 70% or more ($P < 0.05$). The LC3-II decreased and p70/S6K and p62/SQSTM1 increased ($P < 0.05$), indicating autophagy suppression. In addition, AMPK decreased and mTOR increased ($P < 0.05$), suggesting a possible pathway between TRPV4 and autophagy. Pro-inflammatory IL-1β stimulation with TRPV4 RNAi further decreased AMPK and LC3-II and increased mTOR, p70/S6K, p62/SQSTM1 and MMPs ($P < 0.05$), indicating enhancement of the effect of TRPV4 knockdown.

DISCUSSION:

The TRPV4 knockdown suppressed autophagy with AMPK inhibition in rat disc NP and AF cells and developed further suppression of autophagy under pro-inflammatory IL-1β stimulation. This loss-of-function study demonstrates the involvement of TRPV4 in autophagy and extracellular matrix metabolism of rat disc NP and AF cells. The TRPV4 could be a therapeutic target for intervertebral disc diseases via modulating autophagy.

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A systemic review of the association of atherosclerosis, degenerative disc disease, and clinical symptoms of the lumbar spine

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Introduction

Modic changes (MC) are a representation of degenerative changes of vertebral bone marrow and endplate, which are frequently related to disc degeneration (DD), and clinical symptoms like low back pain (LBP) and/or sciatica. However, MC were also observed to coincide with abdominal aortic calcification (AAC). A possible hypothesis for this phenomenon is that MC are an indication of insufficient endplate vascularization. The objective of this literature review was to assess correlations between abdominal aortic calcification (or systemic lipid status of patients), lumbar MC and DD, and LBP or sciatica.

Methods

A literature search was performed (up to February 2021) in PubMed, Embase, Web of Science, Emcare, Cochrane Library, and Academic Search Premier using a sensitive search string combination. Studies were selected by predefined selection criteria, and the risk of bias was assessed using a validated Cochrane checklist adjusted for this purpose. Studies investigating the association of AAC or systemic lipid status and either MC/DD and/or LBP/Sciatica were selected.

Results

Following PRISMA guidelines, 22 papers were included. Six studies examined the association of aortic calcification, arterial stenosis, or cardiovascular risk factors with clinical LBP and sciatica. Five of these were assessed as low risk of bias and one as intermediate risk of bias. All studies showed a positive correlation, especially severe AAC and newly formed artery stenosis were more likely to coincide with LBP and sciatica. Ten studies investigated the correlation between atherosclerosis and its risk factors and MC/DD; 8 showed a positive correlation, of which 3 demonstrated a correlation after adjusting for age. Four of the five laboratory studies on the correlation between lipid levels and DD found a positive correlation. Three other studies showed a correlation between apolipoprotein levels and DD coinciding with chronic inflammation of the endplate.

Discussion

The hypothesis that disc degeneration and endplate degeneration are caused by an insufficient blood supply, which may induce inflammation and clinical symptoms, is not contradicted in the available literature. There is some evidence that there is a direct impact on the endplate due to insufficient blood supply due to poor quality vasculature. However, there are also indications that systemic properties of a patient's lipid profile affect degeneration of the lumbar spine. This is an incentive to develop further research in this direction.

(("Back Pain"[Mesh] OR "Back Pain"[tw] OR "Back Pains"[tw] OR "Backpain"[tw] OR "Backpains"[tw] OR "Backache"[tw] OR "Backaches"[tw] OR "Back Ache"[tw] OR "Back Aches"[tw] OR "vertebral pain"[tw] OR "L5 nerve"[tw] OR "NSLBP"[tw] OR "CNLBP"[tw] OR "Sciatica"[Mesh] OR "sciatica"[tw] OR "Sciatic Neuralgia"[tw] OR "Sciatic Neuropathy"[Mesh] OR "Sciatic Neuropathy"[tw] OR "Sciatic Neuropathies"[tw] OR "Lesion of Sciatic Nerve"[tw] OR "Sciatic Nerve Diseases"[tw] OR "Sciatic Nerve Lesion"[tw] OR "Sciatic Nerve Lesions"[tw] OR "Sciatic Nerve Palsy"[tw] OR "Sciatic Neuritis"[tw] OR "Sciatic Neuropathies"[tw] OR "Intervertebral Disc Degeneration"[mesh] OR "Degenerative Disc Disease"[tw] OR "Degenerative Disc Diseases"[tw] OR "Degenerative Intervertebral Disc"[tw] OR "Degenerative Intervertebral Discs"[tw] OR "Degenerative Intervertebral Disk"[tw] OR "Degenerative Intervertebral Disks"[tw] OR "Disc Degeneration"[tw] OR "Disc Degenerations"[tw] OR "Disc Degradation"[tw] OR "Disk Degeneration"[tw] OR "Disk Degenerations"[tw] OR "Disk Degenerat*"[tw] OR "Disc Degenerat*"[tw] OR "Disk Degradation"[tw] OR "Intervertebral Disc Degeneration"[tw] OR "Intervertebral Disc Degenerations"[tw] OR "Intervertebral Disk Degeneration"[tw] OR "Intervertebral Disk Degenerations"[tw] OR "degenerative IVD"[tw] OR "degenerative IVDs"[tw] OR "Intervertebral Disc Displacement"[mesh] OR "Disk Prolapse"[tw] OR "Disk Prolapses"[tw] OR "Herniated Disc"[tw] OR "Herniated Discs"[tw] OR "Herniated Disk"[tw] OR "Herniated Disks"[tw] OR "disc herniation"[tw] OR "disk herniation"[tw] OR "Intervertebral Disc Displacement"[tw] OR "Intervertebral Disc Displacements"[tw] OR "Intervertebral Disk Displacement"[tw] OR "Intervertebral Disk Displacements"[tw] OR "Prolapsed Disc"[tw] OR "Prolapsed Discs"[tw] OR "Prolapsed Disk"[tw] OR "Prolapsed Disks"[tw] OR "Slipped Disc"[tw] OR "Slipped Discs"[tw] OR "Slipped Disk"[tw] OR "Slipped Disks"[tw])
AND ("aorta calcification"[tw] OR "aorta calcifications"[tw] OR "aortic calcification"[tw] OR "aortic calcifications"[tw] OR "calcified aorta"[tw] OR "calcified aortic"[tw] OR "calcified aorta"[tw] OR "aortic valve calcification"[tw] OR "aortic valve calcifications"[tw] OR "Aortic Valve, Calcification of"[Supplementary Concept] OR (("Aorta"[Mesh] OR "Aorta"[tw] OR "Aortas"[tw] OR "Aortic"[tw]) AND ("Calcification, Physiologic"[Mesh] OR "Calcification"[tw] OR "Calcified"[tw] OR "Calcif*"[tw])) OR "lipid status"[tw] OR "Arteriosclerosis"[Mesh:noexp] OR "Atherosclerosis"[Mesh:noexp] OR "atherosclerosis"[tw] OR "atherosclero*"[tw] OR "arteriosclerosis"[tw] OR "arteriosclero*"[tw] OR "Lipids"[Mesh:noexp] OR "lipid"[tw] OR "lipids"[tw] OR "Lipoproteins"[mesh] OR "lipoprotein"[tw] OR "lipoproteins"[tw] OR "Cholesterol"[Mesh] OR "cholesterol"[tw] OR "cholesterols"[tw] OR "HDL"[tw] OR "LDL"[tw] OR "apolipoproteins"[tw] OR "apolipoprotein"[tw] OR "atherosis"[tw] OR "atheromatous plaque"[tw] OR "calcium deposit"[tw] OR "calcium deposits"[tw] OR "serum calcium"[tw] OR "Dyslipidemias"[Mesh] OR "Dyslipidemias"[tw] OR "Dyslipidemia"[tw] OR "dyslipidaemia"[tw] OR "dyslipidaemias"[tw] OR "Triglycerides"[mesh] OR "triglycerides"[tw] OR "triglyceride"[tw] OR "lumbar artery"[tw] OR "middle sacral artery"[tw] OR "lumbar arteries"[tw] OR "middle sacral arteries"[tw])
AND english[la] NOT ("Animals"[mesh] NOT "Humans"[mesh])
NOT (("Case Reports"[ptyp] OR "case report"[ti]) NOT ("Review"[ptyp] OR "review"[ti] OR "Clinical Study"[ptyp] OR "trial"[ti] OR "RCT"[ti])) NOT ("aortic ruptur*"[ti] OR "aorta ruptur*"[ti] OR "Aortic Rupture"[Majr]))

Fig. 1. Search strategy

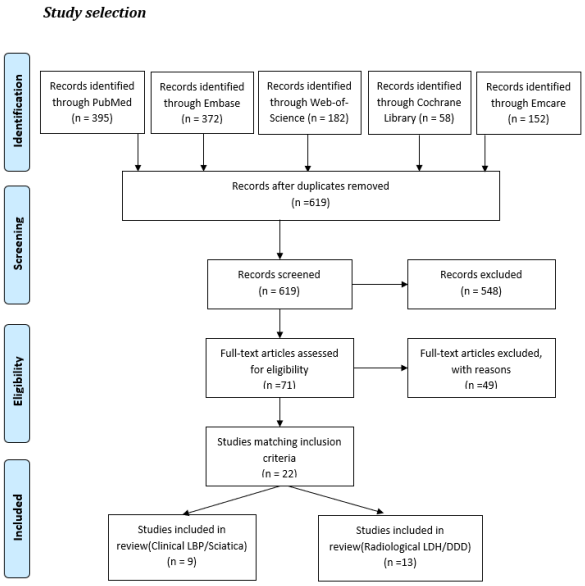

Fig. 2. Flow diagram-Studies selection progress.

Risk of bias in individual studies

Table 1: Criteria for risk-of-bias assessment-Clinical

Key criteria	Criteria for 'yes
P: Clear study objective	Goals of the study stated (1 point)
P: Criteria for inclusion explicit	Inclusion criteria mentioned (1 point (*patient included if he/she has backpain or sciatica*)
P: Age range and mean age reported	Age range and mean age and/or men/women reported (1 point)
S: Can selection-bias be ruled out	Methods for patient selection and inclusion mentioned ('consecutive')(1 point)
O: Clearly defined criteria for measuring outcomes	Outcome measures correct (at least one scale for low back pain or complaints) 1: clinical scale 2: radiological scale 3: laboratory scale or atherosclerosis radiology scale
O: Correlating relevant outcomes	Outcome is systematically evaluated Too little information: 0 points Correlation is given: 1 point Correlation and clear statistics: 2 points
A: Follow-up period, range and mean given	Follow-up data stated or computable
'yes' (2 pt) (only possible in prospective study) 'no, t.f.t.u. <20%, but may not be aselective' (1 pt) * 'no, t.f.t.u. >20%' (0 pt) → exclusion criterium 'too little information / not described' (0 pt) Retrospective maximum 1 point	

Table 2: Criteria for risk-of-bias assessment Non-Clinical

Key criteria	Criteria for 'yes
P: Clear study objective	Goals of the study stated (1 point)
P: Criteria for inclusion explicit	Inclusion criteria mentioned (1 point) (*patient included if he/she has degenerative spine and/or atherosclerosis*)
P: Age range and mean age reported	Age range and mean age reported and/or men and women (1 point)
S: Can selection-bias be ruled out	Methods for patient selection and inclusion mentioned ('consecutive')(1 point)
O: Clearly defined criteria for measuring outcomes	Outcome measures correct 1: radiological outcome with scale 2: atherosclerosis outcome with scale
O: Correlating relevant outcomes	Outcome is systematically evaluated Too little information: 0 points Correlation is given: 1 point Correlation and clear statistics: 2 points
A: Follow-up period, range and mean given	Follow-up data stated or computable
'yes' (2 pt) (only possible in prospective study) 'no, t.f.t.u. <20%, but may not be aselective' (1 pt) * 'no, t.f.t.u. >20%' (0 pt) → exclusion criterium 'too little information / not described' (0 pt) Retrospective maximum 1 point	

Table 4: Risk-of-bias analysis of Non-Clinical Studies

Study (year of publication)	Total risk of bias (10)	Patient group and study goal (3)	Absence of selection bias (1)	Outcome properly examined (4)	Absence of attrition bias (2)
Beckworth et al. 2018	+++++	+	+	++	+
Estublier et al. 2015	+++	+	+	-	+
Hangai et al. 2008	+++++	+	+	++	+
Huang et al. 2016	+	-	-	+	-
Karabag et al. 2016	+++++	+	+	++	+
Karppinen et al. 2003	+++	+	-	+	+
Kauppila et al. 1997	++++	+	-	++	+
Kauppila et al. 1994	++++	+	+	++	+
Kurunlahti et al. 1999	+++	+	-	+	+
Shi et al. 2020	+++	+	-	+	+
Suri et al. 2012	+++++	+	+	++	+
Turgut et al. 2008	++++	+	-	++	+
Yuedong et al. 2016	++++	+	-	++	+

The methodological quality of studies was evaluated according to an adjusted version of the Newcastle-Ottawa Scale(NOS) checklist[31]
P: "-"=0, 1; "+"=2,3 S: "-"=0; "+"=1 O: "-"=0; "+"=1; "++"=2 A: "-"=0; "+"=1,2
Low risk: ++++,+++++ Intermediate risk:++, +++ High risk:-, +

Table 5: Characteristics of studies investigating correlation between AAC and LBP/Sciatica, LDH/DDD

Author/ year	Study population	Sample size (N)	Gender (M:F)	Age (Mean ± SD)	Study Design	Clinical parameters	Radiological evaluation LDH/DDD	Radiological evaluation Atherosis/ Stenosis	Laboratory situation	Follow-up period
Bikbov 2020 [33]	Inhabitant of region in Russia age of 40+ years	5397	45:55	58.6 ± 10.6	Cross-sectional	Pain: GPAQ [1]	NA	NA	HDL; LDL; TG; Chol; CRP	NA
Jhawar 2006 [34]	Female nurses registered in U.S. states	98,407	0:100	Range 30-55	Cohort Prospective	Self-reported LDH	Self-reported with history of CT/MRI	NA	Chol	16 y
Jin 2015 [35]	Healthy Center visitors with routine CT of spine	980	55:45	44.8± 5.3; Range 33–60	Cross-sectional	490 patients with back leg pain/LDH/sciatica ; 490 patients without back leg pain/LDH/sciatica (randomly chosen)	LDH on CT	NA	TC; TG; HDL; LDL; FPG	NA
Keser 2017 [36]	Group-I: LDH surgery(50) Group-II: control patients with headache(50)	100	50:50	41.3± 9.1	Cross-sectional	No specific parameters evaluated	LDH on MRI	NA	TC; TG; LDL-C; HDL-C	NA
Korkiakoski 2009 [37]	Healthy Caucasian males	227	100:0	Range 36-56	Cross-Sectional	VAS leg-pain LBP yes/no	NA	2D TOF-MRA	NA	NA
Kurunlahti 2004 [13]	Non-operated sciatica patients with unilateral symptoms for 1 to 6 months.	147	60:40	Range 43-45	Prospective	Leg and back pain (VAS); Disability (OLBQ); Self-reported physical ability(SEQ)	NA	2D TOF-MRA	NA	3 years
Leino-Arjas 2008 [38]	≥ 30 years old living permanently in Finland	6354	67:33	53.1± 15.2	Cross-sectional	Interviews: history of strenuous physical work; presents of sciatica; medication for hyperlipemia; BMI	NA	NA	TC; LDL; HDL; Chol; TG	NA
Longo 2011 [40]	Group 1 : LDH surgery Group 2: Control arthroscopic meniscectomy (no back pain)	Group 1 : 169 Group 2 : 169	68:32	Range 26-86	Cross-sectional	No specific parameters evaluated	MRI confirmed disc herniation	NA	TC; TG	NA
Xie 2014 [39]	LDH(30+10) Healthy subjects(30+10)	Proteomics study: 30 LDH,30 healthy subjects ELISA test: 10 LDH, 10 healthy subjects	50:50	28.1± 2.3	Cross-sectional	No specific parameters evaluated	MRI confirmed disc herniation	NA	APO-L1; APO-M; TN;IGL	NA
Beckworth 2018 [41]	Population with CTAs	300 lumbar arteries; 120 disks	NA	58.4± 17.1	Retrospective case review	No specific parameters evaluated	DDD-CT documented severity-4 point scale	CTA of lumbar arteries, Lateral Radiographs	NA	NA
Huang 2016 [52]	Case group: patients with surgery for LDH, Control group: Healthy volunteers, SFR, spine spondylolisthesis, vertebral malformation and scoliosis	Case group:30 LDH patients; Control group:30 normal, 30 spinal fracture patients, 30 spine spondylolisthesis, 30 vertebral malformation and scoliosis	50:50	Case group:45±1 Control group 40±1; 40±1; 40±1; 65±2 y	Retrospective	No specific parameters evaluated	Unspecified confirmed disc herniation	NA	ApoL1 detected use MWNT-based probe and conventional ELISA	Baseline + 1 day, 7 day, 1 month, 3 months, 6 months, 12 months In case group
Karabag 2016 [43]	LDH, healthy controls	48 patients ; 50 controls	Patients:50:50 Controls: 64:36	Range 35±14	Cross-sectional	No specific parameters evaluated	Unspecified confirmed disc herniation	NA	TG; TC; HDL-C; LOOH;TOS; PON1; TAS	NA
Karppinen 2003 [49]	unoperated patients with sciatica with unilateral pain below the knee for 3 weeks to 6 months	88 no C. pneumonia antibody titer in blood(controls); 71 patients with increased antibody titer.	Cases: 86:14 Controls: 55:45	Range 48±13	Retrospective	Leg and back pain (100-mm VAS); Disability (0-100% ODI); smoke; BMI	DD: 4 grades Endplates: Modic's criteria	2D-TOF MRA 3 grades of lumbar artery stenosis	NA	3-year
Kauppila 1997 [44]	Members of Framingham cohort	606	35:65	54.0± 4.7	Cross-sectional; Follow-up	1. Back pain-"yes or no" 2. BMI	DD: 4 grades Endplate sclerosis:0 or 1	Abdominal aorta calcification: 0-3	Serum cholesterol	25-year
Kauppila 1994 [45]	Males (sudden unexpected death)	86	100:0	Range 36-69	Cross-sectional	NA	Anteroposterior and lateral radiographs; X-ray: DD 4 grades	Stenosis of the Ostia of sacral arteries: 3 grades	NA	NA
Kurunlahti 1999 [50]	Severe LBP patients	29 LBP, 52 control	62:38	Range 20-63	Cross-sectional	No specific parameters evaluated	CT discography: 4 grades	Calcification of abdominal aorta: 4 grades	NA	NA
Shi 2020 [51]	General population (registered in Eastern China)	678	47:53	48.2 ± 8.3	Cross-sectional	BMI; WHR	Pfirrmann score, Weishaupt scale	NA	TG; TC; HDL-C; LDL-C	NA
Suri 2012 [46]	Framingham Heart Study	435	55:45	58.2 ± 13.1	Cross-sectional	BMI	DHL: 4 grades(0-3)	AAC: 3 grades (no, low, high) Agatston score[2]	TC	NA
Turgut 2008 [12]	LBP with/without leg pain	81	<45 years: 23:77 45-65 years: 16:84 >65 years: 21:79	<45 years: 22 45-65 years: 45 >65 years: 14	Cross-sectional	Self-reported low back pain with/without leg pain of unclear origin.	DD: 4 grades(0-3)	AAC: 4 grades(0-3)	NA	NA
Yuedong 2016 [47]	Group- LDH Group-Trauma	Group-LDH:396 Group-Trauma: 394	Group-LDH 59:41 Group-Trauma 57:43	41.07 ± 11.3	Retrospective	NA	LDH on CT/MRI	NA	TC; TG; LDL-C; HDL-C	NA

HDL: High-density lipoprotein, **LDL:** Low-density lipoprotein, **TG:** Triglycerides, **Chol:** Cholesterol, **CRP:** C-reactive protein, **LDH:** Lumbar disc herniation, **TC:** Total cholesterol **FPG:** Fasting plasma glucose, **LDL-C:** Low-density lipoprotein cholesterol, **HDL-C**: High-density lipoprotein cholesterol, **VAS:** visual analogue scale, **LBP:** Lower back pain, **2D-TOF:** Two-dimensional time-of-flight, **MRA:** Magnetic resonance angiography, **OLBQ:** Oswestry Low Back Questionnaire, **SEQ:** Self-Efficacy questionnaire, **BMI:** Body mass index, **ELISA:** enzyme-linked immunosorbent assay, **APO-L1:** Apolipoprotein-L1, **APO-M:** Apolipoprotein-M, **TN:** Tetranectin, **IGL:** Immunoglobulin light chain, **CTA:** Computed tomography angiography, **DDD:** degenerative disk disease, **DD:** Disc degeneration, **baPWV:** Brachial-ankle pulse wave velocity, **MWNT:** Multiwalled carbon nanotubes, **LOOH:** lipid hydroperoxide, **TOS:** Total oxidative status, **PON1:** Paraoxonase 1, **TAS:** Total antioxidative status, **WHR:** waist to hip, **DHL:** Disc hight loss, **AAC:** abdominal aortic calcification, **SFR:** Spinal fracture patients

Table 6a: Results and conclusion---Correlation between AAC (or lipid status) and Clinical LBP/Sciatica

Author/ year	Clinical outcome	Radiological outcome LDH/DDD	Radiological outcome Atherosis/Stenosis	Laboratory data (intervention group)	Correlation Clinical outcome and LBP/Sciatica	Correlation Radiological outcome LDH/DDD and LBP/Sciatica	Correlation Radiological outcome Atherosis /Stenosis and LBP/sciatica	Correlation Laboratory data and LBP/sciatica	Conclusion
Bikbov 2020	The mean lifetime prevalence of low back pain was 54.0%; 95% CI: 52.6, 55.3; Thoracic spine pain 23.6%; 95% CI: 22.4, 24.7; Neck pain: 29.1%; 95% CI: 27.9, 30.3	NA	NA	No specific data available	Low back pain was associated with higher BMI, history of CV disease. Thoracic spine pain was associated with higher BMI and history of CV disease. Neck pain was associated with higher BMI and history of CV disease.	NA	NA	Low back pain was associated with HDL OR 1.10, 95% CI 1.03-1.18, P=0.002	The prevalence of Low back pain, thoracic spine pain and neck pain were correlated with higher BMI, history of CV disease
Korkiakoski 2009	LBP episodes 78/205; Disabling sciatica 108/220	43% no stenosed arteries; 27% one stenosed arteries; 30% least 2 stenosed artery.	NA	NA	NA	NA	≥1 stenosed arteries not associated with LBP/sciatica; ≥2 stenosed arteries associated with sciatica pain duration of 8-30days during the past months (OR 2.70,95% CI 1.18-6.20),intensity of LBP(1.38. 1.07-1.73), and intensity of leg pain(1.32. 1.02-1.67);	NA	Sciatica and low back pain were associated with arterial stenosis
Kurunlahti 2004	No specific data available, only association mentioned	MRA of the lumbar arteries Baseline: 957 (81%) normal; 219 (19%) narrowed or occluded. 3 years follow-up: 785 (73%) normal; 287 (27%) narrowed or occluded	NA	NA	NA	NA	Baseline: Arterial scores associated with back pain at 1 year(P=0.036) but not at 2 and 3 years follow-up; with leg pain at 2 years, but not at 1 and 3 years follow-up	NA	The association of Diminished blood flow into the disc area with symptoms of lower back pain and leg pain is debateable
Leino-Arjas 2008	The prevalence of sciatica was 3.3% for men and 2.2% for women; pharmacologically treated hyperlipidemia 6.2% (6.7% in men and 5.8% in women). BMI >30 (3%)	NA	NA	No specific data available, only association mentioned	NA	NA	NA	1. In men without hyperlipidemia treatment, sciatica was associated with TC(high vs. low tertile: OR 2.28, 95% CI 1.14–4.55), LDL-C (2.12; 1.11–4.05), and triglycerides (1.92; 1.04–3.55). 2. For men in the highest tertile of both TC and triglycerides(1.92; 1.04-3.55), the OR of sciatica was 3.89 (1.68–8.99) in comparison to men with cholesterol in the lowest tertile and triglycerides in the lowest or the middle tertile. 3. In similar analyses among women no associations. 4. Pharmacologically treated hyperlipidemia was associated with sciatica in women (2.02; 1.01–4.04), but not in men (1.71; 0.83–3.55).	Independent BMI and other possible confounders. clinically assessed sciatica in men was associated with levels of atherogenic serum lipids. Pharmacologically treated hyperlipidemia was associated with sciatica in women.
Karppinen 2003	BMI 28± 4.2; Back pain 59± 22mm; Leg pain 70± 19mm; ODI 40± 14%	Results of grading of DD not given	Results of arterial stenosis not given	NA	Patients with chronic C. pneumoniae had higher BMI(P=0.02), VAS of back pain, leg pain and ODI were comparable.	No specific data available	C. pneumoniae increased the degree of arterial stenosis at L4 segment and the whole lumbar spine at baseline and at 3 years(P< 0.001),L1,L3 segments at 3 years.	NA	Chronic C. pneumoniae infection may induce stenosis of lumbar arteries, and higher Endplate degeneration at L4-5
Kauppila 1997	74%men and 69% women back pain. Baseline: BMI: men 26.5± 3.1; women 24.9± 3.6; Follow-up: BMI: men 26.2± 3.3; women 25.6 ± 4.2	Baseline: anterior osteophytes 85% M, 63% F; Disc space narrowing 19% M, 12% F; Endplate sclerosis 6% M, 2% F; Follow-up: anterior osteophytes 97% M, 92% F; Disc space narrowing 60% M, 60% F; Endplate sclerosis 29% M, 26% F.	Baseline: 39% M and 25% F calcific deposits Follow-up: 91% M and 89% F calcific deposits.	Baseline: Serum cholesterol: Men 5.8± 1.0; women 6.1 ± 1.1 Follow-up: Men 5.9± 1.0; women 6.3 ± 1.1	No correlation between back pain and BMI	Back pain was associated with grade 3 osteophytes (OR 1.46)and grade 3 disc space narrowing(OR 1.82) and endplate sclerosis(OR 1.90). (All P<0.05)	Baseline: after adjustment for age and sex, AC was associated with DD(OR 1.59; 95%CI 1.03-2.45; P=0.036). Individuals with grade 3 AC were more likely to report back pain than others(OR 1.56; 95%CI 1.10-2.21; P=0.014); No correlation between Back pain and Grade 1 or 2 AC.	No correlation between back pain and BMI, serum cholesterol	Severe aortic atherosclerosis is associated with severe DD (age adjusted) and with back pain

BMI: Body mass index, **CV:** Cardiovascular, **HDL:** High-density lipoprotein, **LBP:** Lower back pain, **VAS:** visual analogue scale, **ODI:** Oswestry Disability Index, **AC:** Aortic calcification

Table 6b: Results and conclusion---Correlation between AAC (or lipid) and Radiological LDH/DDD

Author/ year	Clinical outcome	Radiological outcome LDH/DDD	Radiological outcome Atherosis/ Stenosis	Laboratory data (intervention group)	Correlation Clinical outcome and LDH/DDD	Correlation laboratory data and LDH/DDD	Correlation Radiological outcome Atherosis /Stenosis and LDH/DDD	Conclusion
Jhawar 2006	NA	NA	NA	No specific data available	NA	LDH was associated with high cholesterol: RR: 1.26 95% CI: 1.10-1.44	NA	Cardiovascular risk factors are associated with symptomatic LDH.
Jin 2015	NA	NA	NA	No specific data available	NA	LDH was associated with BMI, TG, LDL, Lower HDL (No statistical data)	NA	LDH was associated with BMI, TG, LDL, Lower HDL (No statistical data)
Keser 2017	NA	NA	NA	TC: 95%CI: −17.10, 15.66 (P=0.931) TG: 95%CI :−28.77, 25.13 (P=0.863) LDL-C: 95%CI: −11.49, 15.54 (p=0.767) HDL-C: 95%CI: −6.60, 0.80 (P=0.124) TC/HDL-C: 95%CI: −2.97,0.84 (P=0.344)	NA	No association between the blood lipid profile and LDH	NA	Blood lipid levels in this young adult Turkish population did not predict LDH
Longo 2011	NA	NA	NA	Serum triglycerides: Group1: 1.8 ± 1. 5 Group2: 1.5 ± 0. 8 Total serum cholesterol: Group1:5.6 ± 1. 2 Group2:5.3 ± 1. 0	NA	Patients with LDH demonstrated higher triglyceride and TC concentration, no covariates evaluated	NA	There was an association between serum lipids level and a symptomatic disc herniation, however no covariates evaluated.
Xie 2014	NA	NA	NA	The protein expression of APO-L1 was only found in LDH patients. The protein expression levels of APO-M, TN and IGL in LDH patients were all downregulated by 22±3%, 37±5% and 27±3%, respectively, compared to the healthy subjects.	NA	The ELISA: the mean serum concentrations of APO-M, TN and IGL were significantly lower in LDH patients compared to the healthy control group (P<0.05). Plasma levels of APO-L1 was only detected in LDH patients in contrast to the healthy control group.	NA	Serum APO-L1, TN, APO-M and IGL may serve as LDH biomarkers.
Beckworth 2018	NA	There were 35 disks (29%) with mild disease, 12 (10%) with moderate disease, and 24 (20%) with severe disease.	Median of stenosis in lumbar arteries: 0 in normal DDD, 4 in mild DDD, 6.5 in moderate DDD, 8.5 in severe DDD	NA	NA	NA	Lumbar artery stenosis and DDD score had a strong, positive correlation coefficient of 0.80 (95% CI: 0.68-0.84). Adjusted for age.	Atherosclerotic disease of the lumbar arteries and aorta correlated with lumbar DDD
Estublier 2015	NA	69% had grade 3 osteophytes at ≥1vertebral level; 16% had grade 3 DSN at ≥1 vertebral level ; Overall, grade 2 changes at ≥1vertebral level were found in 86%	29% had severe aorta calcification	Total cholesterol:231± 38 ; HDL cholesterol:49± 14 ; LDL cholesterol:147± 35 ; Triglycerides:171± 90	NA	No clear correlation described	After adjustment for confounders, the odds of severe AAC increased with the total disc space narrowing score (adjusted HR 1.44 per SD [95% CI 1.11–1.87]).	Older men with severe disc degeneration have greater AAC severity
Hangai 2008	190/257 LBP	DD: 57% of lumbar discs in males and 60% in females	baPWV > 1400 cm/sec 191/256	LDL-C ≥140 mg/dl 84/267 ; TG ≥150 mg/dl 28/267	History of LBP had no correlation with DD	high LDL-C correlated only with L4/5 DD(OR, 2.65), no correlation with other parameters	No correlation between DD and brachial-ankle index	Very limited correlation DD with high LDL-C, no correlation for age.
Huang 2016	NA	NA	NA	MWNT: ApoL1 absorbance LDH group vs other groups=ca. 17 (P<0.001); ELISA: ApoL1 absorbance LDH group vs other groups=ca. 10 (P>0.05)	NA	LDH patients demonstrated much higher level of ApoL1 than in controls. The level of ApoL1 decreased with time after surgery.	NA	ApoL1 was a potential biomarker for early diagnosis of LDH and tracking the recovery of LDH patients. Limitation: LDH group was only tested after surgery, not on baseline. Controls were not operated.
Karabag 2016	NA	NA	NA	Serum PON-1 level was lower (P = 0.008), serum TAS and LOOH levels were higher (both P < 0.001) in the LDH group.	NA	PON1 was higher and LOOH was lower in LDH patients compare to controls	NA	The inflammatory-oxidant environment decreased PON1 and increased LOOH may be the cause or reason of LDH. LDH may be related with atherosclerosis.
Kauppila 1994	NA	DD grade 1: 12%, grade 2: 42%, grade 3: 33%, grade 4: 13%	Correlation coefficients between grade of stenosis and DD: L1-2: 3.08, L2-3: 3.03, L3-4: 2.64, L4-5: 2.55, L5-S1: 2.50	NA	NA	NA	Grade of DD was associated with the grade of sacral arterial stenosis. The association was stronger at upper lumbar levels (0.001 < P < 0.01).	Sacral artery stenosis due to atherosclerosis is associated with Lumbar disc degeneration (age corrected)
Kurunlahti 1999	NA	No specific data available	Total: 55% with LBP had AAC; 21% without LBP had AAC. <50 years: 48% with LBP had AAC; 8% without LBP had AAC. >50 years: 83% with LBP had AAC; 50% without LBP had AAC.	NA	NA	NA	no correlation between aortic calcifications and the degree of disc degeneration. The quantity of plaques was correlated with DD in age >50yr and <50yr.	There is an association between atheromatous lesions in the abdominal aorta and LBP.
Shi 2020	Individuals 14.9% UH-NO,11.4% UH-O, 18.1% LA-NO, 55.6% LA-O BMI: UH-NO 22.01, UH-O 24.15, LA-NO 22.61, LA-O 24.88 WHR: UH-NO 0.82, UH-O 0.91, LA-NO 0.82, LA-O 0.91	Degenerated disc percentage: 4.2- 13.5%; Facet joint degeneration: No specific data aviable	NA	TG(mmol/L) UH-NO 0.90, UH-O 1.08, LA-NO 1.66, LA-O 2.25; TC(mmol/L) UH-NO 4.59, UH-O 4.71, LA-NO 5.40, LA-O 5.44; HDL-C(mmol/L) UH-NO 1.47, UH-O 1.34, LA-NO 1.45, LA-O 1.23; LDL-C(mmol/L) UH-NO 2.60, UH-O 2.76, LA-NO 3.27, LA-O 3.38	Increased WHR was associated with DD (OR = 1.052–1.121, P < 0.01). LA-NO demonstrates a high incidence for DD (P < 0.05), UH-O confers a severe DD grade (P < 0.05).	Elevated TG was associated with DD (OR = 1.243–1.629, P < 0.01). No date on correlation with facet joint degeneration	NA	Elevated triglycerides and abdominal obesity (WHR) associated with LDD
Suri 2012	41.4% Overweight (BMI 25-30 kg/m²); 29.1% Obese (BMI>30 kg/m²)	No specific data available	No AAC 34.9%; Low AAC 32.6%; High AAC 32.6%	24.8% had hypercholesterolemia(TC >240 mg/dL)	Age was associated with DHL (OR 1.04 [1.02-1.06];	Hypercholesterolemia was not associated with DHL.	low AAC (OR 2.05[1.27-3.30]; p=0.003) and high AAC (OR 2.24[1.38-3.62]; p=0.001) were both associated with DHL; no AAC was not associated with DHL; however, age corrected no correlation.	The association between AAC and DHL is independent of cardiovascular risk factors, and is largely explained by the influence of age.
Turgut 2008	No specific data available	No specific data available	No specific data available	NA	NA	NA	On CT scan, there was a correlation between AAC and DD (r= 0.306, p < 0.01); Not correlated for age	Both the AAC and DD score increased with advancing age. On CT scan, the degree of AAC was correlated to DD score.
Yuedong 2016	NA	NA	Na	Disc herniation: TC 4.75±1.02, TG 1.46±0.89, LDL-C 2.92±0.86, HDL-C 1.32±0.30; Control group: TC 4.41±0.90, TG 1.35±0.94, LDL-C 2.62±0.73, HDL-C 1.34±0047;	NA	higher LDL-C levels had a higher risk of disc herniation (OR=1.462, 95%CI 1.179 ~ 1.813). Patients with High-TG and borderline High-LDL-C had a higher probability of disc herniation (OR: 2.974, CI: 1.488 ~ 5.945, OR: 1.626, CI: 1.012 ~ 2.612). TC/HDL-C and LDL-C/HDL-C were associated with disc herniation (P < 0.001 for both). Hyperlipidaemia had no associated with LDH (p =0.374).	NA	Patients with higher LDL-C levels, High-TG and borderline High-LDL-C have a higher probability to developing IVDD.

LDH: Lumbar disc herniation, **BMI:** Body mass index, **TG:** Triglycerides, **LDL:** Low-density lipoprotein, **HDL:** High-density lipoprotein, **TC:** Total cholesterol, **LDL-C:** Low-density lipoprotein cholesterol, **HDL-C**: High-density lipoprotein cholesterol, **APO-L1:** Apolipoprotein-L1, **APO-M:** Apolipoprotein-M, **TN:** Tetranectin, **IGL:** Immunoglobulin light chain, **Chol:** Cholesterol, **DDD:** degenerative disk disease, **HR:** Hazard ratio, **SD:** Standard deviation, **baPWV:** Brachial-ankle pulse wave velocity, **MWNT:** Multiwalled carbon nanotubes, **ELISA:** Enzyme-linked immunosorbent assay, **ApoL1:** Apolipoprotein-L1, **PON1:** Paraoxonase 1, **TAS:** Total antioxidative status, **LOOH:** lipid hydroperoxide, **DD:** Disc degeneration, **LBP:** Lower back pain, **AAC:** Abdominal aortic calcification, **WHR:** Waist to hip, **LA-NO:** Lipid abnormal but not obese, **LH-O:** Lipid healthy but obese, **LDD:** Lumbar disc degeneration, **DHL:** Disc hight loss

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Evidence for infection in intervertebral disc degeneration: a systematic review

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INTRODUCTION
Back pain is a major problem worldwide and is linked to intervertebral disc degeneration and Modic change (MC). Several studies report bacterial growth, commonly *Cutibacterium acnes* (previously called *Propionibacterium acnes)*, following extraction of degenerate discs at spine surgery. A pathophysiological role for infection in back pain has been proposed. We aimed to clarify if *C. acnes* is indeed the predominant species in degenerate discs and assess the utility of current laboratory and research practices in the detection and quantification of bacteria in disc material.

METHODS
We conducted a PRISMA systematic review. MEDLINE, PubMed, Scopus and Web of Science were searched with the terms Modic change, intervertebral dis*, bacteria, microb*, and infect*. Date limits of 2001-2021 were set. Human studies investigating the presence or role of bacteria in disc degeneration or MC adjacent discs were included. We also investigated whether discs adjacent to vertebral MC are at increased risk of bacterial proliferation.

RESULTS
Thirty-six articles from 34 research investigations relating to bacteria in human degenerate discs were found. Twenty-seven studies reported finding disc bacteria and nine concluded contamination findings. *C. acnes* was identified in pathological disc material. A 'candidate bacterium' approach was repeatedly adopted likely biasing results to find *C. acnes.* Targeted microbial culture precludes the opportunity to isolate non-*C. acnes* bacteria, making accurate determination of a range of species impossible. Only 6/36 studies used universal PCR or genome-wide sequencing techniques to capture all bacterial DNA present in disc samples.
We identified 12 studies reporting MC v. non-MC adjacent disc bacteria. Eight found MC adjacent discs had higher bacterial loads, yet only one reported that MC1 drove differences. More commonly, MC1 & MC2 cases were pooled when increased bacterial proliferation compared with control discs was found. Five studies reported multiple bacterial species in the disc. Three found bacterial species in healthy disc tissue; interestingly one study showed *C. acnes* was present in similar proportions, but not predominant, in healthy, degenerated and herniated discs.

DISCUSSION
Evidence to date implicates *C. acnes* identified through culture, microscopy and sequencing, with some suggestion of diverse bacterial colonisation in the disc. This review found studies which used culture methods and conventional PCR for bacterial detection. Further agnostic investigation using new genomic methods which identify bacteria by their genetic material rather than by targeted culture and may well identify novel organisms, or combinations of organisms, as yet uncatalogued. Including omics analyses and advanced histological techniques will strengthen disc degeneration research.

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Standardized Histopathology Score of Rabbit Intervertebral Disc Degeneration Model Induced by Monosodium Iodoacetate: Correlation Analysis with MRI T2-value

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INTRODUCTION: The rabbit lumbar spine has been used as an animal model to study intervertebral disc (IVD) degeneration and to pre-clinically evaluate regenerative therapies. Magnetic resonance imaging (MRI) and histological assessments are essential endpoints for the evaluation of IVD degeneration and regeneration in a rabbit animal model. A 'new standardized scoring system' to evaluate disc degeneration in the rabbit model has recently been established. However, its correlation with MRI has not been reported.

The purpose of this study was (1) to determine the effect of monosodium iodoacetate (MIA) injections into rabbit IVDs on IVD degeneration evaluated by the 'new standardized scoring system' and (2) to evaluate the correlation between MRI transverse relaxation time (T2) value and a standardized histopathology score.

METHODS: 24 New Zealand White (NZW) rabbits were used in this study. Under general anesthesia, lumbar discs from L1-L2 to L4-L5 had a posterolateral percutaneous injection of MIA in contrast agent (CA) (L1-L2: CA only; L2-L3: MIA 0.01 mg; L3-L4: MIA 0.1 mg; L4-L5: MIA 1.0 mg). Six rabbits were sacrificed at 2,4,8, and 12 weeks post-injection and processed for MRI (T2-mapping) and histological analyses. Blinded to the experiment, an observer analyzed the histological sections and graded them using the recently established standardized histopathology scoring system of rabbit IVD degeneration that involved seven subclasses (NP shape, area, cellularity and matrix condensation, AF/NP border appearance, AF morphology, and endplate (EP) sclerosis/thickening).

RESULTS SECTION: MRI assessment: Intradiscal injection of 1.0 mg (L4-L5 discs) significantly decreased T2-value compared to that of the CA control (L1-L2) discs ($P<0.01$). At week eight post-injection, the mean T2 value of MIA 1.0 mg (L4-L5) injected discs was significantly lower than that of MIA 0.01 mg (L2-L3) injected discs and CA control discs ($P<0.05$, $P<0.01$, respectively). Histological assessment: The total histological scores of MIA 0.1 mg injected discs were significantly higher than those in the CA control discs at week 12 ($P<0.01$). The intradiscal injection of MIA 1.0 mg significantly increased the total histological scores compared to those of the CA control discs (week 2: $P<0.05$, week 4 to 12: $P<0.01$).

Correlation between MRI T2-values and histological scores: MRI T2-values of the whole disc negatively correlated with the total histological score ($r=-0.83$, $P<0.01$) (Fig. 1). Subclass analysis showed that MRI-T2 values significantly correlated with the NP shape ($r=-0.66$, $P<0.01$), NP area ($r=-0.75$, $P<0.01$), NP matrix ($r=-0.81$, $P<0.01$), NP cellularity ($r=-0.67$, $P<0.01$), AF/NP border ($r=-0.78$, $P<0.01$), AF ($r=-0.80$, $P<0.01$), and EP ($r=-0.32$, $P<0.01$). A strong correlation between whole disc MRI T2-values and histological scores was identified with four subclasses (AF and/or NP scores), while a weak correlation was found with the EP score.

DISCUSSION: A standardized histopathology scoring system showed that the intradiscal injection of MIA significantly affected the total histological score of rabbit disc degeneration throughout the experimental period. Our results also showed that MRI T2-values were strongly correlated with total histological grading score and subclass grading score, except for the weak correlation with the EP score.

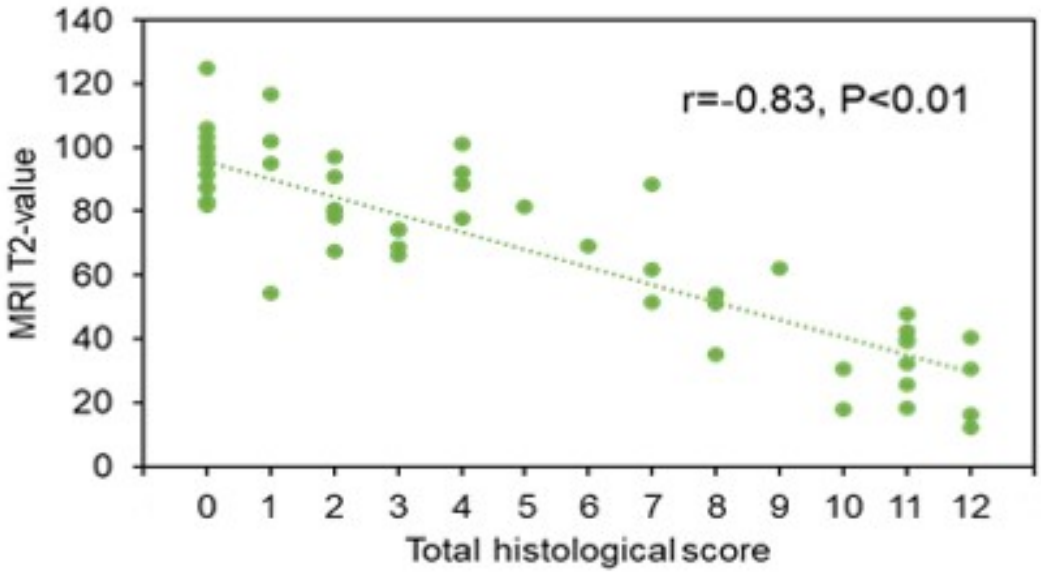

Fig. 1 Correlation between MRI T2-values of the whole disc and the total histological score.

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Characterization of Nucleus Pulposus Allograft for Replacement of Tissue Loss Due to the Degeneration of the Intervertebral Disc

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Introduction: Degenerative disc disease is characterized by a loss in proteoglycan and water in the nucleus pulposus (NP), and a loss in disc height which leads to alterations in the biomechanical function of the intervertebral disc. Injectable NP particulate allograft consists of cryomilled NP tissue and is intended to replace nucleus pulposus tissue loss due to degeneration by introducing additional extracellular matrix into the disc space. The purpose of this study was to assess the characteristics of nucleus pulposus allograft that are responsible for its potential utility as a cushion between the vertebrae. Therefore, GAG content, swelling capacity, total collagen, and GAG:hydroxyproline ratio were assessed. The hypothesis is that nucleus pulposus particulate retains properties similar to that of native tissue.

Methods: NP particulate was generated from cadaveric intervertebral discs from lumbar and thoracic vertebrae. For native tissue, an approximately 1 cm^3 piece of tissue from the nucleus pulposus of a single disc from each donor was collected. A total of 5 donors were used to directly compare native tissue to NP particulate. Additionally, 40 cadaveric donors stratified by age (15-25, 26-35, 36-45, and 46-55 yr-old) were used to further evaluate GAG content and swelling capacity (n=10, 5 females and 5 males per age group). GAG and total collagen (hydroxyproline) content were assessed using commercially available kits, and swelling capacity was determined using a centrifugation method. For GAG content and swelling capacity, two-way ANOVA was used to compare differences between the main effects of age and sex. Sidak's multiple comparison test was used to show differences between age groups within male and female groups. T-tests were used to determine the difference between native and particulate groups for collagen content and GAG:hydroxyproline ratio.

Results: NP particulate and native tissue were not significantly different in the outcomes measured. Total collagen content was 85.11±30.13 in the native group and 118.8±85.87 µg hydroxyproline/tissue dry weight in the particulate group (p=0.38). GAG:hydroxyproline ratio was ~12:1 in native and ~9:1 in particulate (p=0.36). The average GAG content in NP particulate from 40 donors was 666.1 ± 156.9 µg/mg tissue and was not significantly different between males and females. When males and females were pooled GAG content was reduced in older groups compared to 15-25 yr-olds: 1.3-fold lower (p=0.0187) in 36-45 yr olds and 1.5-fold lower (p=0.0005) in 46-55 yr-olds. The average swelling capacity in NP particulate from all donors was 608.4±113.1%. When sexes were pooled, swelling capacity was ~1.2-fold higher in 46-55 yr-olds compared to 15-25 yr-olds.

Discussion: These results suggest that NP particulate has high GAG levels and retains the important original characteristic of swelling. In the 40-donor analysis, the primary differences in levels of GAG and swelling capacity were in the male donors and is consistent with well-established age-associated decline in GAG content. However, the decline in GAGs did not negatively alter the swelling capacity of the particulate. These findings suggest that the NP particulate may be a viable therapeutic option to replace tissue loss in the degenerative disc.

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Novel Collagen Biomarkers of Intervertebral Disc Degeneration And Candidate Molecules For Regeneration -Inferences from Comparative Proteomic Analysis Of Fetal, Healthy Adult And Diseased Discs

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Introduction: Alterations in the collagen (COL) composition have been correlated to degenerative disc disease (DDD). Though 28 different types of COLs are present in humans, most of the literature is focused only on COL-1 and COL-2. There are no detailed studies evaluating the collagen types and their significance in IVD. The current study aimed to analyze the entire COL composition of human intervertebral disc (IVD) across fetal (developmental-FD), normal (healthy-ND), scoliotic (early degeneration-SD), herniated (degenerate-DH), and degenerated (DD) disc phenotypes using high-end proteomic-technology.

Methods: Forty Nucleus pulposus (NP) tissues segregated from from five different disc phenotypes (eight each) under sterile conditions were snap-frozen in liquid nitrogen ((LN_2) -196ºC) immediately before subjecting to proteomic and bioinformatic analysis.

Results: Tandem mass spectrometric analysis revealed a total of 1050 proteins in fetal discs (FD); 1809 in ND; 1487 in SD; 1859 in DH and 1538 in the DD group. Out of 28 major collagens reported in human body, this study identified 24 different Collagens with 34 subtypes in NP. Fibril forming collagens (COL-1,2 and 11A1) and Fibril associated collagens with interrupted triple helices (COL-9A1,12A1 and 14A1) were abundantly expressed in fetal discs representing their role in development of NP. More importantly Multiplexin (COL-15), a hybrid proteoglycan/collagen molecule was found only in fetal discs. Downregulation of COL2A1 and upregulation of COL-10A1 was associated with degeneration.

Conclusion: COL10 was identified as a novel biomarker for disc degeneration. Apart from COL-1 and 2, other important COLs (6,9,11,12,14 and 15) with anabolic potential, abundantly expressed in fetal phenotype could be explored for tissue engineering and regenerative therapies for DDD.

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Is endplate the gateway for establishment of disc microbiome ?-Novel Insights from comparative Metagenomic analysis of Human Nucleus pulposus and Cartilaginous end plates

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Introduction:

Microbial etiology has been recently postulated as a cause of degenerative disc disease (DDD) leading to randomized trials of probiotics and antibiotics to treat chronic LBP. Recently the presence of disc microbiome in both healthy and diseased discs has been established by next-generation sequencing. However, the origin of disc microbiome has not been investigated. This study aims to trace the origin of human IVD microbiome.

Methods:

Lumbar discs from brain dead organ donor volunteers and patients undergoing microdiscectomy/spinal fusion were procured for this study. Normal discs (ND) group had 26 NP (Nucleus Pulposus) tissues and 17 EP (Cartilaginous Endplates) tissues excised from 10 MRI normal asymptomatic organ donor volunteers. Amplicon-sequencing was done to explore the microbial population in endplate (EP) tissues of human intervertebral disc (IVD) using NGS sequencing platform. A comparative analysis of the NP microbiome with that of EP microbiome was performed.

Results:

In total, four dominant phyla were detected in our samples: *Proteobacteria, Firmicutes, Actinobacteriota* and *Bacteroidetes. Proteobacteria* was identified as the dominant phyla in both NP and EP disc with 72% and 68% mean relative abundance respectively. Overall NP and EP had similar microbiome. A marginally higher relative abundance of *Actinobacteria* in NP and minor difference in relative abundance of *Firmicutes* were the only differences found between EP and NP. The predominant bacterial genus was again *Pseudomonas* in both EP and NP. However, the second predominant genus was *Anoxybacillus* in EP in contrast to *Brevundimonas* in NP. Higher abundance of bacteria in EP compared to NP measured by beta diversity was noted.

Conclusion:

Our study explores the route of microbial entry into intervertebral disc. We found that the microbiome of nucleus pulposus and end plates are similar suggesting that the endplate could be gateway for establishment of disc microbiome.

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Nanoroughened Microstructured Orthopaedic Implant Surfaces Support Production of Factors that Induce Ectopic Osteogenesis in a Preclinical Osteoinduction Model

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Introduction: There is a growing clinical need to create implants with material properties that promote accelerated osseointegration and reduced recovery time in compromised bone. We have shown that machined Ti-based implants possessing biomimetic surface topographies can direct osteoblast differentiation of multipotent bone marrow stromal cells (MSCs) *in vitro* and improve osseointegration *in vivo* in both animals and humans and that this process occurs through paracrine signaling and increased local factor production. This study examined the hypothesis that MSCs grown on nanotextured microstructured Ti6Al4V surfaces produce factors that support osteoinduction in vivo.

Methods: Ti6Al4V disks were grit-blasted and acid-etched, producing complex topography at the macro/micro/nanoscale (MMN; Medtronic). All cultures were grown on tissue culture polystyrene (TCPS) or MMN surfaces in MSC growth media (GM) absent of osteogenic growth media supplements.

Study 1: Athymic mice were divided into 4 groups: active demineralized bone matrix (aDBM) (LifeNet Health, Virginia Beach, VA), heat inactivated DBM (iDBM), iDBM+GM (fresh media), and iDBM+TCPS-CM proteins. TCPS-conditioned media was derived by culturing MSCs on TCPS surfaces for 14d and lyophilizing the conditioned media (CM). Gel capsules were implanted bilaterally into intramuscular pockets created in the hind limbs (N=8 capsules/group). Legs were harvested at D35. Mineralization was assessed by micro-CT.

Study 2: Athymic mice were divided into 3 groups: iDBM, iDBM+rhBMP2 (R&D Systems) at a concentration similar to *in vitro* production of MSCs on MMN surfaces (MMN-CM concentration), and iDBM+MMN-CM proteins. MMN-CM was derived by culturing MSCs on MMN surfaces for 10d and lyophilizing the CM from D5-D10 to capture proteins produced after responding to surface properties and during differentiation/maturation. Gel capsules were implanted bilaterally into intramuscular pockets created in the hind limbs (N=8 capsules/group). Legs were harvested at 35D. Bone formation was assessed by micro-CT and histomorphometry (H&E Staining). Histology was scored according to ASTM 2529-13.

Results: Micro-CT demonstrated robust ectopic bone formation in the aDBM group. iDBM, iDBM+GM, and iDBM+TCPS-CM demonstrated significantly little ectopic mineralization. In study 2, micro-CT revealed greater mineralized tissue in iDBM+MMN-CM groups compared to iDBM and iDBM+BMP2. Additionally, there was more live bone in the MMN-CM group compared to iDBM as quantified by quantitative histomorphometry. Scoring of histology slides according to ASTM 2529-13 demonstrated an average scoring rank of 3.125 (passing) for MMN-CM explants and a failing scoring rank of 1.375 for iDBM.

Conclusions: MSCs cultured on nanoroughened microtextured Ti6Al4V surfaces differentiate and produce local factors that can induce ectopic bone formation through a combination of paracrine signaling factors in addition to BMP2. Proteins comprising fresh GM, or TCPS-CM do not possess capabilities of increased osteogenesis in a mouse model. Nanotextured microstructured biomimetic surfaces induce local factor production, which increased bone formation in a mouse model compared to iDBM and iDBM+BMP2 treatment groups. This indicates that the surface topography has an osteoinductive effect via surface-dependent osteogenic differentiation of the MSCs, potentially supporting better osseointegration and may provide an alternative to expensive pharmacologic agents like rhBMP2 during implant placement in patients with compromised bone quality.

Vertebral mesenchymal stromal cell transplantation for intervertebral disc repair; a preliminary rat tail disc degeneration study.

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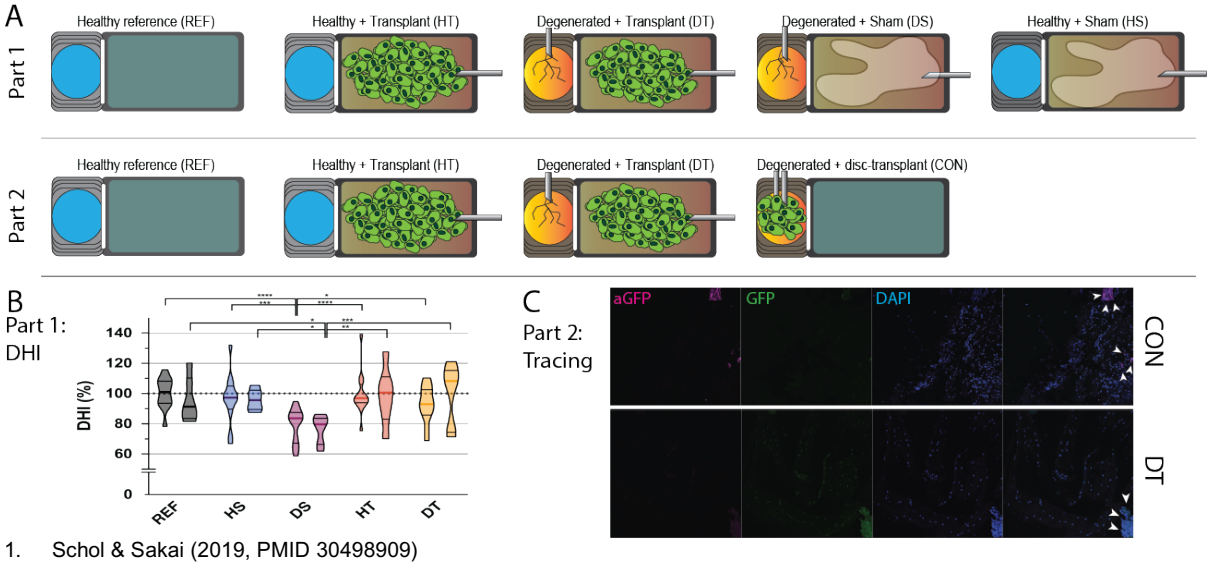
Introduction: Cell transplantation has been explored as a potential therapy against intervertebral disc (**IVD**) degeneration[1]. Nevertheless, intradiscal cell transplantation causes additional damage following needle puncture, potentially promoting further degeneration. In this study, we examined the potential of transplanting mesenchymal stromal cells (**MSC**) into the vertebrae as an alternative strategy for IVD repair and assess the potential of MSC homing into the degenerating IVD[2-4].

Methods: All animal experiments were approved by the Tokai University School of Medicine committee for safe animal experimentation (#214033). 24 female SD rats were subjected to coccygeal IVD degeneration through nucleus pulposus (**NP**) aspiration in two discs. Directly after, from a caudal approach, 10 uL of PBS (Sham) or 10 uL PBS containing $25x10^4$ rat MSC were transplanted into the vertebrae, neighboring either a healthy or degenerating disc. (**Fig1A**) The rats were followed for 4 weeks, with disc height (**DHI**) measurements[5]every 2 weeks, upon which the rats were sacrificed and the degenerative state was examined using paraffin sections. For the second part, we aimed to trace the transplanted MSCs. Ubiquitously GFP-expressing mouse MSCs were obtained and expanded. 24 female rats were similarly subjected to disc degeneration in two coccygeal IVD. 10 uL of $25x10^4$ GFP^+ MSC were transplanted into the vertebrae next to a healthy or degenerated disc. (**Fig1A**) As a positive control, $10x10^4$ GFP^+ MSC were injected intradiscally into a degenerating IVD. DHI measurements were performed on 5, 10, and 14 days post transplantation. Discs were explanted and prepared for cryo-sectionings. GFP was detected through rabbit-anti-GFP (ab290), goat-anti-rabbit Alexa 633 (A21071), and confocal microscopy. Statistical analysis was performed using Two-way ANOVA, post-hoc Tukey's multiple comparison test using Prism 9 (GraphPad).

Results: For the first part, DHI showed a significant decline for the degenerating IVD receiving PBS in the neighboring vertebrae, while DHI was largely maintained when MSC were transplanted.(**Fig1B**) Histological observations suggested a trend of improvement after MSC transplantation. For the second part, DHI was similarly maintained for degenerating IVD neighboring vertebra that received MSC. Surprisingly, intradiscal injection of MSC showed a significant decrease in DHI. MSC tracing showed GFP^+ cells in IVD treated intradiscally with MSCs and a similar rate as in IVD neighboring a vertebra receiving MSCs, although overall numbers were low.(**Fig1C**)

Discussion: MSC transplantation into the vertebrae showed a clear benefit on maintaining DHI following degeneration induction, although this did not directly translate into clear improvements in histology. MSC tracing further revealed the capacity of MSC to migrate from the vertebrae into the IVD, which mainly occurred into degenerating IVDs. Nonetheless, the number of MSC stably integrating into the IVD revealed to be limited, as suggested by the limited numbers detected in the intradiscal injected IVD. Whether the observed effects result from MSC homing, paracrine signaling, or otherwise, remains to be determined. Our work suggests a potential alternative to intradiscal cell transplantation, although further examination and optimization are required.

Figure 1.) (A) Overview of the different transplantation conditions (B) DHI outcomes part 1 (C) Example of MSC tracing part 2



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5. Hiraishi et al (2018, PMID 31463441)

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Dynamic cervical MRI in Juvenile Muscular Atrophy of the Distal Upper Extremity (Hirayama Syndrome) - Do we need to change the Spine Guidelines?

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Introduction:

Juvenile Muscular Atrophy of the distal upper extremity (JMADUE) is caused by a forward displacement of the posterior dura during cervical flexion and was first described by Hirayama et al in 1959. Young male patients at a mean age of around 17 years are primarily affected . It presents with changes in the extensor and flexor muscles of the fingers and wrist. A few patients also show slight symptoms of hypesthesia in localized area of the hand. For diagnosis and subsequent treatment a dynamic MRI in flexion of the cervical spine is essential. Typically the condition progresses slowly and resolves within 5 years.

The aim of this systematic review and meta-analysis was to document the number of reported cases, the necessity of dynamic MRI of the cervical spine and the subsequent treatment in JMADUE.

Methods:

A systematic Review was conducted on 31 Aug 21. The Pubmed/ Medbase, Cochrane, Google, Embase and Ovid database were searched following the PRISMA guidelines. The search terms were (Hirayama) AND ((disease) OR (syndrome)) and a total of 851 abstracts were screened. Studies presenting data on Hirayama disease with more than 7 cases were included where a dynamic MRI was performed for diagnosis. A total of 226 studies reporting 3,539 patients were eligible for screening including 122 case reports (54.0%) and 42 case series (18.6%), leaving 62 retrospective studies for analysis.

Results:

Within the 62 studies, 3,273 patients suffering from JMADUE were reported. The mean age was 20.1±1.71 years and predominantly males in 61.8% were identified. On MRI, the “snake eyes” appearance of the spinal cord was present in 8.2% and the typical time between onset of symptoms and diagnosis was 37.6±16.6 months. Treatments for the condition ranged from observation, the application of a cervical collar, and anterior cervical discectomy and fusion (ACDF). Although the inverventions are suggested to prevent progressive muscular weakness in an early stage, there is no substantial evidence that any of them are superior to observation.

Conclusion:

The number of case reports and case series being published recently on JMADUE and the delay in diagnosis from initial presentation of symptoms show that this condition may be underdiagnosed in a variety of cases. Current guidelines suggest an MRI or CT scan in the supine position may be helpful. However, these may miss functional causes of spinal stenosis such as a dilated venous plexus in the posterior epidural space. This study shows the necessity of dynamic MRIs in flexion and the development of new guidelines especially in adolescents to identify functional spinal and/ or foraminal stenosis for a prompt diagnosis and subsequent treatment.

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Incidence, anatomy, and clinical importance of facet synovial cysts in degenerative spondylolisthesis.

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INTRODUCTION: Degenerative spondylosis (DS) is frequently accompanied by capsular facet cysts that can protrude into the canal and lead to painful radiculopathy. While it has been known to occur in DS, it's actual frequency has not yet been described. Previous authors have either retrospectively reviewed surgical patients with synovial cysts (Tillich, 2001) or groups with cysts to determine the frequency of spondylolisthesis.

METHODS: We analyzed MR (sagittal and axial T2) images presenting to our clinic and coded (738.4) for DS, for the presence of cyst formation, size (3 mm), position within the canal. We also measured the maximum facet gap at the listhetic level, the mid disc height, degree slip, and the degree of motion on flexion extension films. Demographics of age, gender, race and presence of lumbar scoliosis were also noted.

We excluded those with prior instrumented surgery at the listhetic level, trauma, tumor, infection , isthmus spondylolistheis at the index level, patients without proper MRIs and those without a demonstrable slip.

For continuous variables, both parametric (mean, (95%CI) and standard deviation) and non parametric (median interquartile range, range) descriptive statistics were used. To determine whether patient-level demographics deferred between those with and without cysts, chi squared and Fisher's exacts tests were used.

RESULTS: We accessed 593 charts. 69 were ithmic spondylolisthesis; 92 had no slip; 22 had no or poor MRIs and 42 had prior surgery. This left 368 MRI's.

95% complained of back and or leg pain. IT was 75% female although those with a cysts were only 58% female. Mean age was 68. it was 79% caucasian, 15% Asian, 10% Hispanic and 5% Black. 16% had more than one level of slip (P= 0.005). There were no other differences in age sex or race between those with and those without a cyst.

The most common level was L4-5 (725(and the most common slip grade was 1 (83%). 91 of 368 (25%) were found to have a cyst. There was a trend towards more cysts in Grade 1 (28%) versus grade 2 (13%) (p=0.071). Cysts were more common at L4-5 vs. L5-S1 (31% v. 7%) (P=0.002) The anatomic location of the cyst was almost equally divided between antero-medial within the canal (45%) , and posterior to the facet without any canal impingement (47%). 5% were within the foramen and 3% were lateral. They were equally divided between right and left and the average cyst size was 4.9mm. There was no association between flexion extension motion or the presence of scoliosis, and the likelihood of a cyst.

DISCUSSION: In studying, for the first time, a large population of patients with DS, we have identified an incidence of 25% of whom have degenerated facet cysts. The majority are either within the canal with impingement of neural structures (11%); or posterior to the facet into the surrounding muscle (12%). This number is important for treating physicians who care for faffected patients, in not only making the diagnosis but managing the appropriate treatment, whether operative or non-operative.

Endplate deficits and posterior wall injury are predictive of prolonged back pain after osteoporotic vertebral body fracture

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Introduction: Osteoporotic vertebral compression fracture (OVCF) in the elderly is a major public health concern. This retrospective case-control study aimed to determine the difference in interobserver reliability between radiography, magnetic resonance imaging (MRI), and computed tomography (CT), respectively, and whether CT radiological findings can predict prolonged back pain at two weeks after OVCFs.
Methods: Patients were divided into the prolonged back pain group or the recovered back pain group depending on numerical rating scale at two weeks after admission. Radiography, MRI, and CT images were classified based on conventions described by previous classifications. Interobserver reliability was calculated on images rated by two board-certified spine surgeons. Multivariate logistic regression models were used to evaluate whether the presence or absence of anterior wall injury, endplate deficit, posterior wall injury, lateral wall injury, or intervertebral disc deficit on CT was predictive of prolonged back pain.
Results: Of the 130 patients, 89 cases (68.5%) involved prolonged back pain at two weeks after admission. Neither average age (79.8 vs. 80.1 years, respectively) nor duration to initial consultation (9.4 vs. 6.4 days, respectively) differed significantly between the prolonged and recovered back pain groups. Interobserver reliability was 0.51, 0.77 (0.67-0.86), and 0.82 (0.72-0.92) for radiography, MRI and CT, respectively.
After adjusting for confounding factors such as age, sex, duration to initial consultation, and extent of OVCF, the multivariate analysis showed that the presence of endplate deficit and posterior wall injury was a significant predictive factor for prolonged back pain (odds ratio [OR] 8.5, area under the curve (AUC); 0.79 and OR 2.5, AUC 0.72), respectively.
Conclusions: Good reliability assessments of CT-based evaluations was noted. After a detailed novel CT evaluation at initial presentation, the presence of an endplate deficit and posterior wall injury was the significant risk factor for prolonged back pain at two weeks after an OVCF.

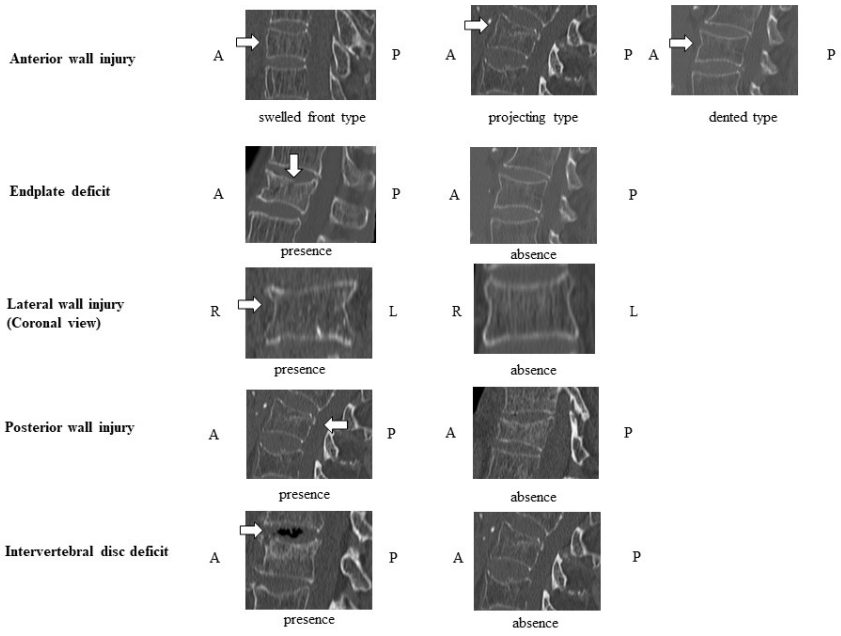

Fig. Osteoporotic vertebral fracture classification on computed tomography.

1. Figure

Lactic acid as a potential chemonucleolytic agent

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Introduction

Lactic acid stimulates collagen deposition in the nucleus pulposus (NP) which increases flexural rigidity of the motion segment. Based on this observation, and on safety data from a phase 1b trial, STA363 (final formulation of lactic acid mixed with iohexol) is currently evaluated in a phase 2b study on patients with degenerative disc disease (DDD). Literature data show that both low pH and lactate reduce the levels of proteoglycans of the NP. It is therefore hypothesized that prior to establishment of fibrosis, STA363 has a chemonucleolytic effect and consequently, it may be used to treat radiculopathy caused by lumbar disc herniation. We therefore re-analyzed MRI data from a previous study on DDD patients to determine whether STA363 may act as a chemonucleolytic as indicated by disc height/volume reduction and dehydration of the NP.

Methods

In a phase 1b study on DDD patients, placebo (n=6) or STA363 (lactic acid at 45, 90 and 180 mg/disc, n=3 in each group) was injected into 1 or 2 lumbar discs (L3/4-L5/S1) of Pfirrmann grade 3, and disc height and width indices (disc height/width relative to the height of the cranial vertebra) were calculated. Intensity was evaluated by comparing MR images before and after injection. All measures were taken 12 months after treatment.

Results

Data from the patients treated with the lowest dose were not analyzed due to early withdrawal of one patient and the fact that only one disc/patient was injected in the two other patients. While disc height decreased by 5% in the placebo group, the decrease was 15% and 20% in the 90 and 180 mg groups, respectively (Table 1). Disc width did not change significantly. There was a consistent loss of intensity of NP in the two dose groups.

Discussion

Chemonucleolytics such as chymopapain and condoliase act by degrading water-binding glycosaminoglycans (GAGs) leading to dehydration, loss of disc height and volume which induces a drop in pressure. The decrease in disc pressure will be mirrored in the herniation as long as it communicates with the NP, causing it to shrink. The present work suggests that STA363 shares these fundamental properties of established chemonucleolytics. Since disc height but not width was reduced, disc volume must have decreased, consistent with water loss. Dehydration as reflected by T2-weighted MRI was also noted. In summary, STA363 may have a therapeutic utility in patients suffering from radiculopathy caused by lumbar disc herniation.

Table 1

Dose of lactic acid (mg/disc)	Number of treated discs	Disc height index at baseline (mean±SD)	Disc height index at 12 months (mean±SD)	Disc width index at baseline (mean±SD)	Disc width index at 12 months (mean±SD)
0	9	0.38±0.07	0.36±0.07*	1.40±0.12	1.39±0.09
90	5	0.34±0.02	0.29±0.04**	1.29±0.14	1.33±0.13
180	5	0.40±0.04	0.32±0.03**	1.40±0.08	1.44±0.09

*p<0.05; **p<0.01, Student's paired t test

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Typical MRI patterns of lumbar disc degeneration in young and middle-aged men

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Introduction:

Intervertebral disc degeneration (DD) is regarded as a significant contributory factor to low back pain[1]. Most grading systems for lumbar DD base on signal intensity (SI) of the nucleus pulposus (NP) on T2-weighted MRI or combinations of SI with disc height and distinction of the border between NP and annulus fibrosus (AF)[2,3]. Same DD grading is usually used for all disc levels and ages of subjects. Knowledge about co-occurrence of DD findings in different disc levels and ages is lacking. Histologically found signs of early degeneration, such as focally increasing fibrosis horizontally in the middle of nuclear complex, intranuclear cleft (INC), and infolding of the inner fibrils of AF[4–6] are detectable on MRI even without decrease of SI of the NP[5]. Our aim is to use a detailed visual MRI classification including early DD findings to find typical age and disc level dependent MRI patterns that could be references to find the pathologic patterns.

Methods:

We evaluated MRI changes in lumbar discs, endplates, and subchondral bone of vertebrae of 26 young men and 164 middle-aged men with a detailed visual grading system to study co-occurrence of various findings and difference of typical disc patterns between two age groups. Prevalence of every grade of each DD variable at each disc level was calculated separately in both age groups. Variables with the strongest differences between age groups were further analysed, observing prevalence of different DD findings of those variables and the combinations of various findings together.

Results:

We found a wide variation in combinations of MRI findings in both age groups, but different combinations were common in the middle-aged than young men (Figure). The strongest differences between the age groups were found at the levels L2/L3 and L3/L4, in patterns including SI of the NP, inhomogeneity of SI of the NP, INC, diameter of the nuclear complex and inhomogeneity of the AF (Figure).

Discussion:

We suggest detailed assessment of anatomic disc structures including INC and nuclear complex when classifying DD on MRI. Differences between young and middle-aged were most remarkable in L2/L3 and L3/L4 discs, which degenerate later and slower than lower lumbar discs[7]. It seems reasonable to analyse specific regions of the intervertebral disc separately by disc level and compare those findings with typical patterns in that age when classifying lumbar DD on MRI.

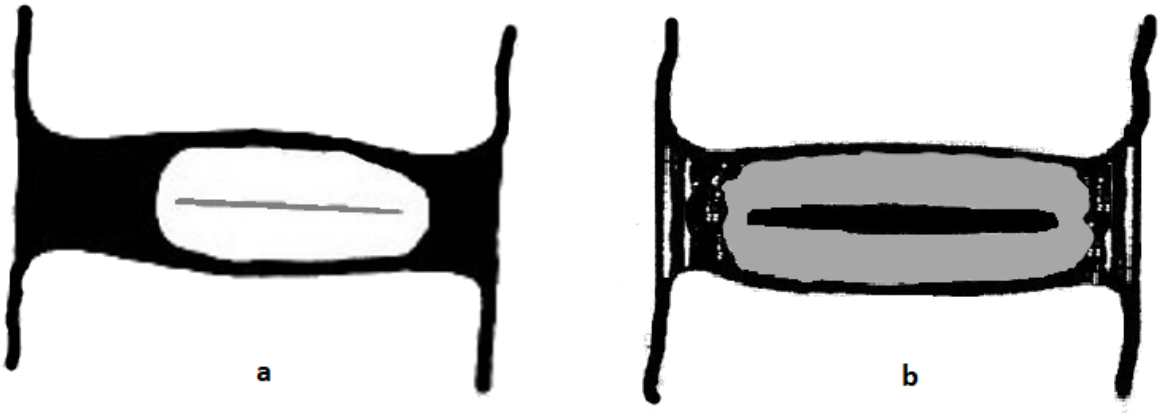

Figure **a** illustrates a common combination of MRI findings found in young men: small nuclear complex; bright, homogenous NP with thin, grey INC and homogeneous, dark lamellar structure of AF. Figure **b** illustrates a common combination of MRI findings found in middle-aged men: large nuclear complex; slightly decreased SI of the NP with regular dense, dark INC and inhomogeneous, irregular AF.

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The change of global spinal alignment after osteoporotic vertebral fracture and the change of lumbar pain.

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Introduction
Previous study showed that the global spinal alignment would change in the patients with osteoporotic vertebral fracture (OVF). However, it is not clear that the change of global spinal alignment will affect the change of low back pain (LBP). Objective of this study is to show how LBP changes as global spinal alignment changes after OVF.
Methods
Fifty-three patients conservatively treated and followed for 96 weeks after new single-level thoracolumbar OVF were enrolled. Conservative treatment was conducted using soft lumbosacral orthosis plus osteoporosis drugs. Patients were divided into two groups depending on the distribution of the change of pelvic incidence minus lumbar lordosis (PI - LL); there were two group showing the PI-LL improved over 10 degrees (Improved PI-LL group, n = 28) and the group showing the PI-LL improved less than 10 degrees (Worsening PI-LL group, n = 25) from 24 weeks to 96 weeks after OVF. Pain scores were acquired at 24 and 96 weeks after treatment initiation using the Oswestry Disability Index (ODI), Roland–Morris Disability Questionnaire (RDQ), and Visual Analogue Scale (VAS). The differences of pain scores were examined between the two groups.
Results
In the base line of Improved group and Worsening group at 24 weeks after OVF, 20.8 ± 2.7 degrees and 16.4 ± 2.7 degrees of PI-LL ($p = 0.244$), 86.2% and 71.4% of the union rate ($p = 0.207$), 20.6 ± 1.6 degrees and 20.9 ± 1.6 degrees of local kyphosis at OVF ($p = 0.883$), 27.1 ± 3.9 and 19.4 ± 4.0 in VAS ($p = 0.172$), 39.5 ± 4.3 and 29.3 ± 4.4 in RDQ(%) ($p = 0.101$), and 27.4 ± 3.0 and 26.1 ± 3.0 in ODI(%) ($p = 0.756$), respectively. Change of pain scores from 24 weeks to 96 weeks in the Improved PI-LL group and the Worsening PI-LL group were -9.8 ± 4.4 and 7.3 ± 4.5 ($p = 0.009$) in VAS, -13.3± 3.0 and -5.3 ± 3.1 ($p = 0.068$) in RDQ(%), and -20.5 ± 4.5 and -7.7 ± 4.6 ($p = 0.051$) in ODI(%), respectively.
Discussion
Change of global spinal alignment after OVF showed the tendency to affect the change of LBP; pain scores from 24 weeks to 96 weeks were decreased in the patients with PI-LL improved over 10 degrees, and increased in the patients with PI-LL improved less than 10 degrees. Previous study showed that the patients with distance from C7 plumb line to OVF > 60 mm was the candidate to prevent restoration of normal global spinal alignment. So, these patients would be needed to prevent progressing global spinal man-alignment and worsening LBP.

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Characteristics of the patients with diffuse idiopathic skeletal hyperostosis of thoracic spine with decreased bone mineral density

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Introduction: Several reports have indicated that intravertebral bone mineral density (BMD) of diffuse idiopathic skeletal hyperostosis (DISH) of thoracic spine did not decreased. However, we often encounter thoracic DISH patients with markedly decreased BMD. Furthermore, the differences between patients with and without decreased BMD remains unclear. This study aimed to verify the characteristics of thoracic DISH patients with decreased BMD by measuring the vertebral Hounsfield unit (HU).

Methods: We retrospectively reviewed the medical records of the patients who underwent whole spine CT between January 2017 and July 2020. A total of 117 patients (83 males and 34 females, mean age of 72.1 years) without thoracic spine fracture or treatment of osteoporosis were included in this study. HU values were measured by setting an oval region of interest (ROI) in the vertebral body at lower 1/3 slice. Furthermore, to clarify the characteristics of the difference among each spinal level, the Tx/T1 ratio was calculated by dividing HU value of each vertebra by that of the T1 vertebra. Whole thoracic kyphosis (T1-12), upper thoracic kyphosis (T1-5) and middle and lower thoracic kyphosis (T5-12) were measured. Patients whose HU values were 150 or more at T9 vertebrae were classified as H-BMD group, and patients whose HU values were less than 150 were classified as L-BMD group. Statical analyses were performed using chi-square tests, Student's t-test and multivariate forward selection stepwise logistic regression.

Results: Multivariate analysis showed that age, obesity (BMI >30 kg/m^2), and women were significantly higher rate in L-BMD group (51 patients) than in H-BMD group (66 patients). Furthermore, the Tx/T1 ratio gradually decreased from upper to lower thoracic vertebrae in both groups, and the Tx/T1 ratio of L-BMD group was significantly lower in each vertebra below T5 than H-BMD group (Figure 1). Upper thoracic kyphosis was not different between the two groups, but whole thoracic kyphosis and mid-lower thoracic kyphosis of L-BMD group were significantly greater than those of H-BMD group.

Discussion: Older age, women, and obesity were risk factors for decreased vertebral BMD in patients with thoracic DISH, suggesting that postmenopausal osteoporosis and the duration of exist of DISH are involved. Furthermore, this study suggested that the patients with advanced osteoporosis had a significant progression of thoracic kyphosis and their BMD decreased especially in the mid and lower thoracic spine.

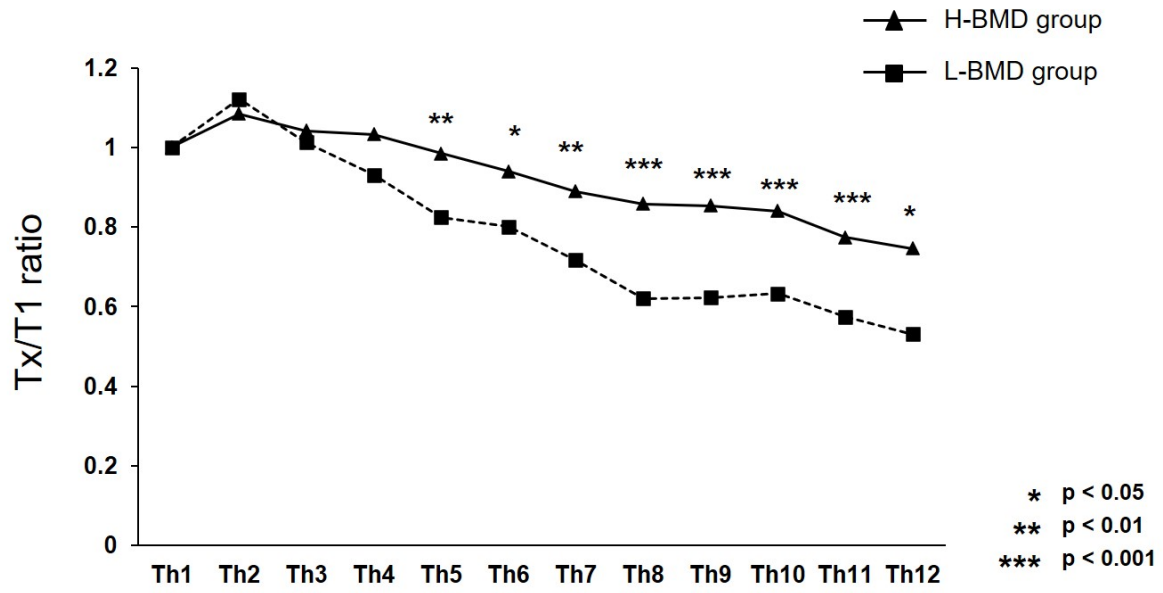

Figure 1

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The Impact of Acute Lumbar Disc Herniation on Male Sexual Function

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Introduction

Sexuality is an important aspect of human life, and an active sex life would require normal mobility and functions of the lumbar spine. The effect of symptomatic lumbar disc herniation (LDH) on male sexual function is rarely researched.

Methods

Sexually active male patients (n=22, 40.8±6.8 years) admitted for microdiscectomy, were evaluated with a questionnaire for assessing sexual function before and 8 weeks after the surgery. The questionnaire included ODI, Hospital Anxiety Depression Score, Brief Sexual Function Inventory (BSFI), and questions regarding perceived sexual dysfunction (frequency, performance and satisfaction).

Results

The average pre-operative VAS score for back pain was 4.36±2.59 (n=18), and leg pain was 6.81±2.1 (n=22). The mean pre-op BSFI score was 27.8±11.2. Among the five components of BSFI, sexual drive was reduced in 63%, while erection and ejaculation were affected in 40.9% and 31.8% respectively. The VAS score for back pain had a negative correlation with pre-op BSFI score ($p<0.03$). After the onset of LDH, 12/22 (54.5%) patients noted decrease in the frequency and 17/22 (77.2%) described decrease in the desire/ satisfaction. At 8 weeks post-surgery, the mean BSFI score improved significantly to 33.23 ($p=0.002$). Sexual drive was normal in 77.7%, while erection and ejaculation were normal in 77.7% and 91% respectively. 59.1% (13/22) had resumed sexual intercourse within 6 weeks of surgery.

Conclusion

LDH resulted in sexual dysfunction in up to 77% of patients, which improved significantly after surgery. By six weeks, majority resumed sexual activity without undue discomfort. The study would help to counsel patients with LDH about sexual function effectively.

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Differences in gait features in patients with lumbar spinal stenosis and knee osteoarthritis, do they change during a 6-minute walk?

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INTRODUCTION

Patients with lumbar spinal stenosis (LSS) and knee osteoarthritis (KOA) suffer from mobility impairment. Clinical observation suggests that the pain from LSS causes gait to deteriorate with time, whereas the pain and stiffness from KOA are more pronounced at the beginning of a walk. However, there is no specific report on the differences in gait disturbance between LSS and KOA over time. In this study, we investigate if changes in gait features during a 6-min walk test (6MWT) can distinguish LSS and KOA.

METHODS

We collected foot-mounted inertial measurement unit (IMU) data during a 6MWT for patients with LSS, KOA, and matched healthy controls (N = 30, 10 for each group). Spatiotemporal gait characteristics were extracted. In total, 11 parameters in 4 domains were evaluated during each minute of the 6MWT; Rhythm domain (cadence, double support, swing), Pace domain (strike length, speed), Asymmetry domain (symmetry Index for strike length, swing), Variability domain (coefficient variation [CV] for double support, swing, strike length, stride time).

Differences in parameters among the 3 groups from the entire 6MWT were analyzed by one-way ANOVA followed by the Tukey test. In addition, differences in parameters between LSS and KOA groups were analyzed for each minute of the 6MWT using the Mann-Whitney U test.

RESULTS

In the analysis of the entire 6MWT, both LSS and KOA groups showed significantly lower cadence and speed compared to the control group. The KOA group showed significantly higher asymmetry, and the LSS group showed significantly higher variability compared to controls. However, there were no significant differences between the LSS and KOA groups in any of the parameters. In the analysis of the 6MWT per minute, the LSS group showed a significantly higher CV for strike length (Variability domain) compared to the KOA group during the middle portion of the 6MWT (4.29 ± 0.94 in LSS group, 3.40 ± 0.45 in KOA group, p=0.01). No other parameter revealed a significant difference at any timepoint between the two groups.

DISCUSSION

When the entire 6MWT is considered, multi spatiotemporal gait parameters distinguished between healthy controls and LSS or KOA, yet the LSS and KOA groups demonstrated no statistical differences in any of the 11 gait parameters. Comparing LSS to KOA minute-by-minute we did observe higher variability in strike length in LSS group during the middle of the walk. Gait variability is described as a potential biomarker for gait impairment and loss of gait rhythmicity[1, 2]. The high variability in the LSS group may represent changes in gait rhythm due to intermittent claudication. Yet, in this study no other parameters distinguished LSS from KOA over time during the 6MWT. Likely, larger studies are required to observe the spatiotemporal gait parameters that distinguish these two patient populations.

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Had Prevalence of Vertebral Fractures Changed over Two Decades? –a Population-based Cohort Study of a Japanese Mountain Village-

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INTRODUCTION: Treatment of osteoporosis has made remarkable progress over the last two decade[1], however, only a few studies reported on the change in the prevalence of vertebral fractures (VFs) during that time. The purpose of this study was to compare the prevalence and pattern of VFs and the treatment rate for osteoporosis in three time points from 1997 to 2019 in a population-based cohort study.

METHODS: The inhabitants of a typical mountain village who participated in the surveys at three time points, 1997 (Group A), 2009 (Group B) and 2019 (Group C), were the subjects of this study. Age and gender-adjusted groups were defined as the Group A', B' and C' (39 males and 85 females: mean age 73.6-74.0 y/o). Type (wedge, biconcave, crush) and extent (G1: mild; G2: moderate; G3: severe) of deformity of the prevalent fractures from T4 to L4 in lateral thoracic and lumbar spine radiographs were evaluated using a Genant's semi-quantitative technique[2]. Subjects whose Bone mineral density (BMD) was less than 70% young adult mean were defined as subjects with osteoporosis. The prevalence, vertebral level, and deformity type of VFs, and the treatment rate of osteoporosis were statistically evaluated using the chi-squared test with Bonferroni's correction post hoc test.

RESULTS: 1. Prevalence of VFs: The prevalence of subjects who had VFs in the Group A', B' and C' had deceased over the two decades (Fig.1). A significantly higher percentage than expected in the Group A' (P<0.01) and a significantly lower percentage than expected in the Group C' (P<0.01) were showed. The percentage of subjects with prevalent G2-3 VFs had also decreased over the two decades. The percentage of those in the Group A' was significantly higher than expected (P<0.05). 2. Characteristics of VFs: In the Group A', thoracic VFs was significantly more frequent than expected (P<0.05), while thoracolumbar VFs was significantly less frequent than expected (P<0.05). The percentage of biconcave type deformity was significantly higher than expected in the Group A' (P<0.01) and significantly lower than expected in the Group B' (P<0.05) (Fig. 2). On the other hand, the percentage of wedge type deformity was significantly lower than expected in the Group A' (P<0.01). 3. BMD and osteoporosis treatment: BMD (young adult mean) had increased over time (Fig. 3a); and one-way ANOVA showed that BMD of the Group C' was significantly higher than the Group A' (P<0.05). The treatment rate of osteoporosis in the subjects with osteoporosis had improved over the two decades (Fig. 3b). The treatment rate was significantly lower than expected in the Group A' (P<0.01) and significantly higher than expected in the Group C' (P<0.05).

DISCUSSION: This study demonstrated, for the first time, that the prevalence of VFs had decreased over the two decades in a typical Japanese mountain village. These data suggest the possibility that the early diagnosis and use of therapeutic drugs for osteoporosis and resulting improvement of BMD would contribute to a continuous decrease in the prevalence of VFs, especially in biconcave type VFs.

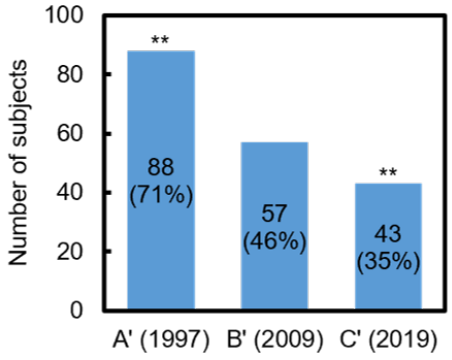

Fig.1 Prevalence of VFs
**: P<0.01

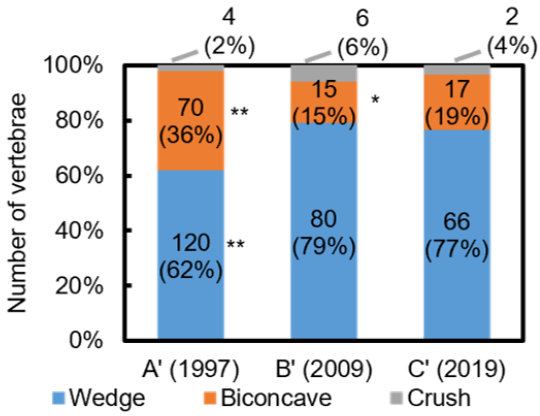

Fig.2 Deformity type of VFs
*: P<0.05, **: P<0.01

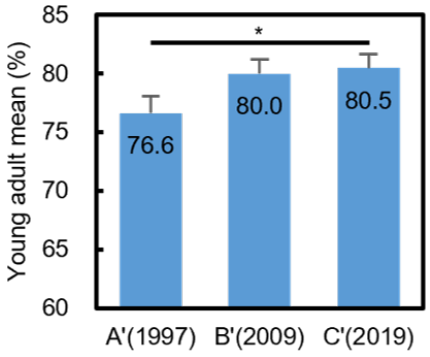

Fig.3a BMD of subjects
*: P<0.05

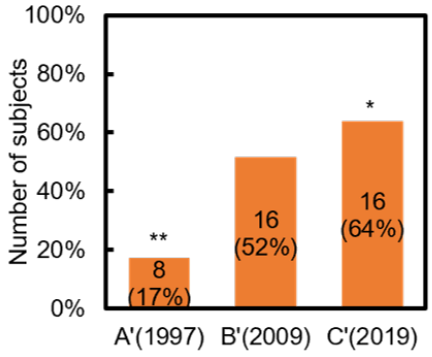

Fig.3b Treatment rate of osteoporosis
*: P<0.05, **: P<0.01

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Modic changes and high intensity zones commonly co-exist in spinal segments in chronic low back pain patients but are not evidently related to patient reported pain

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Intruduction

Low back pain (LBP) has been suggested to be associated to Modic changes (MC) and high intensity zones (HIZ), displayed on conventional magnetic resonance images. In a previous feasibility study, it was shown that patients with chronic LBP frequently display a simultaneous presence of MC and HIZ in the same motion segment [1]. We hypothesized that a simultaneous presence of MC and HIZ in the same motion segment has a stronger association to back pain than the presence of MC only.

The aim of this study was to relate MRI findings to patient-reported back pain in a prospective cohort of patients with chronic LBP.

Methods

The lumbar spine of 100 chronic LBP patients (age: 43±9 years; 66 males), which had experienced >6 consecutive months with LBP, were examined with MRI (Table 1). All patients rated their back pain during the last week using a Numeric Rating Scale (NRS), 0-10, before the MRI. MCs according to Modic *et. al* [2] were typed on sagittal T1- and T2-weighted MR images by a senior radiologist. For mixed types, the dominant type (>50%) was chosen. Patients that displayed MCs, with an affected region of at least 25% of the vertebral body, visible on at least two consecutive MR image slices were included as having a MC. The radiologist evaluated all discs in segments having MCs regarding the presence of HIZ (high signal in the annulus fibrosus, clearly separated from nucleus [3]) or not using T2-weighted images. The independent t-test, adjusted for multiple testing, was used for group comparisons. Mixed effects models, accounting for multiple measurements per subject, were used to estimate least squares mean and Tukey's range tests were used to test differences in least squares mean between groups.

Results

Out of the 100 LBP patients, 42 patients (23 males; age: 47±10 years) had MCs localized in 88 vertebrae, corresponding to 2 MCs per patient. HIZ were frequently displayed in the adjacent discs (n=32/35, 91%). 50% of the HIZs were adjacent to vertebrae with MC type 1, 40% adjacent to type 2 while none was found adjacent to type 3.

Patients that displayed a simultaneous presence of MC and HIZ in at least one motion segment did not report significantly higher pain scores than patients with only MC findings (NRS:5.7±2.1 vs 6.7±1.9; p=0.09), neither when stratifying for Modic type. Moreover, no significant association was found between NRS and the presence of any MC, neither for all MCs stratified for MC type.

Discussion

This work confirms previous findings of that HIZ is commonly present within the same motion segment as MCs. However, chronic LBP patients with both MC and HIZ in the same motion segment did not report significantly higher back pain on NRS than those with only MC findings or no MC findings. Since pain is a subjective experience, the lack of association here does not necessarily imply that MC and HIZ do not play a role in chronic LBP, however the findings does not support these as direct pain imaging biomarkers.

Table 1. The MRI scanning was performed on a 3T MRI scanner (Discovery MR 750 GE Healthcare, Madison, United States) using a scan protocol that was optimized for the lumbar spine (T12/L1 to L5/S1). A fast spin echo T2-weighted sequence without fat suppression was used with a refocusing angle of 142 degrees. Other important scan parameters are presented below.

Sequence	Orientation	Field-of-view (mm^2)	Scan matrix	Slice thickness (mm)	Repetition time (ms)	Echo time (ms)
T1W	SAG	220 x 220	192 x 192	3.5	598	7.8
T2W	SAG	220 x 220	280 x 280	3.5	3936	108
T2W	AX	220 x 220	288 x 288	3.0	3936	108

T1W and T2W: conventional T1 and T2-weighted sequences; SAG: sagittal view; AX: axial view.

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1044

Reliability and agreement of lumbar multifidus volume and fat fraction quantification using magnetic resonance imaging

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Introduction

Magnetic resonance imaging (MRI) is the standard to quantify size and structure of lumbar muscles. Three-dimensional volumetric measures are expected to be more closely related to muscle function than two-dimensional measures such as cross-sectional area. Reliability and agreement of a standardized method should be established to enable the use of MRI to assess lumbar muscle characteristics. This study investigates the intra- and inter-processor reliability for the quantification of (1) muscle volume and (2) fat fraction based on chemical shift MRI images using axial 3D-volume measurements of the lumbar multifidus in patients with low back pain.

Methods

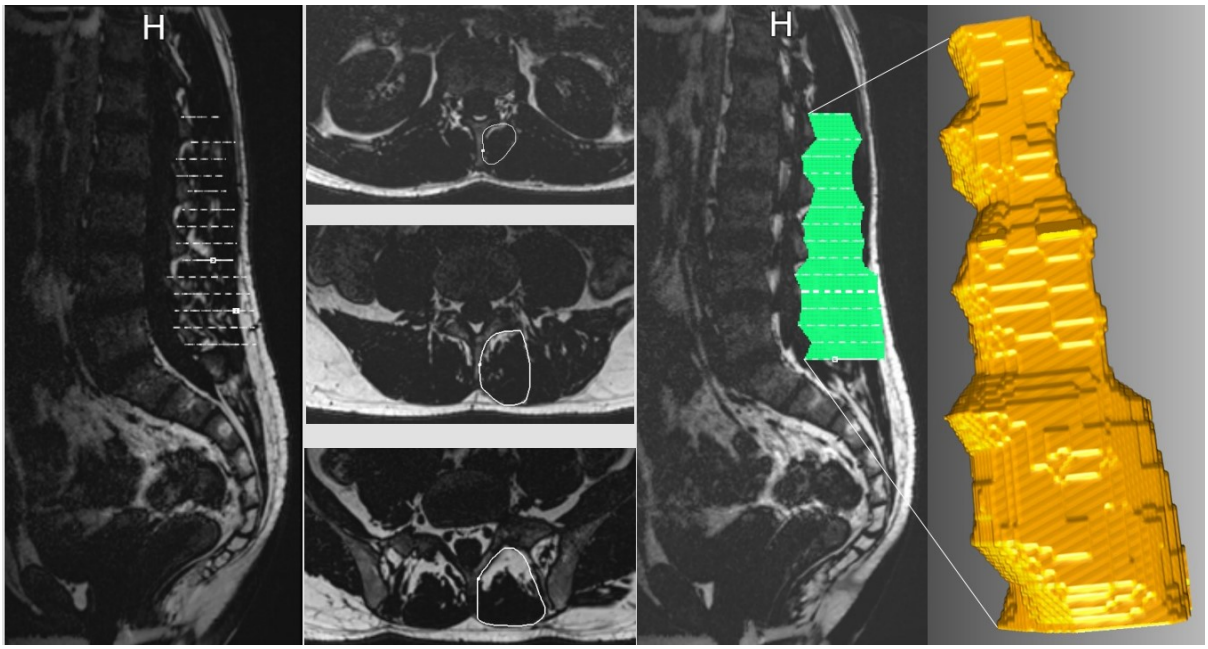
Two processor manually segmented the lumbar multifidus on the MRI scans of 18 patients with low back pain using Mevislab software. (See Figure 1) Fat fraction of the segmented volume was calculated. Reliability and agreement were determined using intra-class correlation coefficients (ICC), and calculation of the standard error of measurement (SEM).

Results

Excellent ICCs were found for both intra-processor as well as inter-processor analysis of lumbar multifidus volume measurement, with slightly better results for the intra-processor reliability. The SEMs for volume were lower than 4.05 cm^3. Excellent reliability and agreement were also found for fat fraction measures, with ICCs of 0.985 – 0.998 and SEMs below 0.946%.

Discussion

The proposed method to quantify muscle volume and fat fraction of the lumbar multifidus on MRI was highly reliable. Future studies could use this method to obtain more in-depth insight into the three-dimensional structural properties of the lumbar multifidus.



1045

The use of 3D freehand ultrasound to determine muscle volume of the lumbar multifidus: preliminary results of a reliability study in people with low back pain

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Introduction

Impairment of the lumbar multifidus has been associated with segmental instability and the pathogenesis of low back pain. However, the relation between macroscopic structure of the multifidus and low back pain remains unclear. This may be explained by the use of single-level cross-sectional area measurements that do not represent the entire muscle. Therefore, we aim to establish the inter- and intra-rater reliability of a 3D freehand ultrasound system (3DfUS) for the assessment of the lumbar multifidus in people with low back pain.

Methods

3DfUS is achieved by combining conventional 2D ultrasound with a synchronized motion-tracking system that obtains the position and orientation of the ultrasound probe during acquisition. Images were processed using Stradwin software. Muscle volume is obtained by manually tracing the contours of the lumbar multifidus, after which the software automatically interpolates these contours to obtain a 3D image. To evaluate intra- and interrater processing reliability, 3DfUS images were processed twice by investigator 1 (SR) and once by investigator 2 (SD).

Results

Data collected in 7 patients with low back pain (mean multifidus volume= 92.65±16.07ml) showed excellent intra-rater reliability (ICC 0.93, 95% CI 0.83-0.97; SEM 4.67ml, MDC 12.92ml) and good interrater reliability for imaging processing (ICC 0.88, 95% CI 0.46-0.98; SEM 8.68ml; MDC 24.07 ml).

Discussion

The repeatability indices for 3DfUS processing are promising. Yet, the observed processing errors suggest that repeated 3DfUS measures in clinical studies should be performed by the same assessor, until processing guidelines are further improved.

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Lumbar muscle oxygenation in people with and without non-specific low back pain. An exploratory study.

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Introduction:

Near-infrared spectroscopy (NIRS) has become an extensively used, non-invasive method for real-time monitoring of microvascular tissue oxygenation in skeletal muscles. The lumbar multifidus muscle plays an important role in spinal control. Impairment of the multifidus has previously been associated with segmental instability and the pathogenesis of LBP. However, the role of hemodynamic properties of the multifidus in LBP is still unclear. Only few studies have investigated this, mainly focusing on the erector spinae using protocols towards maximal fatigue, instead of also including more functional tasks. Therefore, we aim to explore lumbar multifidus oxygenation in functional, daily life postures in people with and without non-specific low back pain (NSLBP).

Methods:

A pair of NIRS (NX200 Hamamatsu Photonics) probe was used to evaluate multifidus fractional Tissue Oxygenation Index (%TOI) during a functional, low load protocol including baseline (prone), sitting, standing and forward bending (B25°) postures in 11 people with recurrent NSLBP and 12 healthy controls. Each posture was maintained for three minutes. First, we determined multifidus %TOI in people with and without NSLBP. Secondly, %TOI data for each posture was expressed as changes from prone (baseline) position. %TOI data were compared within and between groups (i.e., NSLBP vs Healthy) using a two-tailed paired and unpaired t-tests, respectively.

Results:

In people with NSLBP, multifidus %TOI significantly decreased only during bending forward (Baseline= 80.3%; sit= 80.6%, p= 0.73; stand= 76.9%, p= 0.06; B25°= 72.4%, p= 0.002). In healthy controls, multifidus %TOI was significantly decreased in all postures compared to baseline (Baseline= 79.1%; sit= 70.6%, p= 0.011; stand= 68.8%, p= 0.017; B25°= 63.1%, p= 0.005). In addition, healthy controls showed significantly larger decrease in multifidus %TOI compared to people with NSLBP for sitting (sit (NSLBP, change in TOI)= 2.1%; sit (controls, change in TOI)= 8.5%, p= 0.02) and standing (stand (NSLBP, change in TOI)= 3.3%; stand (controls, change in TOI)= 10.3%, p= 0.024), with a trend during bending forward (B25° (NSLBP, change in TOI)= 7.5%; B25° (controls, change in TOI)= 15.9%, p= 0.057).

Discussion:

We observe that people with NSLBP presented a diminished multifidus oxygen utilization in daily tasks such as sitting and standing, while healthy controls demonstrated a more task-appropriate multifidus oxygen use. Future studies are needed to evaluate the mechanism/s of this different oxygenation pattern of the multifidus muscle as well as the effect of exercise training on lumbar muscle oxygenation in daily tasks.

Comparison of quantitative measurement of signal intensity of nucleus pulposus with visual interpretation as method for classification of disc degeneration

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Introduction:
Automated quantitative methods for evaluation and grading of disc degeneration (DD) on MRI are needed for AI-based diagnosis of low back pain[1]. Decrease of signal intensity (SI) of the intervertebral disc (IVD) on T2-weighted MRI (T2WI) is considered as sign of DD as it correlates with loss of proteoglycan and water content in nucleus pulposus (NP)[2]. NP SI is commonly evaluated with visual grading[3], but subjectivity and categorization reduce reliability of these grading systems. Quantitative measurement methods of NP SI have been published but variable regions of the IVD such as collagenous annulus fibrosus and fibrous horizontal band, intranuclear cleft (INC) in the middle of the NP are included in these measurements. These quantitative methods have excellent reliability[4–7]. However, far too little attention has been paid to comparison between different measurement methods[8]. Our aim is to find a reliable method for DD evaluation by comparing different quantitative measurement methods of NP SI with visual interpretation.

Methods:
On lumbar MRI of 19 men (mean age 51 years, SD 0.7), mean SI of 95 IVDs was measured from mid-sagittal T2WI by two observers using three regions of interest (ROI) with different sizes: including the whole IVD (WD-ROI), ellipsoid on the NP including INC (ELLIPS-ROI) and targeted, freehand ROI on the most homogenous, bright area of the NP excluding INC (TARGET-ROI). Mean SI values were adjusted using SI of adjacent cerebrospinal fluid as reference to have comparable values between subjects. Observers graded NP SI also visually with 5-point grading system (Table 1) and assessed DD with Pfirrmann grading. Inter- and intra-observer reliability were assessed with intra-class correlation (ICC) for SI measurements and weighted kappa (κ) for visual grading. Correlation of SI measurements with visual grading was assessed with Spearman's correlation (ρ).

Results:
Reliability of SI measurements was excellent (ICC > 0.94). Reliability of visually graded NP SI varied from moderate to substantial (κ = 0.56-0.72). TARGET-ROI illustrated most clearly the difference of measured NP SI values between visual grades of NP SI (Figure 1). A small group of obviously degenerated discs with widely decreased SI but a small region with high SI in NP ("zebra") was distinct with TARGET-ROI but not with WD-ROI. SI measurements, excluding zebra discs, had a strong negative correlation with visually graded NP SI and Pfirrmann grading. Visually graded NP SI correlated strongest with TARGET-ROI (ρ = -0.84) while Pfirrmann grading strongest with ELLIPS-ROI (ρ = -0.83) and WD-ROI (p=-0.82).

Discussion:
Targeted SI measurement of the most homogeneous NP region gives the best tissue characterization of the NP. INC has a different SI than NP tissue above and below it because of fibrous tissue composition. TARGET-ROI showed most clearly the differences between visually graded NP SI categories. It also showed that some degenerated discs had an exceptionally high SI in NP. For reliable DD grading, we suggest excluding INC from SI measurements of NP as INC has a different tissue composition than the rest of NP region.

Table 1 Visual classification of NP SI

Grade	Structure
0	Normal SI, higher than SI of CSF
1	Slightly decreased SI, same as SI of CSF
2	Decreased SI, lower than SI of CSF
3	Severely decreased SI, with small, bright focus in NP ("zebra")
4	Severely decreased SI, same as cortical bone

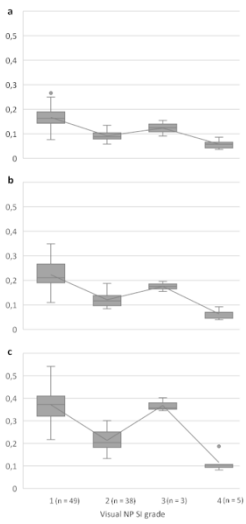

Figure 1. Relationship between visually graded NP SI on a 5-point scale and SI measurements obtained with three ROI sizes: **a** whole disc (WD-ROI), **b** ellipsoid of NP (ELLIPS-ROI) and **c** targeted ROI on the most homogenous, bright area of the NP excluding INC (TARGET-ROI). The sample did not include any discs with grade 0.

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Determinants of Postoperative Compliance of Patient-Reported Outcomes for Lumbar Spine Disorders

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Introduction: Patient-Reported Outcomes (PROs) are a well-established and clinically informative metric in spine surgery to evaluate preoperative patient expectations and postoperative outcomes. However, determinants of compliance of completed postoperative PROs in lumbar spine patients are largely unknown. Therefore, the study aimed to identify patient and operative factors associated with increased postoperative compliance of PROs following lumbar spine surgery.

Methods: A retrospective study of prospectively collected data of 1,680 consecutive adult patients who underwent elective lumbar surgery at a single institution from 2017-2020 was performed. Serial confidential digital surveys were used to assess PROs and patient compliance, defined as the percentage of surveys completed at 3 time-points: preoperative, 3-months and 1-year after surgery. Multivariate logistic regression was used to assess the association of PRO compliance and patient characteristics.

Results: 1,680 patients (53.1% male, mean age: 57.7 years) were included for analysis. Mean PRO compliance was 64.7%. Compliance decreased continuously from initial pre-operative rates (84.5%) to lower rates at 3-month (54.4%) and 12-month (45.6%), respectively, with 33.2% of patients completing zero surveys at 12-month postoperatively. Factors associated with significantly increased PRO compliance included being employed (pre-op: OR=2.58, p=0.002; 3-month post-op: OR=1.25, p=0.095; 12-month post-op: OR=1.34, p=0.028). Factors associated with decreased compliance included pre-operative smoking status (3-month post-op: OR=0.63, p=0.029; 12-month post-op: OR=0.60, p=0.016).

Discussion: Patients who completed greater than 50% of their PROs demonstrated significantly different rates of being employed compared to those who completed less than 50% throughout 1-year of post-surgical follow up. Additional characteristics with positive association for PRO compliance included age, prior spinal surgery, increased BMI, history of radiculopathy or neurogenic claudication. Of the analyzed variables, only preoperative smoking status was associated with decreased compliance throughout follow up. Further investigation, in particular in other cohorts and study sites, is needed to validate our findings and explore additional parameters that affect post-operative compliance of PROs.

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Normal Anatomy of the Lumbar Sublaminar Ridge in the Lateral Recess with Potential implications to Surgical technique in Degenerative Spinal Stenosis.

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Introduction. The lateral extent of the sublaminar ridge – the bony, superior insertion site of the ligamenta flava – and its topological relationship to the nerve root are not described in the literature. Through anatomic dissection of healthy specimens we provide anatomic descriptions of the normal lumbar sublaminar ridge in the lateral recess and it's potential to impact on the exiting nerve root there, with implications to surgical technique in lumbar spinal stenosis. In the setting of degenerative lumbar stenosis this structure can hypertrophy and impinge the nerve root within the lateral recess even after excision of the corresponding ligamentum flavum. Failure to address this may contribute to failed lateral recess decompression.

Methods. Fifteen lumbar vertebrae, not obviously degenerated, were resected en bloc from three fixed adult human cadavers and then transected through the pedicles, leaving the posterior column and neural elements intact and articulated. The shape of the sublaminar ridge in the lateral recess and its relationship to the exiting nerve root were carefully examined.

Results. The exiting nerve root consistently crosses the sublaminar ridge immediately inferior to the mid-pedicle, lateral to the subarticular gutter and on the medial aspect of the true intervertebral foramen. A hypertrophic ridge can compress the exiting root by elevating the nerve root superiorly against the bony underside of the pedicle or displacing it anteriorly against the disc or vertebral body.

Conclusion. The sublaminar ridge in the lateral recess may contribute to degenerative lumbar stenosis, and failure to address it at surgery may account for the frequent clinical failure of spinal stenosis surgery. Comprehensive appreciation of this anatomy may facilitate thorough lateral recess decompression.

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The safety and efficacy of oral Zoledronic acid bisphosphonate for the treatment of chronic low back pain with associated Modic changes: a pilot randomized controlled trial

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Introduction: To assess the safety and efficacy of oral 50 mg of Zoledronic acid (ZA), a bisphosphate, once a week for 6 weeks to placebo among patients with chronic low back pain (LBP) and Modic changes (MC) on MRI.

Methods: A parallel, double-blinded randomized controlled study was performed at a single center, consisted of 25 subjects with chronic LBP and MC that received ZA (n=13) or placebo (n=12). Evaluation was at baseline, 2 weeks, 4 weeks, 3 months and 6 months for assessment of LBP/leg pain intensity, disability, quality of life, and MC component changes on MRI.

Results: Type 2 MC at baseline (56%) were prevalent. In the ZA group, LBP intensity was lower at 4 weeks in comparison to placebo (5.1±1.9 vs. 6.9 ±1.8, p=0.038). A reduction of LBP intensity at 4 weeks and 3 months in the ZA-treated group in comparison to baseline was noted. Metrics for physical function (p=0.038), energy/fatigue (p=0.040) and pain (p=0.003) were improved at 3 months compared to placebo, whereas the pain domain at 6 months exhibited a trend towards significant difference (p=0.051). A reduction in MC endplate affected area at 6-month follow-up was noted in the ZA group (-0.74±0.67cm^2), while in the placebo group an increase in size was observed (+0.42±0.72;p=0.007). Three subjects withdrew from the study.

Discussion: There were no long-lasting adverse events. Oral ZA was a safe and effective treatment that reduced MC affected area, and improved LBP symptoms and health-related quality of life measures in chronic LBP subjects with MCs.

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Reliability and validity of measurement of cross-sectional area ratio of psoas muscle for evaluating sarcopenia: A comparison of CT and MRI

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Introduction: Sarcopenia is defined as low muscle mass combined with a loss of muscle strength or physical performance. Sarcopenia is a poor prognostic facttor in various areas of spinal disases. The psoas muscle (PM) cross-sectional area ratio (CSAR) is a definite indicator of sarcopenia. Numerous studies have shown that a lower CSAR of PM is related to a poor prognosis. However, there is no standard way to measure CSAR of PM. Earlier studies were measured at different levels (L2-3 to L4-5) and different imaging modalities (CT vs. MRI). The purpose of our study was to analyze the difference in CSAR of PM between CT and MRI, as well as the intra- and inter-observer reliability between two imaging modalities.

Methods: We retrospectively analyzed 30 patients who had done both a lumbar CT and a lumbar MRI. We measured the cross sectional areas (CSA) of both the PM and core structures (inter verebral discs and vertebral bodies) at L2-3, L3, L3-4, L4, and L4-5. Two experienced surgeons measured twice, one month apart. The CSAR of PM was calculated by dividing the CSA of PM by the CSA of the core structure. The paired t-test was used to compare the CSAR of PM between CT and MRI. Intra- and inter-observer reliabilities of CT and MRI were analyzed using intra-class correlation methods.

Results: CSAR of PM on both sides of all levels were larger on MRI. At the lower level (L4 and L4-5), the differences between CT and MRI were much larger and statistically significant ($P < 0.05$). The intra-and inter-observer reliabilities of CT for CSAR of PM were 0.757-0.954 and 0.885-962 (good to excellent), respectively. The intra-and inter-observer reliabilities of MR for CSAR of PM were 0.701-0.975 and 0.864-0.967 (moderate to excellent), respectively.

Discussion: The CSAR of PM was significantly larger on MRI than on CT, especially at the lower levels. The intra- and inter-observer reliability was higher in CT scans than in MRI scans. When evaluating sacopenia using the CSAR of PM it would be better to measure CSAR of PM in the upper lumbar region using CT.

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Impact of Insurance Type on Patient-Reported Outcome Measures in Patients with Lumbar Disc Herniation

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Introduction

Lumbar disc herniations (LDH) are amongst the most common spinal pathologies, resulting in substantial individual, societal, and economic burden. Despite increased appreciation for the importance of social determinants of health, the role that these factors play in patients with lumbar disc herniations is poorly defined. We set out to elucidate the influence of these social factors on the manifestation of LDH in various populations by investigating the association between insurance status and patient reported outcome measures (PROMs) in the setting of lumbar disc herniations.

Methods

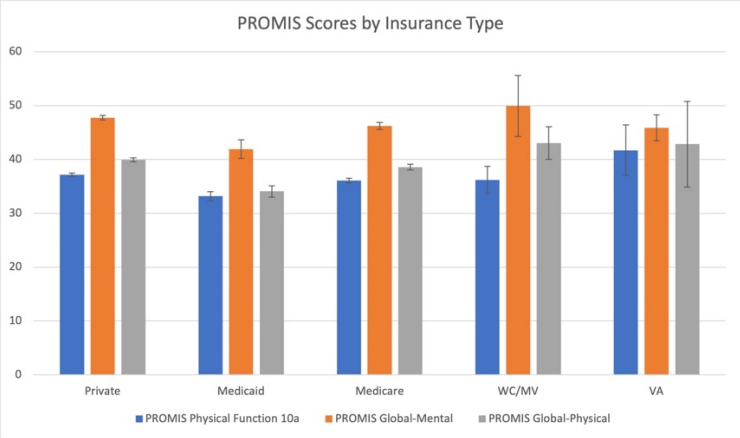
Baseline patient-reported outcome measures (PROMS) were reviewed from 924 patients with lumbar disc herniation according to the International Classification of Diseases, tenth edition (ICD-10) code from 2015-2020 within our institutional system. The Patient-Reported Outcomes Measurement Information System (PROMIS) Physical Function Short Form 10a (PF10a), PROMIS Global-Mental, PROMIS Global-Physical, and visual analogue scale (VAS) for back and leg pain were assessed. Descriptive analysis was conducted with Kruskall-Wallis or chi-squared testing, and negative binomial regression modeling used with insurance type as the primary predictor and all other demographic factors including age, gender, race, language, ethnicity, comorbidity index, and median geospatial household income as covariates.

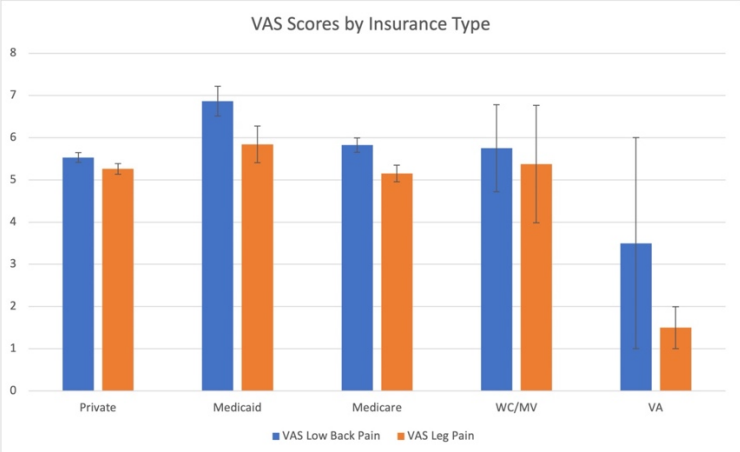
Results

Of 924 included patients, the mean age was 58.4 +/- 15.2 years, with 52.6% male patients. The Medicaid population had a greater proportion of Black, Hispanic, and non-English speaking patients compared with commercially insured patients. The Charlson Comorbidity index was significantly higher in the Medicare group. Baseline scores were poorer for Medicaid patients across all PROMs compared with commercially insured patients, exceeding minimal clinically important differences (MCID) in several domains including PF10 (37.2 versus 33.2 points), global physical score (39.9 versus 34.1 points), and VAS low back pain (5.5 versus 6.9 points) but not leg pain (5.3 versus 5.8 points). These differences remained significant on adjusted analysis.

Discussion

This work is the first to our knowledge to leverage PROMs in a large dataset to demonstrate the systematic disparities in the manifestation of lumbar disc herniation symptoms in different populations. Our findings are consistent with a growing body of literature pointing to the fact that underserved populations report more significant disability and pain metrics as compared to other groups when experiencing the same musculoskeletal pathologies. Notably, increases in baseline axial back pain, but not leg pain, in Medicaid patients compared with other insurance types may herald poor treatment response to surgical management. As health care stakeholders increasingly leverage PROMs for treatment algorithms and as measures of care value, it is imperative that we gain a deeper understanding of the extrinsic factors that affect these metrics, so as not to create health care governance or policies that might adversely affect certain populations. Further, future work will need to investigate the etiology of these differences in baseline PROMs for musculoskeletal pathologies and determine if these are patient driven, or if they may be a result of health system asymmetries in delayed or suboptimal access to care.





1053

The association between low back pain and patterns of physical activity accumulation throughout the day

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Introduction: Physical inactivity is a known risk factor for low back pain (LBP) disability, yet the relationship between objective quantification of daily physical activity pattern and its relationship with pain-related limitations are still sparse among the LBP populations. A better understanding of the connections between routine physical activity and pain-related limitation may lead to better prevention strategies and improvements in LBP rehabilitation. In this study, we aim to objectively characterize the free-living physical activity patterns of people with LBP using a wrist-worn accelerometer (Actigraph), and to investigate the connection between physical activity patterns and pain-induced limitations.

Methods: As part of a clinical trial of pain management skills class (NCT03167086), eighty-two LBP participants' (51% female, mean 51.8 years old) wore an Actigraph GT3X+ sensor on their non-dominant wrist for at least 7 days prior to the intervention. Waking hours (5 am-midnight) signals were extracted to derive the following physical activity data: step count, sedentary time, moderate-vigorous physical activity (MVPA) time, and hourly activity accumulation (step count). Associations between physical activity and patient-reported outcomes (pain catastrophizing scale, LBP pain bothersomeness scale, PROMIS pain interference, PROMIS physical function, etc.) were examined. Among all selected PROs, the pain interference index demonstrated the strongest relationship with the hourly activity accumulation, thus activity data were further divided into three terciles based on the pain interference index to identify potentially sensitive activity markers for stratifying LBP cohorts.

Results: Daily macro physical activity including total steps, sedentary time, and MVPA time were not associated with any patient-reported pain outcome, and were not able to stratify the LBP cohort based on the pain-interference index. However, the hourly activity accumulation pattern identified a distinguishable morning/evening activity pattern that can stratify the LBP cohort. More specifically, individuals in the high pain interference tercile accumulated significantly fewer steps in the morning hours (9-11 am) than those in the low pain interference tercile (600 vs 800 steps per hour), and significantly more steps (350 vs 200 steps per hour) during late-night hours (10 pm to midnight).

Discussion: Even though the total amount of daily physical activity was not associated with any of the pain-related measures, we observed a unique morning/evening activity accumulation pattern that was associated pain interference. Future research is needed to investigate the underlying mechanism for the differential activity patterns between individuals with low/high pain interference, and to investigate whether such activity patterns can be used to optimize individualized LBP rehabilitation programs.

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QUANTITATIVE MRI EVALUATION OF THE SPINE: A 2-YEAR FOLLOW-UP STUDY OF YOUNG INDIVIDUALS REPORTING DIFFERENT TRAINING DOSES

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INTRODUCTION

Disc degeneration is known to gradually increase with age and spine overloading at young age may accelerate this process. Recently, we displayed different disc characteristics between young elite skiers with diverse training histories using quantitative magnetic resonance imaging (MRI)[1].

The present study is a 2-year follow-up of the discs and of the vertebrae in individuals reporting different training doses using quantitative MRI.

METHOD

35 students (Table 1) were recruited from schools with and without athlete competitive sports programs. The thoraco-lumbar spine of all individuals was examined at baseline and at the 2-year follow-up with the same 1.5T scanner and imaging protocol, including standardized sagittal T1- and T2-weighted sequences with FOV=480x480mm^2, thickness=4mm, TE/TR$_{T1}$=<90/560ms, TE/TR$_{T2}$=110/4463ms). After inclusion, the individuals were sub-grouped into high (>5 hours training/week, n=24 of which 22 were athletes) and low-to-normal training dose (0-5 hours training/week, n=11).

The discs (between S1 and T11, n=7) and vertebrae (L5-T11, n=7) were outlined on the mid three slices of the spine in the T2-weighted images. The mean signal intensity (SI) in the discs and vertebrae were normalized to the SI of CSF (hereafter referred to relative SI). Violin plots, displaying the probability density of data, were used to visualize differences between groups. Parametric (t-test and chi-square) and non-parametric (Mann-Whitney U test) tests using $p<0.05$ were used to evaluate statistical differences in demographics and MRI findings, respectively.

RESULTS

Disc findings

At baseline, there was a significant difference in relative disc SI between individuals reporting different training doses for whole spine, as well as for lumbar and thoracic spine separately (Figure 1). Individuals reporting >5 hours training/week (high training dose) had 11% lower median value at baseline compared to individuals reporting 0-5 hours training/week (low-to-normal training dose). Individuals reporting low-to-normal training dose displayed a significantly larger SI-decrease over time for whole spine than individuals reporting high training dose. There were no significant differences between groups at follow-up.

Vertebral findings

There was a significant difference in the relative vertebral SI between the groups at both baseline and follow-up for whole spine as well as for lumbar and thoracic level (Figure 2). Individuals reporting high training dose had 9% lower median value at baseline compared to individuals reporting low-to-normal training dose, and 14% lower at follow-up. The relative vertebral SI showed a decrease over time for both the lumbar and thoracic spine. When stratified for training dose, the decrease did not statistically differ between groups.

DISCUSSION

With quantitative MRI based on a conventional imaging protocol, we have revealed changes in disc and vertebra over time and showed differences in discs over time between individuals reporting high and low-to-normal training doses.

The differences between groups might be an effect of the load on the spine during a longer period, slightly accelerating tissue changes in the higher loading group normally seen with increasing age. This may represent very early signs of a disc degenerative process.

Table 1: Demographics for groups of individuals reporting different training doses.

		Low-to-normal training dose (≤ 5 hours/week, n=11)	High training dose (> 5 hours/week, n=24)	p-value
Age (years)		16.5 ± 0.5	17.2 ± 0.6	**0.02**
BMI		22.1 ± 5.8	22.7 ± 2.1	0.83
Gender (female/male)		7/4 (64/36)	11/13 (46/54)	0.45
Percentage of individuals with training dose (h/week)	0 hours	1 (9)	0 (0)	
	0-2 hours	5 (45)	0 (0)	
	3-5 hours	5 (45)	0 (0)	
	6-8 hours	0 (0)	9 (38)	
	9-11 hours	0 (0)	8 (33)	
	> 11 hours	0 (0)	7 (29)	

BMI = Body Mass Index
All values are presented as mean ± standard deviation or number and percentage (n (%))
Significant difference is indicated with bold p-value

Figure 1: Relative disc signal intensity (SI) at baseline vs 2-year follow-up for whole spine and for lumbar and thoracic level. For individuals with low-to-normal training dose (p=**0.002**, **0.002**, 0.18) and individuals with high training dose (p=0.35, 0.33, 0.47). At baseline, the difference for whole, lumbar and thoracic spine between individuals with high vs low-to-normal training dose was p<**0.001**, p<**0.001** and p=**0.04**, respectively. At follow-up, the respective differences were all p>0.05. For whole spine, the difference over time between groups was p=**0.04**. (Violin widths scaled by count.)

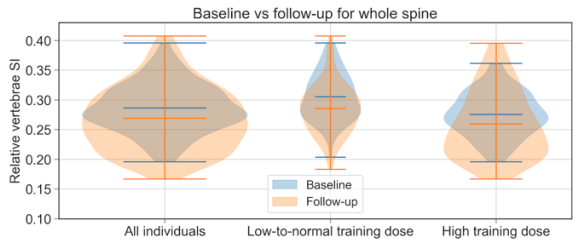

Figure 2: Relative vertebra signal intensity (SI) at baseline vs 2-year follow-up for whole spine in all individuals (p<**0.001**), individuals with low-to-normal training dose (p=**0.006**) and high training dose (p=**0.002**). At both baseline and follow-up, the difference for whole spine between individuals with high vs low-to-normal training dose was p<**0.001**. (Violin widths scaled by count.)

[1] Lagerstrand K., Baranto A., Hebelka H. Different disc characteristics between young elite skiers with diverse training histories revealed with a novel quantitative magnetic resonance imaging method. Eur Spine J. 2021;30(7):2082-2089.

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Is There an Association Between Psychiatric Disorders and Adolescent Idiopathic Scoliosis? A Large-database Study

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Introduction

Children with adolescent idiopathic scoliosis (AIS) have reduced quality of life related to poor self-image, perhaps because cosmetic concerns. However, there has not been a large-database epidemiologic study on the association between psychiatric disorders and scoliosis. Using the Korean National Health Insurance database, we asked: (1) How common are psychiatric disorders among children with AIS? And (2) After controlling for gender, age, insurance type, and residential district, are psychiatric disorders more common among children with AIS than among age-matched controls?

Methods

A retrospective analysis was conducted using sample datasets from the Health Insurance Review and Assessment Service from 2012 to 2016, which is a 10% randomly extracted sample of total inpatients and outpatients each year. The mean number of total patients in each dataset was 1,047,603±34,534. The mean number of children with AIS was 7409±158 for each year. Age criteria of 10 to 19 years was applied for the matching. Mood disorders, anxiety disorders, and behavioral disorders were selected as possibly associated disorders with AIS. Children with AIS who had any of the disorders above were identified, and prevalence was obtained based on diagnostic codes. As an exploratory analysis, clinically meaningful variables were selected among the available codes in the dataset, and univariable logistic regression test was performed for each variable. Multivariable logistic regression test with advanced variables was performed to identify the adjusted odds ratios (OR) of psychiatric disorders in children with AIS.

Results

The mean prevalence of psychiatric disorders in children with AIS from 2012 to 2016 was 6.8±0.4%. Compared with children who did not have AIS, and after controlling for gender, age, insurance type, and residential district, children with AIS were more likely to have psychiatric disorders in all 5 years. The adjusted ORs of psychiatric disorders in children with AIS compared with children who did not have AIS ranged from 1.47 to 1.74 (2012: OR 1.60 [95% CI 1.46-1.75]; p<0.001, 2013: OR 1.73 [95% CI 1.58-1.89]; p<0.001, 2014: OR 1.74 [95% CI 1.59-1.91]; p<0.001, 2015: OR 1.71 [95% CI 1.56-1.88]; p<0.001, 2016: OR 1.47 [95% CI 1.33-1.62]; p<0.001).

Discussion

Considering the higher prevalence of psychiatric disorders in children with AIS compared to children who did not have AIS, children with AIS and their parents should be counselled about the increased risk of deteriorating mental health of the patients, and surgeons should provide early referral to pediatric psychiatrists. Further studies should investigate the effect of the factors related to AIS, such as curve type, Cobb angle and treatment modality.

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A Study of Psoas Morphology with Respect to Safe Surgical Corridors for Lateral Lumbar Interbody Fusion in Indian Population

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Introduction:

Lateral Lumbar Interbody Fusion(LLIF) is an established treatment method for lumbar disc pathologies. LLIF requires dissection through the psoas placing the lumbosacral plexus at risk for injury, particularly at the L4–5 level. Despite defining safe surgical corridors, the reported rate of neurologic complications in this surgical approach ranges 8%-30%. Variations in psoas anatomy, notably the recently described 'rising psoas sign' have been associated with an increased tendency to develop these complications. No study has been done so far to study psoas morphology in Indian population. The objectives of our study were: i) To analyse the psoas morphology in Indian population and correlate the same with age, sex and BMI ii) To correlate the psoas anatomy with respect to the safe surgical corridors defined in LLIF approach.

Methods:

A retrospective radiographic study was done in 180 patients who underwent lumbar spine MRI in a single calendar year. Exclusion criteria included age < 18 years, scoliosis, infective/traumatic pathology, prior abdominal/ spinal surgery and patients with lumbosacral transitional vertebrae. All MRI scans were independently reviewed by two spine surgeons and the following measurements were made at L1/L2, L2/L3, L3/L4, L4/L5 levels: (a) Disc AP distance, (b) Psoas-thecal sac distance (measured as the shortest distance between dorsal psoas border and ventral border of thecal sac) and (c) asymmetry between left and right psoas muscles based on cross-sectional dimensions. Each disc space was divided into Moro's zones and the position of the dorsal psoas border was defined with respect to these zones. Correlation between psoas morphology and age/sex/BMI was done using Pearson's coefficient. The relationship between psoas anatomy and disc AP distance was studied using Student's t test.

Results: The AP disc distance was greater in males at all levels but no significant difference was found with respect to psoas cross-sectional dimensions. The psoas-thecal sac distance decreased with age on both right and left sides at the L4/L5 level. Significant psoas asymmetry was found at L1/L2 level with right psoas smaller than the left. Of the 180 patients, in 4 patients at L1/L2, 3 patients at L3/L4 and 26 patients at L4/L5, the dorsal border of psoas was found in Zone-IV whereas in only 4 patients it was found in Zone-III at L4/L5 level. In the rest, psoas was found in Zone-P.

Discussion: LLIF is a safe surgical technique to treat spinal pathologies at L1-L4 levels. Although, the relationship of psoas to the lumbar spine at L4/5 is variable, we find that the variation is less in Indian patients and its anatomy is more amenable to LLIF. When planning a lateral approach, particularly at L4/L5, a careful preoperative analysis of psoas and its relationship to vertebral body is important and in the event of a 'rising psoas' sign, an alternative approach should be considered.

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Evaluation of Synergistic Effect of Senolytic Combination Treatment for Intervertebral Disc Degeneration

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INTRODUCTION:

Low back pain is a global health problem that is directly related to intervertebral disc (IVD) degeneration. It is experienced by ~ 80% of individuals at some time in their lifespan. Despite its prevalence, little is known about the mechanisms leading to painful IVD degeneration, leaving surgical removal and vertebral fusion in end-stage disease as the most common treatment. There is growing recognition that senescent cells accumulate during tissue degeneration. In ageing and degenerating IVDs, tissue homeostasis is disrupted by the accumulation of senescent cells producing inflammatory and nociceptive factors that cause pain and inflammation, along with proteases degrading the tissue. One drawback of using a single senolytic agent is the failure to target multiple senescent anti-apoptotic pathways in the same cell type, or different cell populations within a target tissue. Concurrently targeting multiple and indirectly related anti-apoptotic pathways may result in increased selectivity for senescent cells in the absence of toxicity for normal proliferating or quiescent cells. The lower therapeutic dosages enabled by combinations also decreased side effects associated with single drugs. Combined treatment at lower doses may allow the repurposing of drugs that, were previously discarded due to undesirable side effects and increase success in clinical trials.

METHODS:

Human IVD cells: A dose response curve of o-Vanillin and RG-7112 was set up to select the most effective concentrations. Cells are treated with the 4 different combinations of o-Vanillin and RG-7112 for 6 hours. Slides are then immunohistochemically stained to measure level of senescence, level of proliferation, level of apoptosis and inflammation.

SPARC-null Mice: Animals 5-6-month-old SPARC-null mice with signs of IVD degeneration and low back pain were used. Drugs were administered by oral, once a week for 8 weeks. Grip strength, acetone-evoked behavior and mechanical sensitivity was assessed on non-treatment days during weeks 0, 2, 4, 6 and 8. The tail suspension test and distance travelled in open field was measured on weeks 4 and 8.

RESULTS SECTION:

The combination of o-Vanillin and RG-7112 significantly reduces the amount of senescence cells when compared to the senolytic drugs alone in degenerate human IVD cells. During pain behavior analysis, it was seen that cold allodynia, radicular pain and axial discomfort have been significantly reduced as of 4 weeks in the SPARC-null senolytic combination groups and single drug treated groups when compared to the SPARC-Null non-treated group. Furthermore, we observe a greater behavioral effect of the senolytic treatments when compared to the non-treated group at the 8-week time point.

DISCUSSION:

Our goal is to demonstrate the synergistic effect of combining these compounds to further reduce the expression of pain behaviours, pain mediators and improve tissue homeostasis in cells from a symptomatic patient population and from a clinically relevant mouse model of lower back pain and IVD degeneration. If proven true, these combinations therapies could revolutionize treatment of back pain for millions of patients worldwide and be one step closer to offering a preventative treatment for individuals at risk of lower back pain or avoid/prolong the need for invasive surgery.

1058

Viable Allograft Supplemented Disc Regeneration in the Treatment of Patients With Low Back Pain (VAST Trial): Interim Results of an Open-label Extension Study

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Introduction: The Viable Allograft Supplemented Disk Regeneration in the Treatment of Patients With Low Back Pain (VAST) trial (NCT03709901) evaluated the safety and efficacy of disc tissue allograft injection (VIA Disc®) into degenerated lumbar discs in patients with discogenic chronic low back pain (N=218; Beall et al. *Pain Physician* 2021). At 12 months, clinically meaningful improvements in pain, assessed via a visual analog scale (VAS), and in function, based on Oswestry Disability Index (ODI) score, were achieved in the investigational allograft and saline groups. An open-label extension study is in progress. Here, we report outcomes in patients who completed the 24-month follow-up.

Methods: The prospective, randomized, controlled VAST trial was conducted in patients with 1- or 2-level degenerative lumbar disc disease and chronic low back pain refractory to nonoperative treatments. At 12 months, patients could continue in an open-label extension study for up to 36 months, with an interim visit at 24 months. In this interim analysis, we assessed mean change from baseline in VAS and ODI scores and categorical responder status. To minimize confounding, we compared these 24-month data with results from prior timepoints in this completer population only.

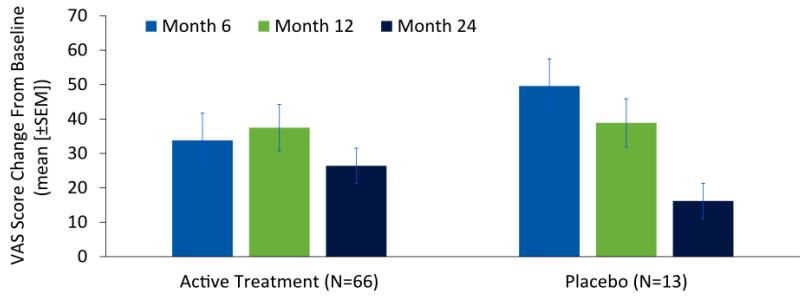
Results: Nine of 12 sites participated in the VAST extension; outcome data were entered for 83 patients at 24 months (allograft-treated, n=70; saline-treated, n=13). The 24-month completer population within each study arm was similar to the intent-to-treat population in age, sex, race, ethnicity, body mass index, and smoking status. In the allograft-treated group, change from baseline in VAS score (mean [95% CI]) at month 24 was -26.4 (-34.29 to -18.41) versus -16.2 (-36.4 to 3.68) in the saline-treated group (Figure 1A). The proportion of patients achieving ≥50% reduction in VAS score at 24 months was 47% versus 31% in the allograft- versus saline-treated group (Figure 1B). From month 6 to 24 there was a steady decline in benefit in the saline-treated group; in the allograft-treated group there was improvement from month 6 to 12 followed by a decline from month 12 to 24 to just below the benefit at month 6 (Figure 1AB). The longitudinal trends for ODI (not shown) were similar to those for VAS score.

Between month 12 and 24, 9/66 allograft-treated patients demonstrated ≥50% reduction in VAS scores and 26/66 attained a VAS score ≤20 points, versus 1/13 and 2/13, respectively, of those receiving saline. Similarly, between months 12 and 24, reduction in ODI score of ≥10 points was seen in 22% of allograft-treated patients versus none in the saline group.

Discussion: This interim analysis of an open-label extension of the VAST trial suggests that viable disc tissue allograft might be a beneficial nonsurgical treatment for patients with chronically painful degenerated lumbar discs. These 24-month data showed durable pain relief and functional improvement in treated patients, whereas initial benefits in patients receiving saline injections diminished by 24 months.

Fig 1. Improvement in Pain Over 24 Months in the Completer Population. **A**, VAS score change versus baseline. **B**, proportion of patients with ≥50% reduction in VAS score

A



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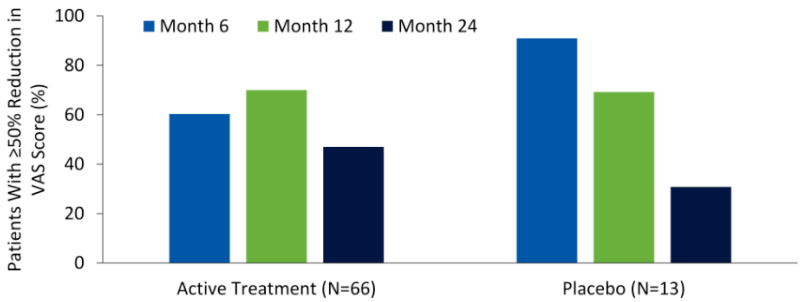

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Effects of Mindfulness Videos and Physical Therapy on Disability Outcomes in Individuals with Spine Pain

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INTRODUCTION: Recent efforts to augment exercise-based physical therapy programs with psychosocially informed treatments have become commonplace. Mindfulness meditation is one method that is becoming popularized as an accessory to physical therapy treatment for spine pain. The purpose of this study was to determine the effect of mindfulness video engagement on the neck and back disability in individuals undergoing exercise-based physical therapy for spine pain.

METHODS: Individuals undergoing a 6-9 week of in-clinic exercise-based rehabilitation were offered enrollment in a 4-week video-based daily mindfulness meditation program on an online platform. Home exercises were simultaneously provided on the same online platform. Low back- and neck-related disability assessed with the Oswestry Disability Index (ODI) and Neck Disability Index (NDI) were compared across no (0 videos), low (1-9 videos), medium (10-19 videos), and high (20-28 videos) engagement, using Analysis of Covariance correcting for age, body mass, and duration of symptoms. A separate model was generated to evaluate the influence of home exercise compliance on treatment outcomes. A receiver operating characteristic (ROC) curve was generated to identify a threshold for video engagement resulting in clinically significant reductions in disability (>10 points).

RESULTS: A total of 342 individuals participated, with 23.3% (80) not engaging, 44.4% (152) with low engagement, 21% (72) with medium engagement, and 11.1% (38) with high engagement in mindfulness videos. Mean (SD) age was higher in the high engagement group compared to the no-engagement group (58 (15) vs 50 (18) years, p=0.031), as was duration of pain (118 (143) vs 63 (99) months, p=0.044). Body mass index (BMI) was greater in the low engagement group compared to the medium engagement group (27.9 (6) vs 25.6 (5) kg/m^2, p=0.035). There was a greater reduction in ODI in participants with high versus low engagement (-11(15) vs -4(10) points, p=0.012) in the adjusted model, while no significant group differences were observed for NDI (p=0.728). When controlling for home exercise completion, these differences were no longer significant(p>0.158). A threshold of 10 videos was identified to predict a clinically important reduction in ODI, with a sensitivity of 46% and a specificity of 72%; AUC=0.59 (95%CI=.512-.665), p<0.05).

DISCUSSION: Greater engagement in mindfulness videos is associated with larger reductions in low back-, but not neck-related disability in individuals undergoing exercise-based physical therapy for spine pain. A minimum of 10 videos is recommended to achieve clinically important improvement. Home exercise completion may moderate the influence of mindfulness on ODI change.

1060

Night-time bracing improves back pain in patients with painful scoliosis: six months results of a retrospective controlled study

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2. "La Statale" University, Milan, Italy
3. IRCCS Istituto Ortopedico Galeazzi, Milan, Italy

	Peak				Custom made			
	Baseline	6 Months			Baseline	6 Months		
	Mean/median (SD/95%CI)	Mean/median (SD/95%CI)	P value intragroup	P value Intergroup pre treatment	Mean/median (SD/95%CI)	Mean/median (SD/95%CI)	P value Intragroup	P value Intergroup post treatment
Worst pain (back or leg)	7.15±2.03	5.6±2.13	0.011*	0.55	6.15±2.47	4.38±2.60	0.035*	0.66
Back Pain	6.55±2.37	5.25±2.69	0.049*	0.23	6.15±2.47	4.04±1.87	0.004*	0.23
Leg Pain	5.65±3.03	4.35±2.66	0,003*	0.48	4.66±2.94	2.83±3.76	0.11	0.27
COMI	5.67 (5.11–6.79)	4.18 (3.34-5.02)	0.002*	0.12	4.00 (2.00-5.99)	3.25 (2.09-4.41)	0.33	0.32
ODI	33.00 (25.26–38.43)	33.05 (26.30-39.79)	0.96	0.50	27.75 (14.85-40.65)	23.50 (12.86-34.14)	0.20	0.11

Introduction: Adult scoliosis is sometimes associated to back pain and severe curves can progress over time. The main approach for these patients is the surgical one, however surgery is not appropriate for all patients, and some do not accept surgery. Despite scoliosis has been estimated to affect up to 68% of the population over 60, there is scant literature about conservative treatment for adult scoliosis. Bracing is a quite common approach in such patients, but only a few papers are available to assess their efficacy. Bracing is usually applied during the day to improve pain and function, but some evidence showed a role for night-time bracing to prevent progression in most severe curves. Since some years we started using this approach in our patients, but so far, no information is available about the role of night-time bracing to improve pain and function.
The aim of the present study was to test the effectiveness of a custom-made brace in reducing pain and improving function in adult scoliosis patients at six months with respect to a prefabricated brace worn 2-4 hours during the day.
Methods: Design: retrospective controlled study.
Population: study group: 9 adults (age 57.0±5.0, curve 56.1±18.1° Cobb) who were treated with a custom-made brace for scoliosis at night.
Control group: 20 adults (age 67.8±10.5, curve 61.9±12.6° Cobb) coming from a previous study from our group.
Inclusion criteria: Adults affected by Idiopathic scoliosis of 30° Cobb or more and chronic low back pain (cLBP). Exclusion criteria: secondary scoliosis.
Sample size: no calculation was made; we included all the patients fulfilling inclusion criteria treated with a night-brace.
Outcome measures: GRS, Oswestry Disability Index (ODI), COMI.
Statistical analysis: paired t-test and non-parametric tests.
Protocol: patients were evaluated at baseline immediately and 6 months after they started wearing their brace. The dosage was night-time for the study group and 2-4 hours daytime for the control group.
Results: All patients from both groups reported a good compliance with bracing.
At six months, worst pain and back pain were significantly improved in both groups, while leg pain and COMI reached a statistically significant improvement only in the control group. For ODI, no relevant changes were noted.
Discussion: Night-time bracing with a custom-made brace showed being as effective as using prefabricated for 2-4 hours during daytime on worst pain and back pain. Results were not significant for leg pain and disability in the study group, and this could depend on the sample included, eventually too small to detect such a change. Achieving a good pain control with night-time bracing could be very important in order to help patients without impacting their ability to actively support their trunk.
We consider these as preliminary data that will justify further research to better understand the role of night-time bracing in adults with scoliosis and low back pain.

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1061

Phenotypic Durability in Viable Bone Allograft

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INTRODUCTION: Surgical graft procedures have established a “gold standard” for successful bone repair: osteoconductive scaffold, osteogenic cells and osteoinductive growth factors such as the bone morphogenetic proteins (BMPs). Adopting a viable cell bone allograft requires transfer of living bone to the site of surgery. Following cryoprotection, assets of viability and identity are critical to the composition of the allograft.

METHODS: 4 different lots of cancellous bone matrix that had been formulated for inclusion with DBM fibers as part of a viable allograft product (VIA Form+ (VIVEX Biologics, Miami, USA) were analyzed for cell count, viability, identity, and retention of identity after expansion. Each lot was from a different tissue donor; Median donor age was 56.25 years, (range 50-70 years). Tissue was protected with a polyampholyte cryoprotectant. Cells were removed with 0.3% NB5 collagenase in a-MEM at 3x volume per sample. Culture conditions were α-MEM w/1% PS and 20% FBS, under hypoxia conditions (5% O_2) in osteogenic conditions.

Previous work had isolated cells from cancellous bone replete with marrow, and expanded the cells to evaluate viability and identity following thaw from cryoprotectant. The comparison was made to demonstrate and compare the identity of attached cells and to compare with cells that were enzymatically removed and collected from bone without previously removing the bone marrow before collection.

RESULTS: Cell number per cc of allograft was consistent in empiric mixtures of cancellous bone and demineralized bone fibers. Viability of cells released from the cancellous bone approached 95% and did not differ between the product conformations. Flow cytometry data demonstrated key markers of osteoblast elaboration. Cancellous-derived cultures fulfilled the minimal criteria for MSCs as evident by the uniform positivity for MSC markers CD73, CD90 and CD105, and the lack of expression for hematopoietic-lineage markers such as CD45 (Figure 1). Figure 2 demonstrates the cell identity and culture expanded phenotypes. The similarities suggest that bone-derived cells that are viable, and cryoprotected maintain identity to those stripped from the cancellous bone.

DISCUSSION: Viable allograft matrices demonstrate clinical utility that rivals autograft use as a biological adjunct.[1],[2] This study demonstrated that attached cells on cancellous bone scaffold demonstrate osteogenic capacity when removed and cultured for 21 days. Cells which attached to cancellous bone have been used in cell-based viable matrices share a similar phenotype that remains durable in expansion and comparable in identity. Furthermore, the clinical efficacy shown with this product supports appropriate osteoinductive, osteoconductive, and osteogenic potential. Viable bone allograft that demonstrate therapeutic benefit offer an alternative to autograft in spine fusion applications.

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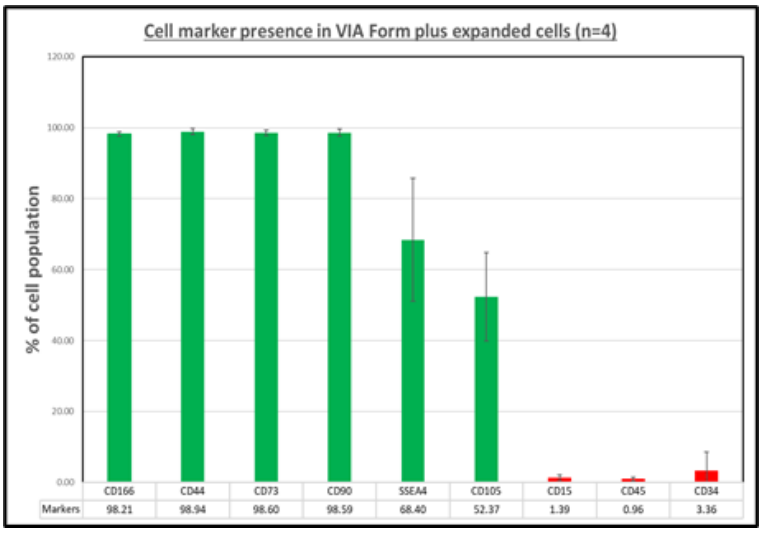

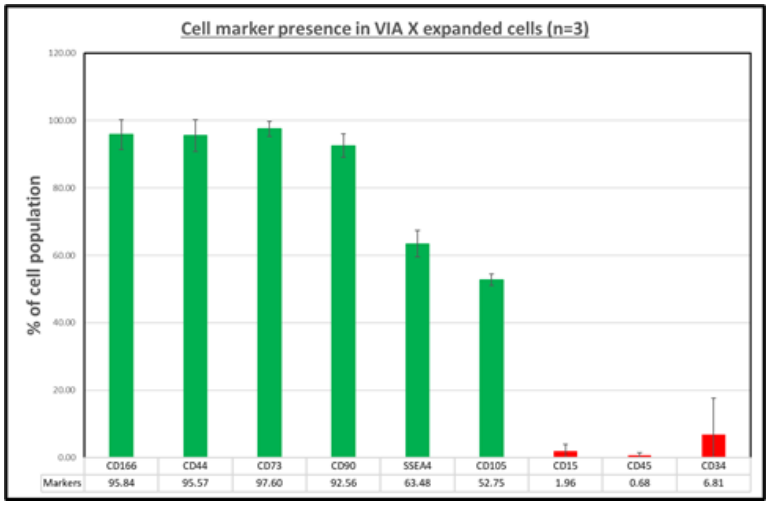

1062

DONOR AGE DOES NOT AFFECT THE THERAPEUTIC POTENTIAL OF CLOTTED BONE MARROW IN BONE TISSUE ENGINEERING AND REGENERATION

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INTRODUCTION

Recently, the use of a new formulation of bone marrow aspirate (BMA), the BMA clot, has been described. This product entails a naturally formed clot from the harvested bone marrow, which retains all the BMA components preserved in a matrix biologically molded by the clot. Since its beneficial effects were demonstrated by some studies, how aging and aging-associated processes could impact, as for other BMA cell-based therapy, on its biological properties and effect is currently unknown. The purpose of our study was to compare selected parameters and properties of clotted BMA and of MSCs residing inside it from younger (<45 years) and older (>65 years) female donors.

METHODS

Clotted BMAs growth factors (GFs) expression, MSCs morphology and viability, doubling time, surface marker expression, clonogenic potential, three-lineage differentiation ability, senescence associated factors and Klotho expression in younger and older donors were compared and analyzed.

RESULTS

Results indicated that donor age does not affects tissue specific BMA clot regenerative properties such as GFs expression and MSCs morphology, viability, doubling time, surface antigens expression, colony-forming units, osteogenic and adipogenic differentiation, and Klotho and senescence-associated gene expression. Only few differences, i.e., increased PDGF-AB and increased MSCs ACAN expression were detected in younger donors in comparison to older ones. However, these differences do not interfere with all the other BMA clot biological properties.

DISCUSSION

These results demonstrated that BMA clot can be applied in an easy way, without any sample processing and avoiding potential risks contamination as well as losing cell viability, proliferation, and differentiation ability, for autologous transplantations in aged patients. The clot BMA seems to work as an early hematoma both in younger and older population and can be considered as novel and advanced therapeutic alternatives for the treatment of orthopedic injuries.

1063

Dysregulated serum lipid transport in Modic changes

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2. Medical Research Center Oulu, Oulu University Hospital and University of Oulu, Oulu, Finland
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INTRODUCTION: Modic changes (MC) are vertebral bone marrow lesions seen on magnetic resonance imaging (MRI). MC are adjacent to degenerated intervertebral discs and are a specific source of chronic low back pain (CLBP). The etiology of MC remains largely unknown. The degenerating disc has been accused to trigger MC by releasing pro-inflammatory cytokines. Biomarker studies showed inconsistent association of MC with pro-inflammatory serum cytokines. A recent study identified very-low-density lipoprotein as risk factor and potential biomarker for MC. The aim of this study was to identify serum biomarkers for MC using an unbiased quantitative mass spectrometry screening approach.

METHODS: One hundred serum samples from the Northern Finland Birth Cohort 1966 have been selected. Patient data including demographic data, comorbidities, psychosocial factors, pain and disability scores were retrieved from the cohort database. Four conditions (n=25 each) were compared: (i) CLBP + MC, (ii) CLBP + no-MC, (iii) no-CLBP + MC, (iv) no-CLBP + no-MC. Serum samples were analyzed using data-independent-acquisition (DIA)-based sequential window acquisition of all theoretical mass spectra (SWATH-MS). DIA-based SWATH-MS is a systematic and unbiased acquisition that combines deep proteome coverage capabilities with quantitative consistency and accuracy. All detected proteins were analyzed with two-way ANOVA for effects of CLBP and MC. Gene ontology analysis and pathway analysis was run to identify enriched pathways. In a sub-population analysis of the 50 subjects with CLBP, proteins with significant changes due to MC were identified. Level of significance was α=0.05. Power to predict MC in the CLBP population was calculated as area-under-the-curve (AUC) of the receiver-operating-characteristics (ROC).

RESULTS: With DIA-based SWATH-MS 1099 proteins were identified. Two-way ANOVA identified 37 significantly dysregulated proteins due to MC and 15 significantly dysregulated proteins due to CLBP. “Lipid transport” (p=1.3e-5) was the top enriched biological process and “Complement and coagulation cascade” (p=4.2e-3) as top enriched pathway. Top differentially expressed proteins in “lipid transport” were apolipoprotein D (APOD), apolipoprotein C3 (APOC3), apolipoprotein F (APOF), insulin receptor (INSR), and very low-density lipoprotein receptor (VLDLR). In the clinically relevant subpopulation with CLBP, the ratio of APOD/APOC3 was significantly higher in MC than no-MC (p=6.82e-5, Fig.1) and had a predictive power for MC of 0.84 (confidence interval: 0.73-0.95, Fig.2)

DISCUSSION: Population-based serum proteomics indicates that lipid transport is dysregulated in MC. This suggests that MC is not only a local inflammatory reaction to degenerated discs but that systemic metabolic factors are risk factors and potential biomarkers for MC. Serum lipoprotein measures could enhance a MC biomarker profile, yet robustness of lipid transport biomarkers for MC with respect to demographics, comorbidities, medication, and psychosocial factors need to be tested. This study lays ground for larger mechanistic and biomarker studies on the clinically relevant MC phenotype of CLBP.

Fig.1

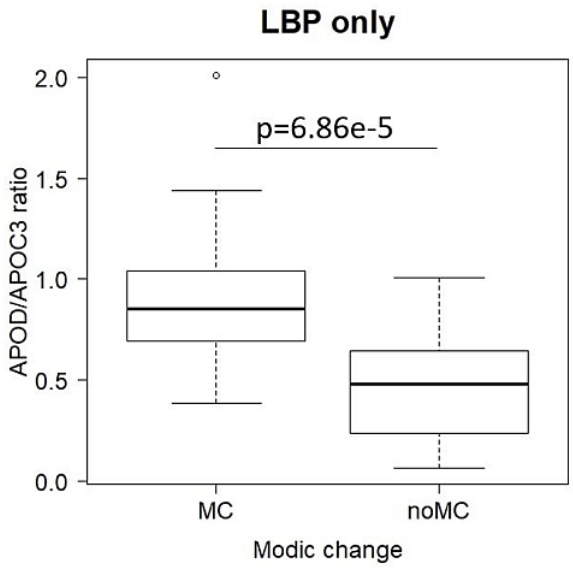
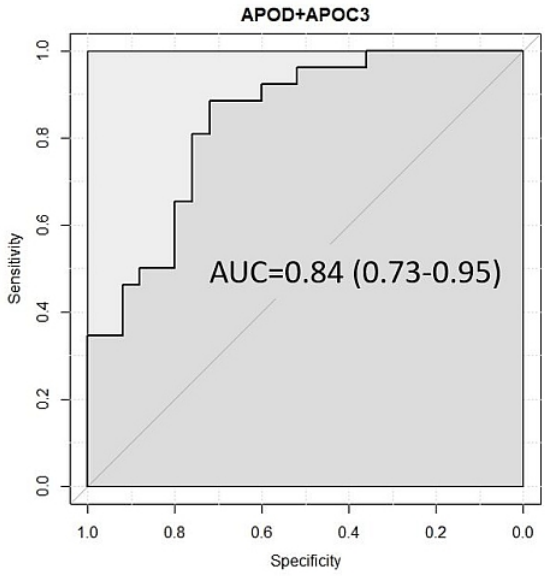


Fig.2



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Reliability of Semi-Automated Spinal Measurement Software

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Introduction

In the treatment of patients with adult spinal deformity, analysis of spinopelvic balance is essential in determining treatment options. This includes pelvic tilt (PT) and incidence (PI), lumbar lordosis (LL), and the sagittal vertical axis (SVA). Historically, the measurement of radiographs was done by hand with poor to moderate inter-observer reliability (1, 2). More recently digital PACS tools provided improved accuracy and reliability (2), with the latest software semi-automating this process with a promise of improved efficiency.

To our knowledge, no studies have examined the inter-observer reliability of semi-automated PACS software. This study aims to compare the reliability of this software versus PACS to determine if the improved efficiency occurs at the cost of reliability.

Methods

Full spine x-rays were retrospectively reviewed from 25 patients older than 18 years seen at a tertiary medical center between 2014 and 2017. Patients were included if they had greater than 5cm of sagittal imbalance, without prior surgical spinal fusion and/or instrumentation. Spinopelvic parameters were measured in two radiographic programs: one with basic, non-spine specific measurement tools (eUnity, Client Outlook, Waterloo, Canada); and a second with spine-specific measurement tools that semi-automate the measurement of these parameters (Sectra, Sectra AB, Linköping, Sweden). Balance parameters included SVA, PI, PT, and LL. Two authors re-measured radiographs after a 6 month interval and results were compared to original measurements. Data were compared by examining inter-rater and inter-program reliability using interclass correlation coefficient (ICC).

We hypothesized that modern semi-automated software, with its promise of increased measurement efficiency, would maintain reliable results.

Results

The subjects' mean age was 67.9 +/- 13.8 years old, and 32% were male. The inter-program reliability was strong, with ICC values greater than 0.91 for each parameter. Similarly, there was strong inter-observer reliability with ICC values greater than 0.88. Delayed re-measurement also showed strong reliability with ICC values greater than 0.90 ($p < 0.001$ for all measurements).

Discussion

There is excellent inter-observer and inter-program reliability between the basic PACS and semi-automated programs. These data demonstrate that the purported efficiency of semi-automated measurement programs does not come at the cost of measurement reliability.

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1065

SOCIAL/WORK/CONTEXTUAL FACTORS ARE CENTRAL TO THE PERSPECTIVES OF OSTEOPATHIC NEUROMUSCULOSKELETAL MEDICINE AND PHYSICAL MEDICINE & REHABILITATION PHYSICIANS' UNDERSTANDING OF LOW BACK PAIN

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INTRODUCTION: Collaborative modeling has recently been used to investigate the most important factors related to low back pain (LBP) by documenting the perspective of experts from multiple disciplines using fuzzy-logic cognitive maps (FCMs). FCMs represent an individual's conceptual understanding (mental model) of a problem and have highlighted the perceived importance of psychological factors in LBP. Although clinicians may consider psychological factors when treating patients with LBP, the relative importance of such factors may differ between disciplines. This study aimed to 1) investigate how osteopathic neuromusculoskeletal medicine (ONMM) and physical medicine & rehabilitation (PM&R) physicians conceptualize the factors and their interactions involved in LBP and 2) compare how these physician groups' models of LBP are different (or similar) to a multidisciplinary cohort with expertise in LBP (EXP).

METHODS: ONMM (n=15) and PM&R (n=16) physicians were compared to a third EXP group of scientists/clinicians (n=29) that represented the following disciplines: Basic Science (n=3), Epidemiology(n=2), Biomechanics (n=3), Chiropractic (n=4), Spine Surgery (n=2), PM&R (n=2), Physical/Exercise Therapy (n=11), and Psychology (n=2). Each participant underwent a structured one-on-one interview to construct FCMs using online software (www.mentalmodeler.org). This process involved the nomination of factors contributing to patients' outcomes (i.e., pain, disability, and quality of life) and the weighting of the connections (strength of the effect) between these factors. Factors from each model were allocated to one of eight categories: 1) Nociceptive Detection & Processing, 2) Behavioral/Lifestyle 3) Tissue Injury/Pathology, 4) Psychological, 5) Social/Work/Contextual, 6) Biomechanical, 7) Comorbidities and 8) Individual Factors. The centrality of each category (sum of centrality for each factor within the designated category) was calculated to determine the importance of factors represented in the FCMs and was expressed as a percentage of the eight categories. FCMs were aggregated into a metamodel for each group to assess the collective opinion it represented. The cognitive diversity index (CDI) was calculated to reflect how many different categories are represented in an FCM. Individual FCMs and metamodels were analyzed with descriptive statistics and ANOVA was used to detect a statistical difference in model metrics among the three groups ($p<0.05$).

RESULTS: There were 1464 Factors and 4799 Connections generated for all FCMs; however, there was no significant difference in the number of Factors ($p=0.67$), Connections ($p=0.27$), or CDI ($p=0.67$) between the three groups. Psychological Factors was clearly the most prominent category in the EXP group accounting for 28.1% of the centrality, whereas Social/Work/Contextual Factors was the most prominent in the PM&R and ONMM groups accounting for 26.3% and 18.6%, respectively (Figure 1). Social/Work/Contextual Factors was the second most prominent category in the EXP group, while Psychological Factors was second in the ONMM and PM&R groups (Figure 2).

DISCUSSION: Although Social/Work/Contextual Factors was the most central/important category in the ONMM and PM&R groups, other categories had similar relative importance in the respective models. These findings speak to the perceived importance of psycho-social and contextual factors from the scientific and clinical community and highlight the unique perceptions of ONMM and PM&R physicians in the management of patients with LBP.

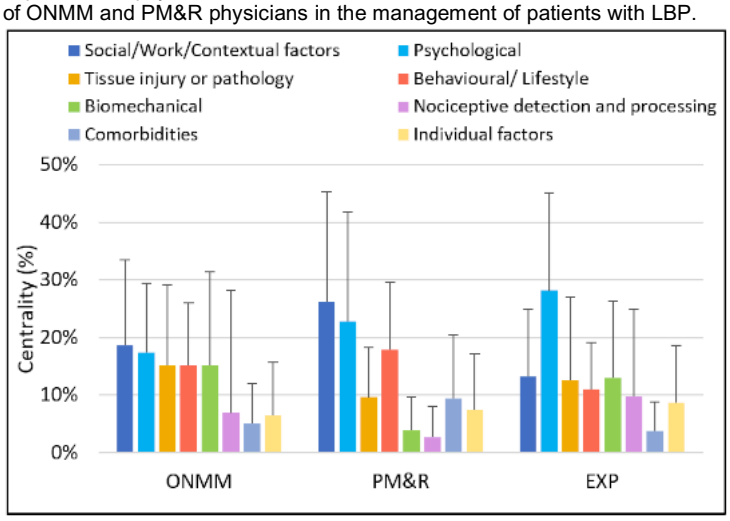

Figure 1. Centrality of categories for the three groups.

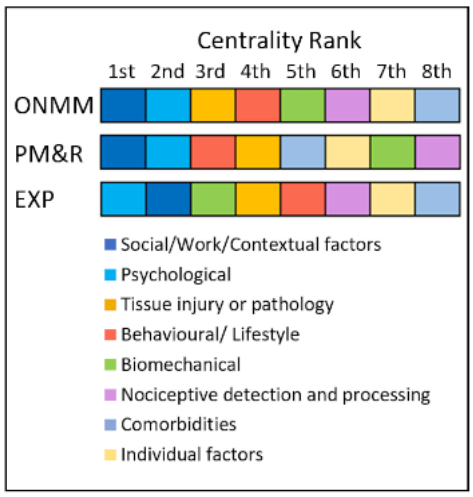

Figure 2. Cognitive Color Spectra of the metamodels for the three groups. Each category is ranked 1st-8th by magnitude of the normalized sum of centrality.

1066

Standing MRI of the lumbar intervertebral discs reveals posture-specific biomarkers of low back pain

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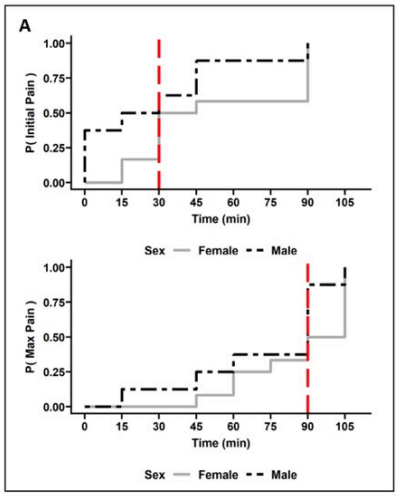
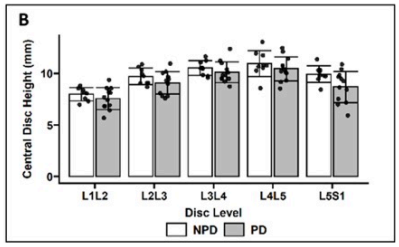
INTRODUCTION: While intervertebral disc degeneration (IDD) is implicated in LBP, the overlapping occurrence of IDD in symptomatic and asymptomatic individuals makes it challenging to identify the painful features provoking LBP. It is thus prudent to examine the initiating mechanisms of LBP in individuals whose symptoms can be noninvasively induced and alleviated. Standing induced LBP is common in young, back-healthy adults, and they experience sustained LBP symptoms after periods of prolonged standing (~2 hours). Pain-developers' (PDs') are three times more likely to experience a near-future bout of clinical LBP than non-pain developers (NPDs) [2]. We hypothesized NPDs and PDs exhibit differential adaptations of the IVD in prolonged standing, and the adaptations of the IVD are associated with the pain symptoms.

METHODS: 40 human back-healthy participants (; 18-30 yo; 21F, 19M) were recruited for a cross-sectional observational MRI study with approval by the Washington University SOM HRPO. T2 weighted sagittal images were collected using a 0.6T pMRI [2]. Subjects were imaged after 15 minutes in the supine position, and for 105 minutes in the standing position in intervals of 15 minutes with reporting of pain severity using the Visual Analogue Scale (VAS) Those who reported sustained, non-zero pain at any time point were classified as PDs, else they were classified as NPDs. The 3D structure of each of the five lumbar IVDs (L1L2 – L5S1) were characterized by measurements of each disc's central height, major axis diameter, minor axis diameter, axis diameter ratio, whole disc (WD) volume, nucleus pulposus (NP) volume, NP volume fraction, intervertebral angle (IV Angle), and anterior-to-posterior height ratio (AP). The sagittal Cobb angle was measured at each time point. In the supine and initial standing positions, the degeneration grade was determined to consensus by two board-certified radiologists using a modified Pfirrmann scale. The ratio of the T2 signal intensity of the NP to the WD (NIDI) defined from the contoured segmentations. Analyses with temporally repeated measures were modeled using an autoregressive covariance structure [3].

RESULTS: WD volume was significantly reduced after standing in both males and females ($p < 0.001$, $p < 0.05$). The MRIs acquired in the supine or the initial standing positions were not sufficient to differentiate PDs from NPDs. Comparing the changes from supine to initial standing, female PDs exhibited a significant reduction of NIDI (5.7%, $p < 0.001$). Male PDs did not differ from NPDs. Pain status was a significant main effect on female disc height during prolonged standing, with female PDs exhibiting 7.8% reduction in disc heights compared to NPDs ($p < 0.01$). Finally, we found that L3L4 and L4L5 morphologies are associated with pain in females, while L1L2 and L2L3 levels morphologies are associated with pain metrics in males (Table 1).

DISCUSSION: While male PDs could not be differentiated from NPDs, we identified the position- and level- specific IVD changes that predict the magnitude of pain in both males and females PDs. The results here suggest that there may be sex-specific variations in the anatomical locations of the pain generator.





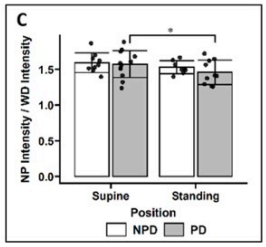


Table 1: Pain-related IVD morphology

	Female (r, *p value*)		Male (r, *p value*)	
	Max VAS	**Pain AUC**	**Max VAS**	**Pain AUC**
L1L2 Width			(-0.84, 0.038)	
L2L3 NIDI				(-0.91, 0.010)
L4L5 AP	(0.79, 0.008)			
L3L4 IV Angle	(0.59, 0.018)			
L4L5 IV Angle	(0.78, 0.012)	(0.80, 0.010)		

Figure 1: A) Survival curves demonstrating the probability of male and female PDs developing their first symptoms of LBP, i.e. first non-zero VAS rating (top), and most severe pain, i.e. max VAS rating (bottom), during the prolonged standing task. Dashed red lines indicate the time points at which approximately half of PDs experienced these events. B) Female disc height was reduced in PDs relative to NPDs ($p < 0.01$). Data points represent the average of an individual throughout prolonged standing. C) Female PDs have decreased NIDI after transitioning from supine to standing. *All bar graphs represent group mean ± SD.*
Table 1 contains IVD morphology that is significantly correlated with pain metrics ($p < 0.05$). P values are Šidák-adjusted to account for multiple tests of significance.

1. [1] Nelson-Wong et al Spine, 2014 [2] Weber et al Clin Biomech, 2019 [3] Pinheiro et al, nlme,2021

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Vacuum Discs in Lumbar Spinal Deformity: Relationships with Pain and Patient Factors

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Introduction. Vacuum discs, the collection of gas within the intervertebral disc space, are believed to represent end-stage disc degeneration. However, the relationship between vacuum discs and pain severity is unknown. The goals of this study are to identify the prevalence of vacuum discs in patients with lumbar spinal deformities and determine whether there is an association with low back or leg pain severity.

Methods. Patients evaluated at a single institution from 2013-2019 were included if they were aged >18 years, had a CT including the T12-S1 discs, and had a diagnosis of scoliosis, kyphosis, or flat back. Patients with prior thoracolumbar fusion or a history of spinal malignancy or inflammatory arthritis were excluded. Patient reported outcomes included numeric pain rating scales (NPRS) for back and leg pain, and the Oswestry Disability Index (ODI). CTs were evaluated for the presence and size of vacuum discs from T12-S1.

Univariate relationships between pain and the presence of vacuum discs (chi-squared/Fisher's exact, Mann-Whitney U), number of levels with vacuum discs (Mann-Whitney U, linear regression), and maximum vacuum size (Fisher's exact & Kruskal Wallis) were first assessed. Subsequently, multivariable GEEs were constructed to relate the presence of vacuum discs to back pain, leg pain and ODI. Analyses were performed with SAS v9.4 with a two-sided α=0.05.

Results. The final cohort included 130 patients [62.3% female, median age=71.8 years (interquartile range (IQR))=65.5, 76.6]. 95.4% of patients had a vacuum in ≥1 disc, and 61.6% had a vacuum in ≥4 levels. The most common level was L3-L4 (72.9% of patients) (Table 1).

Vacuum discs were associated with older age, both when considered overall (p<0.006), or by individual level (p<0.037 for each). Older age was associated with a greater number of vacuum discs, with age increasing 3.5 (2.5, 4.5) years per additional vacuum (p<0.001). Older age was also associated with increased vacuum size (p<0.001). Patients with vacuum size >50% had a higher median age [72.9 (IQR: 66.8, 77.5) years] than those with a vacuum size <50% [65.9 (IQR: 62.4, 67.4), p<0.001], and those with no vacuum [43.9 (IQR: 21.0, 70.8), p<0.011].

Males were more likely to have more levels with vacuum discs [median(IQR) males=5 (3, 5), females=4 (3, 5); p=0.031]. Males also trended towards larger vacuum discs (p=0.089).

Considering all levels together, vacuum discs at L4-L5 were associated with higher NPRS back pain [+1.5 (0.2, 2.7), p=0.023] (Figure 1). Vacuum discs at L5-S1 were associated with greater leg pain [+2.1 (0.4, 3.9), p=0.016]. There was also a trend towards higher ODI (greater disability) with a vacuum at L5-S1 [+5.9, (-0.6, 12.4) p=0.071]. The number of vacuum levels and vacuum size were not associated with pain or ODI.

Discussion. The presence, number, and severity of vacuum discs increased with age, and males had more vacuum discs than females. Vacuum discs were associated with increased pain and potentially increased disability at L4-L5 and L5-S1. These findings are pertinent to surgical planning in spinal deformity, as vacuum discs at these levels may be associated with more severe symptoms.

Table 1. *Vacuum disc characterization.*

		n (%)
# Levels with Vacuum:	0	6 (4.6%)
	1	11 (8.5%)
	2	13 (10%)
	3	20 (15.4%)
	4	30 (23.1%)
	5	33 (25.4%)
	6	17 (13.1%)
Max Vacuum Size:	none	6 (4.6%)
	< 50%	15 (11.5%)
	> 50%	109 (83.8%)
Vacuum Present at:	T12_L1	58 (45%)
	L1_L2	72 (56.3%)
	L2_L3	91 (70.5%)
	L3_L4	94 (72.9%)
	L4_L5	86 (67.2%)
	L5_S1	83 (64.8%)

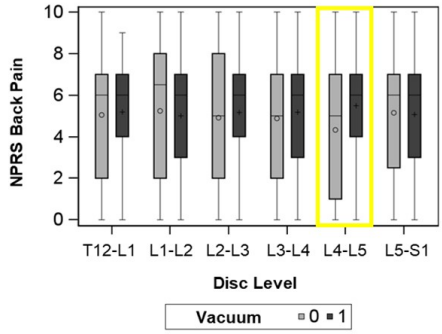

Figure 1. *NPRS back pain versus the presence of a vacuum at each level. Yellow box indcates p < 0.05.*

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The "Disc Degeneration Profile" in Lumbar Disc Herniations that Resorb: a Prospective, One-Year, Multi-Imaging and Clinical Phenotype Study

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Introduction: Symptomatic lumbar disc herniation can occur in any age group and population worldwide. The socioeconomic burden of such an occurrence is substantial. Oftentimes, the LDH can undergo a process of "self-healing" and resorb. However, the degeneration profile of the disc following herniation and resorption remains unknown. As such, this study aimed to examine the "Disc Degeneration Profile" of the LDH following resorption and further investigate associated imaging and clinical risk factors.

Methods: A one-year prospective study was conducted of patients presenting with acute, symptomatic LDH. All patients were managed conservatively by a single clinician. Baseline assessment included patient demographics, herniation characteristics (e.g., herniation size, location, geospatial measurements), and MRI phenotypes (e.g., disc degeneration, endplate abnormalities, vertebral body dimensions). MRIs were performed at initial presentation and approximately every 3 months until symptom resolution or disc resorption on imaging. Disc degeneration was quantified by the Pfirrmann classification system, whereby grades were given to each LDH for MRI obtained, from which a "Disc Degeneration Profile" for each patient was constructed. Group 1 represented patients that had stable/improving discs (i.e. no further disc degeneration throughout follow-up) and Group 2 represented discs with worsening degenerative changes.

Results: 93 patients were included (Group 1 [n=82 stable/n=1 improving]; Group 2 [n=10 worsening]). The mean age was 47.7±12.3 and 49.0±11.9 years for Groups 1 and 2, respectively. Baseline demographics, herniation characteristics, and alignment measurements did not differ between groups. On follow-up, those in Group 1 were more likely to have greater reduction in sagittal disc size compared to those in Group 2 ($p=0.018$). Patients in Group 1 exhibited greater change in their Cobb angles compared to Group 2 ($p=0.037$). Patients in Group 1 were also more likely to have greater L3 anterior body disc height ($p=0.028$) and L4 inferior body disc width ($p=0.029$). Group 1 had higher incidence of index disc grades, greater disc degeneration scores at MRI-1 ($p=0.001$) and MRI-3 ($p=0.039$), higher incidence of Schmorl's nodes above the herniation level ($p=0.016$) and greater incidence of endplate damage above ($p=0.011$) as well as below herniation level ($p=0.008$) compared to Group 2. No differences in resorption rate or time to resolution were observed between those with Group 1 and Group 2, however, those in Group 1 where more likely to have greater amounts of pain medication compared to Group 2 ($p=0.029$).

Discussion: This is the first study to have noted the fate of the "Disc Degeneration Profile" in symptomatic LDH patients that had disc resorption within one year since herniation. Interestingly, those with "stable" degeneration profiles were more likely to have not only degenerative changes (e.g., endplate damage) but required greater amounts of pain medication as well, which may be secondary to the fact that these individuals initially presented with worse disc degeneration. Moreover, this study indicates vertebral dimensions may provide insight into overall disc health. Information of the Disc Degeneration Profile of the LDH patient will assist clinicians in managing patient expectations and perhaps developing more personalized spine care with long-term patient assessment for future sequelae.

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The Impact of COVID-19 Pandemic on Spine Surgeons Worldwide: a 1-year prospective follow-up

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Introduction: After more than a year since its onset, the COVID-19 pandemic continues to be a significant medical, financial, and social crisis. Varying associated government regulations and public health initiatives have produced unique effects on both medicine and those who practice it across the globe. In April 2020, Louie et al[1] conducted a study assessing the multidimensional impact of COVID-19 on healthcare professionals, particularly spine surgeons, and to identify geographical variations. The current follow-up study serves to evaluate how practices and perceptions of spine surgeons have changed over the past year.

Methods: A multidimensional survey, similar to that reported by Louie et al[1], was distributed via email to 3,805 spine surgeons who were members of AO Spine and agreed to receive surveys. Recipients were given 12 days to complete the 90-item questionnaire (3/26/2021 to 4/6/2021), which was categorized into the following domains: demographics, COVID-19 observations, preparedness, vaccination, personal impact, patient care, and future perceptions. Results were compared with those of the prior survey.[1] Statistical analyses were performed with JASP version 0.15. P values <0.05 were deemed statistically significant.

Results: 275 spine surgeons representing 7 global regions completed the follow-up survey, equating to a response rate of 7.2%. Compared to 6.7% in the original survey, 71.3% of respondents had undergone testing for COVID-19, of which 16.7% tested positive, similar to the 15.8% reported by Louie et al.[1] Eighty-nine (32.4%) reported quarantining at some point during the past year. 64.0% had received at least one dose of the COVID-19 vaccine, with specific vaccine type (e.g., Pfizer, Moderna, etc.) being regionally dependent. Amongst those not yet vaccinated, 53.0% indicated they would immediately get the vaccine once available in their respective countries, whereas 5.1% expressed they do not want the vaccine. Family health concerns continued to be the greatest stressor globally (69.5%). Interestingly, only 37.8% noted expected time to baseline clinical practice as a moderately high stressor, down from 44.9% last year. Sixty-four respondents (23.7%) indicated they anticipate returning to baseline clinical practices within 6-12 months, longer than the most common response last year of 8 weeks (26%). Respondents noted reduced clinical time (46.2%), reduced research activities (29.8%), and poorer training experiences for residents (52.0%) due to the pandemic. Research output and teaching/training was similarly impacted worldwide and in comparison, to last year. Loss of income continued to be the most common response for concern secondary to COVID-19 (28%), which was regionally dependent as well. Finally, 64.0% expressed need for formal, international guidelines to manage COVID-19 patients, a 28% decrease from our prior survey.

Discussion: Spine surgeons around the world continue to experience professional, psychological, and social consequences of COVID-19. Substantial variation in experiences across the globe reflect differences in government regulations, public health initiatives, and overall resource allocation. By highlighting the challenges and needs of spine surgeons around the world, results of this study may serve as a foundation to the development and implementation of guidelines that promote a return to safe and effective healthcare provision amid a global health crisis.

1. Louie PK, Harada GK, McCarthy MH, et al. The Impact of COVID-19 Pandemic on Spine Surgeons Worldwide. Global Spine Journal 2020; 10: 534–552.

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Paravertebral chordoma in the posterior mediastinal region found incidentally during empyema treatment

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【Case】 A 71-year-old female patient was admitted to our hospital's Critical Care and Emergency Department due to septic shock associated with pneumonia. Although the shock was ameliorated by antibiotic treatment, pyothorax was found on computed tomography, which was performed because her fever and severe inflammatory reaction persisted. At the same time, an abscess was found in the thoracic paravertebral region of the posterior mediastinum, and thoracoscopic drainage was performed. Pathological examination revealed a chordoma in the paravertebral region. Because the tumor was spread over four vertebrae, complete resection was not an option, and heavy particle radiotherapy was started instead. The patient requires continued, careful follow-up.

【Discussion】

Chordomas are a rare, malignant bone tumor arising from the remnants of the embryonic chorda and most commonly involve the sacrococcygeal bone and base of the skull. Vertebral body involvement is rare, and cases of paravertebral chordoma development do not involve direct invasion of the nervous system and are often subclinical and found by chance.

【Conclusion】

Chordoma should be considered in the differential diagnosis of posterior mediastinal lesions arising from the paravertebral body.

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Predictive Utility of the STarT Back Tool in a Chronic Low Back Pain Specialty Clinic

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Introduction

Identifying subgroups that respond to targeted treatments is a key objective for low back pain (LBP) research. The Keele STarT Back Screening Tool (SBT) assigns patients to one of three subgroups, according to the risk of persistent disability (low risk, medium risk, high risk). Several items in the SBT were chosen because they measured psychosocial domains that were thought to be modifiable in primary care. In primary care settings the SBT successfully predicts long term disability, and targeting treatment to the risk subgroup has been shown to reduce disability. There is much less information on it's performance in specialty clinics. The objectives of our study were to a) determine whether SBT can predict change in disability after referral to a low back pain specialty clinic and b) determine if incorporating features not included in the SBT may improve ability to predict disability.

Methods

This is a retrospective observational cohort study involving LBP patients referred by primary care providers and seen in a US chronic LBP (cLBP) specialty clinic. Patients referred to the clinic are seen for back-to-back appointments with a physical therapist and a physician, who formulate a joint treatment plan. Patients receive consistent messaging about spinal pain from their providers, organized around the principles of pain neuroscience education. There are no standardized treatment pathways, but patients who fall into the SBT high-risk subgroup are discussed at monthly multi-disciplinary case conferences so that progress is closely monitored and treatment adjusted as indicated. SBT and covariates were measured at baseline. Outcome measures were pain intensity (VAS), PROMIS-10 global physical health (PH) and PROMIS-10 global mental health (PH). VAS, PH, and MH were measured at baseline and at pragmatic timepoints following. Multivariable linear regression was used to identify correlations between SBT and covariates with changes in PH and MH.

Results:

241 patients were followed for a mean of 17.0±7.5 months. Baseline pain was 6.6 (SD 2.1), PROMIS-global MH score was 44.4 (SD 9.6), and PH score was 38.5 (SD 8.6). 29.7% were low-risk on the SBT, 41.8% were medium-risk, and 28.5% were high-risk. Mean change in MH and PH scores were 0.8 (SD 8.11) and 2.39 (SD 7.52) respectively. High-risk SBT positively predicted change in MH and both medium- and high-risk status predicted change in PH (Table 1). Additional variables that predicted change in MH include chronic overlapping pain conditions (COPC) and in PH included every-day smoker status, pain down buttock/thigh, Charlson Comorbidity Index (CCI) score, COPCs, and recent injections.

Discussion

The SBT predicts change in dysfunction following treatment in a cLBP specialty clinic, but including other variables, most notably COPC's, improves performance. Effort is needed to identify other factors, even if nonmodifiable, that can help stratify risk in cLBP patients.

Table 1 Predictors of change in PROMIS-global Mental Health and Physical Health

	PROMIS MH		**PROMIS PH**	
Baseline	44.4 (SD 9.6)		38.5 (SD 8.6)	
Mean change	+0.86 (SD 8.11)		+2.39 (SD 7.52)	
	Unadjusted	Multi-variate adjusted	Unadjusted	Multi-variate adjusted
	Difference (95% CI), p-value			
Medium-risk	1.35 (-1.10, 3.80), 0.28	1.50 (-1.22, 4.23), 0.28	3.62 (1.36, 5.87), 0.002	3.82 (1.50, 6.14), 0.002
High-risk	4.51 (1.83, 7.18), 0.001	4.35 (1.47, 7.23), 0.004	3.60 (1.13, 6.06), 0.005	3.54 (1.03, 6.05), 0.006
Everyday smoker	8.96 (2.40, 15.53), 0.008	6.67 (-0.68, 14.02), 0.08	7.67 (1.58, 13.76), 0.01	6.64 (0.46, 12.82), 0.04
Pain down knee (MH), Pain down buttock/thigh (PH)	2.68 (0.09, 5.26), 0.04	2.22 (-0.31, 4.76), 0.09	2.57 (0.55, 4.60), 0.01	2.15 (0.24, 4.06), 0.03
COPC	-3.72 (-5.71, -1.74), 0.0003	-4.23 (-6.35, -2.10), 0.0001	-3.24 (-5.08, -1.39), 0.0007	-4.02 (-5.87, -2.17), <0.0001
Charlson Comorbidity Index Score	-0.39 (-1.15, 0.38), 0.32	N/A	-0.92 (-1.62, -0.22), 0.01	-1.06 (-1.78, -0.34), 0.004
Recent injections	0.65 (-5.08, 6.38), 0.82	N/A	6.89 (1.65, 12.12), 0.01	9.31 (2.47, 16.15), 0.008

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Association between fresh osteoporotic vertebral fractures and muscle mass in patients with postmenopausal osteoporosis.

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INTRODUCTION

Frailty and sarcopenia due to loss of muscle mass in the elderly has gained popularity in recent years.Previous studies have suggested an association between trunk muscle strength and osteoporotic vertebral fractures. However, it has remained unclear the relationship between trunk muscle mass measured by dual-energy X-ray absorptiometry (DXA) and vertebral fractures. The aim of this study was to investigate the association between muscle mass and incidence of fresh vertebral fractures in patients with postmenopausal osteoporosis.

METHODS

A total of 197 patients with postmenopausal osteoporosis between the ages of 65 and 84 were included in this study. They were divided into two groups based on the presence of fresh vertebral fracture during the follow-up period: annual year from the day of muscle mass measurement by DXA. We compared trunk muscle mass, lower limb muscle mass, and skeletal muscle index (SMI) between fracture group and non-fracture group. Trunk muscle mass and lower limb muscle mass were defined as the respective lean mass values measured by DXA, and they were normalized by body mass index (BMI). SMI was calculated by dividing the upper and lower limbs skeletal muscle mass by the square of the height, and the value was obtained by DXA. Additionally, lumbar bone mineral density also examined.

RESULTS

27 patients were in fracture group and 170 patients were in non-fracture group, trunk muscle mass (g/BMI) was 727.5 and 748.1 ($p = 0.25$), and lower limb muscle mass (g/BMI) was 408.8 and 442.1 ($p = 0.02$), with a significant difference in lower limb muscle mass. SMI was 5.79 in the fracture group and 5.68 in the non-fracture group ($p = 0.44$). Lumbar bone mineral density was 0.76 g/cm^2 in the fracture group and 0.87 g/cm^2 in the non-fracture group ($p<0.01$). There was no correlation between lower limb mass and lumber bone mineral density（r=-0.11）

DISCUSSION

Our retrospective review of 197 cases demonstrated that lower limb muscle mass, not trunk muscle mass was associated with fresh vertebral fractures. Although we did not examine the mechanism of injury, Ease of fall following to loss of lower limb muscle mass might be one of the risk factors of vertebral fractures. SMI: the value required for diagnostic criteria of sarcopenia, was not associated with vertebral fractures; it may not be effective in assessing accurate muscle mass loss. The current study showed that lower limb muscle mass is an important factor in indicating vertebral fracture risk, as lumbar bone mineral density.

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Healing rates following rigid lumbo-sacral immobilisation in athletic adolescent pars bone stress injury

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INTRODUCTION:

Adolescent sporting activity predisposes to lumbar bone stress injury of the vertebral pars interarticularis or pedicle (pars bone stress injury) and is the primary cause of significant adolescent low back pain. These injuries are at relatively high risk of non-union and potential progression to isthmic spondylolisthesis. Rigid bracing has been proposed as a treatment method for acute lesions. Bracing not only relieves pain, but increases the likelihood of bony healing, thereby reducing the risk of delayed bony union or non-union and progression to isthmic spondylolisthesis. The objective of this study was to evaluate bony healing rates after twelve weeks of rigid lumbo-sacral orthosis in individuals with pars bone stress injury.

METHODS:

We performed a retrospective analysis of 46 male and female athletes (age mean +/- SD) with acute pars bone stress injuries (as defined by a bone marrow oedema ratio > 2) who wore a lumbosacral orthosis for twelve weeks. All participants underwent a Magnetic Resonance Imaging (MRI) scan for both the symptomatic pars and the contralateral pars at the same level. Participants underwent the MRI scan prior to immobilisation (baseline), 6-weeks and 12-weeks after the commencement of bracing. The main outcomes evaluated were fracture grade (stress reaction/incomplete fracture/complete fracture) and healing outcome on 6-week and 12-week scans (unchanged/ progressed/ healed).

RESULTS:

The presence of a chronic ("cold") contralateral pars stress fracture influenced outcome. (Table 1). The majority of patients presented with a unilateral incomplete fracture (n=18). All of these patients achieved complete healing. In contrast, those with bilateral complete fractures (n=10) showed no healing. A combination of complete and incomplete lesions showed mixed results.

DISCUSSION:

Early detection and immobilisation optimises healing in individuals with unilateral pars bone stress injury. This study raises questions as to the role of bracing for acute pars injury if a contralateral chronic lesion is present. A larger study is currently in progress to explore the influence of contralateral pars bone stress injury on bony healing.

		Outcome (Fracture Healing)			
		Unchanged	Progression	Healed	Total
Unilateral Incomplete Fracture	Count	0	0	18	18
	%	0%	0%	100%	100%
Incomplete Fracture with Incomplete Contralateral Fracture	Count	4	2	7	13
	%	30.8%	15.4%	53.8%	100%
Incomplete Fracture with Complete Contralateral Fracture	Count	0	3	0	3
	%	0%	100%	0%	100%
Complete Fracture with Incomplete Contralateral Fracture	Count	0	0	3	3
	%	0%	0%	100%	100%
Bilateral Complete Fractures	Count	10	0	0	10
	%	100%	0%	0%	100%
Total	Count	14	5	28	47%
	%	29.8%	10.6%	59.6%	100%

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Reduced Incidence of Lumbar Surgery for Low Back Pain after Enhanced MDT Intervention

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Introduction: Low back pain is a leading cause of disability world-wide[1,3]. It is the most common reason for medical consultation in the United States[2,3], yet the determination of specific causes for the majority of presentations remains elusive to most physicians. No one single treatment approach has proven superior[3] which offers the opportunity for the choices that physicians and their patients make to be arbitrary, ineffective, or even detrimental to continued good health. The purpose of this study was to examine the impact of enhanced Mechanical Diagnosis in Therapy(MDT), a highly standardized assessment and care approach, on the rate of surgery for low back pain in a specific population.

Methods: This study is a retrospective claims analysis. The study used claims data from January 01 2019 to December 31 2020. Patients were included if they were diagnosed with low back pain before undergoing lumbar surgery. The patients were then categorized based on their involvement with an MDT based physical therapy program. Claims data from the date of an initial low back pain diagnosis through one year from the initial diagnosis were included in the analysis. If a surgical procedure took place before then end of the year the episode was considered complete. The number of patients that escalated to surgery were identified and group comparisons were made, after adjusting for demographic differences as well as comorbidity risk, duration of care, and frequency of visits. P-values for categorical variables were calculated using Chi-squared test. A p-value < .05 was considered significant.

Results: 1,678 patients were included in the analysis. There were 749 patients in the MDT intervention group with an average age of 44 years and 59% of the patients were male. There were 929 patients who were not part of the MDT intervention group with an average age of 43 and 51% were male. Nineteen patients (2.5%) from the MDT group had lumbar surgery compared to seventy-seven patients (8.3%) in the non-MDT group.

Conclusion: The result of our analysis shows that an enhanced MDT intervention in patients diagnosed with lower back pain reduces the patient's risk of escalating to surgery. Consistent with conservative care guidelines the results of this paper suggest that enhanced MDT based physical therapy reduces the rate of surgery in patients diagnosed with low back pain.

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The Effects of Osteopathic Manipulative Treatment on Pain and Disability in Patients with Chronic Low Back Pain: A Single-Blinded Randomized Controlled Trial

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INTRODUCTION

Several clinical guidelines for the management of patients with chronic low back pain (LBP) include recommendation of spinal manipulative treatment [1] among other interventions. One such intervention is osteopathic manipulative treatment (OMT) that incorporates a number of manual techniques that are delivered by osteopathic physicians. In general, however, the evidence for the efficacy of manipulative treatments as stand-alone interventions is considered weak, [2] and more studies are necessary [3]. Therefore, the purpose of this study was to evaluate the efficacy of OMT in reducing pain and disability in patients with chronic LBP using a randomized controlled trial (RCT) experimental design.

METHODS

A single-blinded cross-over RCT was conducted at a single university-based outpatient clinic. Participants were adults, 21 to 65 years old, with nonspecific LBP. Eligible participants (n=80) were randomized to two treatment arms: an immediate treatment group (OMT group) and a delayed treatment group (control group). The intervention consisted of 3-4 OMT sessions over 4-6 weeks, after which the participants switched groups. The primary clinical outcomes were average pain, current pain measured on a 11-point numerical rating scale, PROMIS-29 v1.0 pain interference and physical function, and modified Oswestry Disability Index. The secondary outcomes included Fear Avoidance and PROMIS-29 fatigue, sleep disturbance, depression, anxiety, and satisfaction with participation in social roles. These measures were taken at baseline (T_0), after one OMT session (T_1), cross-over point (T_2), and after cross-over time-point (T_3). Because of the carryover effects of OMT intervention, only the outcomes obtained at T_2 (prior to cross-over allocation) were evaluated using general linear models and after adjusting for baseline values.

RESULTS

A total of 30 and 31 participants with chronic LBP were available for the analysis at T_2 in the OMT and control groups, respectively. There was no significant reduction in the primary outcomes of pain and disability immediately after one session of OMT (T1). However, a significant reduction in average pain was achieved after the entire intervention period (T_2) with a mean between-group difference of 1.3 points (95% CI: [-2.23, -0.43]; p=0.004). The effect size was 0.8 standard deviation, rendering the reduction in pain post-intervention clinically meaningful [4]. An immediate significant reduction in sleep disturbance and anxiety was seen after one session of OMT (T_1) in the OMT group compared to the control group ($p<0.001$), with anxiety reduction sustained at T_2 ($p=0.03$). No study-related serious adverse events were reported.

DISCUSSION

The results indicate that OMT intervention is safe and effective in reducing pain and anxiety in patients with chronic LBP following 4-6 weeks of treatment. The improvement in anxiety occurred immediately after one OMT session, while the significant reduction in average pain took longer, 3-4 sessions. This is consistent with findings that early-treatment reductions in catastrophizing and pain-related anxiety predict late-treatment improvements in pain severity [5]. Based on the demonstrated efficacy and reported cost savings data [6], OMT could be recommended as a treatment option in the management of patients with chronic LBP.

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Short-term outcomes of biopsychosocial rehabilitation following spine surgery

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INTRODUCTION:

Pre-operative anxiety, depression and kinesiophobia are associated with poorer post-operative recovery. Previous research has related mood disorders and kinesiophobia with increased disability, pain and reduced functional capacity in patients undergoing spine surgery. Current rehabilitation practices concentrate on physical recovery, neglecting to consider the dynamic interaction between biological, psychological and socio-environmental factors. Thus, the purpose of this study is to determine the short-term efficacy of biopsychosocial rehabilitation, compared to physiotherapy alone, in spinal fusion and laminectomy patients with symptoms of anxiety, depression and kinesiophobia pre-operatively.

METHODS:

A randomized controlled trial was conducted in 44 adults aged 33 to 79 years (55.9±12.3y) undergoing spinal fusion or laminectomy surgery, and with heightened anxiety (62.8%), depression (46.5%) or kinesiophobia (87.9%) pre-operatively. Experimental intervention group one (CBPT) received a behaviour change intervention (weekly, for the first six weeks after surgery), consisting of cognitive-behavioural strategies in addition to the standard physiotherapy regime (n= 14). Intervention group two (CC) received a care coordination intervention (weekly, for the first six weeks after surgery) in addition to the standard physiotherapy regime (n= 15). The control group (CON) received a physiotherapy intervention as part of standard post-operative spine care (n= 14). This is the first RCT to compare a structured cognitive-behavioural intervention aimed at reducing underlying unhelpful thought patterns and promoting a return to activity, against a social intervention intended to reduce participant solitude and doubt within the acute post-operative phase through discussion and reassurance about recovery. Baseline (pre-op) and 6-weeks following surgery, all participants completed the Oswestry Disability Index (ODI, primary outcome), Visual Analogue Scale (VAS, primary outcome), 30-Sit to Stand (30-STS) and Timed Up-and-Go (TUG).

RESULTS:

Short-term (6-week) outcomes indicate there were no significant changes in ODI and VAS scores between groups, and at selected time points (all p>0.05). Similarly, no significant changes were seen in functional outcomes between any of the three groups (all p>0.05).

DISCUSSION:

Prior studies have suggested anxiety, depression and kinesiophobia hinder post-operative recovery. This study anticipated poorer outcomes in this population and consequently, included patients' contingent on their pre-operative anxiety, depression or kinesiophobia score. This stratification of patients has failed to generate any statistical significance differences at short-term follow-up and questions the role of biopsychosocial interventions in the acute post-operative period. Data collection is ongoing to achieve a larger sample size (n=117) and follow-up is currently underway to understand the longer-term role of biopsychosocial interventions in at-risk populations.

	Mean change from baseline			
	CBPT Mean (SD)	**CC Mean (SD)**	**CON Mean (SD)**	**P value**
ODI Baseline to 6-weeks post-op	-33.9 ± 14.7	-32.3 ± 18.7	-32.2 ± 22.6	>0.05
VAS: back and neck pain Baseline to 6-weeks post-op	-4.3 ± 3.3	-4.3 ± 2.9	-3.7 ± 2.9	>0.05
VAS: leg and arm pain Baseline to 6-weeks post-op	-5.2 ± 2.9	-6.1 ± 2.4	-5.3 ± 2.8	>0.05
30-STS Baseline to 6-weeks post-op	2.5 ± 5	3.1 ± 2.6	1.4 ± 3.9	>0.05
TUG Baseline to 6-weeks post-op	-2.7 ± 3.2	-1.6 ± 4.7	-2.3 ± 3.4	>0.05

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Continuous local antibiotics perfusion (CLAP) for deep surgical site infection of Cutibaterium Acne after spinal instrumentation surgery

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INTRODUCTION

Cutibacterium acne (C. Acne) is known as a gram-positive anaerobic resident skin bacteria. It is also known as a pathogen of surgical site infection(SSI). Biofilm formation by C. Acne generally leads to intractable infections, and it has been reported that preservation of instruments is usually difficult. We report two cases of C.Acne infection after spinal instrumentation treated with continuous local antibiotics perfusion (CLAP). In one case, spinal instrumentation was preserved.

CASE PRESENTATION

Case 1: 84-year-old male, who underwent C7-T3 posterior fixation was diagnosed as deep SSI, 4 months after primary surgery. C. Acne was detected as a pathogen, and CLAP was installed after surgical irrigation and debridement and implant removal. CLAP was used for 14 days. Wound dehiscence occurred 6 days after CLAP removal, CLAP was reinstalled after second surgical irrigation and debridement .Patient discharged after 14 days of CLAP and 6 weeks of intravenous vancomycin administration. There is no recurrence after 1 year.

Case2: 68-year-old male, who underwent C2-T3 posterior decompression fusion for myelopathy due to cervical ossification of longitudinal ligament had fever and swelling of the wound 4 weeks after surgery. He was diagnosed as having deep SSI and CLAP was installed after surgical irrigation and debridement. C.Acne was detected from samples obtained during debridement. CLAP was used for 10 days, and 6 weeks of intravenous Teicoplanin (TEIC) and Ceftriaxone (CTRX) were administered. There is no recurrence after 10 months.

DISCUSSION

CLAP has been introduced recently and has been used for intratable SSI, mainly trauma cases in orthopaedics. Local administration/perfusion of high concentration Gentamicin (GM) is considered effective to eradicate biofilms around implants. CLAP enables continuous appropriate local antibiotic concentration without systemic side effects of antibiotics by continuously draining them by negative pressure wound therapy (NPWT) system. Previous studies have shown difficulties in C. Acne infection after surgery with implants, especially in preserving implants due to its biofilm formation. In our cases, C. Acne infections were successfully controlled by CLAP, and implants were preserved in one case.

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Flash Align – A pilot study of an innovative method to measure spine alignment using machine-vision optical technology

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Introduction: Within the field of spinal fusion surgery, it is recognized that sub-optimal spinal alignment can accelerate degeneration of the spine, change of shape of the spine over time, and may increase the likelihood of revision surgery for the patient.

The current standard of care to assess intraoperative spinal alignment is to either visually inspect the anatomy or use fluoroscopic imaging. There is currently no intraoperative solution that enables surgeons to precisely visualize changes in alignment without the use of potentially harmful ionizing radiation.

A novel real-time information software called Flash™ Align has been developed using machine-vision technology in conjunction with a registration algorithm requiring only visible light that matches the patient's 3D intraoperative position with a preoperative CT scan to quantify intraoperative spinal alignment without radiation in the operating room.

Methods: The results presented have been obtained via a single arm, single-center pilot study to test the Flash Align Software for the quantification of spinal alignment during posterior spine surgery. Three three-dimensional (3D) images were taken intraoperatively using the FLASH Navigation System, at three time points: (A) after patient positioning, (B) after decompression and interbody placement, and (C) after final positioning of the screws and interconnecting rods. These images were postoperatively analyzed using the Flash Align software where endplates were defined in 3D, a registration was simulated, and spinal parameters were calculated. The spinal alignment measurements from the Flash Align Software were compared to those of the participant's intraoperative fluoroscopy images at the same three time points. Flash Align measurements from time (C) were also compared to a postoperative CT scan.

Results: In total, 16 patients were included in this study, however it was not possible to analyze all patients at each time point with all imaging modalities. The difference between the mean intraoperative sagittal Cobb angle using Flash Align and the fluoroscopy image at time (A) was 4.2 degrees (N=15, p=0.93); time (B) was 5.3 degrees (N=10, p=0.24); and time (C) was 5.2 degrees (N=10, p=0.33).

A total of 10 patients were analyzed at time (C) comparing the calculated angle from Flash Align and the measured angle based on the postoperative CT scan. Four comparative measures were taken with absolute differences of; 1.7 degrees (p=0.80) in the sagittal Cobb angle, 2.2 degrees (p=0.38) in the coronal Cobb angle, 2.2 mm (p<0.5) in the coronal shift and 2.0 degrees (p=0.80) in the relative rotation.

Discussion: When comparing the sagittal and coronal Cobb angles calculated by Flash Align to those of fluoroscopic and CT imaging, the angles calculated using CT imaging modality presented a smaller mean difference. Two-dimensional fluoroscopic images lack critical information especially considering spinal deformity is characterized as a three-dimensional problem defined by sagittal and coronal alignment as well as axial rotation. By analyzing the spine in three dimensions, the endplate definition technique as employed in Flash Align is analogous to a standard post-operative CT scan analysis. Flash Align also enables a user to re-define the sagittal plane using anatomical landmarks such as aligning the femoral heads.

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SPAM: Subacute post-traumatic ascending myelopathy is a rare but devastating disorder - What do we know?

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Introduction:

Subacute post-traumatic ascending myelopathy (SPAM) is a rare, potentially fatal disorder characterized by progressive neurological deterioration in a surgically stabilized, post-traumatic spine. The deficit cannot be attributable to ongoing mechanical instability, syrinx formation or iatrogenic causes. To report the incidence and potential treatments of SPAM we performed a systematic review.

Methods:

The systematic search for medical literature on SPAM following the PRISMA guidelines was performed on Medline, Ovid, Cochrane, Embase and PubMed databases between 1969 and August 2021. The search term was (ascending myelopathy) and all articles reporting SPAM in English were included. Of the 904 abstracts identified for this search term, 18 articles were included for final analysis. Cases were reviewed and the findings summarized.

Results:

Within the 18 articles, a total of 39 cases were reported. It is estimated to occur in 0.4-0.7% of spinal cord injuries. The mortality rate is up to10% primarily due to respiratory compromise. It effects predominately male patients (71.9%) in the age group between 21 and 30 years (n=15/39; 38.9%). The latent period prior to onset ranges from 1 day to almost 3 months with the mean between 1 and 2 weeks. It can cause either partial or complete motor and/or sensory deficits. Patients typically describe pain or sensory changes above the level of the traumatic spinal cord injury. Pyrexia was described by five authors with no underlying cause found. The typical MRI changes seen in SPAM is a central region of T2 weighted hyper intensity, with generalized cord expansion and occasionally cord surrounding lesions, most commonly proximal to the original injury. Fortunately, in long term there is potential for improvement in the neurological impairment.

Conclusion:

This systematic review shows that the incidence rate of SPAM is low but the mortality rate is high; up to 10%. There is no efficient way to predict the onset and there is no effective treatment of this condition. However, there is some evidence that monitoring CSF pressures following spinal cord injury this may help confirm the aetiology and suggest therapies such as drains or expansion duraplasty to reduce spinal cord pressures.

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Long term results of povidone-iodine irrigation for prevention Surgical Site Infection following spinal instrumentation

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Introduction

Surgical site infections (SSI) following instrumented fixation of the spine pose major problem to the spinal surgeon. In particular, deep SSI after spinal instrumentation were refractory to control infection, while were often required removal of instrumentation. We attempted to reduce SSI following spinal instumentation, using the povidone-iodine irrigation protocol. The aim of this study was to evaluate the long-term results of this protocol for preventing SSI following instrumented stabilization of the spine.

Methods

All cases of spinal instrumentation at our institution between October 2011 and September 2019were retrospectively reviewed. The patients were subdivided into those who had received saline irrigation after 90 seconds of 1% povidone-iodine pooling and normal saline irrigation every 1.5 hours (study group) and only routine saline irrigation every 1.5 hours (control group). The study and control groups comprised 289 and 247 patients, respectively. This study compared the rate of SSI with and without the use of povidone-iodine irrigation protocol.

Results

SSI rates were 1.03% of the study group (3 for 289 patients) and 2.47% of the control group (6 for 247 patients). SSI rates were decreased, although statistically significant different ($p=0.948$). Deep SSI occurred 0 cases in study group and in 3 cases in the control group. Deep SSI rates were significantly reduced in study group ($p=0.046$). No adverse events of were occurred in study group and there was no incidence of MRSA infection in study group.

Conclusion

In this small preliminary study, our findings underscored the clinical benefits of our treatment strategy using the povidone-iodine irrigation protocol. Deep SSI were significantly reduced and there was no MRSA infection in this study. This method can be a simple and safe SSI prevention method.

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Analysis of Risk Factors Associated with Proximal Junctional Kyphosis Following Long Instrumented Fusion from L1 to Sacrum

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Introduction: There have been consistently opposing reports regarding selection of uppermost instrumented vertebra (UIV) at thoracolumbar junction in long spinal fusion. However, some recent literatures claimed thoracolumbar junction could be considered selectively as UIV for long spinal fusion without certain potential risk factors. There have been a paucity of study investigating the risk factors associated with proximal junctional kyphosis (PJK) following long instrumented spinal fusion from L1 to the sacrum. Therefore, we aimed to investigate the incidence and risk factors of PJK following spinal instrumented fusion from L1 to sacrum in patients with mild to moderate sagittal imbalance.

Methods: This retrospective study recruited consecutive patients undergone instrumented fusion from L1 to the sacrum for degenerative lumbar disease between June 2006 and November 2019 in single institution. Inclusion criteria were as follows: 1) etiology of spinal stenosis, spondylolisthesis, or adjacent segment disease following previous spinal fusion; 2) completion of a long-segment spinal instrumented fusion surgery from L1 vertebra to the sacrum; 3) with a minimum follow-up period of 2 years. Exclusion criteria were as follows: 1) C7 sagittal vertical axis (SVA) more than 15cm; 2) history of pedicle subtraction osteotomy or other equivalent procedures; 3) early postoperative (within 1 year) complications requiring revision for index surgery. The patients' preoperative clinical data, muscle status at T12-L1 on magnetic resonance images, and sagittal spinopelvic parameters on radiographs at preoperative, immediate postoperative, regular postoperative visits were collected and analyzed. PJK was defined if postoperative proximal junctional angle (made by T11 upper endplate and L1 lower endplate) was >20 degrees or increased more than 10 degrees compared to the baseline. Univariate analysis was used to compare clinical and radiographic data between PJK and non-PJK patients. Logistic regression analysis was used to investigate the independent risk factors for PJK.

Results: A total of 41 patients were included as study cohort. The mean age at surgery was 67.3 years and mean follow-up period was 37.3 months. Seven were male and 34 were female. PJK developed in 17 (41.5%) out of 41; of these patients, 15 (88.2%) developed PJK within postoperative 1 year and 5 (29.4%) of them were diagnosed with proximal junctional failure. On univariate analysis between PJK and non-PJK patients, PJK group showed more frequent osteoporosis, lower body mass index, smaller cross-sectional area (CSA) and more fat infiltration (FI) in erector spinae muscle at T12-L1, larger preoperative TLK and PT with statistical significance ($p<0.05$). On logistic regression analysis, severe (>50%) FI in erector spinae muscle (OR=43.60, CI 4.10-463.06, R^2_N =0.730, p=0.002) and osteoporosis (OR=20.49, CI 1.58-264.99, R^2_N =0.730, p=0.021) were identified as significant risk factors for PJK.

Discussion: In a review of minimum 2 years, most (88.2%) of PJK developed within postoperative 1 year. Preexisting severe (>50%) fat infiltration in erector spinae muscle and osteoporosis were significant independent risk factors associated with PJK following instrumented fusion from L1 to the sacrum.

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Importance of early diagnosis and intervention with balloon kyphoplasty of thoraco-lumbar osteoporotic vertebral body fractures

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Introduction

As the population ages, the number of osteoporotic vertebral fractures (OVF) is increasing. Delayed union, non-union, pseudoarthrosis could be occurred when the diagnosis for VCFs delays or its treatment did not work. The effects of early diagnosis of OVF and its treatment by balloon kyphoplasty (BKP) were examined.

Methods

A total of 118 patients who were diagnosed with OVF and underwent BKP were analyzed. After their OVF diagnosis was confirmed, patients were placed in a brace and hospitalized for BKP. Numerical rating scale (NRS) at 3 months post-BKP, radiological subsequent fracture (SF) at adjacent level, painful SF at adjacent level, correction angle and correction loss were used as the objective variables for Fisher's exact test. The time taken to confirm the diagnosis (within 7 days; early diagnosis group vs. after 7 days of injury; late diagnosis group) and the timing of BKP (within 28 days; early BKP group vs. after 28 days of OVF diagnosis; late BKP group) were used as explanatory variables, respectively, and a multivariate logistic regression analysis of the objective variables was performed after adjusting for sex, age, bone material density, and affected vertebrae level.

Results

The study participants comprised 26 men and 92 women with a mean age of 80.8 years. Patients who had their diagnosis of OVF confirmed in early diagnosis group had significantly lower NRS scores at 3 months than those who had their diagnosis confirmed in late diagnosis group (0.62 vs. 1.46, $p < 0.05$). Likewise, radiological SF was also significantly lower in those who had their diagnosis of OVF confirmed in early diagnosis group as opposed to those who had their diagnosis confirmed in late diagnosis group (11.8% vs. 34.0%, $p < 0.005$). The percentage of radiological SF at 3 months was significantly lower in early BKP group than in late BKP group. (12.5% vs. 39.5%, $p < 0.005$). Furthermore, although not significant in the early diagnosis group and the late diagnosis group, the correction angle was larger in the late diagnosis group (6.0 ° vs 6.6 °, $p = 0.57$). On the other hand, the late BKP group had a significantly larger correction angle than the early BKP group (5.4 ° vs 8.0 °, $p <0.05$). In multivariate analysis, radiological SF was significantly higher in those who had their OVF diagnosis confirmed in late diagnosis group (odds ratio, 3.4; 95% CI, 1.06–10.9; $p < 0.05$). Furthermore, radiological SF was also significantly higher in late BKP group (odds ratio, 3.9; 95% CI, 1.2–12.8; $p < 0.05$).

Discussion

Our results revealed that radiological SF significantly increased in patients who had their diagnosis of OVF confirmed after 7 days of injury and in those who underwent BKP after 28 days of OVF diagnosis.

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Postoperative physical therapy program focused on low back pain can improve treatment satisfaction after minimally invasive lumbar decompression

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Object:
Currently, patient satisfaction ratings play a critical role in pay-for-performance initiatives. To achieve further improvement in satisfaction, modifiable factors should be identified according to the type of surgery. This study aimed to compare the overall treatment satisfaction after microendoscopic lumbar decompression between the patients treated with a postoperative physical therapy (PT) program focused on low back pain (LBP) improvement and those treated with a conventional physical therapy program.

Methods:
This is a prospective cohort study including 200 consecutive patients who undergoing microendoscopic lumbar decompression for disc herniation or spinal stenosis. Initially, 100 consecutive patients were enrolled into the control cohort, and were treated with a conventional physical therapy (PT) program postoperatively. Subsequently, 100 consecutive patients undergoing surgery under the same indications as the control cohort were enrolled into the test cohort, and were treated with a PT program focused on LBP improvement. Both PT programs included 40-min outpatient sessions, once per week for 3 months postoperatively. Background factors, clinical scores, and treatment satisfaction at three months postoperatively were compared between the groups. The primary outcome was set as overall treatment satisfaction at 3 months postoperatively. Secondly outcomes were set as patient characteristics (age at surgery, sex, height, weight, body mass index, comorbidities, surgical levels and diagnosis), Japanese Orthopaedic Association score, Oswestry Disability Index, EuroQoL-5 dimensions 5 levels.

Results:
Adequate compliance was achieved in 92 and 84 patients in the control and test cohorts, respectively. There were no significant differences in background factors; however, the postoperative patient-reported pain score was significantly better, and the treatment satisfaction was significantly higher, in the test cohort than in the control cohort (p=0.029 and 0.045, respectively). On multivariate logistic regression analysis, patients treated with the LBP program tended to be more satisfied than those treated with the conventional program, independent of age, sex, and diagnosis (adjusted odds ratio=2.34, p=0.012).

Conclusions
Patients treated with a physical therapy focused on LBP improvement showed significantly better pain scores and higher overall satisfaction than those treated with a conventional physical therapy program at three months postoperatively. Current results suggest options for postoperative management that could reduce pain more effectively and achieve higher overall satisfaction after minimally invasive lumbar decompression without additional pharmacological therapy including perioperative opioid. These results could guide spine surgeons in achieving higher short-term satisfaction after minimally invasive lumbar decompression.

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Polyethylene tapes at the proximal end of fusion reduce the revision rate related with Proximal Junctional Kyphosis in long spinal fusions.

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INTRODUCTION: Recently, long spinal fusions for adult spinal deformity (ASD) have been markedly increasing in the aging society. However, they have high complication rate because the patients often have severe osteoporosis and other medical problems. Therefore, revision surgery due to proximal junctional kyphosis (PJK) is a big problem in the populations. Because PJK is multifactorial, the preventive measures against PJK and consequent revision surgery have not been established. The purpose of this study was to elucidate the preventive effects of different proximal end fixation methods, hooks and polyethylene tapes, on PJK as well as revision surgeries.

METHODS: Eighty-three adult patients with spinal deformity who underwent corrective long spinal fusion with S2AI screws as distal anchors and followed up at least for 12 months were enrolled. As the proximal end of fusion constructs, hooks (group H) or polyethylene tapes (group T) were used. The PJK was defined as the progression of kyphosis over 10 degrees at the proximal end of fusion. In addition, revision surgery due to PJK was defined as proximal junctional failure (PJF). We evaluated age, gender, operation time, estimated blood loss, presence or absence of severe osteoporosis, pre- and postoperative sagittal parameters (TK, LL, SS, and PI), sagittal vertical axis (SVA), and the incidence of PJK and PJF in the two groups.

RESULTS: Twenty patients were involved in group H (age, 72.3 years) and 63 in group T (age, 74.4 years). Mean operation time was 452 minutes and 440 minutes, respectively. Mean estimated blood loss was 1151 ml and 1197 ml, respectively. There were 7 patients with severe osteoporosis in group H and 27 patients in group T. There was no significant difference in age, gender, operation time, estimated blood loss, presence or absence of severe osteoporosis, and pre- and postoperative sagittal parameters between the two groups. Group H had 11 PJK (55.0%), while group T had 15 (23.8%), indicating that PJK was significantly prevented in group T (P=0.013). Moreover, group H had 8 PJF (40.0%) and group T had 7 (11.1%), indicating that PJF was also significantly prevented in group T (P=0.007). No clinical problems related to S2AI screws were found, regardless of the presence or absence of screw loosening.

DISCUSSION: It was suggested that PJK and PJF were suppressed by using polyethylene tapes at the proximal end of fusion constructs and the S2AI screw would be a reliable distal anchor with minimal clinical problems.

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Risk factor analysis of surgical site infections after spinal surgery: a single-center prospective surveillance study

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INTRODUCTION

Surgical site infection (SSI) is one of the most serious complications after spinal surgery. It is associated with high morbidity rates, high healthcare costs, and poor patient outcomes. Accurate identification of risk factors is essential in developing strategies to prevent devastating infections. This study aimed to identify independent risk factors for SSI following spinal surgery, using a prospective single-centered surveillance study method in analyzing preoperative patient and operative variables.

METHODS

We performed a prospective surveillance study of patients who developed SSI after undergoing spinal surgery at our hospital from July 2010 to June 2020. Only patients who underwent orthopedic spinal surgery were included in the study. Preoperative and operative patient characteristics were prospectively recorded using a standardized data collection format. The definition of SSI, as established by the Centers for Disease Control and Prevention, was followed. Patients who underwent surgery for the treatment of spinal infections were excluded from the analysis. Moreover, patients who underwent posterior instrumentation removal, percutaneous vertebroplasty, and endoscopic surgery, were also excluded. The recorded preoperative patient characteristics included age at the time of surgery, sex, height, weight, and surgical pathology (spinal trauma, spinal degenerative diseases, tumor or cancer, or spinal deformity). Preoperative patient-related risk factors for SSI included smoking status, diabetes mellitus, body mass index, American Society of Anesthesiologists score, hemodialysis, rheumatoid arthritis, previous spinal surgery, and preoperative steroid intake. In addition, surgery-related factors, considered as possible risk factors for SSI, were collected and analyzed. These included duration of operation, estimated blood loss, anatomic location (cervical, thoracic, and/or lumbosacral), emergency surgery, use of posterior instrumentation, intraoperative dural tear, and use of intraoperative fluoroscopy.

RESULTS

A total of 1578 patients who underwent spinal surgeries were enrolled, of which 28 (1.8%) developed postoperative SSIs. Multivariate regression analysis indicated three independent risk factors. Male sex ($P = 0.023$, odds ratio [OR] = 2.93, 95% confidence interval [CI] 1.16–7.46) was a statistically significant independent patient-related risk factor. The use of posterior instrumentation ($P = 0.004$, OR = 3.37, 95% CI 1.48–7.70) and use of intraoperative fluoroscopy ($P < 0.001$, OR = 6.75, 95% CI 2.32–19.67) were surgery-related independent risk factors. Microbiologic cultures were routinely taken in all 28 patients who developed SSI, and 85.7% (24/28) of the patients had wound infections associated with gram-positive organisms.

DISCUSSION

The male sex, use of posterior instrumentation, and use of intraoperative fluoroscopy, were shown to be independent risk factors for SSI after spinal surgery. Identification of these risk factors may be used to develop protocols aimed at decreasing the risk of SSIs. To the best of our knowledge, this is the first study to identify the use of intraoperative fluoroscopy as an independent risk factor for SSI after spinal surgery, using a prospective surveillance research method. Awareness of these risk factors can improve clinicians' risk perception in patients undergoing spinal surgery and may provide better patient counseling.

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Lumbar interbody fusion augmented with a novel bioactive glass bone graft substitute: safety and fusion outcomes from a retrospective cohort study

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Introduction: Lumbar interbody fusion (LIF) may treat a range of degenerative lumbar pathologies, including degenerative disc disease (DDD), spondylolisthesis, and spondylosis. Selecting the ideal bone graft material is important to optimize graft incorporation and promote efficacy and safe use. Bioactive glass (45S5) is a unique, synthetic, ceramic bone graft substitute that is known to form hydroxyapatite (HA) on its surface within 24 hours when exposed to aqueous solution. The purpose of this study was to evaluate the fusion and safety outcomes of a bioactive glass bone graft substitute in lumbar interbody fusion (LIF) procedures performed by a single surgeon.

Methods: The study included a retrospective cohort with prospective data collection, performed under an IRB-approved protocol. Patients undergoing surgery for non-degenerative pathologies were excluded. The full safety cohort consisted of a consecutive series of patients who underwent LIF between April 2017 and April 2018. A combination of bioactive bone graft (FIBERGRAFT® BG Putty) and autograft was used at each LIF level. The full safety cohort consisted of 66 patients (58% female, average age 65.2 years) diagnosed with DDD (57.5%), stenosis (69.7%), degenerative scoliosis (30.3%), and/or spondylolisthesis (43.9%). Eight patients declined prospective study participation and 4 were not eligible due to revision LIF surgeries, resulting in CT fusion assessment in 54 subjects. CT scans were done at a minimum of 8 months postop. De-identified images were evaluated independently by the principal investigator to determine fusion status at each level using the grading method of Brantigan and Steffee as modified with the Fraser definition of locked pseudoarthrosis (BSF scale)[1-3]. CTs were also inspected for subsidence and cage migration, expulsion, or damage. Patient demographics and perioperative variables were summarized with descriptive statistics. Incidence of LIF revision and other adverse events as well as the overall fusion rate were computed. Continuous variables were analyzed by Student's t-test, and categorical variables were analyzed by Fisher's exact test, with $p < 0.05$ considered statistically significant.

Results: CT fusion assessment was done for 54 patients (87 levels) at 19.9±9.6 months after LIF surgery. Across all levels, the fused (BSF-3) rate was 89.7%; the rate of locked pseudoarthrosis (BSF-2) was 9.8%, and the rate of pseudoarthrosis (BSF-1) was 1.1%. Of the 33 levels performed by TLIF approach, 85.3% were BSF-3, 11.8% were BSF-2, and 2.9% were BSF-1. Similar rates were found for the ALIF approach, with 88.2% BSF-3 and 11.8% BSF-2. The LLIF levels had the highest rate of fusion with 95.7% BSF-3 and 4.3% BSF-2. Separately, 6 cases of cage subsidence were noted on CT. There was one instance of cage migration noted in the adverse event analysis, but no cases of expulsion or damage.

Discussion: The study results show an acceptable rate of fusion for all approaches and similar rates of AEs compared to other LIF studies[4]. It is reasonable to suggest that this bioactive bone graft augmented with autologous bone provides comparable fusion results and safety profile to previously published results.

1. Fogel et al. Spine J 8(4) 2008.
2. Brantigan et al. Spine 18(14) 1993.
3. Santos et al. Spine 28(10) 2003.
4. Lee et al. Clin Orthop Surg 3, 2011.

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Telemedicine in Spine Patients: Utilization and Satisfaction Remain High Even After COVID-19 Lockdown

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Introduction:

At the height of the coronavirus pandemic, remote spine care was heavily utilized out of necessity due to closure of in-person clinics and efforts at physical distancing. However, data on rates of telemedicine utilization and satisfaction after reopening of in-person clinical visits remain unknown.

Methods:

All patients who had an in-person or telemedicine visit in the Spine Surgery, Physiatry, or Pain Management departments at an urban tertiary specialty hospital from April, 1, 2020 – April, 15, 2021 were identified. Peak coronavirus pandemic period was defined as from April, 1, 2020 – May, 31, 2020 based on daily case volumes at the authors' institution location. Rates of overall telemedicine utilization as well as categorized by specialty and type (new patient versus follow-up) over time were delineated. Patient satisfaction with telemedicine, as assessed through a series of questionnaires, was also evaluated over time.

Results:

Overall, 60,368 patients who had an in-person or telemedicine visit in the Spine Surgery, Physiatry, or Pain Management departments during the study period were identified. Of these, 19,568 patients (32.4%) had a telemedicine visit. During the peak coronavirus pandemic period, rate of overall telemedicine utilization was greater than 90%. After the peak period, the rate of overall telemedicine utilization was at approximately 29% of all visits per month. With regards to patient satisfaction, the rate of top-box response to the question "How likely is it that you would recommend telehealth visits to friends" remained statistically similar throughout the study period ($p>0.05$ for both).

Conclusions:

The rate of telemedicine utilization in spine patients remains high, at approximately 1/3 of all visits, even after the peak coronavirus pandemic period. In addition, patient satisfaction with telemedicine remained consistent throughout the study period, regardless of pandemic restrictions on in-person visits.

Figure 1: Percentage of Telemedicine Visits

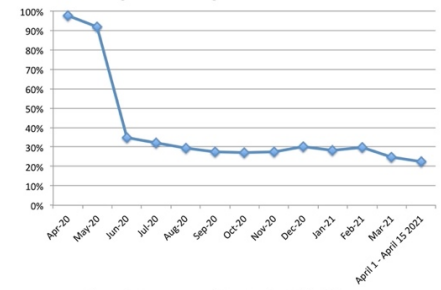


Figure 2: Percentage of Telemedicine Visits By Specialty

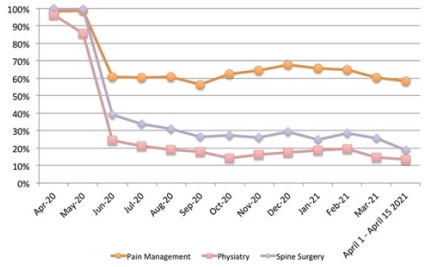


Figure 3: Percentage of New Patient Tele-visits

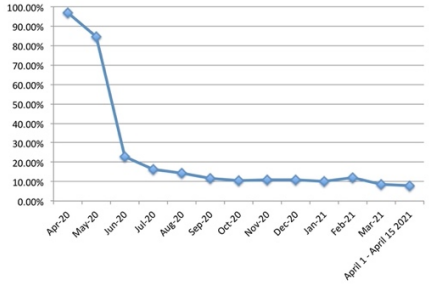


Figure 4: Percentage of Follow-up Tele-visits

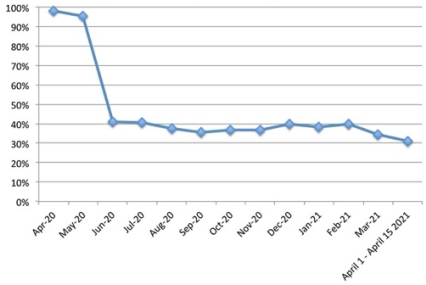


Figure 5: Percentage of Patients Who Prefer Telehealth Visit Compared to a Recent In-Person Visit

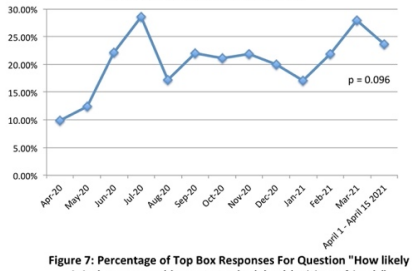


Figure 6: Percentage of Top Box Responses For Question "Did the telehealth visit address all of your questions and care concerns?"

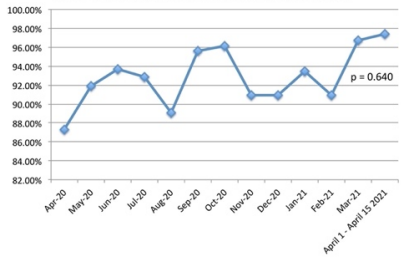
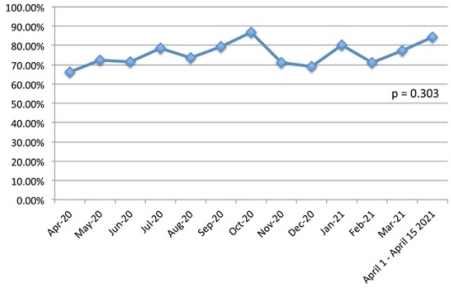


Figure 7: Percentage of Top Box Responses For Question "How likely is it that you would recommend telehealth visits to friends"



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Prediction of objective and subjective outcome measures two years after lumbar fusion surgery

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Introduction

The outcome of lumbar fusion surgery is traditionally measured with patient-reported outcome measures (PROMs) However, recent research indicates that PROMs are not sufficient to cover the outcome, and physical capacity tasks, e.g. timed up-and-go (TUG), have therefore been recommended. The aim was to investigate which factors that can predict the postoperative change of ODI and four physical capacity tasks in patients with chronic low back pain (LBP) and degenerative disc disease (DDD) two years after lumbar fusion surgery.

Method

A cohort of 118 patients with chronic LBP and DDD scheduled for lumbar fusion surgery were included. Dependent variables were the change from baseline to two years postoperatively of Oswestry Disability Index (ODI) and the physical capacity tasks TUG, five-minute walk, 15-meter fast walk, and one-minute stair climbing. Preoperative predictors were age, sex, income, body mass index, sick leave before surgery, smoking, duration of LBP, pain intensity in back and leg/legs (Visual Analog Scale), pain-related catastrophizing thoughts (Pain Catastrophizing Scale), fear of movement (Tampa Scale of Kinesiophobia), beliefs of self-efficacy (Self-Efficacy for Exercise Scale, SEESV), depressive symptoms (Hospital Anxiety and Depression Scale) and the preoperative results of ODI and the four physical capacity tasks. Stepwise multiple linear regression analysis was performed in separate models for each dependent variable.

Results

Baseline ODI and baseline TUG significantly predicted the change of ODI (R^2 = 0.333), meaning that a preoperatively higher score on ODI and longer time on TUG predicted a larger improvement two years postoperatively. In all four physical capacity tasks, the postoperative change from baseline was predicted by the baseline measure of the same physical capacity task (R^2 = 0.368–0.870), meaning that a worse performance preoperatively predicted a larger improvement postoperatively. A larger improvement in TUG and 15-meter fast walk was also predicted by a higher degree of self-efficacy. Finally, a larger improvement in 5-minute walk was predicted by more intense back pain at baseline.

Discussion

To our knowledge, this is the first time a physical capacity task has been shown to predict postoperative change in disability measured with ODI. The findings suggest that patients with worse preoperative results of ODI and physical capacity tasks have more to gain from lumbar fusion surgery than patients with a lower degree of disability and greater physical capacity. This could be an important aspect to consider in the patient selection for lumbar fusion surgery. Moreover, a low self-efficacy predicted smaller improvements in TUG and 15-meter fast walk, but if increasing patients´ self-efficacy before surgery leads to a better postoperative outcome is beyond the scope of this study. The fact that ODI and the physical capacity tasks were predicted by different variables could indicate that the measurements represent somewhat different constructs. Thus, using both objective and subjective outcome measures might be important when evaluating the outcome of lumbar fusion surgery to get a broader perspective of the patient's status.

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Clinical outcomes of short segment posterior lumbar interbody fusion in the elderly over 85 years of age

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Introduction: With increasing life expectancy and health expectancy, number of elderly patients requiring lumbar interbody fusion has continuously increased. However, when the patient was extremely elderly, surgeon tend to choose lumbar decompression surgery instead of lumbar fusion with instrumentation. One of the reasons is that postoperative outcomes of lumbar spine fusion for the extremely elderly remains unknown. The aim of this study was to evaluate the outcomes of lumbar interbody fusion in the elderly over 85 years of age.

Methods: Twenty-nine patients (8 males and 21 females) aged 85 years or older who underwent single or double PLIF/TLIF for lumbar degenerative disease at our hospital from 2012 to 2019 were retrospectively studied (minimum follow-up period of 2 years, follow-up rate: 81%). For each extremely elderly patient, 3 control patients whose age were from 60 years to 75 years were randomly selected using a random number table. Each control patient underwent a procedure of similar complexity, with the same gender and the same fusion levels in the same part of the spine, performed during the preceding or following year. Oswestry Disability Index (ODI), the visual analogue scale (VAS) scores for low back pain (LBP) and leg pain, and the recovery rate of Japanese Orthopaedic Association (JOA) score were assessed during the postoperative follow-up. The lumbar interbody fusion rate was evaluated by CT scanning, and perioperative complication was reviewed from the medical records.

Results: Preoperative JOA score was significantly lower in Extremely elderly group than in Control group (10.9 vs. 13.5, P = 0.02), whereas preoperative ODI was not significantly different between the two groups (29.1 vs. 28.0, P = 0.74). The means of the 2-year postoperative clinical score for the recovery rate of the JOA score (58.1% vs. 62.1%, P = 0.62), ODI (10.8 vs.9.3, P = 0.54), and VAS of leg pain (14.5/100 mm vs. 11.1/100 mm, P = 0.47) were not significantly different between Extremely elderly group and Control group (Figure 1). On the other hand, VAS of LBP was significantly lower in Extremely elderly group than in Control group (5.9/100 mm vs. 18.0/100 mm, P = 0.01). The fusion rate was 90% in Extremely elderly group and 94% in Control group (P = 0.44). In Extremely elderly group, there were 3 cases of delirium, one case of surgical site infection, and in Control group, there were one case of delirium, 2 cases of surgical site infection, and 4 cases of dural injury. Perioperative complication rate was not significantly different between the two groups (13.7% vs. 8.0%, P = 0.36).

Discussion: Lumbar interbody fusion in the elderly over 85 years of age is effective procedure with no difference compared with the Control group. When the pathology requires spinal fusion, lumbar fusion with instrumentation is worth to be chosen even in the elderly over 85 years of age.

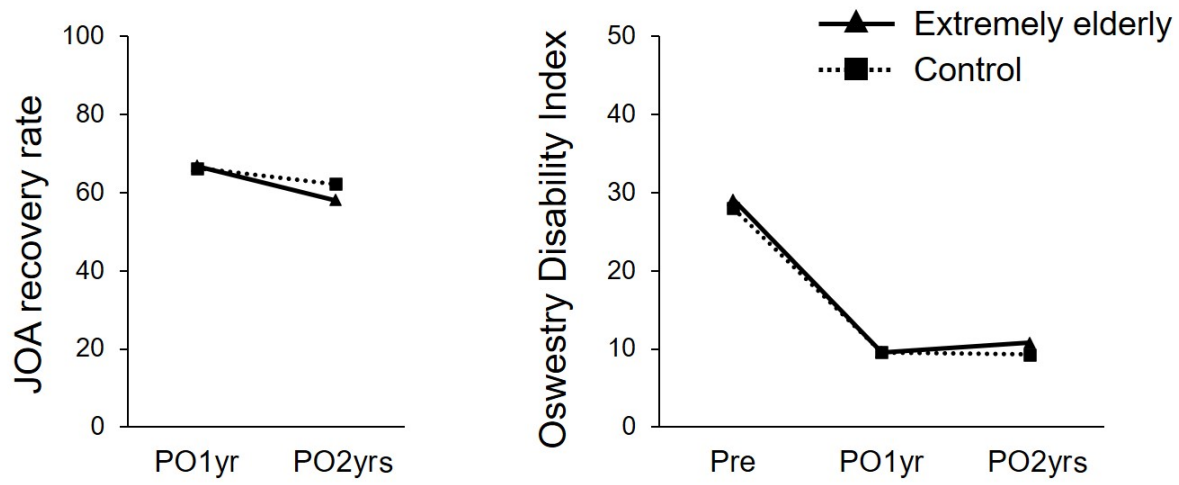

Figure 1

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Surgical outcome of scoliosis with muscular dystrophy

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Recently the development of respiratory management and powered wheelchair improve the prognosis and the quality of life of the patients with muscular dystrophy. Following this improvement, the importance of management of scoliosis is enlarged. The aim of study is to elucidate the surgical outcome of scoliosis with muscular dystrophy.

Eight patients with muscular dystrophy was retrospectively studied. Fukuyama type is three patients, congenital, Duchenn type were each two patients and limb girdle type was one. Cobb angle, lumbar lordosis, hospital stay or ICU, and postoperative complication were investigated.

The preoperative cobb angle of scoliosis and lumbar lordosis was mean 85.8 ± 12.7 degree and 7.9 ± 43.2 degree, respectively. Surgical duration was 473.1 ± 60.7 minutes and intraoperative bleeding was 2980.1 ± 2070.0g. The mean hospitalization was 34.1 ± 9.7 days. And the mean stay of ICU and the duration of respiratory management were 4.0 ± 2.3 and 2.1 ± 2.7, respectively. The postoperative cobb angle of scoliosis and LL was mean 41.3 ± 15.2 degree and 30.5 ± 17.3 degree, respectively. SS was mean 37.3 ± 19.3 degree. Correction rate was 51.6 ± 17.5%. Every patient was improved their sitting balance, they felt the improvement of dietary, respiration and bowel motion. Whereas, 5 patients had surgical complications, 1 patient; intraoperative massive bleeding, 2 patients; pneumonia and massive hematemesis, 1 patient; adynamic ileus and suture leakage. Three patients who had received excessive correction of SS represented knee contracture after scoliosis surgery.

Surgery of scoliosis with muscular dystrophy was highly invasive and highly effective to maintain the ADL and QOL. Excessive correction of pelvic retroversion may lead the deterioration of knee contracture.

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Risk factors for an incidental durotomy during posterior spine surgery for degenerative diseases in adults: a prospective single-center observational study

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INTRODUCTION
An incidental durotomy (ID) is a common intraoperative complication of spine surgery that can lead to persistent cerebrospinal fluid leakage, which may cause serious complications, including severe headaches, pseudomeningocele formation, nerve root entrapment, and intracranial hemorrhaging. Therefore, the purpose of this study was to clarify the independent risk factors for IDs during posterior open spinal surgery for lumbar degenerative diseases in adults.

METHODS
Between July 2010 and June 2020, we conducted a prospective observational study of adult patients (>17 years) who underwent posterior open spinal surgery for lumbar degenerative diseases in our hospital. Only the patients who underwent orthopedic spinal surgery were included in the study. We analyzed the associations between ID and multiple potential factors, including the patient's age at the time of the surgery, sex, height, weight, body mass index, American Society of Anesthesiologists physical status classification, diabetes, hemodialysis, smoking, preoperative chronic steroid intake, type of procedure (laminectomy/herniotomy/fusion), use of posterior instrumentation, and past surgical history in the operated area. A Fisher's exact test was used for the categorical variables and a Student's t-test was used for the continuous variables. A multivariate analysis was performed to evaluate the risk factors for the occurrence of an intraoperative ID. The significant variables and the variables that correlated ($P < 0.20$) with SSI in the univariate analysis were entered into a stepwise multiple logistic regression model. Significance was set at $P<0.05$. In addition, the odds ratio (OR) and 95% confidence interval (CI) were calculated for each of the variables.

RESULTS
A total of 947 consecutive patients were enrolled (mean age: 65.0 years) in this study. The total incidence of IDs during the posterior surgeries was 7.2% (68 cases). The univariate analysis indicated that older age ($P=0.019$) was a significant risk factor for an ID. Older age and the factors with a P value <0.20 in the univariate analysis (diabetes [$P=0.073$], body height [$P=0.110$], smoking [$P=0.129$], preoperative chronic steroid intake [$P=0.130$]) were included in a multivariate analysis to further examine the risk factors for an ID. The results of the multivariate analysis revealed that older age ($P=0.020$, OR=1.025, 95%CI: 1.004-1.046) was the sole independent risk factor for the occurrence of an ID during posterior surgery.

DISCUSSION
Knowing the risk factors that are associated with an increased risk of an ID is critical because IDs can cause large lacerations that cannot form sufficiently strong and watertight seals, which can lead to severe complications. Indeed, while repairing the dura after an ID is important, being conscious of the related risk factors and trying to avoid IDs is more important. The results of the present analysis can contribute to informing surgeons of the risk factors for IDs, and they can also be useful for counseling patients on the risks and complications that are associated with posterior open spine surgery for lumbar degenerative diseases.

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The Clinical Impact of Enhanced Surface Technology on Post-Operative Opioid Consumption in Patients Undergoing Anterior Lumbar Interbody Fusion

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Introduction: Interbody fusion devices with nano-surface topography technology have been shown to stimulate a local cellular response promoting osteogenic differentiation and angiogenic growth factors, which are essential to interbody fusion [1,2].The nano-surface topography has also been shown to decrease pro-inflammatory interleukins and increase anti-inflammatory cytokines, when compared to alternatives [3]. This change in inflammatory cytokine response to a nano-surface interbody cage might reduce postoperative pain and opioid consumption.There have been several studies that have examined the effect of multimodal pain regimens on reducing pain and opioid consumption following spine surgery. However, we are unaware of any studies that have evaluated the effect of specific spinal fusion implants on postoperative pain and opioid use.

Methods: This is a retrospective cohort study of consecutively treated patients undergoing ALIF. Patients received either the standard control surface technology (Endoskeleton™) or the investigational nano-enhanced surface technology (NanoLOCK™). Patients were assessed at three post-operative follow-up visits for ongoing presence or absence of opioid use and for total daily morphine milligram equivalents (MME) consumption. Surgical demographic variables were recorded. A logistic multivariate regression as performed to identify factors predictive of opioid use at final follow-up. Two-way repeated measures ANOVA was used to compare the groups at each time point.

Results: 120 patients were included in the analysis, with 61 patients receiving the standard control cage surface and 59 receiving the experimental surface technology. The control group had a higher rate of smokers and pre-operative opioid use. Regression analysis confirmed that smoking status and cage surface type were predictive of opioid use at final follow-up. Two-way repeated measures ANOVA demonstrated that the opioid usage rate was significantly lower in the experimental cage group at all post-operative time points. Patients in the control cohort were found to have a 4.5 times greater likelihood of using opioids at the three-month follow-up appointment.

Discussion:Studies have shown that osteoblasts and stem cell interact with specifically engineered surface features on a nano-surface implant initiating an endogenous cellular and biochemical response. Effects include increased production of TGF-B1 and BMPs 2, 4, and 7 with up-regulation of osteoblast differentiation and reduction of Interleukins 1B, 6, and 8 to minimize pathologic inflammatory responses [1-5]. It is the modulation of the pro-inflammatory cytokines which may result in decreased pain in the investigational cohort as well as the potential for more rapid osseointegration of the implant. By reducing the negative inflammatory effects of spinal fusion and promoting an osteogenic tissue response in patients undergoing an ALIF procedure with a nano-surface implant, a reduction in opioid usage and daily MME consumption may be achieved, compared to standard implants.

1. 1.Olivares-Navarrete R, Gittens RA, Schenider JM, Hyzy SL, Haithcock DA, Ullrich PF, Schwartz Z, Boyan BD. Osteoblasts exhibit a more differentiated phenotype and increased bone morphogenetic protein production on titanium alloy substrates than on poly-ether-ether-ketone. Spine J. 2012;12(3):265-72.
2. 2.Olivares-Navarerete R, Hyzy SL, Gittens RA 1st, Schneider JM, Haithcock DA, Ullrich PF, Slosar PJ, Schwartz Z, Boyan BD. Rough titanium alloys regulate osteoblast production of angiogenic factors. Spine J. 2013;13(11):1563-70.
3. 3.Olivares-Navarerete R, Hyzy SL, Slosar PJ, Schneider JM, Schwartz Z, Boyan BD. Implant materials generate different peri-implant inflammatory factors: poly-ether-ether- ketone promotes fibrosis and microtextured titanium promotes osteogenic factors. Spine J. 2015;40(6):399-404
4. 4.Olivares-Navarrete, R, Hyzy SL, Gittens, RA, Berg, ME, Schneider, JM, Hotchkiss, K, Schwartz, Z, Boyan, BD. Osteoblast lineage cells can discriminate microscale topographic features on titanium-aluminum-vanadium surfaces. Ann Biomed Eng. 2014 Dec; 42 (12): 2551- 61.
5. 5.Olivares-Navarrete R, Hyzy SL, Slosar PJ, Schneider J., Schwartz Z, Boyan, BD. Implant materials generate different peri-implant inflammatory factors: PEEK promotes fibrosis and micro-textured titanium promotes osteogenic factors. Spine. 2015 Mar; 40(6): 399- 404.

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Incidence of hip and knee outcomes following MISS versus open lumbar fusion

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Introduction

Surgery of the lumbar spine has been shown to alter the mechanics of the hip and knee joints, leading to osteoarthritis and eventually, joint arthroplasty. Minimally invasive spinal (MIS) surgery has been shown to lead to decreased complication rates and improved range of motion when compared to open spinal surgery. In this retrospective analysis, we examine the incidence of hip and knee pathology following MISS and open lumbar fusion.

Methods

Using the PearlDiver Mariner database of insurance claims from Q32015 to 2018, patient receiving MIS or open lumbar fusion (single- and multi-level) were selected using ICD-10 procedural codes. MIS and open cohorts were matched based on age, sex, and comorbidities. Matched cohorts were followed longitudinally for the length of the database to determine rates of the following outcomes (first instance only): hip/knee pain, hip/knee osteoarthritis, total hip arthroplasty (THA) and total knee arthroplasty (TKA). The mean days to each outcome were also determined.

Results

A total of 1923 patients received MISS lumbar fusion compared to 179,614 open fusions. The majority of patients from both cohorts were older than 65 (56% MIS and 56% open). The mean number of comorbidities was 2.6 for MIS and 2.5 for open. Length of stay was 3.1 days for MIS and 3.5 days for open. For single level fusions, 12% of MIS patients and 11% of open developed hip or knee osteoarthritis ($p = 0.70$); 3% of MIS and 4% of open received TKA ($p= 0.69$); 3% of MIS and 2% of open received THA (0.33). Mean time to hip or knee arthritis was 439 days for MIS and 460 days for open ($p = 0.69$). Mean time to TKA was 686 days for MIS and 565 days for open ($p = 0.22$). Mean time to THA was 382 days for MIS and 420 days for open ($p = 0.69$). For multi-level fusions, 14% of MIS patients and 11% of open developed hip or knee osteoarthritis ($p = 0.14$); 6% of MIS and 5% of open received TKA ($p= 0.38$); 3% of both MIS and open received THA (0.75). Mean time to hip or knee arthritis was 481 days for MIS and 532 days for open ($p = 0.69$). Mean time to TKA was 561 days for MIS and 502 days for open ($p = 0.52$). Mean time to THA was 471 days for MIS and 677 days for open ($p = 0.11$).

Discussion

Rates of hip and knee pathology and arthroplasties following lumbar fusions were not significantly different between surgical techniques. MIS lumbar fusion may be considered an acceptable alternative to open procedures and, given the technique's benefits of lower cost, decreased hospital stay, and fewer complications, may be superior to older open techniques. Future research can compare outcomes of MIS and open techniques for additional spinal surgeries and spinal levels.

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Hypoalbuminemia is associated with mortality in a general spine surgery population: a retrospective analysis

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Introduction:

Hypoalbuminemia as a risk factor for mortality following spine surgery has primarily focused on cohorts with spinal metastatic cancer. Low serum albumin is a known marker of inflammation, often associated with poor nutritional status and frailty. We assess the association between pre-operative hypoalbuminemia and mortality among a generalizable population of patients undergoing surgery for any indication, and to determine its association with post-operative patient-reported outcomes and readmission.

Methods:

An Electronic Medical Record (EMR) query identified all patients with pre-operative plasma albumin lab values who underwent Orthopedic spine surgery at a US public university health system between 2014 and 2021. Demographic, comorbidity, and mortality data were collected along with pre- and post-operative Oswestry Disability Index (ODI). All cause hospital readmission within one year of surgery was also identified. Hypoalbuminemia was based on a well-established clinical threshold of ≤3.5 g/dl. We initially examined Kaplan-Meier survival plot by albumin status. Subsequent multivariable regression models were used to identify the association between pre-operative hypoalbuminemia with mortality, readmission and ODI, while controlling for age, sex, race, ethnicity, and the Charlson Comorbidity Index (CCI).

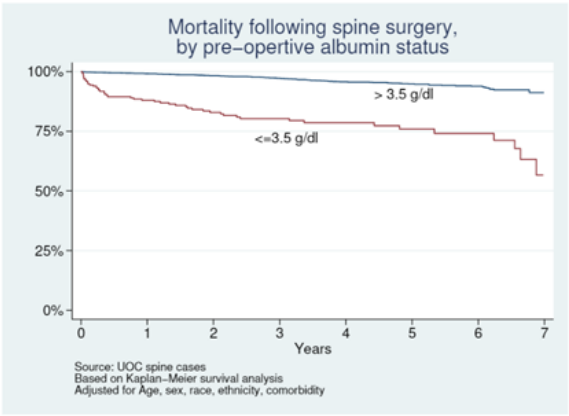
Results:

Of 3425 spine surgery patients with pre-operative serum albumin lab values, 220 were identified as hypoalbuminemic (4.9%). Mean age was not significantly different between groups; mean age of all participants was 59.6 years old. Sex was not significantly different between groups with 6.0% of all males classified as hypoalbuminemic and 4.5% of all females. The unadjusted mortality rate was 1.8% at 1 year and 5.6% through 7 years. Relative to patients with normal preoperative albumin, those with hypoalbuminemia had a significantly greater adjusted risk of mortality by 1-year (OR 11.24; 95%CI 6.47 – 19.52; p<0.001) and through 7 years (HR 4.27; 95%CI 3.06 – 5.94; p < 0.001). Average pre-operative ODI scores were 5.5 points higher among hypoalbuminemia patients (5.5 points; 95%CI 0.14 – 10.9; p=0.044) compared to patients with normal albumin levels but showed similar rates of improvement through 12 months postoperative.

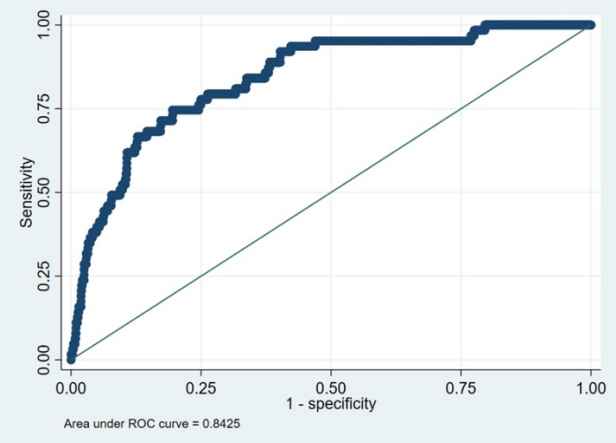
Discussion:

Pre-operative hypoalbuminemia was strongly associated with post-operative mortality among a general spine surgery cohort. Patients with hypoalbuminemia showed a similar rate of post-operative disability improvement and a slightly lower rate of all-cause readmission. However, causal inference is limited in this retrospective study. Additional research should seek to clarify the role of serum albumin as an independent risk factor of mortality follow all types of spine surgery, and to better elucidate the role of hypoalbuminemia in the selection and management of spine surgery patients.

Figure 3: Association between pre-operative albumin status with post operative mortality following spine surgery



Note: none



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Spinal canal occupancy of posterior wall fragments in lumbar burst fractures correlates with the occurrence of entrapped cauda equina

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Introduction; Thoracolumbar (TL) burst fractures accounts for 20% of all spine fractures. The complexity of the injury pattern complicates treatment decisions. Dural tears and entrapped cauda equina (ECE) should be assessed preoperatively because any reduction maneuver results in crushing the entrapped nerve. However, presence of ECE may be difficult to determine unambiguously by clinical and radiological examination before surgical treatment. This study aimed to identify the radiological features of ECEs and to provide an index to predict the occurrence of ECEs preoperatively.

Methods; This retrospective observational study included 143 patients who underwent surgical treatment for thoracolumbar burst fractures at the Hokkaido Spinal Injury Center. The relationship between the occurrence of ECE and the spinal canal occupancy rate (OR) of the vertebral posterior wall bone fragments (PWF) (OR–PWF) in the axial view of computed tomography was investigated. We investigated the differences between the ECE-positive and ECE-negative groups in terms of the demographic data, the injured vertebral levels, the presence and type of lamina fracture, and the OR–PWF.

Results; One hundred one patients (103 vertebrae) fulfilled the inclusion criteria for this study (74 males and 27 females, mean age: 48.4 ± 19.4 years). Average follow-up period was 51.2 ± 40.0 months (median: 42.5 months). The preoperative MRI showed that ECE was suspected in 9 cases, of which 7 cases actually occurred. There were no significant differences in age, height, or BMI according to the presence or absence of ECE, but weight was significantly heavier in the ECE-positive group than in the ECE-negative group. The levels of the injury in the ECE-positive group were at L2 in 3 cases, at L3 in 3 cases and at L4 in 1 case. The distribution of the vertebral level of lumbar burst fracture occurrence was highest in L1, followed by L2, 3, 4, and 5. There were 28 cases of complete type lamina fractures (27.2 %) and 60 cases of incomplete type lamina fractures (58.3 %) on axial view, and 68 cases of whole type lamina fractures (66.0 %) and 19 cases of partial type lamina fractures (18.4 %) on coronal view. One case was unclassifiable. In 14 cases, no lamina fractures occurred. In the ECE-positive group, all cases had lamina fractures; 4 complete type lamina fractures and 3 incomplete type lamina fractures. On the coronal view, all cases were whole type lamina fractures. The OR–PWF was significantly higher in the ECE-positive group than in the ECE-negative group ($P = 0.03$).

Discussion; This study was the first to clarify the relationship between the degree of protrusion of the PWF and ECE. In addition, it was shown that burst fractures with ECE were more likely to occur at the L2 and L3 levels. OR–PWF was considered to be a highly accurate predictor of ECE occurrence. Correct preoperative evaluation of ECE and cauda equina salvage prior to any reduction maneuver is essential for proper treatment of TL burst fractures.

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Comparison of Value Per Operative Time Between Primary and Revision Adult Spinal Deformity Surgery: A Propensity Score-Matched Analysis

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Introduction: Adult spinal deformity (ASD) surgery is technically demanding and is often burdened by complications and high revision rates[1, 2]. This common need for additional surgery can increase the overall cost of care for ASD. Relative value unit (RVU) is the basis for the Medicare reimbursement formula and is used to determine physician payments nationally. RVUs consider the physician's work, the expenses of the physician's practice, and professional liability insurance[3]. However, in arthroplasty literature, several studies have reported lower RVU compensation for revision procedures compared to primary despite the higher difficulty associated with revision surgeries[4, 5]. While previous studies have evaluated cost effectiveness of ASD surgeries, RVUs per minute has not been previously compared between primary and revision ASD surgery. The aim of the current study is to compare the RVUs per minute for primary vs. revision adult spinal deformity surgery.

Methods: This study utilizes data obtained from the ACS-NSQIP database. Patients ≥18 years old who underwent spinal deformity surgery between 2011 and 2019 were identified and included based on Current Procedural Terminology codes 22800, 22802, and 22804. Patients undergoing anterior-only and concurrent anterior-posterior fusions were excluded to ensure that a homogenous patient cohort undergoing posterior-only fusions were compared. Patients with missing demographic or surgical complication data were also removed to prevent biases in the results. Propensity score matching analysis was performed with a match tolerance of 0.01 according to demographic characteristics, comorbidities, and preoperative laboratory values. Patients were paired using nearest neighbor approach and without replacement. Matched groups were compared via Fisher's exact test and independent t-test for categorical and continuous variables, respectively.

Results: 326 revision surgery patients were matched with 152 primary surgery patients via propensity score matching. Age, sex, race, and ethnicity were statistically similar between groups after matching. Revision rate was significantly higher among patients with diabetes mellitus and ASA class 3 or greater (Table 1). Within the revision group, 152 patients (46.6%) included osteotomy codes, and 61 cases (18.7%) used interbody devices. In the primary group, 58 patients (38.2%) had osteotomy codes, while 23 (15.1%) cases used interbody devices. Mean RVUs per minute was significantly higher for the revision surgery group compared to the primary surgery group (0.331 vs. 0.250, p<0.001). However, the primary surgery group was found to have significantly worse 30-day outcomes, including readmission, reoperation, and morbidity. In addition, rates of pulmonary embolism, ventilator need >48 hours, myocardial infarction, deep venous thrombosis, and sepsis were significantly higher in the primary surgery group (Table 2).

Conclusion: Revision ASD surgery was associated with significantly higher RVUs per minute compared to primary surgery. Primary surgery was associated with higher 30-day readmission, reoperation, morbidity, and individual complication rates.

Table 1. Demographic and clinical characteristics before and after propensity score matching

	Total cohort			Propensity matched cohort		
	Primary *N* **(%)**	**Revision** *N* **(%)**	***p*-value**	**Primary** *N* **(%)**	**Revision** *N* **(%)**	***p*-value**
N of subjects	3121	326		152	326	
Age (years), mean±SD	56.72±18.4	60.3±15.3	0.001*	61.1±14.3	60.3±15.3	0.589
Female sex	1917 (61.4%)	205 (62.9%)	0.635	103 (67.8%)	205 (62.9%)	0.307
Non-white race	282 (10.3%)	28 (11.3%)	0.588	25 (16.4%)	28 (11.3%)	0.172
Hispanic ethnicity	120 (4.3%)	8 (3.3%)	0.511	3 (2.0%)	8 (3.3%)	0.542
Comorbidities						
BMI (kg/m2), mean±SD	28.3±6.5	29.6±6.6	<0.001*	29.8±6.5	29.6±6.6	0.758
Diabetes mellitus	449 (14.4%)	44 (13.5%)	0.739	10 (6.6%)	44 (13.5%)	0.029*
Current smoker within 1 year	586 (18.8%)	54 (16.6%)	0.369	29 (19.1%)	54 (16.6%)	0.518
Dyspnea	141 (4.5%)	20 (6.1%)	0.212	19 (12.5%)	20 (6.1%)	0.030*
Independent prior to surgery	2901 (93.0%)	289 (88.7%)	0.008*	120 (78.9%)	289 (88.7%)	0.008*
Severe COPD	123 (3.9%)	9 (2.8%)	0.362	3 (2.0%)	9 (2.8%)	0.760
Hypertension requiring medication	1454 (46.6%)	170 (52.1%)	0.062	102 (67.1%)	170 (52.1%)	0.002*
Dialysis	14 (0.4%)	1 (0.3%)	1.000	1 (0.7%)	1 (0.3%)	0.535
Disseminated cancer	74 (2.4%)	3 (0.9%)	0.113	3 (2.0%)	3 (0.9%)	0.335
Open wound/wound infection	29 (0.9%)	7 (2.1%)	0.076	5 (3.3%)	7 (2.1%)	0.388
Chronic steroid use	166 (5.3%)	31 (9.5%)	0.004*	17 (11.2%)	31 (9.5%)	0.624
Bleeding disorders	86 (2.8%)	13 (4.0%)	0.220	7 (4.6%)	13 (4.0%)	0.807
Sepsis or SIRS	50 (1.6%)	3 (0.9%)	0.478	3 (2.0%)	3 (0.9%)	0.388
ASA ≥3	1718 (55.3%)	234 (71.8%)	<0.001*	53 (34.9%)	234 (71.8%)	<0.001*
Preoperative laboratory values						
Elevated creatinine	282 (10.0%)	25 (8.2%)	0.362	11 (7.2%)	25 (8.2%)	0.854
Elevated white blood cells	240 (8.2%)	19 (6.2%)	0.269	12 (7.9%)	19 (6.2%)	0.554
Decreased hematocrit	455 (15.5%)	52 (16.8%)	0.564	54 (35.5%)	52 (16.8%)	<0.001*
Decreased platelet count	160 (5.5%)	24 (7.8%)	0.093	25 (16.4%)	24 (7.8%)	0.006*

Fisher's exact test performed for categorical variables; independent t-test performed for continuous variables. *Statistically significant (p <0.05). SD, standard deviation. COPD, chronic obstructive pulmonary disease. SIRS, systemic inflammatory response syndrome. ASA, American Society of Anesthesiologists.

Table 2. RVUs per minute and 30-day outcomes in propensity score matched groups

	Primary *N* **(%)**	**Revision** *N* **(%)**	***p*-value**
RVUs per minute, mean±SD	0.250±0.153	0.331±0.214	<0.001*
30-day outcomes			
Readmission	27 (17.8%)	23 (7.1%)	0.001*
Reoperation	26 (17.1%)	18 (5.5%)	<0.001*
Morbidity	112 (73.7%)	188 (57.7%)	0.001*
Complications			
Superficial wound infections	2 (1.3%)	7 (2.1%)	0.726
Pulmonary embolism	10 (6.6%)	5 (1.5%)	0.008*
Ventilator >48 hours	15 (9.9%)	10 (3.1%)	0.003*
Progressive renal insufficiency	1 (0.7%)	1 (0.3%)	0.535
Urinary tract infection	10 (6.6%)	14 (4.3%)	0.368
Stroke	4 (2.6%)	2 (0.6%)	0.084
Myocardial infarction	5 (3.3%)	2 (0.6%)	0.036*
Deep venous thrombosis	8 (5.3%)	5 (1.5%)	0.008*
Sepsis	10 (6.6%)	5 (1.5%)	0.008*
Blood transfusions	95 (62.5%)	174 (53.4%)	0.075

Fisher's exact test performed for categorical variables; independent t-test performed for continuous variables. *Statistically significant (p <0.05). SD, standard deviation. RVUs, relative value units.

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Error verification in S2 alar-iliac screw insertion using a patient-specific 3D guide : Comparison with the superimposing method

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Background: The S2 alar-iliac (S2AI) screw is useful as a caudal anchor for lumbosacral fusion. In our clinic, we use MySpine (Medacta International SA, Strada Regina, Switzerland), a patient-specific three-dimensional (3D) guide that allows safe and accurate S2AI screw insertion.
Objective: The objective of this study was to verify the rate of error between the preoperative plan and the actual screw used for insertion with MySpine.
Subjects and Methods: Ten patients underwent S2AI screw insertion using MySpine for treatment of degenerative spinal diseases between September 2020 and August 2021 at our hospital; of these, eight cases were included in the study because we were able to compare them with the superimposing method that uses computed tomography (CT) data taken before and after the surgery. Mimics (Materialise, Leuven, Belgium) and SOLIDWORKS (Dassault Systems, Vélizy-Villacoublay, France) were used to reconstruct images and create 3D models from CT data. The error between the preoperative plan and the trajectory executed along with the final inserted screw was measured by superimposing a model of the sacrum created from pre- and postoperative CT data over the body surface.
Results: All 16 S2AI screws in the eight cases were inserted in the optimal position, and no deviations outside the iliac bone were observed. The mean errors between the insertion points and the superimposed image were 1.65±1.44 mm cephalad and 1.68±1.11 mm medial and lateral, and the mean errors of insertion angles were 2.07±1.19° in the sagittal plane and 2.00±1.26° in the transverse plane. No difference was found between the right and left sides in any of the items (Student's t-test, $P>0.05$). Using the above results, we simulated screw insertion using mean + 1 standard deviation from planning in each direction in each case, but none of the screws deviated outside the iliac bone.
Discussions: For the insertion of S2AI screw, several methods are applied. Freehand technique or insertion with fluoroscopy is the simple method based on anatomical features. In these days, navigation systems or robotics are applied for this technique to decrease the risks of malposition, but it needs complex systems and many costs. The rate of S2AI screw deviation outside the iliac bone has been reported to be 2.2 to 20%, and this rate is lower when using a navigation system or with robotics than when using a freehand or fluoroscopy alone. In the present study, accurate insertion of the S2AI screw was achieved by using a patient-specific 3D guide created from preoperative CT data. The insertion error was small with this method, and we believe that safe and accurate insertion of the S2AI screw is possible using patient-specific 3D guides.

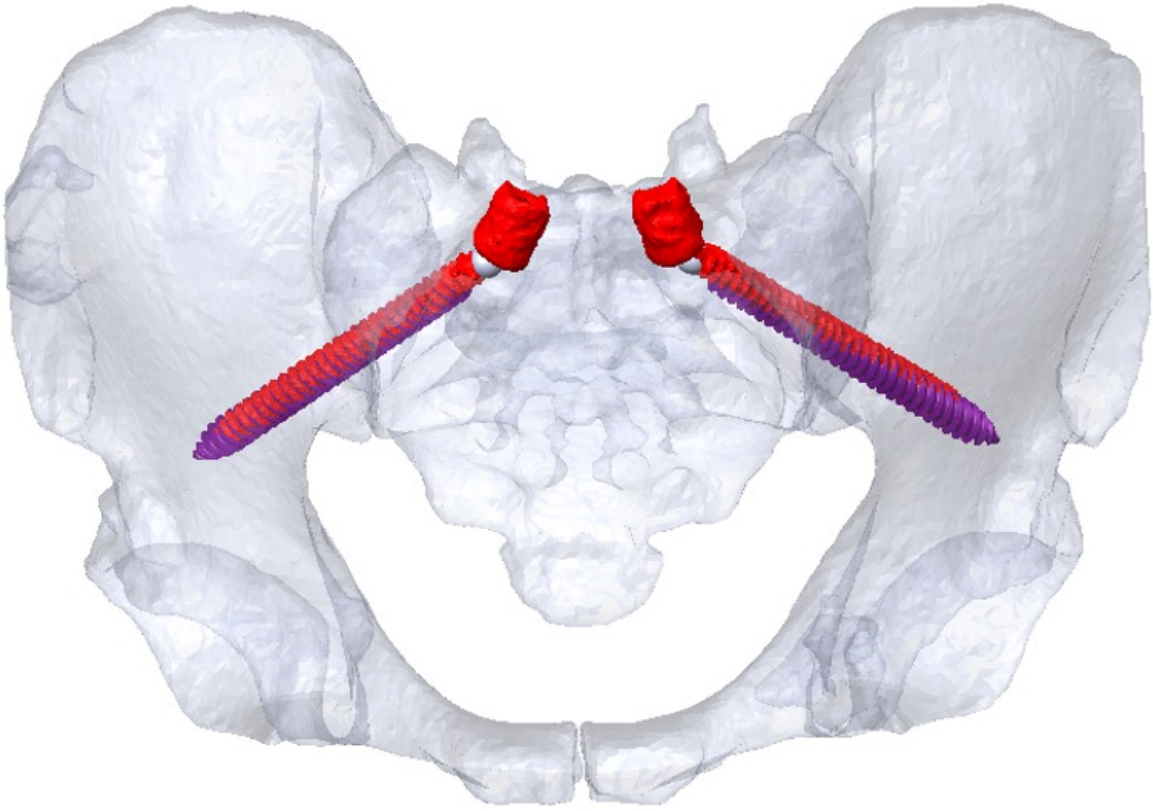

Fig.1 preoperative planned screws (purple screws) and actually inserted screws (red screws)

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Surgery for extraforaminal lumbar disc herniation: a single center comparative observational study

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Introduction

Surgery on extraforaminal lumbar disc herniation (ELDH) is a commonly performed procedure. Operating on this type of herniation is known to come with more difficulties than on the frequently seen paramedian lumbar disc herniation (PLDH). However, no comparative data are available on the effectiveness and safety of this operation. We sought out to compare clinical outcomes at 1 year following surgery for ELDH and PLDH.

Methods

Data were collected through the Norwegian Registry for Spine Surgery (NORspine). The primary outcome measure was change at 1 year in the Oswestry Disability Index (ODI). Secondary outcome measures were quality of life measured with EuroQol 5 dimensions (EQ-5D); and numeric rating scales (NRSs).

Results

Data of a total of 1750 patients were evaluated in this study, including 72 ELDH patients (4.1%). One year after surgery, there were no differences in any of the patient reported outcome measurements (PROMs) between the two groups. PLDH and ELDH patients experienced similar changes in ODI (− 30.92 vs. − 34.00, $P = 0.325$); EQ-5D (0.50 vs. 0.51, $P = 0.859$); NRS back (− 3.69 vs. − 3.83, $P = 0.745$); and NRS leg (− 4.69 vs. − 4.46, $P = 0.607$) after 1 year. The proportion of patients achieving a clinical success (defined as an ODI score of less than 20 points) at 1 year was similar in both groups (61.5% vs. 52.7%, $P = 0.204$).

Discussion

Patients operated for ELDH reported similar improvement after 1 year compared with patients operated for PLDH.

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Bone marrow edema after lumbar interbody fusion and its clinical relevance

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【Introduction】 Vertebral bone marrow edema (BME) reflects various pathologies including osteoporotic vertebral fracture, disc degeneration with Modic type 1 change and osteomyelitis. Among patients who underwent posterior/transforaminal lumbar interbody fusion (PLIF/TLIF), we often observed vertebral BME on postoperative magnetic resonance imaging. However, its clinical relevance remains unclear. The purpose of this study is to examine the appearance of BME on postoperative MRI in those who showed normal healing course of PLIF/TLIF and clarify its clinical relevance.

【Methods】 Using a prospectively established database, 97 consecutive patients who had undergone PLIF/TLIF for lumbar degenerative disease were retrospectively reviewed. Patterns and extent of BME (percentage to whole vertebral area) were evaluated on MRI at postoperative week 3. Presence or absence of cage subsidence, cage back out and screw loosening were assessed on X-ray images at postoperative week 3. Back pain was also evaluated by visual analogue scale (VAS).

【Results】 Excluding surgical site infection, implant failure and early revision cases, 90 patients (30 men and 60 women, mean age 71.2 ± 9.2 years) were eligible for analysis. Fifty-eight patients had one cage inserted (Single cage group), and 32 patients had two cages placed bilaterally (Dual cage group). Sixty-eight patients underwent a single-level fusion, and 22 patients underwent a 2-level fusion. Of 180 instrumented vertebrae, BME was found in 148 vertebrae. BME patterns were categorized into the following four types: no edema type (17.7%, 32/180 vertebrae), anterior corner type (37.7%, 68/180 vertebrae), around-the-cage focal type (42.2%, 76/180 vertebrae) and diffuse type (2.2%, 4/180 vertebrae). Single cage group had 6.9% in no edema type, 46.3% in anterior corner type, 45.7% in around-the-cage focal type, and 0.9% in diffuse type. In the dual cage group, there were 37.5% in no edema type, 21.9% in anterior corner type, 36.0% in around-the-cage focal type, and 4.7% in diffuse type. Single cage group had significantly higher rate of BME than the dual cage group (93.1% versus 62.5%, $p<.001$ in chi-square test). Anterior corner type was significantly more frequent in the single cage group than the dual cage group ($p<.001$ in chi-square test). BME extent was significantly greater in the single cage group than the dual cage group (38.8% vs 20.1%, $p<.001$ in student`s t-test), and was significantly greater in patients with cage subsidence than those without cage subsidence (45.7% vs 29.6%, $p<.001$ in student`s t-test). BME extent had no significant correlation with cage back out, screw loosening and VAS of back pain.

【Discussion】 The current results showed that BME was frequently observed even in the normal healing course of lumbar interbody fusion; the rate reached 93.1% in the single cage group and 62.5% in the dual cage group. However, diffuse type BME was rarely observed, and the incidence was 0.9% in the single cage group and 4.7% in the dual cage group. Diffuse type BME might be one of the findings related to pathological events. As well, BME extent was significantly greater in cage subsidence group, suggesting a potential parameter predicting cage subsidence.

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Evaluation of the cross-sectional area, maximum torque-out force, and shape of expandable interbody cages

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Introduction: Expandable interbody cages have evolved since their introduction to the market in the early 2000s, with the goal of reducing rates of cage migration, expulsion, nonunion, and subsidence[1]. Notably, larger contact area has been shown to require significantly greater force increments to induce clinically significant subsidence[2]. However, data describing contact area of modern expandable TLIF cages is limited. Interest in this data has grown as surgeons and device manufacturers increasingly seek to incorporate expandable cage technology with minimally invasive techniques. The objective of the present study was to evaluate cross-sectional surface area (CSA) of modern expandable TLIF cages and explore relationships between cage footprints and their respective torque-out value, maximum lordosis, and expansion heights.

Methods: Publicly available FDA, patent information, and product technique guides were evaluated for pre- and post-expansion cage length, width, height, lordosis, and torque-out value for the smallest and largest cages manufactured. Torque-out value was treated as a surrogate for force generated at maximum expansion. CSA of rectangular and banana-shaped cages were calculated as the CSA of a rectangle or an ellipse, respectively. Pearson's Correlation and regression were used to evaluate for relationships between CSA and the above parameters.

Results: Twenty-one expandable TLIF cages were identified (two banana), with CSA ranging from 176-630mm^2. Lordosis ranged from 0-23°. Torque-out values ranged from 10-40 in-lbs. Maximum cage expansion ranged from 3-10mm of total excursion. Of the smallest and largest cages offered, collapsed to expanded cage heights ranged from 6-17mm and 7-17mm, respectively.

Of the largest cages offered for a specific device, CSA positively correlated with maximally expanded height (r=0.497, p=0.042) and maximum range-of-expansion (r=0.617, p=0.008). There were no significant relationships between CSA and lordosis, torque-out value, or collapsed height. Cage-shape did not predict torque-out value (p=0.366, OR=1.087, CI^{95}=0.907-1.300).

The mean ratios of CSA-to-collapsed-height and of CSA-to-expanded-height were 31mm and 19mm for the smallest cages offered, respectively, and significantly differed (p<0.001), and were 33mm and 21mm for the largest cages offered, respectively, and significantly differed (p<0.001).

Conclusions: The smallest and largest cages had similar collapsed to maximally-expanded heights. Amongst the largest sized cages offered, cages with larger CSA had greater maximally expanded cage height and total expansion range, but the ratio of proportional CSA per expansion was significantly lower at maximally expanded height compared to fully collapsed height. Thus, expandable cages had less proportional CSA at maximum expansion. Further research evaluating CSA and endplate-contact-force would further highlight the relationship between parameters associated with subsidence within expandable cages.

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Three-dimensional Gait Analysis in Patients with Lumbar Degenerative Scoliosis -Correlation Analysis with Spino-pelvic Parameters-

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INTRODUCTION: Gait disturbance is a characteristic difficulty for patients with degenerative lumbar spinal disorder. Objective evaluation of the gait will help to fully understand how the spinal pathology results in disability. Three-dimensional (3D) gait analysis can obtain real-time information without any known risks to the patients. There is little information about the assessment of gait ability and comparison with radiographic parameters in patients with degenerative lumbar scoliosis (DLS). The purpose of this study was to measure pre-and postoperative gait characteristics in patients with DLS using 3D gait analysis and to analyze the correlation between the gait parameters and the radiographic spinopelvic parameters.

METHODS: Subjects: Twenty-two patients (4 men and 18 women; avg. age: 68.9 years) who received lumbar spinal surgery in our institutions were included. Ten patients with DLS (10 women; 66.4 years) and twelve patients with lumbar spinal stenosis (LSS: 4 men, 8 women; 70.9 years) were evaluated before spinal surgery and after 6 months.

Gait analysis: Sixteen reflective markers were attached to the surface of the body. Gait data were collected using six infrared cameras. Each subject performed a series of over-ground gait trials at a comfortable self-selected speed. The gait parameters (gait speed, stride length, step width, and cadence) and gait cycle (swing phase, stance phase, double support, and single support phase) were measured.

Radiographic measurements of spinopelvic parameter: Full-length free-standing lateral radiographs were taken. Radiographic measures included sagittal vertical axis (SVA), pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), and lumbar lordosis (LL).

Statistical analysis: Student t-test was used to determine differences in gait parameters and gait cycle between DLS and LSS groups. Correlations between radiographic parameters and gait characteristics were analyzed using the Pearson coefficient.

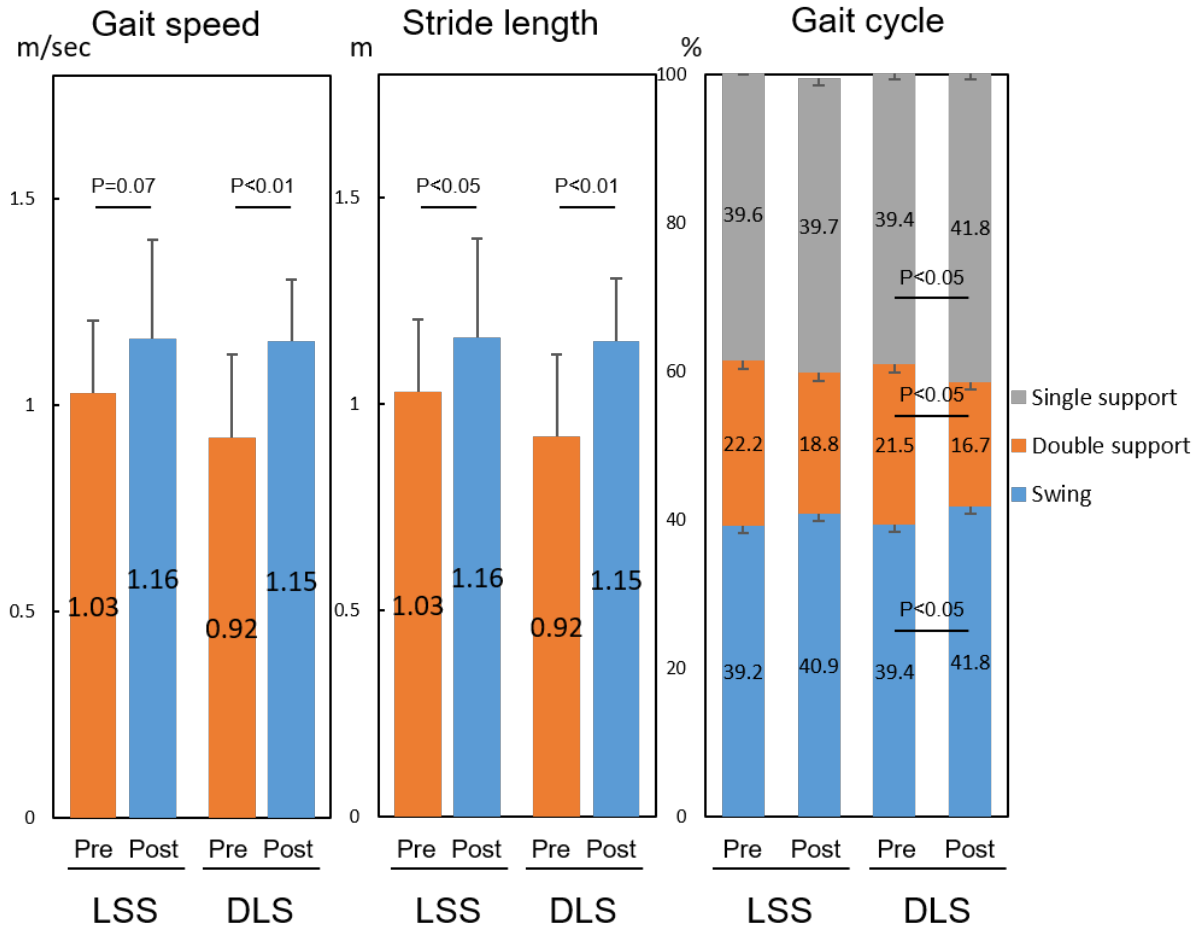
RESULTS: Subject characteristics: There were no significant differences in age, gender, body weight, and body height between DLS and LSS groups.

Gait parameters: There were no significant differences in gait speed, stride length, step width, and cadence between DLS and LSS groups before surgery. The gait speed and stride length in the DLS group after surgery were significantly higher than those before surgery. However, there were no significant differences in cadence and step width between DLS and LSS groups before surgery and after 6 months.

Gait cycle: The swing phase in the DLS group after surgery was significantly higher than that before surgery.

Correlations between radiographic parameters and gait characteristics: Correlation coefficient analyses identified significant correlations between the gait speed/stride length and SVA, LL, and PI-LL before surgery. ($P<0.05$; correlation coefficient 0.51 to 0.64). Correlation coefficient analyses identified significant correlations between the gait speed/stride length and SVA after surgery ($P<0.05$; correlation coefficient 0.65 to 0.77).

DISCUSSION: We have evaluated the gait characteristics of patients with spinal disorders using 3D gait analysis and compared the data between the patients with DLS and LSS. Our study showed that gait parameters/cycle were improved after corrective spinal surgery and gait speed/stride length had a significant correlation with SVA before and after surgery.



1103

Internal Lumbar Disc Derangement with Instability Catch. The Forgotten Mechanical and Kinetic Back Pain Syndrome.

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Introduction. The literature of fusion surgery for back pain relief in “mechanical” back pain reveals inconsistent results and in the majority presents only a vague description of these syndromes. From a retrospective cohort experience reported with concurrent survey PROM outcomes, we describe the results of open PLIF reconstruction for a select group of mechanical back pain patients who have mono- or bi-segmental discopathy on MRI imaging, a clinical history of repeated severe and disabling acute mechanical back pain symptoms, and the irregular lumbar motion pattern in returning erect from the flexed position known as the “instability catch”.

Methods. The senior author (DAB) in midsummer 2015 began to offer smaller fusion procedures to selected patients on an overnight-stay basis using a standard perioperative care protocol. For practice audit, in December 2020 a mailed survey questionnaire requesting VAS pain scores and SF-36 physical function scores was sent out to all 111 patients who had been treated this way, which group included 30 cases of ILDDIC. We report here on the success of open PLIF reconstruction in achieving back pain relief for these patients.

Results. Some 24 of 30 patients returned the mailed survey questionnaire, and the remaining six could not be reached. All 24 reported significant relief of back pain and improved physical function.

Discussion. The diagnosis of ILDDIC requires both imaging and clinical correlates and may define a subgroup of the mechanical back pain population uniquely suited to achieve pain relief through lumbar fusion. Internal Lumbar Disc Degeneration with Instability catch “ILDDIC” may be one subset of these patients who are uniquely benefitted from spine stabilization.

1104

Exploring the Role of an Enhanced Recovery after Surgery (ERAS) Protocol for Elective Lumbar Spine Surgery by Posterior Approach in a Developing Country: A Retrospective, Comparative Study

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Introduction

The integrated multidisciplinary approach of ERAS aims to reduce surgical stress to achieve better outcomes – it has been widely adopted across various surgical disciplines in the past decade. While there are early, encouraging reports of the success of ERAS in spine surgery from developed countries, the design and implementation of an ERAS protocol for spine surgery has not yet been explored in developing countries. The objectives of our study were: i) To design an enhanced recovery after surgery (ERAS) protocol for elective lumbar spine surgery by posterior approach and, ii) To compare the results after ERAS implementation in patients undergoing elective lumbar spine surgery with conventional perioperative care in the setting of a public healthcare facility in a developing country

Methods: Hospital records of adult patients who underwent 1- to 3-level elective lumbar spine surgery (either lumbar decompression or lumbar spine fusion) by posterior approach at a single centre were retrospectively studied. An ERAS protocol was designed based on the prevalent hospital practices, local resources and supportive evidence from literature. The ERAS protocol was implemented in totality at our institute in December 2016 – dividing patients into pre-ERAS and post-ERAS groups. The outcome measures for comparison were: length of hospital stay (LOS), postoperative complications, 60-day readmission rate, 60-day reoperation rate and patient reported outcome measures (VAS and ODI score) at stipulated time intervals.

Results: A total of 944 patients were included – 502 in the pre-ERAS group and 442 in the post-ERAS group. The two groups did not differ from each other in baseline demographic, clinical and surgery-related variables, including the type and number of levels operated upon. While there was no significant difference between the two groups in the rate of postoperative complications (13.2% v/s 11.8%), 60-day readmissions (1.6% v/s 2.1%) and 60-day reoperation (1.1% v/s 1.1%), a significantly shorter LOS (2.72 days v/s 3.52 days) was observed in the post-ERAS group. Patient-reported outcome scores (VAS and ODI) were similar between the two groups at baseline – but were found to be significantly lower in the post-ERAS group (VAS: 46.8 ± 10.4 v/s 42.8 ± 10.2, ODI: 32.6 ± 14.2 v/s 28.6 ± 11.8) at 4 weeks after surgery. This difference, however, was not significant at intermediate follow-up (6 months and 12 months).

Discussion: It is imperative to validate fruitful use of ERAS in different healthcare settings for it to gain global sanction as a standard of care practice. Our results demonstrate the feasibility of applying ERAS to elective lumbar spine surgery in a developing country. Implementation of an ERAS in such a setting leads to shorter LOS and improved early pain and functional outcome scores, without an added incidence of complications or reoperations.

1105

Mental status plays an important role in outcome of spinal stenosis surgery

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Introduction: Mental status can be an important determinant of physical wellbeing. Patients suffering from spinal stenosis are likely to experience their complaints as more disabling if they are depressed or anxious. Likewise, this can also affect postoperative recovery and satisfaction with the surgical intervention. Management of expectations plays an important role in contentment with surgical outcome and it is therefore relevant to appraise the influence of mental status on outcome of spinal stenosis surgery.

Methods: Patients that underwent decompression for spinal stenosis (450 randomly selected patients operated between 2007-2013) were evaluated with patient reported outcome questionnaires after a mean follow up of 9 years. Questionnaires assessing pain and functionality (Oswestry Disability Score; ODI), quality of life (EQ-5D) and satisfaction with the surgery (Likert-7 point scale) were submitted as well as a questionnaire concerning anxiety and depression (Hospital Anxiety and Depression scale (HADS). ODI, EQ-5D and Likert scale outcome were compared between patients that scored deviant on the HADS score (score ≥ 8) and those that scored non-deviant (HADS score < 8). The outcomes were compared between and within these groups using the independent students t-test and chi-square tests.

Results: 147 patients returned the questionnaires (response rate 33%). 115 patients had a HADS score below 8 (non-deviant cases) and 32 patients demonstrated anxiety and/or depression (deviant cases). In the latter group 69% was female; mean age was not different between the groups. The mean ODI score of the deviant cases was 42.46 ±16.24 in contrast to 18.48 ±18.25 for the non-deviant cases ($p < 0.001$). The mean EQ-5D score for the deviant cases was 0.55 ±0.29 whilst the not deviant cases had a mean EQ-5D score of 0.79 ±0.22 ($p < 0.001$). Perceived recovery (Likert score ≥ 6) was reported in 29.0% of the deviant cases and in 78.3% of the non-deviant cases ($p < 0.001$).
In the anxious and/or depressed (deviant) group, only 12.5% had both a good functional outcome (ODI ≤ 24) and reported satisfaction with the outcome of surgery (Likert ≥ 6), compared with 58.4% in the non-deviant group. In the deviant group 68.8% had both an inferior functional outcome and a negative perceived recovery score, compared with 14.1% in the non-deviant group.

Discussion: Patients that report to be anxious and/or depressed demonstrate an inferior long-term outcome after spinal stenosis surgery, in contrast to patients that do not. The difference is convincing and clinically relevant and thus deserves to be addressed in preoperative counseling. Confronting patients with the mean outcome of their peers may improve their expectations of surgery. Future research should be aimed both at the effect of pretreatment with medication to improve anxiety and depression and at the influence of preoperative HADS scores on outcome.

1106

Comparison of Efficacy and Safety of Percutaneous Vesselplasty and Vertebroplasty in Chronic, Non-healing Thoracolumbar Osteoporotic Vertebral Compression Fractures: A Prospective, Comparative Study

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Introduction:

Osteoporotic vertebral compression fractures (OVCF), not responsive to conservative management are often treated with vertebral augmentation procedures (VAP) like vertebroplasty and kyphoplasty. Both these procedures, however, carry a risk of cement leakage causing pulmonary embolism or spinal cord compression. Vesselplasty is a new modification of percutaneous vertebroplasty (PVP) which involves the use of a polyethylene terephthalate (PET) balloon container which serves the dual purposes of creating space within the vertebral body as well as containing the injected cement, theoretically eliminating the risk of cement leakage. We aimed to compare the safety and efficacy of vesselplasty and PVP in patients with chronic, non-healing, symptomatic cases of thoracolumbar OVCF who did not respond to conservative management.

Methods:

Forty-four consecutive patients with chronic thoracolumbar OVCF (duration ≥ 8 weeks) causing severe pain (Visual analogue scale; VAS ≥ 7) and disability attributable to OVCF who were not responding to conservative treatment, were included in the study. Twenty-eight patients underwent vertebroplasty (Group A) and 16 patients underwent vesselplasty (Group B) using a standardized technique. The two groups were compared for difference in the post-procedure physical functionality (SF-36 physical function) and post-procedure VAS scores at one week and three months post procedure. Comparative analysis was also done for reduction in analgesic requirement, volume of cement injected, change in the vertebral body height and rate of complications, including cement leakage.

Results:

A total of 44 patients (31 females; 13 males) with a mean age of 69 years (range: 51 – 83 years) underwent 49 VAPs. Twenty-eight patients underwent vertebroplasty involving 33 vertebrae (Group A) and 16 patients underwent vesselplasty in 16 vertebrae (Group B). The distribution of the fractures by location was as follows: D11 = 9, D12 = 15, L1 = 17, L2 = 8. The two groups did not differ with respect to baseline demographic or clinical characteristics. The mean VAS score at one week (Group A: 3.13, 95% CI – 2.65/3.61 v/s Group B: 3.07, 95% CI – 2.31/3.32) and 3 months post-procedure (Group A: 2.81, 95% CI – 2.31/3.32 v/s Group B: 2.72, 95% CI – 2.36/3.06) was comparable between the two groups. Patients in Group B (vesselplasty) however had a significantly better post-procedure SF-36 physical functionality score at one week and 3 months follow-up. The quantity of cement injected (Group A: 3.84 ml v/s Group B: 4.68 ml), mean increase in anterior vertebral height (Group A: 0.635 mm v/s Group B: 2.472 mm, mean increase in central vertebral height (Group A: 0.63mm v/s Group B: 1.96mm) also differed significantly between the two groups. Cement leakage, though asymptomatic, was seen in 14 patients (50%) in Group A whereas no patient in Group B had a cement leak.

Discussion:

Vesselplasty significantly reduces the incidence of cement leakage in thoracolumbar OVCF with similar or better relief in pain, improvement in disability scores and vertebral body height. It can be a safer alternative to PVP especially in patients with posterior cortical breach.

1107

Multidimensional analysis on residual pain following posterior fusion surgery for lumbar degenerative disorders; A minimum 2-year follow-up

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INTRODUCTION

Symptoms left behind after spine surgery often hamper patients' activities of daily living and reduce their quality of life. However, most reports on residual pain after fusion surgery are based on surgery-related factors, and there have been few multidimensional studies. The purpose of this study was to investigate residual pain after fusion surgery for lumbar degenerative diseases in a multidimensional analysis.

METHODS

The subjects were 232 patients (111 males and 121 females; mean age 67.7 years) who underwent posterior interbody fusion for lumbar degenerative diseases from 2012 to 2019 with no missing data. The preoperative diagnosis was degenerative spondylolisthesis (175 cases), foraminal stenosis (36 cases), and isthmic spondylolisthesis (21 cases). Outcome measures, including the Roland-Morris Disability Questionnaire (RDQ), the Japanese Orthopaedic Association back pain evaluation questionnaire (JOABPEQ), were used to evaluate preoperatively and at 6 months, 1 year, and 2 years postoperatively. The JOABPEQ is a disease specific QOL measure developed in Japan. Its validation study has been completed. It consists of five domains, including "body pain", "lumbar spine function", "locomotive function", "social disfunction", and "mentality". Higher the points, more favorable the results in JOABPEQ.

The presence of residual pain was determined using the domain of “Body pain” in the JOABPEQ. In accordance with previous studies regarding the JOABPEQ, at 6 months postoperatively, those with improvement of 20 points or more compared to the preoperative score were defined as the improved group, and those with improvement less than 20 were defined as the residual group. Statistical analysis was performed using general linear regression to compare between groups, and before and after surgery. Statistical significance was defined as a p-value of less than 0.05.

RESULTS

There were 66 patients in the residual group (30 females; mean age 69.7±8.6 years) and 166 patients in the improvement group (91 females; mean age 66.4±11.2 years). As a whole, RDQ and all domains of the JOABPEQ showed significant improvement postoperatively compared to preoperatively. RDQ and JOABPEQ "Body pain" were significantly higher in the preoperative residual group, compared with the improvement group. At 2 years postoperatively, the residual group demonstrated significantly lower values in RDQ and all domains of JOABPEQ than the improvement group.

DISCUSSION

The residual group was preoperatively found to have less pain than the improvement group, but there was no significant difference in social disfunction and mentality between the groups. The results of this study showed that residual pain at 6 months postoperatively can be a predictive factor for poor prognosis, and it can affect the other domains of the JOABPEQ such as functional disability, social life, and psychological disability. Multidisciplinary pain management from the early postoperative period is important to further improve the outcome after lumbar fusion surgery.

1108

A systematic review of validated classification systems for lumbar and cervical spinal foraminal stenosis based on magnetic resonance imaging

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Introduction In patients with radiating pain in extremities foraminal stenosis is commonly evaluated with radiology, however there is a lack of consensus regarding the methodology to assess the compression of the nerve roots. The purpose of this systematic review was to evaluate validated classification systems for foraminal stenosis in the lumbar and cervical spine based on Magnetic Resonance Imaging (MRI).

Methods A systematic review was performed according to PRISMA guidelines. The systematic search was conducted by a professional librarian in Cochrane, Embase, Medline and PubMed databases for the time period 1980 to september 2021 in English literature using numerous search words within three categories: foraminal stenosis, MRI and scoring. From the yielded search, two of the authors selected articles according to the predefined criteria, including reliability testing of the classification systems.

Results A total of 823 articles were identified based on the used search words. The selection process included initial abstract reviews and thereafter full-text review of 64 articles. Finally 14 articles were included, fulfilling the predefined inclusion criteria. One validated classification system for foraminal lumbar stenosis by Lee et al [1] and two validated classification systems for the cervical spine were identified [2, 3]. The remaining included articles presented validations and modifications of these three classification systems (fig 1 and 2). The reliability was found to be moderate to good for all three classifications, both in the original articles and in the articles validating them.

Discussion The three identified validated classification systems for lumbar and cervical foraminal stenosis demonstrated all moderate to good reliability and have all been shown to be feasible to use in the clinical setting. There is however a need for studies evaluating how valid these classifications are in relation to both clinical symptoms/findings and to surgical outcome data, when used in the surgery selection process.

Fig 1 Lumbar spine. Visualization of the Lee classification system in orange. The diamond shapes are the articles testing and validating the Lee system.

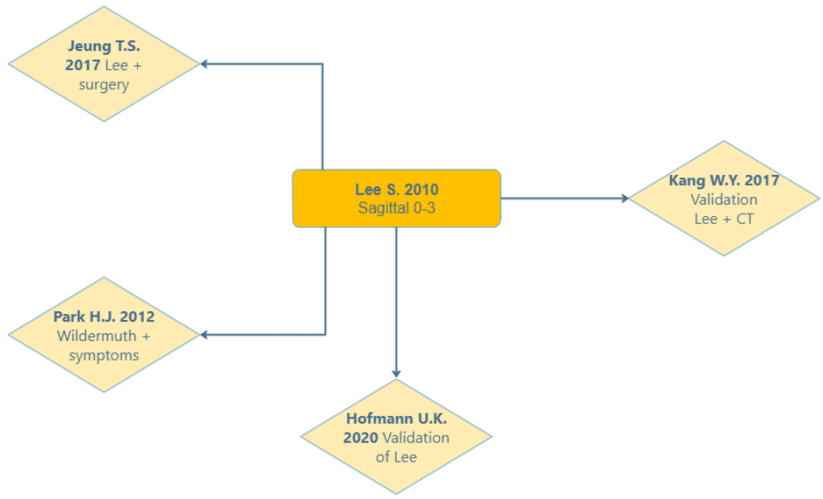
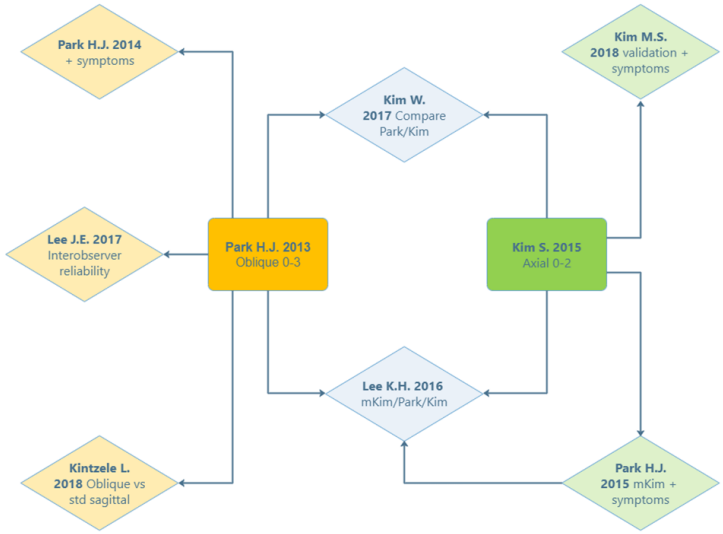


Fig 2 Cervical spine. Visualization of the two major classification systems in orange to the left (Park - oblique sagittal grading) and green to the right (Kim - axial grading). The arrows point in the direction from the origin of the classification system to the correlating article in which it is compared or validated. The light green diamond shaped boxes are articles processing its green predecessor and the orange diamond shapes in a respective manner to the orange box. The blue diamond shapes are articles comparing the two major classification systems



1109

Analyzing the Influence of Chronic Hyperlipidemia on Perioperative Complications of Lumbar Spinal Fusion Using Propensity Score Matching

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Introduction

Degenerative and traumatic disorders of the lumbar spine can be treated with spinal fusion. There are known complications following spinal fusion; however, chronic hyperlipidemia has not been examined for its impact on perioperative complications. Hence, the purpose of this study was to compare the perioperative complications of lumbar spinal fusion in patients with and without chronic hyperlipidemia.

Methods

This study was conducted using the MSpine division of the PearlDiver database. The study included patients with or without chronic hyperlipidemia who had lumbar spinal fusions between 2010 and the first quarter of 2019. The appropriate Current Procedural Terminology (CPT) codes were used to identify patients with single- and multi-level lumbar spinal fusion surgeries. The International Classification of Diseases (ICD-9 and ICD-10) codes were used to identify patients with chronic hyperlipidemia. Using relevant ICD-9, ICD-10, and CPT codes, we retrieved perioperative surgical and medical complications. Propensity score matching analysis was conducted to control for the confounding factors, including age, gender, and Elixhauser Comorbidity Index (ECI). Chi-square test was applied to compare the incidence of complications among patients with and without hyperlipidemia.

Results

In total, 65674 patients with hyperlipidemia (n=18395) and without hyperlipidemia (n=47279) had single-level lumbar fusions. Propensity score matching resulted in 16930 patients in each group.

Patients with hyperlipidemia compared to patients without hyperlipidemia had higher rates of wound complications [481 (2.8%) versus 357 (2.1%), P<0.001], surgical site infection [370 (2.2%) versus 231 (1.4%), P<0.001], failed back syndrome [1914 (11.3%) versus 1605 (9.5%), P<0.001], hardware removal [1006 (5.9%) versus 761 (4.5%), P<0.001], deep venous thrombosis/pulmonary embolism [264 (1.6%) versus 216 (1.3%), P=0.031], myocardial infarction [81 (0.5%) versus 23 (0.1%), P<0.001], cerebrovascular accident [86 (0.5%) versus 39 (0.2%), P<0.001], renal failure [305 (1.8%) versus 197 (1.2%), P<0.001], sepsis [103 (0.6%) versus 51 (0.3%), P<0.001], urinary tract infection/incontinence [697 (4.1%) versus 436 (2.6%), P<0.001].

In total, 48928 patients with hyperlipidemia (n=15527) and without hyperlipidemia (n=33401) had multi-level lumbar fusions. Propensity score matching resulted in 14218 patients in each group.

Patients with hyperlipidemia compared to patients without hyperlipidemia had higher rates of nerve root injury [33 (0.2%) versus 17 (0.1%), P=0.034], wound complications [624 (4.4%) versus 508 (3.6%), P<0.001], surgical site infection [438 (3.1%) versus 307 (2.2%), P<0.001], failed back syndrome [2024 (14.2%) versus 1642 (11.5%), P<0.001], hardware removal [1146 (8.1%) versus 885 (6.2%), P<0.001], revision [922 (6.5%) versus 1055 (7.4%), P=0.002], myocardial infarction [120 (0.8%) versus 41 (0.3%), P<0.001], renal failure [472 (3.3%) versus 313 (2.2%), P<0.001], urinary tract infection/incontinence [810 (5.7%) versus 618 (4.3%), P<0.001].

Discussion

The findings of this study showed that following single- or multi-level lumbar fusions, chronic hyperlipidemia is associated with an increased risk of wound complications, surgical site infection, failed back syndrome, hardware removal, myocardial infarction, renal failure, and urinary tract infection/incontinence. Additionally, chronic hyperlipidemia is associated with an increased risk of nerve root injury and revision rates after multi-level lumbar fusions.

1110

The length of edema in conus medullaris region is a risk factor for long-term (a minimum 2 year follow-up) bladder dysfunction in traumatic conus medullaris syndrome

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Introduction: Neurogenic bladder dysfunction is one of devastating sequelae of traumatic conus medullaris syndrome (T-CMS). The aim of this study was to develop a model for predicting neurogenic bladder dysfunction in a minimum of 2 years after T-CMS development.

Methods: We evaluated 39 patients who presented with acute T-CMS. T-CMS was defined with any neurological deficit (sensory change, leg weakness, or autonomic dysfunction) occurred immediately after trauma, combined with compression due to fractured fragment or epidural hematoma, or signal change of conus medullaris, which were confirmed on MRI. All patients underwent spinal surgery and were followed-up for more than 2 years. At minimum 2 years post-injury, neurogenic bladder dysfunction was scored using SCIM III (0, indwelling catheter; 3, Residual urine volume [RUV] > 100cc, no regular catheterization or assisted intermittent catheterization; 6. RUV < 100cc or intermittent self-catheterization, needs assistance for applying drainage instrument; 9, Intermittent self-catheterization, uses external drainage instrument, does not need assistance for applying; 11, Intermittent self-catheterization, continent between catheterizations, does not use external drainage instrument; 13, RUV <100cc, needs only external urine drainage, no assistance is required for drainage; 15, RUV <100cc; continent; does not use external drainage instrument). Of possible outcome predictors, we evaluated age, gender, cause of injury, American Spinal Injury Association Impairment Scale grade, time to magnetic resonance imaging, fracture level, fracture type, canal diameter, occupation ratio, signal changes in the conus medullaris (normal, edema, hemorrhage), extent of edema, time to surgery, and surgical approach. Comparison was done between patients with continent group and incontinent group. The relationships between these parameters and neurogenic bladder dysfunction were assessed via multivariate logistic analyses.

Results: At the final assessment, fifteen patients (38.5%) had 11 of SCIM III bladder dysfunction score (using catheter), three patients (7.7%) had 13 of SCIM III bladder dysfunction score (using diapers), and twenty-one patients (53.8%) had 15 of SCIM III bladder dysfunction score (continent). Between continent and incontinent groups, the presence of hematoma and the length of high signal change (extent of edema) were significantly different between groups ($P<0.05$). Independent risk factors for bladder dysfunction included only the length of edema in multivariate logistic analyses (adjusted odds ratio = 1. 164, 95% confidence interval = 1.020-1.330).

Discussion: Our results highlight the relatively high prevalence of bladder dysfunction in T-CMS patients in a minimum 2 year follow-up. The length of edema in conus medullaris region was associated with an increased risk for long-term neurogenic bladder dysfunction in T-CMS patients.

1111

Clinical outcome and MRI appearance in a group of chronic low back pain patients over 10 years after thorough radiological evaluation and consideration for surgery

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Introduction:
It is an ongoing debate whether fusion surgery is superior to non-operative treatment for non-specific low back pain (LBP) in terms of patient outcome [1; 2]. Further, the evidence for how signs of intervertebral disc (IVD) degeneration on magnetic resonance imaging (MRI) correlate with patient outcome is insufficient. Longitudinal studies of LBP patients are thus of interest for increased knowledge. The current aim was to investigate the long-term self-reported patient outcome and longitudinal MRI appearance in LBP patients, in a group of patients in whom discography had been performed as diagnostic guidance at baseline.
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Methods:
30 LBP patients, prospectively enrolled year 2007-2010 in a comparative discography-MRI study (1.5T, sagittal T2/T1-weighted) were asked to participate in this long-term follow-up. The reason for discography at baseline was LBP (>6 months), severe enough to consider surgery. Those accepting to participate in the follow-up performed MRI year 2021 and answered validated questionnaires (VAS/ODI/EQ5D). MRIs (Th12-S1) at baseline and follow-up were evaluated, blinded, according to Pfirrmann classification, Endplate Classification Score (EPS) and HIZ. Each IVD segment was also classified into if surgery (any type of fusion) had been performed between baseline and follow-up. Numbers of IVDs with Pfirrmann≥3, IVDs with HIZ and segments with EPS≥4 per individual were calculated and fused segments allocated in the high score Pfirrmann and EPS groups.

Results:
17 patients (6 male/mean 58.5 years; range 49-72), accepted participation, at this 11-14 year follow-up. Reasons for not participating were; 2 deceased, 5 unreachable, 1 had obtained a non-MR compatible device and 5 declined participation. Between baseline and follow-up, 10 patients (27 IVDs) had undergone fusion surgery, including all lumbar levels in 2 patients and 1-3 IVDs in 8 patients. No significant differences were found regarding VAS/ODI/EQ5D between the surgical patients (mean;51/32/0.54) and the non-surgery patients (mean;50/37/0.40) ($0.77<p>0.65$). Neither were any significant differences for MRI parameters at baseline nor at follow-up found, except for significantly more HIZ IVDs at follow-up in the non-surgery group ($p<0.05$) (Fig1). Comparing the groups regarding longitudinal changes of MRI parameters, no differences were found, except for more segments with EPS≥4 in the surgery group ($p<0.05$) (Table 1).

Discussion:
In this group of chronic patients with LBP, severe enough to be considered for fusion surgery, no differences in self-reported patient outcome could be established at the long-term follow-up between patients treated with or without surgery. Further, over a period of more than 10 years, only minimal differences were found between the groups in terms of in changes of MR parameters. Thus, this study confirms the complexity of LBP and that based on MRI appearance at baseline, neither long-term self-reported patient outcome, nor progression of degeneration can be anticipated.

Figure 1. Pairs of sagittal MRI at baseline (left) and follow-up (right) for the 7 individuals who had not undergone surgery during the follow-up period

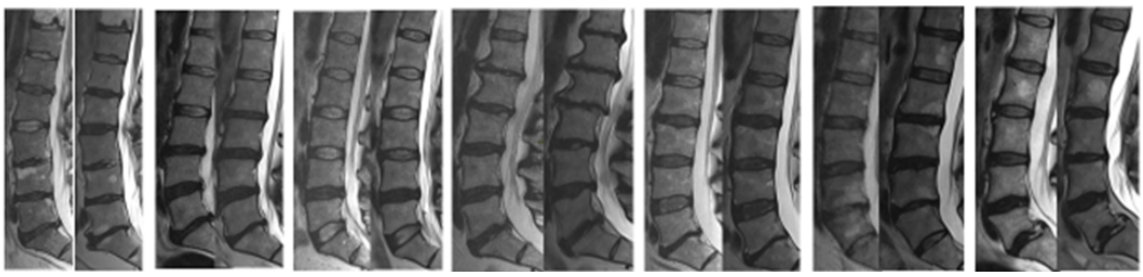

Table 1: MRI parameters at baseline and follow-up for patients with and without surgery during the follow-up period.

	Baseline			Follow-up			Change from baseline		
	no surgery n=7	surgery n=10		no surgery n=7	surgery n=10		no surgery n=7	surgery n=10	
per individual	mean(SD)	mean(SD)	p-value	mean(SD)	mean(SD)	p-value	mean(SD)	mean(SD)	p-value
Pfirrmann≥3	3.1(1.07)	3.2 (0.8)	0.96	3.9 (1.57)	5.1 (1.1)	0.09	0.7 (1.1)	1.9 (1.5)	0.098
Endplate Score (EPS)≥4	2.0 (1.3)	1.1 (0.9)	0.14	3.0 (2.0)	4.10 (1.37)	0.29	1.0 (1.4)	3.0 (1.9)	0.037
HIZ	1.9 (1.2)	2.0 (0.94)	0.60	1.1 (0.9)	0.3 (0.5)	0.047	(-)0.7 (0.9)	(-)1.7(0.9)	0.065

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Anterior Column Realignment versus Hybrid Minimal Invasive-Lateral Lumbar Interbody Fusion for Degenerative Sagittal Imbalance

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Introduction: There are few reports on comparative study between anterior column realignment (ACR) through conventional approaches (pre-posterior release-anterior-posterior surgery, PAP) and minimal invasive surgery–lateral lumbar interbody fusion (MIS-LLIF) through hybrid approaches (anterior-posterior surgery, AP) for severe DSI. Therefore, this study was to investigate radiographic and clinical outcomes after surgical correction for adult spinal deformity (ASD) with degenerative sagittal imbalance (DSI) by 2 different surgical procedures.

Methods: This retrospective study included a total of 91 patients (average age 69.7 years) who had undergone two different surgical procedures for ASD with DSI between May 2012 and July 2019. Inclusion criteria were 1) age > 65 years, 2) ASD with DSI, 3) long-segment fusion from T10 to sacrum with sacropelvic fixation using bilateral iliac screws, 4) posterior 2-rod instrumentation, and 5) patients undergone LLIF on 3 or more segments from L1 to L5, and/or posterior lumbar interbody fusion (PLIF) or anterior lumbar interbody fusion (ALIF) for L5-S1. Hybrid MIS-LLIF was performed on 26 patients as AP group, and ACR was performed on 65 patients as PAP group. Clinical data collected from medical records included age at the index surgery, sex, body mass index, smoking history, bone mineral density, Charlson Comorbidity Index and previous spinal surgery. Spinopelvic parameters in whole spine standing radiographs were collected and compared at preoperative and regular postoperative follow-ups. After 1:1 propensity-score matching, 24 pairs of patients in each group were selected and analyzed again.

Results: Operative time was longer and estimated blood loss was greater in PAP group than AP group ($p<0.05$). ICU care was needed in 15.4% of AP group and 23.1% of PAP group without statistical significance ($p>0.05$). Also, The incidences of other perioperative complications were not different between the two groups. Although preoperative LL and PI-LL were lower in PAP group, T1 pelvic angle and pelvic incidence minus lumbar lordosis were better in PAP group. However, proximal junctional angle was higher at postoperative 3-month and the last follow-up in PAP group than AP group ($p=0.001$ and 0.047, respectively). T1PA, PI-LL, and sagittal vertical axis were not different between the two groups at the last follow-up. Before matching, the incidence of PJK/PJFs was similar between these two groups (19.2% in AP and 26.2% in PAP, $p>0.05$). However, the incidences of sagittal imbalance without PJK/PJF (34.6% in AP and 3.1% in PAP, $p=0.014$) and rod fracture (3.8% in AP and 24.6% in PAP, $p=0.008$) were different between the two groups. After matching for age, BMI, and BMD, 24 patients in each group were included. The incidences of sagittal imbalance without PJK/PJF (37.5% in AP and 4.2% in PAP, $p=0.036$) and rod fracture (4.2% in AP and 33.3% in PAP, $p=0.01$) were also different between the two groups

Discussion: Although PAP group achieved more correction of sagittal malalignment, PAP group showed higher tendency of mechanical complications. However, the rate of revision surgery was not significantly different between the two groups. We suggest surgeons should choose each treatment with considering their own advantages and disadvantages.

1113

Development of a machine-learning based model for predicting multidimensional outcome after surgery for degenerative disorders of the spine

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INTRODUCTION Recent years have seen the emergence and increasing use of patient-reported outcomes in clinical studies of treatment effectiveness, and it has become clear that individual outcomes can be quite heterogeneous. When consenting a patient for surgery, it is important to be able to offer an evidence-based, individualised prediction regarding the likely outcome. This study used a comprehensive set of data collected over 12 years in an in-house registry to develop a parsimonious model to predict the multidimensional outcome of patients undergoing surgery for degenerative spinal pathology.
METHODS Data from 8374 patients (mean age 63.9 (14.9-96.3) yrs, 53.4% female) were used for model development, predicting the 12-month scores for the Core Outcome Measures Index (COMI) and its subdomain scores. The data were split 80:20 into a training and test set. The top predictors were selected by applying recursive feature elimination based on a Lasso cross validation model retaining the top 15 predictors (out of 172) per outcome, allowing the retention of a practical number of 20 (out of 39) input variables to be used as a clinical decision-support system (CDSS). Based on the 111 top predictors (of the 20 variables), Ridge cross validation models were trained, validated, and tested for each outcome dimension.
RESULTS Preoperative back and leg pain, nationality, the number of previous spine surgeries, age, type of intervention, preoperative quality-of-life, body-mass index, number of affected levels, Charlson comorbidity, and ASA score, were among the strongest outcome predictors in most models. The R-squared of the models on the validation/test sets averaged 0.16/0.13. Models based on all 39 input variables performed only slightly better in terms of R-squared (0.17/0.14) underlining the good performance of the CDSS based on 20 input variables. A preliminary online tool was programmed to present the predicted outcomes for individual patients, based on their presenting characteristics.
DISCUSSION The prediction models provide reliable estimates to enable a bespoke prediction of the outcome of surgery for individual patients with varying degenerative pathologies and baseline features. The models form the basis of a simple, freely-available online prognostic tool developed to improve access to and usability of prognostic information in clinical practice. This should serve to facilitate decision-making and assist in managing patient expectations.

1114

Autologous mesenchymal stem cells in the treatment of spinal aneurysmal bone cyst

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INTRODUCTION

Aneurysmal bone cyst (ABC) of the spine is a locally aggressive benign lesion which can be treated by en bloc resection with wide margin to reduce the risk of local recurrence. To avoid morbidity associated with surgery, selective arterial embolization (SAE) can be considered the first-line treatment for ABCs of the spine. Other emerging treatments for ABCs include bisphosphonates, percutaneous doxycycline, sclerotherapy and Denosumab. In addition, we previously introduced the use of autologous bone marrow concentrate (BMC) injection therapy to stimulate bone healing and regeneration in ABC of the spine. One of the potential advantages of such a method is that surgical treatments are not necessary, thus allowing for both a minimally invasive approach and the treatment of poorly accessible lesions.
In this prospective study we described the clinical and radiological outcomes of percutaneous injection of autologous BMC in a series of patients affected by ABCs of the spine and followed for at least one year.

METHODS

Fourteen patients (6 male, 8 female) were treated between June 2014 to December 2019 with BMC injection for ABC of the spine. The mean age was 17.85 years. The mean follow up was 37.4 months (range 12- 60 months). The dimension of the cyst and the degree of ossification were measured by Computed Tomography (CT) scans before the treatment and during follow-up visits.

RESULTS

Six patients received a single dose of BMC, five patients received two doses and in three patients three doses of BMC were administered. The mean ossification of the cyst (expressed in Hounsfield units) increased statistically from 43.48±2.36 HU to 161.71±23.48 HU during follow-up time and the ossification was associated to an improvement of the clinical outcomes. The mean ossification over time was significantly higher in patients treated with a single injection compared to patients treated with multiple injections. No significant difference in ossification was found between cervical and non-cervical localization of the cyst. Moreover, the initial size of the cyst was not statistically associated with the degree of ossification during follow-up.
We also observed that five out of six female patients (83.3%) were less than sixteen years old and four of these (66.7%) were managed with a single dose of BMC injection, while a higher percentage of male patients (6/8, 75%) were more than sixteen years old and more than one injection was administered to them.

DISCUSSION

The results of this study reinforce our previous evidence on the use of BMC as a valid alternative for spinal ABC management when SAE is contraindicated or ineffective.
The initial size of the cyst and its localization does not influence the efficacy of the treatment. However, BMC injection could be indicated as treatment of choice for spinal ABC in young adolescent women.

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Performance Outcomes and Contract Signings in National Football League Players Treated for Lumbar Disc Herniation

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Introduction: Lumbar disc herniation (LDH) is a debilitating injury that results in significant morbidity and loss of playing time among professional athletes of high-impact contact sports such as American football.[1] Previous studies have found that return to play (RTP) rates following surgery for a LDH range from 72.7% to 80.8%.[2-5] As the perceived implication of a LDH can include the loss of income, poor performance, or the end of a career,[6] it is important to assess the impact, if any, that LDH and its management may have on the professional football player's ability to sign future contracts.

Methods: National Football League (NFL) players treated for LDH from 2000-2020 were identified from a public records search. Age, position, type of treatment, and return to play measures were collected. Pro Football Focus (PFF) performance grade and contract values were compared before injury and after treatment. Multivariable logistic regression was used to identify independent risk factors associated with ability to return to play and sign high-value contracts.

Results:101 players were treated for a LDH, of which 75 returned to play. Post-treatment performance as measured by PFF was similar to pre-injury levels ($p=0.2$). However, both total and guaranteed contract values were significantly reduced ($p<0.01$). In multivariable analysis, both lower age and higher pre-injury PFF grade were independent predictors of return to play and ability to sign a new contract. A pre-injury contract that contained a high proportion of guaranteed money was found to be an independent predictor of ability to sign a contract that was >20% guaranteed.

Conclusion: Although the majority of players were able to return to play at preserved performance levels following LDH treatment, their contract values were significantly reduced. RTP and contract-signing ability were not associated with the type of treatment, but rather baseline factors such as the player's age, performance, and pre-injury compensation.

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1116

Comparison of short versus long fusion in lumbar adult spinal deformity: surgical, radiographic and patient-reported outcomes.

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INTRODUCTION

Lumbar adult spinal deformity (ASD) represents a challenge to the physician as there is currently no established decision-making pathway to determine the optimal surgical treatment. The ideal procedure aims to limit the extensiveness of surgery without compromising the outcome, though in practice many uncertainties exist. The aim of this study was to compare the surgical, radiographic and patient-rated outcomes in patients with ASD of the lumbar spine undergoing either short fusion (SF; max 2 levels) or long fusion (LF; 3 or more levels), while controlling for potential confounders.

METHODS

An international, multicentre database (7 European sites, 4 countries) containing the prospectively collected data from patients with adult deformity was searched for patients with deformity of either a degenerative or idiopathic origin, undergoing fusion surgery that included the lumbar spine (for SF, upper instrumented vertebrae L1 or below; for LF, T10 or below), at least 1yr ago. We identified 57 SF and 137 LF patients. Propensity score (PS) adjustment was used to evaluate the difference in outcome between the treatment groups, controlling for relevant baseline variables (age, ASA classification, SRS-22 subtotal score, relative lumbar lordosis, coronal Cobb angle, NRS back pain (% compared with leg pain as well as average pain intensity), sagittal and coronal balance, spondylolisthesis, central stenosis, and osteoporosis/osteopenia). Surgical outcomes (blood-loss, duration of surgery, length of stay) as well as 1-yr patient-rated outcomes (SRS-22) and coronal and sagittal curves were evaluated.

RESULTS

Compared with long fusion, short fusion was associated with less blood-loss during surgery (by 725ml, 95%CI 613-838; p<0.001), a shorter duration of surgery (by 86 min, 95%CI 66-107; p=0.001), and a shorter length of stay (by 3.5 days, 95%CI 2.5-4.5, p=0.001). However, at 1-yr follow-up, it was associated with a higher TL/L coronal curve (by 12.1 deg, 95% CI 9.5-14.6; p<0.001), a higher LS/S coronal curve (by 4.3 deg, 95% CI 2.9-5.8; p<0.001) and a lower relative lumbar lordosis (by 6.4 deg, 95% CI 3.5-9.4; p<0.001). SRS-subtotal scores at 1yr (completed by 74% of all patients) were slightly, but not significantly better in the short fusion group (by 0.11 points, 95%CI, -0.03-0.25; p=0.13); similarly, sagittal balance showed no significant difference between the groups (difference, 0.37, 95%CI, -8.5-9.3; p=0.93).

DISCUSSION

In analyses that controlled for potential confounders, short fusion was shown to be significantly less complex than long fusion — as evidenced by the shorter duration of surgery, lesser blood loss and lesser curve correction — and appeared to have no significant influence on patient-rated outcomes. This likely reflects appropriate and careful patient selection in this cohort. Further analyses of the selection procedure are warranted to refine indications for longer fusion and determine whether there exists, for example, a maximum level of deformity that can still be treated successfully with short fusion.

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THE IMPACT OF THE COVID-19 PANDEMIC ON SPINE SURGERY PRACTICE AND OUTCOMES IN AN URBAN HEALTHCARE SYSTEM

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Introduction

Significant health care accessibility and administrative restrictions were imposed on hospitals providing care for individuals with spine pathology during the first wave of the COVID-19 pandemic. The purpose of this study was to elucidate the effect of COVID-19 on patient demographics, surgical care, logistics, and patient outcomes in spine patients.

Methods

This is a retrospective study of patients who had spine surgery at UCSD from 3/1/19 to 5/31/19 (pre-COVID-19) and 3/1/20 to 5/31/20 (first COVID-19 surge). 331 subjects met the study criteria. Demographic and surgical data were collected from medical records. Pain levels at pre-operative, discharge, short- (3-6 month) and long-term (9-15 month) timepoints were extracted.

Results

There were no significant differences in patient demographics including age, BMI, gender, race, ethnicity, ASA rating, smoking status, or diabetes status between groups ($p>0.14$). The diagnostic indications for surgery of spondylolisthesis, scoliosis, tumor/infection, and spondylosis/stenosis were less prevalent during COVID-19 ($p<0.012$), whereas a diagnostic indication of fracture was more prevalent ($p<0.001$). There were no differences in operating room duration and skin-to-skin time ($p>0.64$); however, length of stay was 4.7 days shorter during the COVID-19 pandemic ($p=0.03$), and more cases were classified as 'urgent' ($p=0.04$). There were less postoperative complications at 90 days ($p=0.02$), a lower reoperation rate ($p<0.01$), and a lower 90-day readmission rate ($p=0.04$) during COVID-19. Preoperative pain scores did not differ between groups ($p=0.58$); however, pain levels at discharge were significantly higher in patients operated upon during COVID ($p=0.04$). Pain scores trended towards remaining higher in the short- ($p=0.06$), but not long-term ($p=0.21$) after surgery (Table).

Discussion

The pandemic resulted in a greater proportion of 'urgent' spine surgery cases and shorter hospital length of stay. Individuals undergoing surgery during this time had fewer surgery related complications and reoperations, potentially indicating more stringent patient selection. Pain levels upon discharge and at short-term timepoints were higher following surgery; however, these differences did not persist in the long term.

1118

Interbody fusion does not influence development of lumbar compensatory mechanisms 10 year after lumbar fusion

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INTRODUCTION: Restoration of lumbar lordosis in lumbar spine surgery is thought to be associated with better postoperative outcomes. Various inter- body fusion techniques can theoretical help to change and correct sagittal balance. Pelvic plays a central role in sagittal balance. The Three key pelvic parameters are pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS). The last 2 can change due to compensatory mechanism. Decrease in SS is posed to increase risk of adjacent segment degeneration (ASD) Aim: To assess radiographic signs of degenerative changes and compensatory mechanisms after lumbar fusion at 10 year follow-up and their relation to outcome comparing posterolateral instrumented fusion (PLF) to Transforaminal interbody lumbar fusion (TLIF) in a RCT

METHODS: 100 pat. enrolled in a RCT between TLIF and PLF had standing lumbar radiographs analyzed with respect to olisthesis, lordotic angle at adjacent level (AL) and differences in SS. SS was determined by PI = PT + SS. Clinical outcome was measured by Owestry disability index (ODI) and SF-36 Physical Function (PF), Bodily pain (BP) and Physical Component Summary(PCS). Data was analyzed using STATA

RESULTS: There was no difference in development of olisthesis at the (AL) between the two groups at 10 year follow-up (p=0.43). Lordotic angle of the adjacent disc decreased with 5 or more degrees in 6 patients in the TLIF group and 3 in the PLF group. Three pats in the TLIF group and 4 in the PLF group had an increase in lordotic angle at the adjacent disc, the remainders were unchanged (p=0.58). Five pat. in the TLIF group and 7 in the PLF groups had a decrease in SS of 5 degrees or more (p=0.51).There was no difference in ODI score nor PF, BS & PCS at 10 year follow-up between those who developed changes in adjacent disc angle and those who remained unchanged (p=0.49, p=0.20, p=0.94 p=0.65). The same held true for changes in SS (p=0.46, p=0.49, p=0.39, p= 0.58)

DISCUSSION: No difference between the two fusion methods with respect to degenerative changes visible on radiographs at 10 years follow-up. Signs suggesting development in compensatory mechanisms (SS) was not associated with poorer clinical outcome

1119

Does Interbody fusion change ASD in disc next to the fusion? – 10 years MRI follow-up on a randomized controlled study

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INTRODUCTION: Due to the increasing number of spinal procedures performed worldwide, adjacent degenerative disease (ASD) has become a new focus area. Whether ASD is a matter of normal degenerative development in the disc over time or a result of increased stiffness and stress due to the fusion is still debated. Nowadays TLIF is the most widely used interbody fusion method. The use of inter- body fusion has be claimed to reduce the degenerative changes in the spared free disc over time due to better sagittal balance and restoration of the lost lumbar lordosis. Aim: To compare degenerative changes on MRI between PLF and TLIF 10 years post surgery.

METHODS: 100 patients included in a prospective RCT between inter-body fusion and Instrumented posterolateral fusion were seen in the outpatient clinic and offered a MRI at long term follow-up. All MRI were classified according to degree of Modic changes, Pfirmanns classification, Schizas classification and Fardon and Milette classification in order to show the degree of degeneration of the discs above and below the fusion. The grading was done by to independent observers without any contact to the patient. In patients who underwent secondary surgery, the MR prior to that was used and the degenerative changes measured according to the above mentioned classifications.

RESULTS: 79 patients were available for long-term follow up. The groups were equal regarding sex, age, diagnosis and number operated levels. The follow up length was 9.6 years. The Modic change found at the first upper level was none in (85%/68%), mostly grade 2 (12%TLIF/26%PLF). There were no significant difference between the two groups p=0.274. Nearly all patients did not show any sign of treatment needs regarding spinal stenosis according to Schizas classification 92%/92% only 8/8% had type C and D at the 1 proximal level 9.6 year after surgery. No difference between groups could be detected p = 0.930. The Pfirmann grading at the first proximal level did not show any difference between groups,too p = 0.952.

DISCUSSION: In a prospective randomized design the use of inter-body fusion do not reduce the amount of degenerative changes in the first proximal disc in comparison to a normal posterolateral instrumented fusion.

1120

THE VERTEBRAL BONE MARROW CLOT AS NEW AND ADVANCED AUTOLOGOUS CELL THERAPY IN SPINAL SURGICAL PROCEDURES

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INTRODUCTION

Due to the presence of megakaryocytes, platelets and clotting factors, bone marrow aspirate (BMA) tends to coagulate. For the first time, starting from our previous studies on mesenchymal vertebral stem cells, it has been hypothesized that coagulated BMA represents a safe and effective autologous biological scaffold for bone regeneration in spinal surgery. The present research involved advanced preclinical in vitro models and the execution of a pilot clinical study.

METHODS

Evaluation of cell morphology, growth kinetics, immunophenotyping, clonogenicity, trilineage-differentiation, growth-factors and HOX and TALE gene expression were analyzed on clotted- and un-clotted human V-BMA (1). In parallel, a pilot clinical study on ten patients with degenerative spine diseases submitted to instrumented posterior arthrodesis, is ongoing to assess the ability of clotted-V-BMA to improve spinal fusion at 6- and 12-months follow-up.

RESULTS

Results demonstrated that clotted-V-BMA have significantly higher growth-factor expression and mesenchymal stem cell (MSCs) viability, homogeneity, clonogenicity, and ability to differentiate towards the osteogenic phenotype than un-clotted-V-BMA. Clotted-V-BMA also highlighted significant reduced expression of PBX1 and of MEIS3 genes negatively involved in osteoblast maturation and differentiation. From December 2020, eight patients have already been enrolled with first promising results that will be finally evaluated in the next two months.

DISCUSSION

The application of V-BMA-clot as carrier of progenitors and cytokines and as natural scaffold with a structural texture represents a point-of-care orthobiologic product to improve spinal fusion. Clinical application seems to be efficacy, and we will confirm and strengthen these data with the final results of the pilot clinical study.

1121

Incidence and Risk Factors Of Rod Fracture After Pedicle Subtraction Osteotomy Using Side-Tightening Pedicle Screw System

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Introduction:

Rod fractures (RF) after pedicle subtraction osteotomy (PSO) for sagittal imbalance are not uncommon. Because previous reports analyzed cases using popular top-tightening pedicle screw system, there has not been a study reporting RF after PSO using side-tightening (ST) pedicle screw system. The purpose of this study was to investigate the incidence and risk factors of RF after a single-level lumbar PSO using a ST pedicle screw system.

Material and Methods:

Fifty-seven consecutive patients who underwent a single-level lumbar PSO for their degenerative sagittal imbalance at a single institution were retrospectively reviewed. All surgeries were performed by a single surgeon using a ST pedicle screw system. Demographic, surgical, and radiographic data were analyzed to investigate the prevalence and risk factors for RF.

Results:

Seven (12.3%) patients showed RF after PSO. Four patients had bilateral RFs and three patients had unilateral RF. The location of RF was at the PSO level in 6 of 7 patients. The ratio of adjacent interbody fusion was significantly different between the group with RF and the group without RF (16.7% versus 74.0%, P=0.004). Radiographic measurements revealed that preoperative segmental angle at the PSO vertebra (-6.1° ± 5.5° versus -1.7° ± 4.6°, P=0.049) and postsurgical change in LL (48.4° ± 8.8° versus 37.8° ± 11.9°, P=0.033) were significantly different between the two groups. Risk factor analysis using stepwise logistic regression analysis revealed that the absence of adjacent interbody cages (odds ratio [OR]: 0.011, 95% confidence interval [CI]: 0.000-0.390, p = 0.013) was a significant risk factor.

Discussion:

The incidence of RF after a single-level lumbar PSO using ST pedicle screw system was 12.3%. Absence of adjacent interbody cage was a significant risk factor for RF in our series.

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Do Robotic Procedures Have Improved Perioperative Outcomes After Overcoming the Learning Curve?

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Background: Robot-assisted surgical techniques are being increasingly implemented in spine surgery to increase accuracy and mitigate surgeon stamina. There are known variations in the learning curve required for effective use however literature on the effect of robot-assisted techniques on perioperative outcomes, after overcoming the learning curve, remains scarce.

Methods: Robot-assisted cases were isolated from a single-center multi-surgeon database. Cases were ranked by the date of surgery into 3 tertiles. The 1st Tertile, 2018, denoted as "Early," was analyzed against the 3rd Tertile, 2020, denoted as "Late." Univariate analysis was used to assess differences between tertiles. Propensity score matched (PSM) cohorts of patients who underwent identical surgical procedures (matched for age, BMI, levels fused, surgical approach, and type of interbody fusion) without robotic assistance were included as control groups and compared to both Early and Late groups.

Results: A total of 388 patients met inclusion criteria (Age: 56±12.5, BMI: 30±6, 42% female). 26.3% had an ALIF, 11.3% had an LLIF, and 57.7% had a TLIF. The Early group had 110 patients and the Late group had 112. Comparison of Early vs Late baseline demographics showed no differences in age, BMI, gender, or ASA status. The Early and Late groups had similar levels fused (2.14 versus 2.18, p=0.8), comparable LOS (4.3 vs 4.5 days, p=0.7), comparable operative time (288min vs 310 min, p=0.35), comparable return to the OR by 30 days (4% vs 2%), and comparable return to the OR by 90 days (12% vs 9%, p=0.62). Late cohort had more levels decompressed (2.3 versus 0.9, p<0.001). The Late group had a lower EBL (604ml vs 367ml, p= 0.043), fewer intraoperative complications (5% vs 10%, p=.2), and less postoperative complications (54% vs 39%, p= =0.025),). Compared to the control group (no robotic assistance), the Early robotic cohort had less return to the OR by 30 days (4% vs 15%,p=0.12) and 90 days (12% vs 15%, p=0.6). Conversely, the Early robotic cohort had a higher EBL (604ml vs 551ml, p=0.16). There was comparable LOS (4.5 vs 4.5 days, p=0.4), operative time (310min vs 330min p=0.31), intraoperative complications (10% vs 12%, p= 0.52), and postoperative complications (54% vs 54%, p =0.4) between the Early robotic cohort and the control group. Compared to the control group, the Late robotic group had a lower EBL (367ml vs 550ml, p= 0.007), shorter operative time (288min vs 330 min, p= 0.005), less return to the OR by 30 days (2% vs 15%, p=0.028) and 90 days (9% vs 15%, p=.33), less intraoperative complications (5% vs 12%, p =0.074), fewer postoperative complications (54% vs 39%, p =0.04). There was comparable LOS (4.4 vs 4.5 days, p=0.6) between the Late robotic group and the control group.

Discussion: There is a substantial learning curve that exists prior to maximizing the surgical outcomes after robot-assisted spine surgery. Increasing caseload over time helps mitigate the learning curve, resulting in shorter LOS, less blood loss, and fewer complications. These outcomes may be superior to those experienced by patients undergoing non-robotic surgery.

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Durability of Alignment in the Sagittal Age-Adjusted Score Following Surgical Adult Spinal Deformity Correction

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Introduction: Despite multiple reports showing positive long-term alignment outcomes following adult spinal deformity (ASD) corrective surgery, it is still unclear to the effect of which this is true regarding the Sagittal age-adjusted score (SAAS).

Methods: Included: ASD surgical patients (≥18yrs, scoliosis≥20°, SVA≥5cm, PT≥25° and/or TK>60°) with available baseline (BL) radiographs, and 1-year postop (1Y) radiographs for patients matched in Sagittal age-adjusted score (SAAS, 1 < x > -1points) at 1Y. Patient cohorts were created: those remaining matched in SAAS beyond 1Y postop (sustained alignment), and those who did not (deteriorated alignment). Means comparison tests assessed differences in patient-related and surgical variables between cohorts. Significance was set $p<0.05$.

Results: Included were 220 surgical ASD patients (57.7yrs, 27.4kg/m2, 77% Female, CCI: 1.49), all of which were matched in SAAS at 1Y postop. 116 patients (52.7%) went from unmatched in SAAS at BL to matched at 1Y postop. Adjusted for patients lost to follow-up, patients matched in SAAS following their 1Y postoperative interval was: 71.0% at 2Y postop, 59.1% at 3Y, and 33.7% at both 2Y and 3Y. There were no differences in BL age, BMI, CCI, mFI or surgical variables (Levels fused, LIV, UIV, OpTime, EBL) between sustained alignment and deteriorated alignment cohorts. Patients who sustained alignment beyond 1Y had better outcomes as shown by the ODI (20.6 vs. 28.5; p=0.039), SF-36 Role physical (46.0 vs. 40.6; p=0.038), and SF-36 Body Pain (45.4 vs. 41.0; p=0.040) at 1Y follow-up.

Conclusions: SAAS is a novel ASD classification system with three age adjusted radiographic parameters. Once postop matched alignment is achieved, a substantial amount of patients remain matched at subsequent follow-ups and these patients are observed to have superior reported outcomes.

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Navigational Assistance in Interbody Device Placement Optimizes Realignment in Adult Spinal Deformity Patients

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INTRODUCTION: Minimally-invasive surgery (MIS) and associated robotic or navigational guidance is being increasingly implemented due to its potential to increase surgical accuracy while reducing the risk for complications associated with open spine surgery. However, there remains a paucity in literature as to the patients who may best benefit from MIS surgery in terms of interbody device (IBD) placement.

METHODS: Operative ASD patients undergoing surgery utilizing navigational guidance in IBD placement with pre-(BL) and 1-year(1Y) postop radiographic/HRQL data were included. At 1Y, a favorable outcome was defined as meeting at least 2 of the following 5 criteria: 1) improving in at least 1 GAP or age-adjusted criteria at 1Y 2) achieving ideal PT per SRS-Schwab at 1Y, 3) Achieving ideal PI-LL per SRS-Schwab at 1Y, 4) No adjacent segment reoperation, 5) No complication requiring reoperation. Means comparison analysis assessed differences in radiographic and patient-reported outcomes at BL and 1Y post-op.

RESULTS: 72 MIS patients (59.9±13.1 years, 59.7% female, 28.8±5.5 kg/m^2, mean CCI: 0.86±1.215) were included. 20 patients (27.8%) considered optimized. Optimized patients were significantly more likely to be female (p=.013). At BL, optimized patients had a significantly lower S1PI than non-optimized patients (p=.005), as well as lower mean PI-LL (p=.020), and higher L4-S1 lordosis (p=.033). Perioperatively, optimized patients had a higher mean LIV (p=.037), were less likely to undergo ALIF (p=.000), and more likely to undergo LLIF, XLIF, or OLIF (p=.000). Furthermore, optimized patients were less likely to be administered BMP (p=.001). In terms of op time and intraoperative complications, optimized patients experienced significantly higher mean op time (p=.001), yet lower rates of intraoperative complications (p=.000). Optimized patients had a significantly lower mean S1PT than non-optimized patients (p=.038) at 1Y. Additionally, optimized patients had significantly lower 1Y L1PA (p=.021) and L4PA (p=.009). In terms of post-operative complications, optimized patients were significantly less likely to experience post-operative neurological complications (p=.009).

DISCUSSION: Despite increased operative time associated with optimizing IBD placement in MIS patients, such patients demonstrated significantly improved radiographic deformity markers and reduced neurological complication rates by 1Y.

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Assessing the Incremental Benefits of Minimally Invasive Surgery for Frail Adult Spinal Deformity Patients

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INTRODUCTION: Minimally-invasive surgery (MIS) is an emerging and increasingly utilized technique within spine surgery that may facilitate recovery and increase fusion rates. Yet, there remains a paucity in literature as to the potential increased incremental benefit MIS spine surgery may offer frail patients. This study sought to assess if frail and severely frail patients undergoing minimally invasive spine surgery will display increased incremental patient-reported, perioperative, and post-operative benefits as compared to not-frail patients.

METHODS: 820 Operative MIS patients undergoing surgery with pre-(BL) and 1-year(1Y) postop radiographic/HRQL data were included. Patients were stratified into 3 groups: Not Frail (NF), Frail (F), and Severely Frail (SF). Means comparison analyses via one-way Analysis of Variance (ANOVA) assessed baseline demographics, HRQLs, and radiographics. Analysis of post-operative outcomes was conducted via ANCOVA and MANCOVA while controlling for BL PI-LL and S1SS.

RESULTS: 120 MIS patients (69.12±10.60 years, 61.7% female, 29.05±6.23 kg/m^2, mean CCI: 2.13±1.54) were included. At BL, NF patients had significantly lower mean BMI than F or SF patients (p=<.001, .001), and both NF and F patients had significantly lower mean CCI than SF (p=.001, .002). Baseline radiographic analysis revealed significant differences in BL Roussouly typing (p=.044), relative spinopelvic (SP) alignment (p=.028), and BL SP categorization (p=.016), with NF patients presenting with significantly higher Roussouly typing, lower relative SP alignment, and lower SP categorization than SF patients (p=.046, .021, .027). By BL HQRLs, signficantly signficant differences were observed between frailty categories in ODI, SRS-22 and all subcomponents, EQ5D and all subcomponents, and SF-36 and all subcomponents (all p<.05). Perioperatively, NF patients experienced significantly shorter LOS than F patients (p=.047). Post-operatively, signficant differences were noted between BL and 1Y in SRS-22 Activity scores (p=.044), with SF patients demonstrating the greatest positive difference in scores. Adjusting for BL PI-LL and S1SS, by 1Y there were also signficant differences noted between groups in ODI amd SF-36 and all subcomponents (all p<.05). In terms of radiographic alignment at 1Y, significant differences were observed in acheiving ideal sacral slope (=.018), ideal lumbar lordosis (p=.018), idea global tilt (p=.018), and spinopelvic categorization (p=.037), with F and SF patients presenting with the lowest SP categorizations. Assessing post-operative complications, signficant differences were observed in undergoing any medical complication or infection (p=.005, .041), with SF patients demonstrating the lowest rates overall.

DISCUSSION: Despite more severe HRQL and radiographic descriptors at baseline, as well as increased overall surgical invasiveness and EBL, patients with increased frailty states operated on using MIS techniques demonstrated increased incremental benefits post-operative patient-reported and radiographic outcomes at 1Y as compared to their NF counterparts. This may suggest that MIS spine surgery can offer substantial benefits to the frail patient by increasing their chance of achieving radiographic alignment and quality-of-life targets.

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Are Grit and Self-Control associated with Patient-Reported Outcomes following Lumbar Spine Surgery?

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Introduction: Grit, defined as perseverance and passion for long-term goals, and self-control, defined as the capacity to regulate impulses in the presence of momentarily gratifying temptations or diversion, have been shown to be important predictors for achievement in professional domains[1]. Grit has been previously studied among orthopedic surgeons[2] as well as orthopedic surgery applicants[3] with the goal of predicting success. Although grit and self-control have been well-explored in their relationship with achieving professional achievement, the association between these traits and outcomes following spine surgery has not been studied. We hypothesized that patients with higher grit and self-control scores have greater improvement in their patient-reported outcome measures (PROMs) following lumbar spine surgery.

Methods: This is a retrospective review of prospectively collected patient data. Patients that underwent minimally invasive decompression via laminectomy or laminoplasty and had a minimum of 1-year follow-up were included. Grit and self-control were assessed using the validated 8-Question Short Grit Scale and the 10-Item Self-Scoring Self-Control Scale. PROMs included visual analogue scale (VAS) for leg/back pain, 12-Item Short Form Mental Component Score (SF-12 MCS), and Patient Reported Outcomes Measurement Information System Physical Function (PROMIS-PF). VAS is expected to decrease post-operatively, and SF-12 and PROMIS-PF are expected to increase. The difference was calculated for each post-operative PROM relative to the pre-operative timepoint. Bivariate analysis was performed to assess for the association between grit/self-control and change in PROM. Pearson's correlation coefficients were generated for each analysis, and a significance threshold of $p<0.05$ was used.

Results: In total, 66 patients reached at least 1-year follow-up and were included in the analysis. The mean grit and self-control scores for the cohort were 4.00 ± 0.54 and 3.87 ± 0.55, respectively. In bivariate analysis, higher self-control scores were found to be associated with greater improvement in VAS leg pain scores at the 1-year ($r=-0.28$, $p=0.03$) and 2-year ($r=-0.40$, $p=0.02$) timepoints (Table 1). Grit and self-control were not found to be significantly associated with other PROMs at any of the other timepoints included.

Conclusion: These correlation analyses suggest self-control may play a role in the degree of leg pain improvement among patients undergoing minimally invasive decompression. The association was only seen at 1-year and 2-year follow-ups, which suggests that self-control may be more related to long-term outcomes rather than the immediate post-operative period. Grittier patients, by definition, have more passion and perseverance for their long-term goals. Thus, we expected grit to be associated with improvements in PROMs especially at later post-operative timepoints, but this was not seen in the analysis. While a statistically significant correlation was not shown between grit and the PROMs studied, a more extensive prospective study should be conducted in the future to further understand the role of grit and self-control in PROMs.

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Bilateral decompression alone for Degenerative Spondylolisthesis: 3-5 years reoperation rates and mobility profiles

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Introduction:

The optimal surgical treatment for patients with degenerative spondylolisthesis and stenosis is controversial. Surgical alternatives for these patients involve a decompression alone, or one performed concomitantly with a lumbar fusion. The aim of this study was to carefully follow patients with degenerative spondylolisthesis undergoing bilateral decompression alone to determine the reoperation rate, demographic predictors of this, and the change in mobility profiles of the involved segments over the period of followup after the index surgery.

Methods:

Patients with degenerative spondylolisthesis undergoing bilateral decompression alone from a university spine practice involving 3 different surgeons were recruited to enroll in the study. Most patients (80.4%) were treated with a midline-sparing unilateral approach for a bilateral decompression. Flexion/extension films, preoperative MRI or CT scans, and preoperative demographic and patient reported outcome measures (PROMs) including the Oswestry Disability Index (ODI) and NPRS leg and back pain. Postoperative clinical follow up was obtained at (3 months, 6 months, 1 year, and 2 years, and then yearly if possible) including PA and flexion/extension lateral lumbar films. Postoperative MRI scans were obtained as clinically indicated for recurrent or new symptoms. The university IRB approved the study. Changes in radiographic and PROM outcomes with time were assessed with repeated measures GEEs. We tested relationships between reoperation and previously suggested thresholds of 1.25mm translation, 6.5 mm disc height, and 50° facet joint angulation (Blumenthal et al. 2013) via Fisher's exact tests.

Results:

The final cohort included 46 patients (52.2% female, 69.7±9.3 years). The range of dynamic translation was a 2 mm and angular motion was a mean of 7° on flexion/extension films preoperatively. Average disc heights on MRI were 8.6 (95% CI: 7.8, 9.4) mm and Facet joint angulation was a median of 45.0 (IQR: 45.0, 54.0) degrees. In the postoperative period, Flexion increased by 1.0 (0.4, 1.6) degrees ($p = 0.011$). Patients improved after surgery with a median ODI of 32.5 (20.0, 42.0) preop decreasing to a median of 10.0 (4.0, 18.0) 2 years postop ($p < 0.001$). 28.3% of patients had a reoperation, and 19.6% had a reoperation at the same level during the course of followup, which was a median of 28.1 months (range 6 – 51 months). Preoperative translation greater than 1.25 mm (Blumenthal et al. 2013) was associated with reoperation, with no patients under this threshold having reoperation, while 39.4% of patients over this threshold had a reoperation ($p = 0.009$). No other cutoffs or radiographic parameters were significantly associated with reoperation. Patients with higher back and leg pain preop were more likely to have a reoperation at the same level ($p = 0.043$, 0.013, respectively).

Discussion:

In this patient group of 46 people treated with decompression alone for stenosis in the setting of degenerative spondylolisthesis, we found a rate of reoperation of 28.3% with a median follow up of over 2 years postop, and found that reoperation was higher in patients with more than 1.25 mm of dynamic translation, as well as in patients with higher preoperative back and leg pain.

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The Learning Curve for Pedicle Screw Selection in Robotic-assisted and Intra-operative Navigation guided Minimally Invasive Transforaminal Lumbar Interbody Fusion (MI-TLIF)

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Introduction:

Minimally invasive transforaminal lumbar interbody fusion(MI-TLIF) has been performed using 2D fluoroscopy[1], intra-operative navigation (ION)[2,3] and more recently, robotic navigation. While there are reports on the learning curve of MI-TLIF using fluoroscopy[1] and ION[4] in terms of operative time and radiation exposure, there is little data on the learning curve of implant selection with intra-operative image-guidance modalities. Pedicle screw size is linked to construct stability, and consequently fusion rates and outcomes. Thus, the goal is typically to place the largest possible screw that can be safely accommodated within the patient's anatomy. The purpose of this study was to assess pedicle screw size selection for ION and robotic navigation, and to assess the learning curve for the same.

Methods:

- Study design: Retrospective review of prospectively collected data
- Population: Consecutive patients who underwent elective single-level MI-TLIF by a single surgeon using ION or robotic navigation were selected (ION 2017-19, robotic navigation 2019-21, resulting in prospective cohorts of consecutive patients for each modality).
- Outcomes: Pedicle screw size (diameter and length). For each patient, the mean length and mean diameter of all the screws placed was calculated. E.g. if a patient received two 7.5x45mm screws and two 8.5x50mm screws, the mean length and mean diameter would 8 and 47.5mm respectively. This "mean screw size" calculated for each patient was used for analysis.
- Statistical Analysis: Chronologic case number was plotted against each outcome for each modality. Derivative of a nonlinear curve fit to the dataset was solved for the point at which the slope of the curve equalled the linear slope, suggesting a plateau in learning had occurred.

Results:

154 patients (77 ION, 77 robotic navigation) were included. There were no significant differences in age (p=0.104), gender (p=1.00), BMI (p=0.826), race (p=0.910), insurance type (p=0.068), Charlson Comorbidity Index (p=0.108), ASA class (p=0.378), diabetes (p=0.100) or hypertension (p=0.735).

Robotic navigation resulted in the placement of larger pedicle screws (median diameter of 7.42 [IQR 6.5-7.88] mm vs 6.5 [IQR 6.5-6.5] for ION, p<0.0001; median length 47.5 [IQR 45-50] mm vs 45 [IQR 43.75-47.5] for ION, p<0.0001). There were no intraoperative complications in either group.

For ION, screw size selection was not associated with chronology (p=0.079 for screw length, p=0.752) i.e. there was no learning curve.

For robotic navigation, proficiency in screw diameter selection was achieved at 20 cases, with median diameter of 6.5mm before proficiency vs 7.5mm afterwards (p<0.0001) and proficiency for screw length was achieved at 15 cases, with median length of 45mm before proficiency vs 48.75mm afterwards (p=0.139)

Conclusion:

Robotic navigation resulted in the placement of larger screws compared to ION, likely attributable to the intraoperative screw size and trajectory planning capabilities of newer generation robotic systems. Furthermore, robotic navigation, but not ION demonstrated a learning curve in pedicle screw sizing, with proficiency achieved at 15 and 20 cases for screw length and diameter respectively. These findings suggest that robotic navigation likely allows for the safe placement of larger pedicle screws, but this benefit may only be apparent after an initial learning curve.

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Decision Making Factors Leading to Fusion vs. Decompression for One Level Degenerative Spondylolisthesis

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Introduction: Degenerative spondylolisthesis is one of the most common pathologies spine surgeons treat. While a number of potential factors have been identified, there is no current consensus on which variables most impact the decision to fuse vs. decompress alone in this population. The aim of this study was to identify radiographic and clinical factors leading to the decision to fuse segments for one level spondylolisthesis.

Methods: A survey consisting of questions pertaining to decision factors leading to fusion or decompression alone in the setting of degenerative lumbar spondylolisthesis was administered to the Lumbar Spine Research Society and Society of Minimally Invasive Spine Surgery. Radiographic parameters included grade of spondylolisthesis, instability, facet orientation > 60 degrees, facet diastasis, laterolisthesis or scoliosis, synovial cysts, vacuum disc, vertical disc space, preserved disc height, concomitant herniated nucleus pulposus, and symptomatic foraminal stenosis. Clinical factors included age > 70 years, activity level, patient sex, body mass index >35, osteoporosis, primary complaint of low back pain, primary complaint of neurogenic claudication, smoking, and anxiety/depression. Following completion, surveys were collected and analyzed using SPSS version 27. The primary analysis was limited to completed surveys. Baseline characteristics were summarized. Clinical and radiographic parameters were ranked and compared. The most important, top three most important, and top five most important parameters were ordered given each parameter ranking. Using Chi-Squared, Fisher's exact test, or two-sample t-test as appropriate.

Results: Of 561 surveys, 381 (67.9%) were returned completed. Respondents mean years in practice was 17.8 ± 9.4 years and 296 (77.7%) had undergone a formal spine fellowship. The majority of respondents were from the US (45.9%) followed by Europe (24.1%), and Asia/Pacific (17.1%). The practice setting included academics (32.5%), private practice (31.0%), hospital employed (17.1%), or a combination (19.4%). The mean number of degenerative spondylolisthesis cases performed per year for each surgeon was 53.8 ± 46.7 cases with 49.9% of the cohort performing these cases utilizing minimally invasive techniques. With regards to fusion vs. decompression, 19.9% fuse all cases, 39.1% fuse > 75%, 17.8% fuse 50-75%, and 23.2% fuse <25%. Instability (93.2%), spondylolisthesis grade (59.8%), and laterolisthesis (37.3%) were the most common radiographic factors impacting the decision to fuse (Table 1), whereas mechanical low back pain (83.2%), activity level (58.3%), and neurogenic claudication (42.8%) were the top clinical parameters (Table 2).

Conclusion: There is little consensus on the treatment of degenerative spondylolisthesis, with society members showing substantial variation in treatment patterns. The most common radiographic parameters impacting treatment are instability, spondylolisthesis grade, and laterolisthesis while mechanical low back pain, activity level, and neurogenic claudication are the most common clinical parameters.

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Factors Delaying Discharge in Patients Eligible for Ambulatory Lumbar Fusion Surgery

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Introduction: Assessing postoperative inefficiencies is vital to increase the feasibility of ambulatory lumbar fusion. This study aimed to identify patients who would have been eligible for same-day discharge following minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) and then analyze the limiting factors in their postoperative pathway that led to a delay in discharge.

Methods: Patients who would have met the eligibility criteria determined a priori for ambulatory lumbar fusion were included. Patient demographics, surgical data (start time, operative time, estimated blood loss [EBL], and complications) and postoperative in-hospital data (postoperative length of stay [LOS]; time in post-anesthesia recovery unit [PACU]; alertness check, neurological exam, and pain scores at 3 hours and 6 hours; type of analgesia; time to physical therapy [PT] visit; reasons for PT non-clearance; time to per-oral [PO] intake; time to 1st and 2nd voids; time to readiness for discharge; complications) were analyzed. Time taken to meet each discharge criterion was calculated. Time of discharge readiness was taken as the point when the patient had fulfilled all the criteria. The percentage of patients meeting each discharge criterion at 3 hours and 6 hours post-surgery was calculated. Correlation and regression analyses were performed to study the effect of postoperative variables on LOS. Multiple linear and logistic regression analyses were performed to study the effect of preoperative and operative variables on postoperative parameters influencing discharge.

Results: 71 patients were included of which only 4% were discharged on the same day. 69% of patients were discharged on postoperative day one. Physical therapy (PT) clearance was the last-met discharge criterion in 93% of patients. 66% of patients did not get a PT evaluation on the day of surgery. 76% of patients required intravenous (IV) opioids and <60% of patients had adequate pain control. 27% had orthostatic intolerance (OI). The median postoperative length of stay (LOS) was 26.9 hours, time in post-anesthesia care unit (PACU) was 4.2 hours, time to per-oral (PO) intake was 6.5 hours, time to 1st void was 6.3 hours, time to 1st PT visit was 17.7 hours, time to PT clearance was 21.8 hours, and time to discharge readiness was 21.9 hours. Regression analysis showed that time to PT clearance, time to PO intake, time to voiding, time in PACU, and pain score at 3 hours had a significant effect on LOS. There was no effect of preoperative and operative variables on postoperative parameters influencing discharge.

Conclusion: Unavailability of PT, orthostatic intolerance, inadequate pain control, prolonged PACU stay, and long feeding and voiding times were identified as modifiable factors preventing same-day discharge in patients eligible for ambulatory lumbar fusion. After the foremost step of appropriate patient selection, interventions like prehabilitation, recruitment and re-allocation of PT personnel and resources, scheduling of surgeries for the earlier part of the day, use of pre-emptive analgesia with paracetamol and NSAIDs or COX-2 inhibitors, reduction of peri-operative opioid use, PACU fast-tracking, and early postoperative feeding and voiding could increase the feasibility of ambulatory lumbar fusion.

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Practical Answers to Frequently Asked Questions in Minimally Invasive Lumbar Spine Surgery

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Introduction: Surgical counseling enables shared decision-making (SDM) by improving patients' understanding. The purpose of this study was to provide answers to frequently asked questions (FAQs) in minimally invasive lumbar spine surgery.

Methods: This was a retrospective review of prospectively collected data from a single-surgeon surgical database. Consecutive patients who underwent primary minimally invasive lumbar spine surgery in form of transforaminal lumbar interbody fusion (TLIF), decompression alone (unilateral laminectomy for bilateral decompression), or tubular microdiscectomy were selected. Only single-level TLIFs were included, whereas for decompression and microdiscectomy, patients were included irrespective of the number of levels operated. All patients had a minimum of 1-year follow-up. A list of ten FAQs was compiled.

Patient demographics, surgical data (type of surgery, radiation exposure, and intraoperative complications), postoperative in-hospital data (postoperative length of stay [LOS] and complications) and post-discharge data (Visual Analog Scale- back and leg, VAS; Oswestry Disability Index, ODI; 12-Item Short Form Survey Physical Component Score, SF-12 PCS; Patient-Reported Outcomes Measurement Information System Physical Function, PROMIS PF; Global Rating Change, GRC; return to activities; complications) were analyzed.

Changes in VAS back, VAS leg, ODI, and SF-12 PCS from preoperative values to the early (<6 months) and late (>6 months) timepoints were analyzed with Wilcoxon Signed Rank Tests. The percentage of patients achieving minimal clinically important difference (MCID) for these patient-reported outcome measures (PROMs) at the two timepoints was also evaluated.

Results: 366 patients (104 TLIF, 147 decompression, 115 microdiscectomy) were included. The following FAQs were answered:

1. Will my back pain improve? Most patients report improvement by >50%.
2. Will my leg pain improve? Most patients report improvement by >50%.
3. Will my activity level improve? Most patients report significant improvement.
4. Is there a chance I will get worse? 6% after TLIF, 14% after decompression, and 5% after microdiscectomy.
5. Will I receive a significant amount of radiation? The radiation exposure is likely to be tolerable and nearly insignificant in terms of radiation-related risks.
6. What is the likelihood that I will have a complication? 17% (15% minor, 2% major) for TLIF, 10% (9.3% minor and 0.7% major) for decompression, 1.7% (all minor) for microdiscectomy.
7. Will I need another surgery? 6% after TLIF, 16.3% after decompression, 13% after microdiscectomy.
8. How long will I stay in the hospital? Most patients get discharged on postoperative day one after TLIF and on the same day after decompression and microdiscectomy.
9. When will I be able to return to work? >80% of patients return to work (average: 25 days after TLIF, 14 days after decompression, 11 days after microdiscectomy).
10. Will I be able to drive again? >90% of patients return to driving (average: 22 days after TLIF, 11 days after decompression, 14 days after microdiscectomy).

Conclusion: The above list provides concise answers to ten FAQs in minimally invasive lumbar spine surgery. We believe that this can be used by physicians as a reference to enable patient education and SDM.

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Outcomes of Minimally Invasive Transforaminal Lumbar Interbody Fusion using Robotic Navigation

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Introduction: Literature on the utilization of newer robots in minimally invasive spine surgery (MISS) is sparse. We aimed to analyze outcomes of minimally invasive transforaminal interbody fusion (MI-TLIF) using the ExcelsiusGPS (Globus Medical, Inc., Audubon, PA) robotic system.

Methods: This was a retrospective review of prospectively collected data from a single-surgeon surgical database. Consecutive patients who underwent primary or revision MI-TLIF using ExcelsiusGPS and had a minimum of 1-year follow-up were included. Patient demographics, surgical data (type of surgery, fusion levels, operative time, estimated blood loss [EBL], radiation exposure, and intraoperative complications),M ol.9ikmk0km postoperative in-hospital data (postoperative length of stay [LOS] and complications), and post-discharge data (Visual Analog Scale- back and leg [VAS], Oswestry Disability Index [ODI], 12-Item Short Form Survey Physical Component Score [SF-12 PCS], return to activities, radiological parameters including pedicle screw accuracy and fusion rate, and complications) were analyzed. The CT-based Gertzbein-Robbins system (GRS) was used to assess pedicle screw accuracy. Fusion status was assessed in the 1-year postoperative CT scan.

Changes in VAS back, VAS leg, ODI, and SF-12 PCS from preoperative values to the early (<6 months) and late (>6 months) postoperative timepoints were analyzed with Wilcoxon Signed Rank Tests. The percentage of patients achieving minimal clinically important difference (MCID) for these patient-reported outcome measures (PROMs) at the two timepoints was evaluated.

Results: 47 patients were included (53% male, mean age 61.4 years, mean BMI 27.8 kg/m2). 79% were primary surgeries for degenerative disc disease or spondylolisthesis and 21% were secondary surgeries for recurrent same segment stenosis. 94% of patients underwent single-level fusion. In none of the cases was the use of the robot aborted due to any reason. The average operative time and EBL were 105 minutes and 50 mL, respectively. The average radiation dose and time were 38 mGy (17 mGy- surgery, 21 mGy- image capture) and 19 seconds (10 s- surgery, 9 s- image capture), respectively. 70% of patients were discharged on postoperative day one.

194 pedicle screws were placed with 1 dangerous breach requiring revision. Pedicle screw accuracy was 97.7 % and fusion rate was 90%. 1.1% of screws had violated the superior level facet joint.

There were significant improvements in VAS back, VAS leg, ODI, SF-12 PCS with most patients achieving MCID at both the early (<6 months) and late (>6 months) timepoints except SF-12 PCS at the early timepoint. 75% of the previously employed patients returned to work (average 20 days). 90% of the previously driving patients returned to driving (average 19.5 days).

There were no intraoperative complications, 7 in-hospital complications (2 major and 5 minor), and 6 post-discharge complications (3 major and 3 minor). The overall complication rate was 27.3% (12.3% major and 17% minor) and reoperation rate was 6.4%.

Discussion/Conclusion: Robotic navigation for MI-TLIF leads to superior pedicle screw accuracy, less proximal facet violation, less radiation exposure, and favorable clinical outcomes. Comparative studies with larger sample sizes should be conducted to assess long-term outcomes and cost-effectiveness of robotic navigation in MISS.

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Does the application of neoadjuvant high energy particle therapy change the overall survival rate and local control in intentional Enneking inappropriate surgical treatment of Osteogenic sarcoma (OGS) of the spine?

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INTRODUCTION

OGS is a rare malignant bone tumor. Wide margins resection associated with chemotherapy is the gold standard of treatment. Advances in radiotherapy have provided another treatment consideration to complement surgery.

METHODS

We retrospectively reviewed a series of 23 patients affected by primary OGS of the spine treated at tertiary referral hospital between 2009 and 2020. The clinical, pathologic, and radiographic data were reviewed in all cases. All cases were classified according to the classification proposed by Enneking and also by the Weinstein, Boriani, Biagini (WBB) classification.

RESULTS

23 patients were initially included in the present study. Three patients were excluded because they were initially surgically treated at other institutions or because affected by low grade OGS. The median follow-up was 15.7 months (range 4- 95) or until death. Thirteen of twenty patients were dead at final follow up (65%). The disease specific one- and five- year survival rate for the global cohort were 68.4% and 36.8% respectively. Four over 20 patients received high energy particles as adjuvant therapy after aggressive, extracapsular intralesional excision. In this group of patients, the disease specific survival rate was 100% at one year and 100% at five years. Four over 20 patients received adjuvant photons therapy. In this group of patients, the survival rate was 25% at one year and 0% at five years. Eight patients underwent a planned en-bloc spondylectomy. Five of the 8 patients who underwent en-bloc resection had a negative margin. The median survival for patient who underwent planned en-bloc resection was 26.4 months. The median overall survival for the five patients who underwent en-bloc resection with confirmed negative margins was 15.8 months. The one-year survival was 80% while the five-year survival was 40%. Twelve patients underwent planned intralesional resections. The median survival for all patient who underwent planned intralesional gross total resection was 14.3 months. Four out of this 12 patients received adjuvant high energy particle therapy, the median disease-specific survival for this subgroup of patients was 25.7 months. The other 8 patients had a median disease-specific overall survival of 8.6 months. Patients treated with intralesional gross total resection and particle therapy had a significant higher disease-specific survival ($p = 0.029$).

DISCUSSION

Wide or marginal margins resection coupled with modern chemotherapy protocols is the gold standard approach to OGS.
From a technical point of view an en-bloc excision in terms of margin-free spondylectomy can be performed when the tumor extends to only one pedicle, i.e., it is centrally located and confined only to zone 4–8 or 5–9 according to the WBB system. However, a considerable number of cases of OGS of the spine fall in the group of planned inappropriate resection due to the extension of the tumor.
This is the group of patients which mostly benefits of the advent of high energy particle radiotherapy. The concept of “separation surgery” is changing the surgical paradigms also for the treatment of primary tumors of the spine.

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Incomplete cefuroxime penetration to the anterior and posterior column of the lumbar spine – An experimental porcine study

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Introduction

Surgical site infection following spine surgery is associated with increased morbidity and possibly mortality as well as increased cost for the health care system. The reported pooled incidence is 3%. Perioperative antibiotic prophylaxis is a key factor in lowering the risk of acquiring an infection. Previous studies have assessed perioperative cefuroxime concentrations in the anterior column of the cervical spine with an anterior surgical approach. However, the majority of surgeries are performed in the posterior column and often involve the lumbar spine. Along with the potential of achieving subtherapeutic perioperative antibiotic concentrations across the vertebral column, particularly in posterior spine surgery due to a theoretically impaired blood flow to the PC, it seems prudent to investigate cefuroxime concentrations across the vertebral column. Accordingly, the objective of this study was to compare the perioperative tissue concentrations of cefuroxime in the anterior and posterior column of the same lumbar vertebrae using microdialysis in an *in vivo* experimental acute preclinical porcine model.

Methods

The lumbar vertebral column was exposed from L1 to L5 in 8 female pigs. Microdialysis catheters were placed for sampling in the anterior column (vertebral body) and posterior column (posterior arch) within the same vertebra (L5). Cefuroxime (1.5 g) was administered intravenously over 10 min. Microdialysates and plasma samples were continuously obtained over 8 hours. Cefuroxime concentrations were quantified by Ultra High Performance Liquid Chromatography Tandem Mass Spectrometry. Microdialysis is a catheter-based pharmacokinetic tool, that allows dynamic sampling of unbound and pharmacologic active fraction of drugs e.g., cefuroxime. The primary endpoint was the time with cefuroxime above the clinical breakpoint minimal inhibitory concentration (T>MIC) for *Staphylococcus aureus*of 4 µg/mL as this has been suggested as the best predictor of efficacy for cefuroxime. The secondary endpoint was tissue penetration ($AUC_{tissue}/AUC_{plasma}$).

Results

Mean T>MIC 4 µg/mL (95% confidence interval) was 123 min (105-141) in plasma, 97 min (79-115) in the anterior column and 93 min (75-111) in the posterior column. Tissue penetration (95% confidence interval) was incomplete for both the anterior column 0.48 (0.40-0.56) and posterior column 0.40 (0.33-0.48).

Discussion

Open lumbar spine surgery often involves extensive soft tissue dissection, stripping and retraction of the paraspinal muscles which may impair the local blood flow exposing the lumbar vertebra to postoperative infections. A single intravenous administration of 1.5 g cefuroxime resulted in comparable T>MIC between the anterior and posterior column of the lumbar spine. Mean cefuroxime concentrations decreased below the clinical breakpoint MIC for *S. aureus* of 4 µg/mL after 123 min (plasma), 97 min (anterior column) and 93 min (posterior column). This is shorter than the duration of most lumbar spine surgeries, and therefore alternative dosing regimens should be considered in posterior open lumbar spine surgeries lasting more than 1.5 hours.

Figure 1. Cefuroxime concentration-time profiles. Arrow: time of cefuroxime administration.

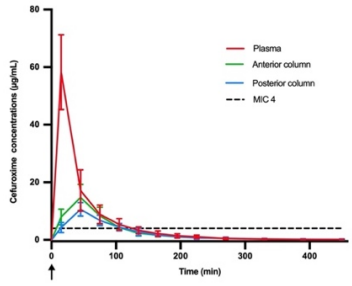
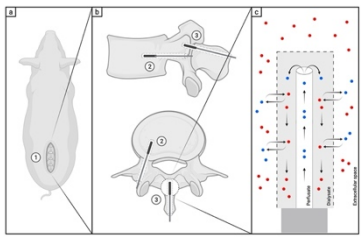


Figure 2. Illustration of the investigated area (a), placement of microdialysis catheters (b) and the microdialysis method (c). Red dots: cefuroxime, blue dots: meropenem as internal calibrator.



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Early versus delayed kyphoplasty for thoracolumbar osteoporotic vertebral fractures: the effect of timing on clinical and radiographic outcomes and subsequent compression fractures

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INTRODUCTION: The osteoporotic vertebral body fractures (OVFs) represent a significant medical and socioeconomic burden. There is ongoing debate concerning the role of cement augmentation versus conservative management, but we are increasingly recognizing the longer-term effects of kyphotic vertebral alignment on functional outcomes, pain, and subsequent fracture rates. The purpose of this study was to determine the effect of timing of intervention with percutaneous balloon kyphoplasty (BKP) for OVF on clinical and radiographic outcomes.

PATIENTS AND METHODS: 101 patients (mean age, 76.8 years) who underwent BKP for OVF were analyzed. All patients underwent plain radiographs of the spine, MR imaging, and bone scan within 1 weeks of treatment. The inclusion criteria were as follows: (1) 0–90 % loss of vertebral body height on plain X-rays; (2) severe back pain associated with a single VCF refractory to analgesic medication; (3) pain score on a visual analog scale of five or higher; and (4) the affected vertebral body showing a confined high signal intensity on T2-weighted MR imaging, a diffuse low signal intensity on T2-weighted MR imaging [1], or a diffuse low signal intensity on T1-weighted MR imaging [2]. Patients with multiple myeloma, metastatic bone disease, radiculopathy, history of spinal surgery, or who had follow-up less than 6 months were excluded. Patients were divided into two groups based on timing of BKP: early (<4 weeks) or late (>4 weeks). Multiple factors were assessed preoperatively and throughout follow up and compared between groups using bivariate testing, including: focal kyphosis, subsequent vertebral fracture, and low back pain.

RESULTS: This was a retrospective sub-group analysis. There were 74 patients in the early group and 27 patients in the late group. There was no significant difference in preoperative bone density between groups. Mean follow-up was 1.2 years. Local kyphosis at final follow-up was significantly greater in the late group (-25.4°) than in the early group (-11.7°; $p < 0.001$). There was no significant difference in local kyphosis between preoperative measurement and final follow-up in the early ($p = 0.741$) or late cohort ($p = 0.794$). Patients treated with early BKP demonstrated significantly better LBP scores ($p < 0.05$) and a lower rate of subsequent vertebral fracture ($p < 0.05$).

CONCLUSION: BKP is able to prevent progressive collapse and kyphosis after OVF, but not effectively restore alignment, and as a result, patients who undergo early BKP (<4 wks) demonstrate improved alignment, better LBP scores, and reduced rates of subsequent fracture at an average of 1.2 years following treatment.

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Prospective cohort study of surgical outcome in patients with spinal metastasis aged 70 years or older

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Introduction

Palliative surgery for spinal metastasis plays an important role in improving and maintaining the activity of daily living (ADL) and quality of life (QOL). With recent progress in cancer treatment and aging society, the elderly patients with spinal metastasis have been increasing rapidly. However, it is still unclear whether the surgery for elderly patients is effective as well as younger patients.

Aim

The purpose of this study was to elucidate surgical outcomes for spinal metastasis in elderly patients, especially with a focus on ADL and QOL.

Material and Methods

We prospectively analyzed 101 patients with spinal metastases who underwent palliative surgery from 2013 to 2016 due to progressive neurological deficits or intractable pain. These patients were divided into the two groups (<70 years and ≥70 years). Eastern Cooperative Oncology Group Performance Status (PS), Barthel index (BI), and EuroQol-5 dimension (EQ-5D) were assessed at study enrollment (baseline), one, three, and six months postoperatively. Improvement or deterioration of each subjective health state value was defined as a ≥ one-level change in the PS, a ≥ ten-point change in the BI, and a ≥ 10% change in the EQ-5D score. The survival times and complications were also collected. Unpaired t test and the Fischer exact test were used to identify the difference of perioperative factors between the two groups. The chronological changes between the two groups were identified by Kruskal-Wallis test and Scheffe post hoc test. All statistical analyses were performed with significance set at a *P* value <0.05.

Results

There were 65 patients aged <70 years (mean, 59.6; range, 32–69) and 36 patients aged ≥70 years (75.9, 70–90), respectively. The overall median postoperative survival time was 10.2 months in patients aged <70 years, while 11.2 months in patients aged ≥70 years (*P*=0.44). Except for age, there was no significant difference in new Katagiri score, revised Tokuhashi score, blood loss, operative time, and the rate of postoperative complications between the two groups. The median of PS was PS3 at baseline and improved to PS1 or PS2 at all postoperative timepoints in both groups. In addition, the mean value of BI greatly improved from <60 to >80 points and the mean score of EQ-5D improved from 0.0 to >0.7 points after surgery in both groups. These values were also maintained at least six months in both groups. Interestingly, there were no significant differences in PS, BI, and EQ-5D at all timepoints including baseline between the two groups. Furthermore, all of the PS, BI, and EQ-5D improved throughout the follow-up period in approximately 90% patients of each group. However, the improved PS, BI, and EQ-5D scores subsequently deteriorated in some patients and the rate of re-deterioration of EQ-5D was significantly higher in the patients aged ≥70 years than <70 years (*P*=0.03).

Conclusion

In the current study, palliative surgery for spinal metastasis improved PS, ADL, and QOL in the patients aged ≥70 years as well as <70 years. However, we should pay attention to the higher risk of re-deterioration of QOL in the elderly.

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Radiological characteristics of posterior lumbar interbody fusion with silicate-substituted calcium phosphate bone graft (Actifuse®) using traditional pedicle screw and cortical bone trajectory techniques

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INTRODUCTION:

Lumbar interbody fusion using bone substitutes is a common procedure. The use of silicated calcium phosphate bone substitute (Actifuse®) is associated with fusion rates in the order of 80% in previous studies. The aim of this study was to review the rates and characteristics of the interbody arthrodesis in patients undergoing lumbar interbody fusion surgery and compare traditional pedicle screw and cortical bone trajectory techniques.

METHODS:

A consecutive series of patients undergoing primary single level posterior interbody fusion for degenerative lumbar conditions were treated by a single surgeon and prospectively studied. The choice between techniques was based on surgical pathology. Fusion was assessed at 12 months by an independent radiologist using fine cut computed tomography. The radiological parameters assessed were implant-related (screw loosening, screw breakage, cage subsidence and lucency around the cage) and bone-related (bone growth through the cage, bone growth outside the cage, new end-plate sclerosis and new end-plate cyst formation). Fusion was assessed as a non-union, a locked pseudarthrosis or a solid union depending on the presence of bridging bone through the cage. A functional fusion was considered to be a locked pseudarthrosis or solid union. Data was analysed using Fisher exact and unpaired t-tests.

RESULTS:

Between July 2015 and January 2018, 121 patients met the inclusion criteria. The 12-month CT scan was available for 106 patients. Of these, the cortical technique was used in 42 and the traditional in 64. Overall, 91/106 patients (85.8%) achieved functional fusion, with 83/91 (91.2%) of these having a solid union and 8/91 (8.8%) a locked pseudarthrosis. Non-union rates between the cortical screw and pedicle screw groups (14.2% vs 14.1%) were similar. There were more solid unions in the cortical group (46/64 (71.8%) vs 37/42 (88.1%)) but this did not reach statistical significance ($p=0.056$). For the rest of the analysis we considered the two groups together and assessed the characteristics of the non-unions, of which there were 15/106 (14.2%). The nonunions when compared with the functional fusions, showed a statistically significant association with cysts (93.3 vs 7.7%), sclerosis (86.7 vs 12%), screw loosening or breakage (60 vs 2.2%), lucency (66.7 vs 32.9%) and subsidence (93.3 vs 6.6%). All values were highly significant ($p<0.01$).

DISCUSSION:

We demonstrated a satisfactory rate of fusion in both groups of 85.8%, which is comparable to previously published studies. We found no statistical difference in functional fusion rate between pedicle and cortical screw techniques. We identified radiological predictors of non-union on CT scan, the most significant of which was the presence of new end-plate cyst formation and sclerosis. These may represent a consequence of the osteostimulatory nature of the bone graft substitute. Accepted classification systems of interbody fusion success have not included these criteria. We propose that end-plate cyst formation and sclerosis should be considered as additional parameters in assessment of fusion, especially where bone substitutes are used.

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Is Balloon kyphoplasty applicable to osteoporotic vertebral fractures related to diffuse idiopathic skeletal hyperostosis?

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Introduction.
Treatment of diffuse idiopathic skeletal hyperostosis (DISH)-related osteoporotic vertebral fractures (OVFs) is challenging due to the vertebral instability and weakness of cancellous bone. Therefore, spinal fixation with instrumentation has been deemed a common option for such fractures. However, elderly patients with multiple comorbidities may not be eligible for aggressive surgery. It remains unclear whether these fractures can apply to Balloon Kyphoplasty (BKP) without instrumentation, which has been seldom reported. The purpose of this study is to elucidate the effectiveness and limitations of BKP for OVFs related to DISH.

Methods.
Consecutive patients older than 65 with acute OVFs underwent BKP in ten different institutions between 2015 and 2017. Clinical and radiographic data were collected pre-and six months post-operatively. Patients with OVFs at the lower end or one caudal to the DISH were assigned to the DISH group, and the others were to the non-DISH group. Two groups were compared for the following outcomes and complications: activity of daily life (ADL), a visual analog scale (VAS) for back pain, the short form (SF)-36, reoperation, adjacent vertebral fracture (AVF), and cement dislodgement. Multivariate analysis was performed to investigate whether DISH is an independent risk factor for poor clinical outcomes and complications.

Results.
Of the 116 patients included, 14 patients were classified as the DISH group. Demographic data showed severer vertebral angular motion in the DISH group. There was no significant difference between the two groups in terms of ADL and SF-36. In addition, the reoperation rate (7%) and AVF rate (29%) of the DISH group were similar to those of the non-DISH group. The VAS of back pain improved in the non-DISH group (72.8 to 28.9), while the improvement in the DISH group (74.4 to 44.1) was significantly poor ($p = 0.04$). In addition, cement dislodgement at 6 months postoperatively was significantly more common in the DISH group (21%) than in the non-DISH group (4%) ($p = 0.04$). However, multivariate analysis showed that the significant risk factor for those was preoperative vertebral instability rather than the DISH itself.

Discussion.
Patients with DISH had similar improvement of ADL and SF-36, reoperation rate, and AVF rate at 6 months postoperatively compared to those without DISH. Although the DISH group achieved poor improvement in back pain and experienced more cement dislodgement, multivariate analysis identified preoperative vertebral instability, rather than DISH, as a significant risk factor for these poor outcomes. BKP can be applied to the OVF at or adjacent to the lower end of the DISH, though careful attention should be paid in cases with severe preoperative vertebral instability.

1140

The effect of minimally invasive lumbar decompression surgery on sagittal spinopelvic alignment in patients with lumbar spinal stenosis: a 5-year follow-up study

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INTRODUCTION

Several studies have examined the relationship between sagittal spinopelvic alignment and clinical outcomes after spinal surgery. However, the long-term reciprocal changes of sagittal spinopelvic alignment in lumbar spinal stenosis after decompression surgery remain unclear. The aim of this study was to investigate the radiographic changes in sagittal spinopelvic alignment and clinical outcomes at 2-year and 5-year follow-up after minimally invasive lumbar decompression surgery.

METHODS

We retrospectively studied 110 patients who underwent bilateral decompression via a unilateral approach for lumbar spinal stenosis. The Japanese Orthopaedic Association (JOA) and visual analog scale (VAS) scores for lower back pain (LBP), leg pain, leg numbness, and spinopelvic parameters were evaluated before surgery and at 2-year and 5-year follow-up. Sagittal malalignment was defined as a sagittal vertical axis (SVA) ≥50 mm.

RESULTS

Compared with baseline, lumbar lordosis was significantly increased after decompression surgery at 2-year (30.2º vs 38.5º, respectively; $p < 0.001$) and 5-year (30.2º vs 35.7º, respectively; $p < 0.001$) follow-up. SVA was significantly decreased at 2-year follow-up compared with baseline (36.1mm vs 51.5mm, respectively; $p < 0.001$). However, there were no differences in SVA at 5-year follow-up compared with baseline (50.6mm vs 51.5 mm, respectively; $p = 0.812$). At 5-year follow-up, 82.5% of patients in the preoperatively normal alignment group maintained normal alignment, while 42.6% of patients in the preoperatively malalignment group developed normal alignment. Preoperative sagittal malalignment was associated with VAS for LBP at baseline and 2-year and 5-year follow-up and JOA score at 5-year follow-up. Postoperative sagittal malalignment was associated with VAS for LBP at 2-year and 5-year follow-up and VAS for leg pain at 5-year follow-up. There was a trend towards a deterioration in clinical outcomes in persistent postural malalignment patients compared with the other groups.

DISCUSSION

Following minimally invasive surgery, spinal sagittal malalignment can convert to normal alignment at both short-term and long-term follow-up. Sagittal malalignment has a negative impact on VAS for LBP and a weak negative impact on the JOA score after decompression surgery.

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Balloon Kyphoplasty for osteoporotic thoracolumbar vertebral fracture with diffuse idiopathic skeletal hyperostosis

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(Introduction) Since thoracolumbar vertebral fracture with diffuse idiopathic skeletal hyperostosis (DISH) is common in the elderly, it may occur with low-energy trauma based on osteoporosis. Conservative treatment such as bed rest and brace may cause nonunion and delayed paralysis due to the long lever arms of the fractured segments that make the fracture extremely unstable, long fusion surgery using instrumentation is often performed. On the other hand, Balloon kyphoplasty (BKP) is indicated for primary osteoporotic vertebral fracture that cannot be treated with conservative treatment, but in recent years, it is often indicated early for patients with poor prognosis on images.

(Objectives) The purpose of this study was to investigate the effectiveness of treatment with BKP for the osteoporotic thoracolumbar vertebral fracture with DISH.

(Materials and Methods) 16 patients (7 males and 9 females, average 84.1 years old, range 77-92) with thoracolumbar fracture with DISH were treated with BKP at our department and related hospitals. The periods from injury to first visit were average 18.8 days (range 0-80). Follow-up periods was 16.9 months (range 3-36). The number of DISH affected vertebral body were average 8.9 (range5-17). Fracture sites were T8: 1 case, T10: 1 case, T12: 6 cases, L1: 5 cases, L2: 1 case, T12/L1: 1 case, L1/L2: 1 case. Outcome measurements were operation time, bleeding at operation, Numerical Rating Scale (NRS), bone mineral density (BMD), use of medication for osteoporosis and use periods of brace. Radiographic measurements were fracture type, existence of bone union, existence of postoperative subsequent fracture, local kyphosis angle and wedged angle of fractured vertebral body.

(Results) Operation time was average 31.9 minutes(range19～83) and bleeding at operation was average 2.4ml(range 0～5). All patients had bone union at average 6.4 months after BKP. All patients were wearing hard braces for average 4.1 months with using teriparatide for average 8.6 months after BKP. Fracture types were wedged compression type (14 patients) and insufficient fracture (2 patients), there was no dislocation, the posterior ligament injury and facet joint injury in all patients. NRS was 8.6 before BKP, 0.8 after BKP and 1.7 at final follow-up. Local kyphosis angle was 20.1° before BKP, 10.2° after BKP and 18.1°at final follow-up. Wedged angle of fractured vertebral body was 15.5°before BKP, 6.4°after BKP and 10.9°at final follow-up. Postoperative subsequent fractures occurred in 4 patients, but they were healed with conservative treatment.

(Discussion and Conclusions) 1. BKP for thoracolumbar vertebral fracture with DISH is indicated to fracture of the anterior column without dislocation, the posterior ligaments injury and facet joints injury. 2. BKP for thoracolumbar vertebral fracture with DISH is minimum invasive surgery and more effective method by adding teriparatide and rigid hard brace.

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Beliefs, perceptions and experiences of adults pre- and/or post- lumbar spine surgery: a meta-ethnography

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Introduction: Lumbar spine surgery is one of the most common procedures in older adults. Approximately 10-40% of patients, however, continue to experience significant pain, disability, and numbness post-operatively, leading to poorer quality of life. The purpose of this study is to understand the patient experience pre-and/or post-lumbar spine surgery to help to inform future recommendations for lower back pain.

Methods: Qualitative meta-ethnography. Pre-registered with OSF:10.17605/OSF.IO/UTZE6. A literature search was conducted in MEDLINE, EMBASE, EmCare and CINAHL from inception to January 20th, 2021.Peer-reviewed qualitative or mixed-method studies investigating the beliefs, perceptions, or experiences of adults (≥18 years old) pre-and/or post-lumbar spine surgery for degenerative concerns. The eMERGE meta-ethnography reporting guidelines werefollowed to create themes and subthemes from the original themes of the included studies. A quality appraisal was performed using the McMaster Quality Appraisal tool.

Results: 14 studies were included. Five themes emerged from the themes of the included studies separated into pre- from post-operative categories. Two themes emerged pre-operatively: (1) the influence of exercise on patients' experiences and (2) the importance of education / the power of communication. Three post-operative themes included: (1) psychosocial coping, (2) redefining oneself post-operatively, and (3) experience with the healthcare system.

Discussion: Three key findings were established: the value of communication, the importance of using best practice in physiotherapy, and the impact of psychosocial factors on recovery. Healthcare providers should consider patients' unique level of health-literacy and engage in open communication to ensure the quantity and quality of provided information is being sufficiently tailored to each patient.

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A Prospective Randomized Study Assessing the Impact of a Standardized Educational Curriculum on Resident Rod Bending Proficiency

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Introduction

Precise and efficient contouring of rods during posterior spinal instrumented fusion is essential to reduce hardware complications, improve the likelihood of achieving a solid arthrodesis, and minimize operative time and cost. Yet, surgical trainees receive little training on this topic. The purpose of the present study was to evaluate a novel standardized training program for teaching residents to bend rods.

Methods

We prospectively enrolled orthopedic surgery trainees at a single academic institution in a rod bending educational study. Upon enrollment, each participant completed a preparticipation survey indicating their postgraduate year and experience with rod bending. Participants then performed a timed rod bending test using a spinal fusion model designed to mimic a unilateral T7 to pelvis posterior instrumented fusion construct using 13 contemporary pedicle screws with polyaxial screw heads. Participants were required to bend a 6.0mm stainless steel rod into the screw heads using bar benders, in situ benders, a French bender, and coronal benders, and then affix the rod to the screw heads using set screws and drivers. This test was timed, with a maximum allotted time to complete the task of 20 minutes; if participants were unable to complete the task in the allotted time, then the number of incomplete set screws was recorded. After completion of the first rod bending test, participants were immediately randomized in a 1:1 ratio into one of two groups: Group 1 was provided with an educational curriculum regarding rod bending, and Group 2 did not receive any additional education. The educational curriculum included 1 video reviewing each rod bending instrument and its appropriate use and 2 videos of fellowship-trained spine surgeons providing instruction on appropriate rod bending technique. Three months after the first rod bending test, participants completed a second identical rod bending test and completed a post-participation survey.

Results

Fourteen trainees were enrolled. Six participants randomized to Group 1 and completed the educational curriculum between rod bending tests. Eight participants randomized to Group 2 and did not receive any rod bending education between tests. There were no differences identified between groups with regards to their pre- or post-participation survey responses (Table 1). During the first rod bending test, there was no difference in baseline characteristics between groups (Table 2). The education group experienced a significant improvement in the number of participants who completed the task (3 to 6, P=0.04) and the time required to complete the task (18:40 to 10:58; P<0.001). During the second rod bending test, the education group outperformed the non-education group in number of participants completing the task (100% vs 37.5%, P=0.01), time to complete the task (10:58 vs 17:11, P=0.005), and number of incomplete set screws (0 vs 3.4, P=0.03)

Discussion

Orthopedic surgery and neurosurgery trainees who received a dedicated educational curriculum regarding rod bending improved significantly in all measured metrics, while those who received no dedicated training failed to improve. This study both demonstrates the efficacy of this educational curriculum and identifies an avenue for improving resident education.

Table 1: Pre- and Postparticipation Survey

	Education Group (n=6)	No Education Group (n=8)	P Value
Training Year			
PGY1-2	3 (50.0)	4 (50.0)	1.00
PGY3 - Fellow	3 (50.0)	4 (50.0)	
Personal Experience Level with Rod Bending			
Preparticipation	1.8	1.7	0.85
Postparticipation	2.0	2.2	0.59
P Value	0.73	0.23	
Personal Comfort Level with Rod Bending			
Preparticipation	1.8	1.5	0.43
Postparticipation	2.3	1.9	0.33
P Value	0.30	0.36	
Previous Education Received on Rod Bending			
Preparticipation	2.0	1.8	0.64
Postparticipation	2.7	1.8	0.09
P Value	0.21	1.00	
Perceived Education Available on Rod Bending			
Preparticipation	1.7	1.3	0.30
Postparticipation	2.2	1.6	0.21
P Value	0.30	0.25	
Number of Participants who found Educational Curriculum Helpful			
Yes	6 (100.0)		
No	0 (0.0)		

Table 2: Comparison of Rod Bending Proficiency

	Education Group (n=6)	No Education Group (n=8)	P Value
Number of Participants who Completed Task			
First Test	3 (50.0)	2 (25.0)	0.39
Second Test	6 (100.0)	3 (37.5)	**0.01**
P Value	**0.04**	0.62	
Time to Complete Task			
First Test	18:40	18:53	0.88
Second Test	10:58	17:11	**0.005**
Δ	-7:41	-1:41	**<0.001**
P Value	**<0.001**	0.34	
Number of Incomplete Set Screws (n=13)			
First Test	2.3 (2.9)	4.4 (3.2)	0.28
Second Test	0 (0)	3 (3.4)	**0.03**
P Value	0.13	0.45	

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ALIF versus TLIF for L5-S1 Isthmic Spondylolisthesis: A Comparative Analysis of Radiographic and Clinical Outcomes

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Introduction

Isthmic spondylolistheses are more frequently being treated with interbody fusion via anterior (ALIF) or posterior (TLIF) approaches. Robust comparisons of radiographic and patient-focused clinical outcomes are lacking. We compared segmental and regional radiographic parameters between ALIF with posterior spinal fusion and TLIF for surgical treatment of L5-S1 isthmic spondylolisthesis. Secondarily, we compared patient-reported outcome measures (PROMs) between techniques.

Methods

We reviewed pre- and post-operative radiographs as well as Patient-Reported Outcomes Measurement Information System (PROMIS) elements for patients who received L5-S1 interbody fusions for isthmic spondylolisthesis in the Mass General Brigham (MGB) health system between 2016-2020. Intraclass correlation testing and nonparametric independent and paired t-tests were used for reliability and validity assessments, respectively.

Results

A total of 47 patients were included for analysis; 31 (66%) underwent ALIF and 16 (34%) were treated with TLIF. First and final postoperative X-rays were obtained at 29 days (SE 5) and 385 days (SE 50) following surgery, on average. ALIF demonstrated significantly greater generation of segmental lordosis than TLIF, both at first postoperative visit (11.7º vs 1.5º, $p < 0.001$) and at final follow up (9.0º vs -0.1º, $p < 0.001$) (Figure 1). Significantly greater regional L4-S1 lordosis was also observed for the ALIF group at both time points (6.4º vs 0.2º, $p = 0.01$, first postoperative visit; 7.5º vs 2.5º, $p = 0.03$, final follow up). ALIF also demonstrated a significantly greater increase in disc height than TLIF, both at first postoperative visit (9.8 vs 5.5mm, $p = 0.002$) and final follow up (8.4 vs 3.8mm, $p < 0.001$). Disc height significantly decreased over time in both cohorts (ALIF 9.8 vs 8.4mm, $p = 0.03$; TLIF 5.5 vs 3.8mm, $p = 0.01$). No differences in preoperative and postoperative PROMIS components were detected between techniques. Intragroup analysis revealed significant improvements in physical function, pain interference, and the physical subsection of global health between pre- and postoperative time points for ALIF patients; TLIF patients demonstrated improvements in pain interference and pain intensity following surgery.

Figure 1. Preoperative, first postoperative, and final follow up radiographs of ALIF (A, B, C) and TLIF (D, E, F) constructs with segmental and L4-S1 lordosis calculated.

Discussion

This work furthers understanding regarding the important role of sagittal alignment and the substantial influence of the lumbosacral junction on global parameters of spinal balance. ALIF generated greater segmental lordosis, regional lordosis, and restoration of disc height compared to TLIF following treatment for isthmic spondylolisthesis. These differences persisted at one year follow up. We also found equivalence across PROMs between techniques, with patients in both groups benefitting from surgery across PROMIS parameters. Surgeons should consider these projected differences in radiographic outcomes as well as clinical and approach related factors when selecting the optimal surgical intervention for L5-S1 isthmic spondylolisthesis.

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Is Blood Type Related to Lumbar Spine Degeneration and Postoperative Spine Surgery Outcomes?

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Introduction: Low back pain (LBP) is a highly prevalent and disabling condition worldwide. LBP risk factors are multifactorial, yet determinants of spine degenerative changes and phenotypes on MRI remain debatable. Lumbar spine fusion is a common spine surgical procedure, and in efforts to optimize patient care, great emphasis has been placed on understanding causes of spine degeneration and identifying factors contributing to negative surgical outcomes, such as early-onset adjacent segment degeneration/disease (EO-ASD). Blood group antigens have previously been linked to numerous vascular, infectious, autoimmune, and musculoskeletal disease processes; however, its implications in lumbar spine health are unknown. As such, the purpose of this study was to explore relationships of blood type with preoperative degenerative phenotypes and postoperative EO-ASD of the lumbar spine following fusion surgery.

Methods: Prospective data from patients who underwent lumbar spinal fusion at a single institute were reviewed. Demographic, operative, clinical, and blood type information was recorded, and available MRI and radiographic imaging was analyzed. Specifically, MRIs were assessed for presence of black disc, disc space narrowing, disc displacement, high intensity zones, endplate abnormalities, Modic change, osteophytes, spondylolisthesis, and facet joint edema from L1-S1, whereas plain radiographs were examined for signs of EO-ASD adjacent to the index fusion. Univariate and multivariate regression analyses were performed.

Results: Of the 1,016 patients in the cohort, imaging phenotypes were randomly assessed in 212 patients with preoperative MRI and 445 with pre- and postoperative plain radiographic data. Baseline demographics did not differ by blood type with the exception that A- patients were older than O+ patients. Significant associations were observed between blood type and endplate abnormalities on preoperative MRI (p=0.012) and postoperative EO-ASD (mean follow-up: 8.78±2.85 months; p=0.038). Relationships persisted in multivariate analyses, as B+ patients were more likely to exhibit endplate abnormalities than O+ (odds ratio [OR]:0.28, 95% confidence interval [CI]:0.09–0.90, p=0.032), A+ (OR:0.24, 95% CI:0.07–0.78, p=0.018), A- (OR:0.22, 95% CI:0.05–0.99, p=0.048), and AB+ (OR:0.06, 95% CI:0.01–0.47, p=0.007) patients. B+ patients were also more likely to develop EO-ASD than O+ (OR:0.24, 95% CI:0.09–0.62, p=0.003) and A+ (OR:0.32, 95% CI:0.13–0.80, p=0.014) patients.

Discussion: This large-scale study is the first, to our knowledge, to address and demonstrate proof-of-principle that blood type is associated with specific lumbar spine degenerative phenotypes and EO-ASD. Specifically, B+ blood type was associated with increased risk for endplate abnormalities and EO-ASD, particularly relative to O+ and A+ types. Historically, endplate abnormalities have been noted to potentially precede or increase severity of disc degeneration and predispose to EO-ASD. As a non-modifiable risk factor, “blood type” therefore warrants careful attention in efforts to understand the spine degenerative process and mechanisms, and to develop more precision-based spine care that may assist in predictive modeling. Considering previous studies have associated blood group antigens with unique systemic inflammatory cytokine profiles implicated in musculoskeletal disease progression and pain, it is plausible that blood type may drive lumbar degenerative processes via similar pathophysiology. Nonetheless, further research is needed to validate our findings.

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Risk factors for recurrence based on preoperative MRI in percutaneuos endoscopic sequestrectomy of the far lateral disc prolapse

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Introduction

The present gold standard in surgical treatment of lumbar disc herniation is the microscopic discectomy via interlaminar approach. However it is not suitable for far lateral disc prolapse, therefor we usually need an additional partial or complete arthrectomy of the facet joint. As an alternative we can provide the percutaneous endoscopic approach as a safe and tissue conserving method. Though we had to note a relatively high recurrence rate up to 15% in the literature leading to repeated surgery. This scientific work examines risk factors for recurrent far lateral disc prolapse liable to repeated surgery in various aspects of degeneration and instability in preoperative MRI scans.

Methods

A retrospective analysis of 126 patients, following percutaneuos endoscopic sequestrectomy for a far lateral disc prolapse in BG Klinikum Bergmannstrost Halle, Germany between December 2012 and June 2019 was performed. To detect patients with recurrent prolapse, that required surgery, we dispatched a questionnaire and analyzed the medical records. Finally we divided them into the Recurrence-group and Control-group.

The preoperative MRI of the lumbar spine were investigated for signs of degeneration and instability: degeneration of disc (Pfirrmann) and vertebral endplates (Modic), spondylolisthesis (Meyerding and percentage), degeneration of facet joints (Pathria/Weishaupt), facet joint angles, facet tropism (Vanharanta), facet fluid sign, angle of lordosis and a newly introduced segmental Cobb angle, reconstructed out of the biplanar acquired MRI sequences.

A total of 73 patients were analyzed (17 patients Recurrence-group, 56 patients Conrol-group). After univariate examination of the patient related and treatment related risk factors we examined the MRI based parameter on the parameters distribution. The significant parameters underwent logistic regression binary and multinominal.

Results

We found comparable precondition for patients with and without recurrence. There were three variables to be related to recurrent disc herniation: 1) high grade degeneration of the disc itself (Pfirrmann grades 4 and 5), 2) presence of Modic (Type 1 or 2) degeneration of the vertebral endplate and 3) coronar angulation of the segment towards the prolapse.

Especially the segmental Cobb angle seems to have a strong impact on recurrence: 88% of patients who suffered from recurrent prolapse showed a deviation of coronar axis towards the side of the prolapse.

Discussion

Far lateral disc prolapse is a challenging condition in therapy of lumbar spine diseases. Endoscopic approach is smart, safe and fast, even though there is a relatively high rate of recurrence at least in our experience. A major reason might be preexisting (micro-) instability, which leads to increased stress. Especially disturbance of the alignment in coronar plain might be a newly identified predictor for recurrence. As future purpose it would be desirable to develop a scoring system to assess the individual patients risk. Particularly the segmental Cobb angle, detected in coronar reconstruction of the MRI data, seems to be a strong parameter for predicting recurrence without necessity of additive X-ray examination

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“Satellite Pedicle Screws” - A novel technique of pedicle screw insertion in Obese patients

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Introduction

The presence of thick sub-cutaneous fat and bulky paraspinal musculature mandates extensive surgical dissection in obese patients undergoing Transforaminal lumbar interbody fusion surgery. Securing a ‘converging’ pedicle screw trajectory becomes difficult by the counterforces of the erector spinae muscles and thick sub-cutaneous fat in obese patients, especially at the L5-S1 level.

Methods:

We describe the use of a limited standard posterior midline exposure and a separate, far lateral ‘satellite’ incision to insert pedicle screws in an optimal trajectory in obese patients. Through proper pre-operative planning of the axial and sagittal MRI, the appropriate entry site is determined which is executed intra-operatively to insert pedicle screws freehand. Through a single 1.5cm incision, both L5-S1 screws were inserted.

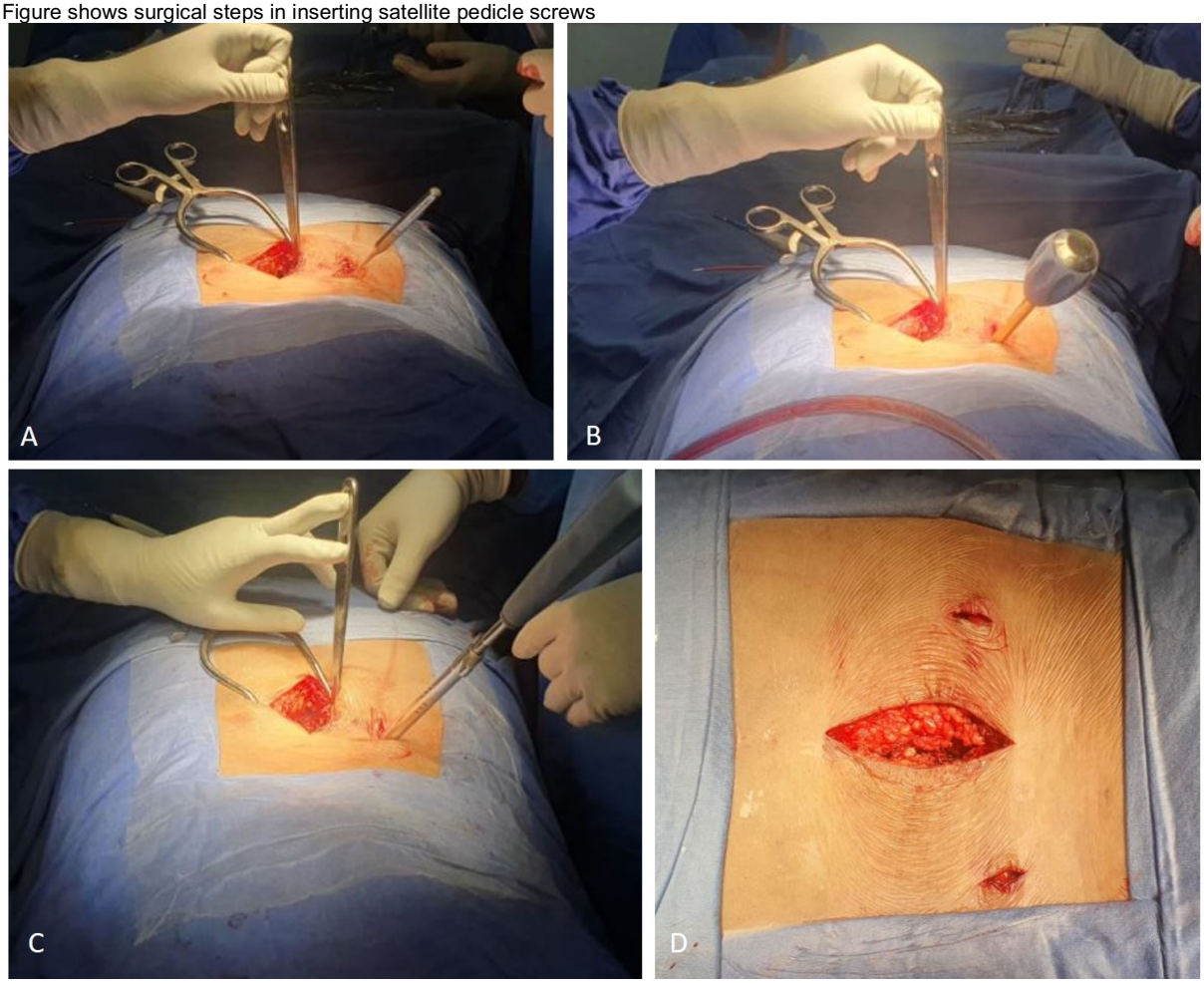
Results:

Fourteen obese patients (mean BMI was 30.5 ± 1.1) received 56 satellite pedicle screws for TLIF at L5-S1 level. The mean age was 48.3 ± 9.7 years. The mean blood loss was 244.8 ±114 ml and the mean operative time was 126.7 ± 82.8 minutes. In all patients, the screws were inserted as per pre-operative planning without any difficulties. All wounds healed well without wound complications. There were no screw related complications, and in the antero-posterior and lateral radiographs, there were no screw breaches.

Conclusion:

Satellite free-hand pedicle screws are safe and easily reproducible. They enable limited dissection of the main surgical wound and well-medialised converging pedicle screws in obese patients.

Figure shows surgical steps in inserting satellite pedicle screws



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A retrospective study about the outcome of spinal metastasis surgery for the patients aged 80 years or older compared to those aged younger than 70 years

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INTRODUCTION: We have reported that spinal metastasis surgery for the patients aged 70 years or older had as good outcome as that for the patients aged younger than 70 years. However, the number of aged spinal metastasis patients is rapidly increasing in Japan, the most super-aged society in the world. The aim of current study was to retrospectively investigate the outcome of spinal metastasis surgery for the patients aged 80 years or older compared to those aged younger than 70 years.

METHODS: Of one hundred eighty-one patients who had palliative spinal metastasis surgeries from 2013 to 2020, 24 patients aged 80 years or older (mean 83.9 years) (E-group) and 79 patients aged younger than 70 years (mean 56.3 years) (Y-group) were included in current study. Performance Status (PS), Barthel index (BI), EuroQol-5 dimension (EQ-5D) score, and pain (Numerical Rating Scale: NRS) were assessed at pre-operation, one, three and six months after surgery.

RESULTS: Gender, Katagiri New score, malignancy of the primary lesion of tumor based on Katagiri New Score, operation time, blood loss during the operation and the number of fixed vertebrae did not show significant difference between the groups. The median survival time of E-group and Y-group did not show significant difference (3.7 and 6.2 months, respectively). E-group had significantly worse preoperative PS, BI and EQ-5D score than Y-group ($p<0.05$). E-group also showed a trend to have higher preoperative NRS than Y-group ($p=0.0536$). The change of median PS, average BI, EQ-5D score, and NRS of E-group and Y-group at pre-operation, one, three and six months after surgery were 4→3→3→3 and 3→2→1→1 (PS), 45.3→63.2→68.5→92.0 and 63.5→80.7→90.2→97.5 (BI), -0.266→0.275→0.552→0.422 and 0.009→0.535→0.737→0.762 (EQ-5D score), 8.2→3.8→3.9→4.3 and 7.2→3.8→3.4→2.9 (NRS), respectively. Although both groups showed significant improvement of all indexes even six months after surgery compared to those at pre-operation, E-group showed some deterioration of EQ-5D score and pain at that point.

DISCUSSION: Although the current study indicated that spinal metastasis surgery for the patients aged 80 years or older showed less good outcome compared to that for the patients aged younger than 70 years, palliative spinal metastasis surgery for the patients aged 80 years or older, who have less reserve capacity of the body with some more risks of deterioration of general condition, would be an effective option to achieve the improvement of PS, activities of daily living, and quality of life as well as pain relief. Further studies are needed to create the optimal medical care system of spinal metastasis.

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Comparison in the adaptability of thoraco-lumbo-sacral orthosis designed by a conventional contact casting technique with a plaster bandage versus by a new non-contact 3D digital scanning technique

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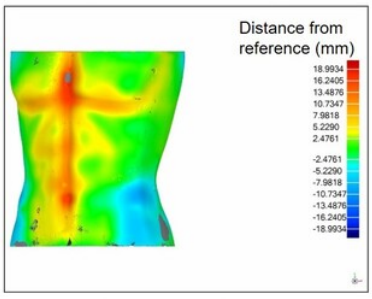
INTRODUCTION: The plaster bandage technique is a common conventional method for spinal orthosis molding. However, this technique requires a body contact and close distance to patients. To reduce potential risks of unexpected sexual harassment, personal space violation, environmental pollution by plastic waste, and COVID-19 pandemic, the development of non-contact spinal orthosis-molding techniques is highly demanded. Thus, to clarify the usefulness of a recently developed 3D digital scanning technology, we investigated the difference in the adaptability of thoraco–lumbo–sacral orthosis designed by a conventional contact casting technique with a plaster bandage versus by a new non-contact 3D digital scanning technique.

METHODS: We purchased commercially available Japanese mannequins individually simulating an adult man, adult woman, obese adult woman, and child (height 113 cm) (total 4 models), molded and actually made thoraco–lumbo–sacral orthoses based on the plaster bandage technique and on the 3D digital scanning technique (total 8 groups), and compared the fitting adaptability. (1) Corseted mannequins were scanned with a high-precision scanner, the data of which were superimposed to analyze the accuracy of the body shape reproduction. (2) Corseted mannequins were further scanned with computed tomography (CT), in which the gap between the mannequin's body and orthosis was evaluated by using ImageJ (https://imagej.nih.gov/ij/). The area of the gap was measured and summed up on respectively four consecutive axial CT slices at four different segments (bust, underbust, torso, and waist) for each model (total 16 slices). Then, the percentage of the gap area relative to the mannequin's body area on each axial slice was calculated. Two-way ANOVA with Tukey post-hoc test was used.

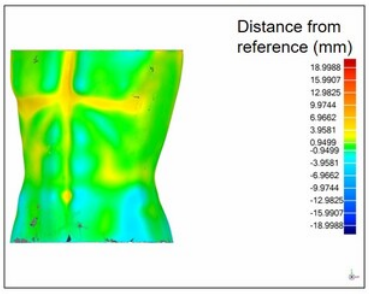
RESULTS: (1) The reproducibility of the mannequin's shape was higher for the orthosis using the 3D digital scanner (Fig. 1). The difference in the shape reproducibility was distinct particularly in the areas with uneven, curvy surfaces, e.g. the mid-back, protruding ilium, and around the bust. (2) In CT comparison between techniques (Fig. 2), the mean gap in models for an adult man, woman, plus-sized woman, and kid was 12.0%, 17.2%, 9.5%, and 12.0% in the plaster bandage-based orthosis but 8.4% (p = 0.0004), 10.9% (p < 0.00001), 5.4% (p = 0.00003), and 7.8% (p = 0.00001) in the 3D digital scanner-based orthosis, consistently indicating the decreased gap area by the 3D digital scanning technique. Between models, adult woman had the biggest gap by both techniques with significance to all other models by the plaster bandage (all p < 0.00001) but only to obese woman (p < 0.00001) and kid models (p = 0.004) by the 3D scanning.

DISCUSSION: In addition to known advantages of using the non-contact 3D digital scanner including a reduced working time and skill bias in orthotists, capability of molding in the supine position, and no need for patient contact, this pilot study presents an improved accuracy of the thoraco–lumbo–sacral orthosis adaptability. As the next step, we will further collect the data on the 3D digital scanning technology from comparative studies of healthy volunteers and then patients with lumbar deformity.

Fig. 1 Findings of high-precision scanner analysis. (An adult male model)

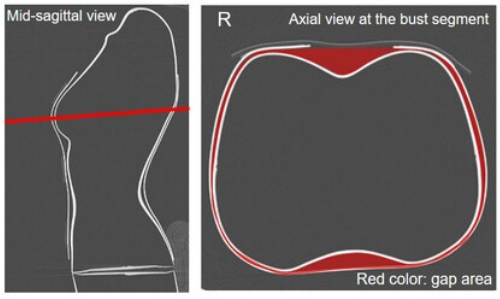


Plaster bandage

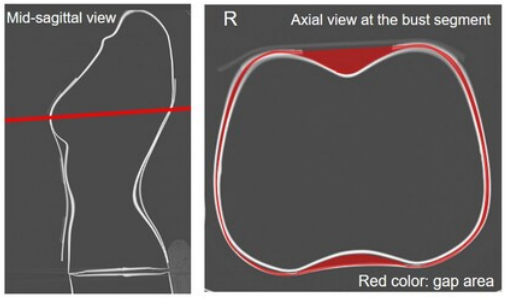


3D digital scanner

Fig. 2 Findings of axial CT analysis at the bust segment. (An adult female model)



Plaster bandage



3D digital scanner

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Supervised exercise therapy versus surgery for patients with lumbar spinal stenosis: a propensity score-matched analysis

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INTRODUCTION: Supervised physical therapy for patients with lumbar spinal stenosis (LSS) has been reported to produce greater improvements in symptom severity and physical function than unsupervised exercise and be associated with lower likelihood of receiving surgery within 1 year.[1] However, it is unknown how effective supervised physical therapy is compared with decompression surgery with or without fusion for LSS. The purpose of this study was to compare the 1-year follow-up outcomes of LSS patients treated with supervised physical therapy or surgery using a propensity score-matched analysis.

METHODS: Patients treated with supervised physical therapy twice a week for 6 weeks in a randomized controlled trial (PT group) and patients who underwent decompression surgery with or without spinal fusion in same institute (Surgery group) were included. Loss to follow-up at 1 year, receiving surgery or additional surgery within 1-year follow-up, previous spine surgery, spondylolysis and foraminal stenosis were excluded. Clinical outcomes included: the Zurich Claudication Questionnaire (ZCQ), a numerical rating scale (NRS) of low back pain, leg pain, and leg numbness, and the Medical Outcomes Study 36-item Short-Form General Health Survey (SF-36) at 1 year. The Hospital Anxiety and Depression Scale (HADS), Pain Catastrophizing Scale (PCS), and Pain Anxiety Symptoms Scale were used to evaluate psychological status at baseline. Propensity score matching (PSM) was used, including age, sex, body mass index, duration of symptoms, number of stenosis, %slip, presence of slippage, ZCQ symptom severity and physical function, NRS of low back pain, leg pain, and leg numbness, and SF-36 physical functioning, bodily pain, and mental health. At before and after PSM, clinical outcomes at baseline and 1 year were compared between the groups.

RESULTS: Thirty-eight patients (PT group) and 186 (Surgery group) patients (95 patients received decompression with fusion) were included in this study. At baseline before PSM, the Surgery group had higher number of stenoses, and worse scores on ZCQ symptom severity and physical function, SF-36 physical functioning, bodily pain, mental health, role physical, role emotional, and social functioning, PCS, and HADS anxiety than the PT group. At 1year before PSM, the Surgery group showed significant improvements compared with the PT group for ZCQ symptom severity and physical function, NRS of low back pain, and SF-36 physical functioning, bodily pain, role emotional, and mental health. Thirty-three pairs were selected by PSM. Fifteen out of 33 patients in the Surgery group received decompression with fusion. After PSM, there were no significant differences in all clinical outcomes at 1 year, except for the percentage of responders achieving minimum clinically important difference in SF-36 role emotional (PT group; 19.4% vs. Surgery group; 44.8%, $P < 0.05$).

DISCUSSION: The patients who underwent lumbar surgery showed greater improvements in clinical outcomes, but had more severe LSS symptoms than the patients who received supervised physical therapy at baseline. When baseline characteristics were considered, supervised physical therapy yielded similar effects to lumbar surgery among patients with LSS. These results suggest that surgery for LSS should be considered after supervised exercise therapy, especially in mild cases of LSS.

1. Minetama M, Kawakami M, Teraguchi M, et al. Supervised physical therapy versus unsupervised exercise for patients with lumbar spinal stenosis: 1-year follow-up of a randomized controlled trial. Clin Rehabil 2021; 35: 964–975.

Morphometric Analysis of Lumbar Disc Bulging by CT and MRI for Lumbar Spinal Stenosis Patients

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INTRODUCTION: The presence of disc tissue extending beyond the edges of the ring apophyses, throughout the circumference of the disc, is called "disc bulging" and is not considered a form of herniation. However, the definition of 'disc bulging' is unclear and the radiological differences between disc bulging and herniation are not clearly identified. The purpose of this study was to investigate the morphometry of disc bulging by computed tomography (CT) and magnetic resonance imaging (MRI).

METHODS: 52 patients (43 men, 9 women, average age: 70 ± 8.0 years-old) who underwent posterior decompression surgery for lumbar canal stenosis from August 2018 to February 2021were included in this study. Patients were CT-scanned pre-operatively. An axial CT–multiplanar reconstruction (MPR) was performed at all the lumbar intervertebral levels. The cross-sectional area of endplates (endplate area) was determined at the superior endplate (Fig. 1A) of each disc level. The cross-sectional area of IVDs (disc area) was determined at the midline between the superior and interior endplates (Fig. 1B). **1. Extended area of disc** (**EAD**) was calculated as the subtraction of the endplate area from the disc area (Fig. 1). **%EAD** was calculated as follows: (disc area-endplate area)/endplate area×100. **2. Disc bulging length (DBL)**, defined as the distance from the posterior end of disc bulging to the posterior wall of the lumbar vertebra was measured at the mid-sagittal MRI (T2-weighted image) (Fig. 2). Disc height was evaluated by the **disc height index (DHI)** on MRI, as previously reported with a modification [1]. The **cross-sectional area of the thecal sac (CSA)** (mm^2) was measured by tracing the outline of the thecal sac at the mid-axial slice of each disc level [2]. The correlation between %EAD and each parameter was evaluated using the Pearson correlation coefficient test.

RESULTS: The %EAD was highest at L3/L4 (21.8 ± 11.5), followed by L4/L5 (21.6 ± 11.8), L2/L3 (19.0 ± 10.9), L1/L2 (12.6 ± 11.3) and L5/S1 (12.1 ± 10.0). The %EAD at L2/L3, L3/L4 and L4/L5 was significantly higher than those at L1/L2 and L5/S1 (Fig. 2A). The DBL was highest at L4/L5 (5.1 ± 1.6), followed by L3/L4 (4.5 ± 1.8), L5/S1 (4.0 ± 2.1), L2/L3 (3.8 ± 1.7) and L1/L2 (3.2 ± 1.8). The DBL at L4/L5 was significantly higher than those at L1/L2, L2/L3 (P<0.01) and L5/S1 (P<0.05). (Fig. 2B). There was a weak positive correlation between %EAD and DBL (r=0.26, P<0.01), and a weak negative correlation between %EAD and CSA (r=-0.33, P<0.01) and DHI (r=-0.22, P<0.01).

DISCUSSION: This study successfully evalated the disc bulging as represented by EAD (%EAD) from pre-operative axial CT–MPR and showed significant differences among the lumbar spinal levels. Our results showed %EAD was weakly correlated with DBL, CSA and DHI, suggesting that %EDA is not directly associated with disc height narrowing and lumbar canal stenosis.

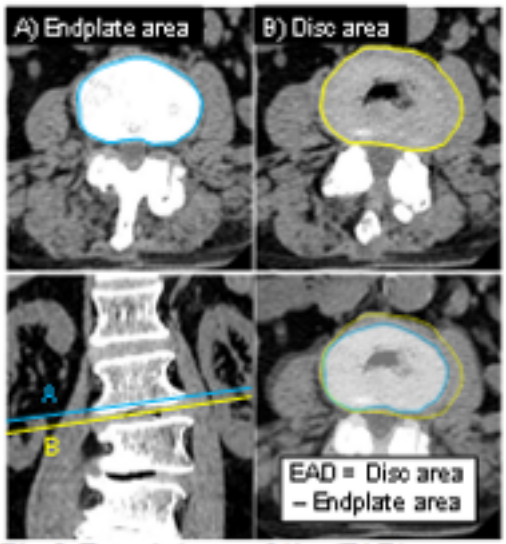

Fig. 1. Extended area of disc (EAD)

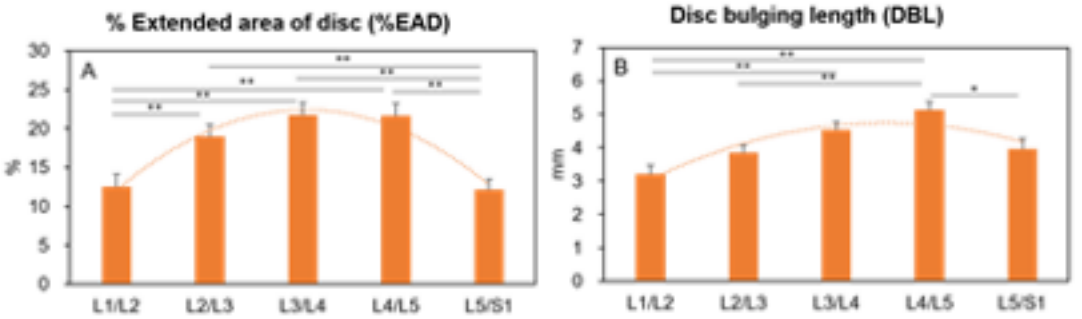

Fig. 2. % Extended area of disc (%EAD, A) and disc bulging length (DBL, B) at each disc levels

1. [1] Akeda, et al. BMC Musculoskeletal Disorders (2015) 16:344 :1-9
2. [2] Akeda, et al. European Spine J 30, 1355-1364, 2021.

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Impact of the COVID-19 pandemic on the productivity and career prospects of musculoskeletal researchers: an international study

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INTRODUCTION: During the COVID-19 pandemic, widespread economic decline, social distancing, and personal challenges profoundly impacted the world and the workplace. In academic research, many were forced to end in-person lab work, animal studies, and the recruitment of human subjects, while shifting their research meetings to an online format. These new laboratory practices likely impacted MSK research productivity and could have disparate effects on certain populations. This study was initiated by members of the **Orthopaedic Research Society Spine Section** to determine the impact of the COVID-19 the productivity and career prospects of MSK researchers.

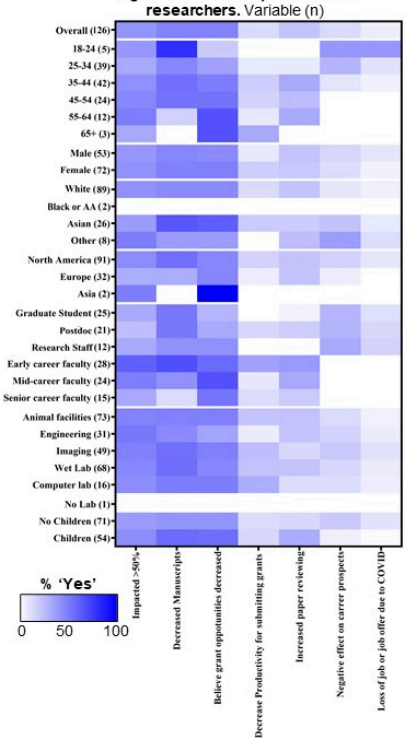
METHODS: We developed a comprehensive, web-based, anonymous survey on the impact of COVID-19 on musculoskeletal researchers, which included questions that assessed personal experiences with BHD. This survey was approved by an Institutional Review Board and was distributed in English to MSK researchers at universities and research societies in North America, Europe, and Asia (~4000 individuals). Responses were collected between 7/30/21 and 10/17/21. Here, we report descriptive statistics of COVID-19 impact on research productivity and career prospects across demographics, career stage, laboratory type, and childcare responsibilities.

RESULTS: 138 MSK researchers responded to the survey (response rate, 3-4%), and 126 completed the COVID-19 impact questions. 41% reported >50% impact or complete stop of research activities due to COVID-19, where 48% reported decreased manuscript submissions, 48% believed funding opportunities had decreased, and 14% reported decreased grant application submission **(Figure 1)**. The greatest perceived impact on grant opportunities was reported by those of Asian race (62% n=16; n=2 living in Asia). Furthermore, more MSK researchers with children (57%) reported decreased manuscript submissions during the pandemic than those without children (41%). For faculty, the overall impact of COVID-19 was reported highest by early career faculty, with decreased publication productivity. Of the 45 respondents whose research involved patients or patient samples, 91% reported reduced recruitment, whilst the 79 respondents who used animals in their research 28% reported >10 animals were culled due to COVID-19.

Of concern, 14% of respondents reported a negative effect on career prospects and 6% reported they had lost their job or job offer due to COVID-19. The negative effects on career prospects were predominantly reported by graduate students (40%), postdoctoral researchers (29%), and research staff (10%), but not faculty (0%).

DISCUSSION: Decreased research capabilities, publication productivity, grant opportunities and submissions were reported across demographic groups. These hardships should be considered by funding agencies and institutions when evaluating grant and employment applications. Our findings related to childcare confirm that teleworking parents found it harder to balance work and childcare responsibilities during the pandemic. Institutions may need to protect their employees by improving childcare benefits. Trainees and research staff reported concerning impacts on career prospects or even loss of jobs and job offers, perhaps because >400 US institutions initiated hiring slowdowns or freezes in 2020. Strategies to identify and protect the careers of junior scientists need to be developed to mitigate fall-out from the current pandemic. These results provide a framework for developing targeted programs that serve those most affected.

Fig. 1 - COVID-19 impact on MSK researchers. Variable (n)



Mechanically Induced Scoliosis Progressively Varies with Anatomic Location and Between Disc and Bone

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INTRODUCTION: Scoliosis is a three-dimensional spinal deformity that presents predominantly as a lateral curve in the coronal plane >10°. In children and adolescents scoliosis is caused either by congenital vertebral anomalies or is acquired as a consequence of disease (syndromic, neuromuscular), but most often the etiology is idiopathic. Stokes hypothesized that spinal deformity progresses as a "vicious cycle" in which asymmetric stresses applied to the growing spine induce deformity of both osseous and non-osseous tissues, causing growth modulation in agreement with the Hueter-Volkmann Principle (*i.e.,* tension applied to the physis stimulates growth, compression inhibits growth). Currently, it is unknown how asymmetric loading alters the growth of the intervertebral disc (IVD) relative to the vertebrae (VB). In this work we investigate the influence of asymmetric loading on a growing pig to create a reciprocal model of scoliosis. The goal of this study is to characterize a progressive thoracolumbar spinal deformity and transitions in osseous and non-osseous tissues. Our long-term goal is to map the structural, mechanical, and biological transitions with the progression of the spinal deformity to inform clinical interventions (cable tension, timing of correction surgery, and new tethering systems).

METHODS: With IACUC approval, a 12-week-old Yorkshire pig was instrumented with a CoCr cable spanning T13 to L5; this offset tether created a lateral bending moment and an initial scoliosis that progressed as the pig matured (**Fig 1**). Anatomical changes to the IVD and VB as a function of time were measured with serial CT scans at -2, 0, 6, 12, and 19 weeks post-op and MRI at 6 and 19 weeks post-op. CT scans were used to quantify lateral wedging and axial rotation between the instrumented levels. Two MRI sequences were utilized, a T_1-weighted FLASH sequence to evaluate IVD volume and a T_2-weighted CPMG echo sequence to evaluate IVD T_2 relaxation time. The T_2 relaxation time, which is positively correlated with water and is decreased in IVD degeneration, was calculated for the nucleus pulposus.

RESULTS: 3D CT reconstructions demonstrate progression of spinal deformity and vertebral growth modulation due to the tether (**Fig 2**). A 17° Cobb angle, localized primarily through the lumbar IVDs, was produced immediately post-op (**Fig 3**). At 6 weeks, deformity progression was approximately equally distributed between the thoracolumbar (45%) and lumbar (41%) regions (**Fig 3A**) with VB wedging accounting for 60% of the total deformity (**Fig 3B**). From 12 to 19 weeks post-op, the spine deformity transitioned from nearly equal contributions of IVD and VB to only VB (**Fig 3B**). A 19 weeks post-op, the spine developed a 41° Cobb angle and 9° axial rotation. The T_2 times (290 ± 40 ms) were similar to an age-matched untreated pig (340 ± 10 ms) suggesting that the tether did not induce degeneration.

DISCUSSION: The asymmetric loading produced by the tether provoked asymmetric spinal growth. Early-stage deformity was localized to the lumbar and thoracolumbar regions in both the IVD and VB. However, from 12 to 19 weeks the deformity transitioned to be primarily located in the VB.

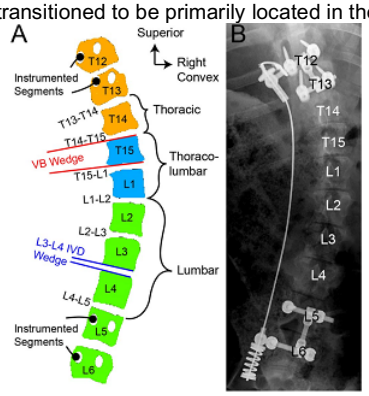

Fig 1: (A) Schematic and (B) radiograph showing instrumentation and curvature at 6 weeks postoperative. Analysis was conducted from the inferior side of T13 to the superior side of L5. Color coding indicates the thoracic (orange), thoracolumbar junction (blue), and lumbar (green) regions.

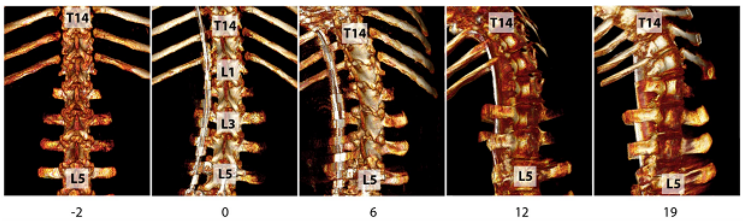

Fig 2: Serial CT reconstructions in weeks post-op demonstrating progressive curvature.

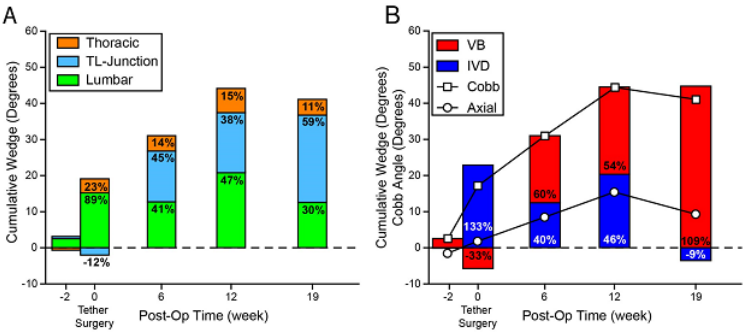

Fig 3: Sum of segmental IVD and VB wedge angle by (A) anatomical region and (B) tissue type with Cobb angle and Axial rotation shown in B. Positive = right curve and counterclockwise rotation.

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Bone-Anchored Implant to Reduce Reherniation: Effect of laminar bone removal on segmental stability and clinical outcomes

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Bone-Anchored Implant to Reduce Reherniation: Effect of laminar bone removal on segmental stability and clinical outcomes

Tung Nguyen, MD, Claudius Thomé, MD, Peter Douglas Klassen, MD, Adisa Kursumovic, MD

Introduction

Laminectomy and laminotomy are often required to decompress neural tissue in several spinal procedures including central decompression and discectomy. A randomized control trial (RCT) comparing outcomes after discectomy-alone and discectomy with a bone-anchored implant (Barricaid) showed that the implant reduced reherniation and reoperation rates by 51% and 45%, respectively at two-years. During surgery of that RCT, the amount of bone removed from the lamina was evaluated for both the discectomy-alone group and the Barricaid group. Results showed that, when compared to the surgeon's typical discectomy patient, 50.7% of Barricaid subjects had an "above average amount of bone removal" as compared to 23.4% of Control patients.[1]

Objective

To investigate the effects of increased bone removal in the Barricaid group, which have not previously been investigated.

Methods

This is a retrospective analysis of a 554 patient RCT, which investigated the use of a bone-anchored implant (Barricaid). During surgery, laminotomy was completed, and the surgeon qualitatively scored the amount of bone removal relative to their average discectomy procedure. Potential responses were above average, average, or below average bone removal. Correlations were evaluated between the amount of bone removal and 1) the subject's segmental instability assessed via rotational and translational (A-P) range of motion (ROM) during flexion-extension and change in spondylolisthesis; and 2) disability assessed through VAS leg, VAS Back, ODI, and reoperation to treat instability.

Results

Above average bone removal occurred in 50.7% of Barricaid subjects. When comparing subjects with "above average" bone removal to subjects with "equal to or less than average" bone removal, segmental instability and disability scores were not found to be statistically different. (**Radiographic Stability –** Flexion-Extension: p=0.47, Translational ROM: p=0.89, Change in Spondylolisthesis: p=0.4347; **Disability** – VAS leg: p=0.54, VAS Back: p=0.54, ODI: p=0.51, Reoperation for instability: p=0.68).

Conclusion

Bone-anchored implant has previously been shown to reduce reherniation and reoperation rates by ~50%. This study showed that, although Barricaid patients require more bone removal compared to a typical discectomy, these patients did not suffer from an increase in instability or disability.

1. C Thomé, PD Klassen, GJ Bouma, A Kuršumović, J Fandino, M Barth, M Arts, W van den Brink, R Bostelmann, A Hegewald, V Heidecke, P Vajkoczy, S Fröhlich, J Wolfs, R Assaker, E Van de Kelft, S Jadik, S Eustacchio, R Hes, F Martens, Annular closure in lumbar microdiscectomy for prevention of reherniation: a randomized clinical trial, The Spine Journal 18 (2018) 2278-2287

1201

Age-related differences in limited flexibility of the lower extremities and correlations with low back pain in young baseball players: a cross-sectional study of 1228 players

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Introduction: Age-related differences in limited flexibility of the lower extremities, such as muscle tightness of the iliopsoas, hamstring, and quadriceps femoris muscles, and their correlations with low back pain (LBP) in juvenile athletes have not been well assessed. The purpose of this study was to investigate the relationships between LBP during the baseball season and tightness of lower extremity muscles with growth in young baseball players.

Methods: Participants comprised 1228 baseball players (220 pitchers, 1008 fielders) between 6 and 16 years old who underwent medical checkups (self-completed questionnaire and physical examination). We investigated the relationships between LBP during the season and measurements of flexibility of the lower extremity muscles, including the Thomas test (iliopsoas tightness), straight-leg-raising angle (hamstring tightness), and heel-to-buttock-test (quadriceps femoris tightness). We compared participants with and without seasonal LBP based on limited flexibility of the lower extremities on both sides using univariate analysis (chi-square tests) stratified by age groups (≤10 years, 11–12 years, 13–14 years, and 15–16 years). Multivariable logistic regression analysis was then performed, and odds ratios and 95% confidence intervals were calculated. We restricted the age group for the model based on the results of univariate analyses ($P<0.05$). In multivariable analysis, the following factors were analyzed as explanatory variables: total amount of practice per week greater than the median of this study population; Rohrer index greater than 145; and limited flexibility of the lower extremities defined as iliopsoas, hamstring or quadriceps femoris muscle tightness on either side. All tests used were two-sided, and values of $P<0.05$ were considered significant.

Results: Of the 1228 players, 255 (20.9%) reported experiencing seasonal LBP requiring rest during the previous year. Prevalence of LBP and tightness of the iliopsoas, hamstrings, and quadriceps femoris all increased with age. Univariate analyses revealed tightness of the hamstrings on the non-throwing-arm side and tightness of the quadriceps femoris on both sides were associated with seasonal LBP at 11–12 years old ($P=0.027$, $P=0.005$, and $P=0.021$, respectively). Multivariable analysis adjusting for factors associated with LBP showed significant associations between quadriceps femoris tightness (odds ratio 1.78, 95% confidence interval 1.13–2.81; $P=0.013$) and LBP in players at 11–14 years old.

Discussion: Tightness of the hamstrings and quadriceps femoris were identified as risk factors potentially associated with LBP among school-aged baseball players. These findings may guide the management of LBP among this age range of baseball players. In addition, particular attention should be paid to quadriceps femoris tightness in players at 11–14 years old.

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A novel quantitative method to identify hip flexion contracture in sagittal radiographs

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Introduction

Hip flexion contracture can severely alter the patient's alignment, and therefore have a negative effect on the patient's quality of life. Hip contracture is not well studied, partly because of the difficulties of its diagnosis which is often qualitative or based on physical examination. The aim of this study was to propose a quantitative definition of hip flexion contracture in hip osteoarthritis patients, and to analyze sagittal alignment in contracture patients compared to non-contracture ones, before and 12 months after total hip arthroplasty (THA).

Methods

One-hundred twenty-three patients with an indication of THA were included in a prospective and consecutive cohort (101 women and 22 men, median age 70 [63; 76]). Exclusion criteria were: spinal implant more than two vertebral levels or with iliosacral screws, and scoliosis (Cobb angle > 25°). IRB approved the data collection.

Patients underwent lateral full-body radiographs in free standing position and in extension (Figure 1). Acquisitions were obtained preoperatively and, for 70 patients, 12 months postoperatively. Spinopelvic parameters were measured in both radiographs: pelvic tilt, pelvic incidence (PI), T1-pelvic angle and pelvic-femur angle (PFA), i.e. is the angle between the femur and a line drawn from the middle of the sacrum endplate to the centre of the interacetabular hip axis.

Patients with low PI (< 45°) were included in the hip contracture group if their PFA > 5°, or when PFA > -5° for patients with standard or high PI (PI ≥ 45°). Examples are provided in Figure 1.

Results

Thirty-seven patients (30%) were in the hip flexion contracture group (30%). Flexion hip contracture patients showed a specific pattern of sagittal spinopelvic alignment (Table 1), with lower pelvic tilt and T1-pelvis angle, and higher lordosis. A similar pattern was observed postoperatively. In particular, PFA significantly decreased after surgery (p= 0.004, i.e., range of motion improved), but hip contracture was still present in 8% of patients.

Discussion

A method was proposed to identify patients with hip contracture in a cohort of hip osteoarthritis patient, based on PFA in extension. High PFA in extension, corresponding to reduced hip range of motion, was associated with hip flexion contracture; these patients showed a specific pattern of sagittal alignment which involved the whole chain of compensation, from lower limb to the proximal spine. Further studies will show how to improve treatment for these patients.

Parameter	Preop: Contracture group	Normal group	p-value	12 months postoperatively: Contracture group	Normal group	p-value
Pelvic-femur angle (ext.) [°]	2 [-2; 8]	-12 [-18; -5]	p < 0.001	-4 [-9; 0]	-9 [-15; -5]	0.007
Pelvic incidence [°]	48 [37; 55]	46 [40; 55]	-	50 [41; 56]	48 [41; 57]	-
Pelvic tilt [°]	8 [3; 12]	18 [13; 23]	p < 0.001	8 [4; 12]	17 [13; 22]	p < 0.001
Lumbar lordosis [°]	50 [45; 57]	39 [27; 48]	p < 0.001	51 [47; 54]	39 [28; 52]	0.02
T1-pelvis angle [°]	10 [1; 16]	18 [11; 27]	p < 0.001	9 [3; 14]	19 [12; 26]	p < 0.001

Compensatory ground reaction forces during scoliotic gait in subjects with and without right adolescent idiopathic scoliosis

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Introduction: Although the asymmetries of scoliotic gait in the adolescent idiopathic scoliosis (AIS) group were extensively studied, recent studies indicated conflicting results of the ground reaction forces (GRF) during gait in subjects with spinal deformity. The asymmetry during the stance phase might be clarified with 3D compensations of GRF between similar characteristics of subjects with and without AIS.
The purpose of this study was to compare the differences on three-dimensional (3D) GRFs, kinetic asymmetry indices (KAI) during gait, and the Cobb angle between subjects with and without right AIS.

Methods: There were 23 subjects with right convexity of thoracic idiopathic scoliosis and 22 age- and gender-matched control subjects. All subjects were right upper/lower limb dominant, and the outcome measures included the Cobb angles, normalized GRF, and KAI.

Results: The mediolateral third peak force on the dominant limb significantly decreased in the AIS group ($t = 2.58$, $p = 0.01$). Both groups demonstrated a significant interaction with the 3D indices ($F = 5.41$, $p = 0.02$). The post-hoc analysis identified that the mediolateral plane of asymmetry was significantly different between groups. The Cobb angles were negatively correlated with the vertical asymmetry index ($r = -0.45$, $p = 0.03$); however, there was no significant correlation with age ($r = -0.10$, $p = 0.65$) or body mass index ($r = -0.28$, $p = 0.20$).

Discussion: The AIS group demonstrated decreased GRF in the dominant limb mediolateral plane of the terminal stance phase. This compensatory motion was confirmed by a significant group difference on the mediolateral plane of the KAI. This KAI of vertical asymmetry correlated negatively with the Cobb angle. The asymmetric load transmission with compensatory vertical reactions was evident due to abnormal loading in the stance phase. These kinetic compensatory patterns need to be considered with asymmetry on the dominant limb when developing rehabilitation strategies for patients with AIS.

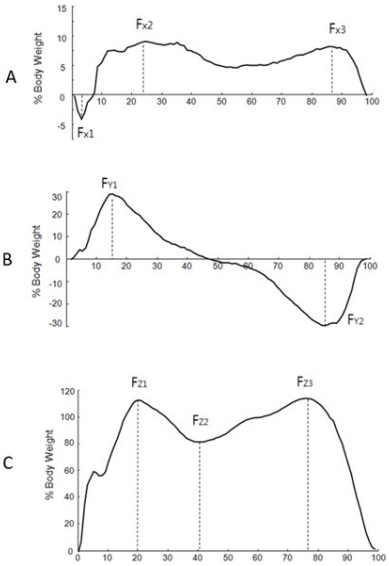

Figure 1. The typical pattern of the mediolateral (M/L), anteroposterior (A/P), and vertical planes of the ground reaction force. The horizontal line indicates the normalized stance phase, and the vertical line indicates force percent body weight.

A. M/L plane: Fx1: first negative peak force, Fx2: second peak force, Fx3: third peak force.

B. A/P plane. Fy1: positive peak in anteroposterior, Fy2: negative peak.

C. Vertical plane: Fz1: vertical first peak force, Fz2: vertical second peak force, Fz3: vertical third peak force.

Gait asymmetry comparison between subjects with and without nonspecific chronic low back pain

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Introduction: Individuals with chronic low back pain (LBP) report impaired somatosensory function and balance. However, there is a lack of investigation on kinematic similarities during gait. The aim of this study was to compare gait parameters as well as combined limb motions for the kinematic similarity index (KSI) between subjects with and without LBP.
Methods: Twenty-two subjects with LBP and 19 age- and body mass index-matched control subjects participated in this study. The combined limb motions in the gait cycle were compared between subjects with LBP and those of a prototype derived from healthy subjects. The KSI was computed as the normalized inner product or the cosine of the solid angle between the vector representing the distribution of activity generated by subjects without LBP (prototype response vector: PRV) and that representing the distribution in the subjects with LBP (RV). Thus, the index is constrained to lie between 0 and 1The calculations resulted in response vectors that were analyzed to controls-derived prototype response vectors for the normalized index at 5 % increments in the gait cycle (Figure 1).
Results: The overall index in the gait cycle was significantly different between groups (t = 6.52, p = 0.001, Cohen's d = 1.43) and the standard deviation of KSI (t = -7.62, p = 0.001, Cohen's d = 1.53). There was also a significant difference for the KSI of the stance phase (t = 6.26, p = 0.001, Cohen's d = 1.40) and the KSI of the swing phase (t = 4.23, p = 0.001, Cohen's d = 1.11). The results of our study indicated that the LBP group demonstrated greater variability based on the standard deviation than the control group in the GC (Figure 2). The LBP group may have modified their walking patterns during these specific phases.
Discussion: The KSI is useful for clinical outcome measures to differentiate kinematic changes and to demonstrate quantified similarities in the gait cycle. It is warranted to validate the KSI along with a larger sample size for physiological gait asymmetry in future studies.

Keywords: kinematic similarity index; normalization; gait cycle; low back pain; and asymmetry.

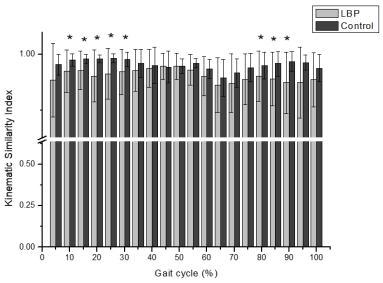
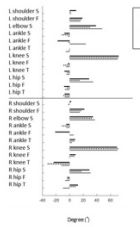


Figure 2. The Kinematic Similarity Index (KSI) values were obtained from the control and LBP groups at each 5% interval of the gait cycle (GC). The mean of the KSIs calculated for a whole GC from the control group (0.99 ± 0.01) was higher than the LBP group (0.91 ± 0.05). However, the standard deviation of the KSI was less than 0.01 in the control group, which supports that the prototype represents similar kinematic patterns within the group.



$$KSI_x = \frac{\sum PRV_{x,i} \cdot RV_{x,i}}{|PRV_x||RV_x|} \quad \text{Eq 1}$$

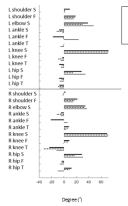
PRV_x= [PRVx_1, PRVx_1, … PRVx_n] at x% in the GC
PRVx_1: averaged value of R-Hip Rotation angles (T) from all control subjects
PRVx_2: averaged value of R-Hip Abduction angles (F) from all control subjects

PRVx_n: averaged value of n'th channel from all control subjects

RV_x= [RVx_1, RVx_2, … RVx_n] at x% in the GC
RVx_1: R-Hip Rotation angle (T) from a test subject
RVx_2: R-Hip Abduction angle (F) from a test subject

RVx_n: n'th channel from a test subject

Figure 1. Example of KSI_x computation. The left column shows the range of otions of the individual joints in the GC. The dark lines represent the averages of the control subjects. Subject A with LBP demonstrated good matching with the prototype in certain joints (R knee S, but mismatch in R hip S), and subject B with LBP showed the opposite direction in L ankle abduction. On the right panel, Eq. 1 explains the principle of computing KSI. The PRV_x is a vector with elements of individual joint angles at a specific gait cycle x by averaging all control subjects. The RV_x is a vector with elements of individual joint angles at a specific gait cycle for a specific subject. The KSI_x is computed by comparison between PRV_x and RV_x by using Eq.1 as an inner product of two vectors. To cover the full GC (0 to 100%), PRV_x and RV_x were computed in increments of 5% of the GC (KSI: kinematic similarity index, R: right. L: left, GC: gait cycle, S: sagittal plane, F: frontal plane, T: transverse plane with all 24 channels (12 for each side), LBP: low back pain).



$$KSI_x = \frac{\sum PRV_{x,i} \cdot RV_{x,i}}{|PRV_x||RV_x|} \quad \text{Eq 1}$$

PRV_x= [PRVx_1, PRVx_1, … PRVx_n] at x% in the GC
PRVx_1: averaged value of R-Hip Rotation angles (T) from all control subjects
PRVx_2: averaged value of R-Hip Abduction angles (F) from all control subjects

PRVx_n: averaged value of n'th channel from all control subjects

RV_x= [RVx_1, RVx_2, … RVx_n] at x% in the GC
RVx_1: R-Hip Rotation angle (T) from a test subject
RVx_2: R-Hip Abduction angle (F) from a test subject

RVx_n: n'th channel from a test subject

Figure 1. Example of KSI_x computation. The left column shows the range of otions of the individual joints in the GC. The dark lines represent the averages of the control subjects. Subject A with LBP demonstrated good matching with the prototype in certain joints (R knee S, but mismatch in R hip S), and subject B with LBP showed the opposite direction in L ankle abduction. On the right panel, Eq. 1 explains the principle of computing KSI. The PRV_x is a vector with elements of individual joint angles at a specific gait cycle x by averaging all control subjects. The RV_x is a vector with elements of individual joint angles at a specific gait cycle for a specific subject. The KSI_x is computed by comparison between PRV_x and RV_x by using Eq.1 as an inner product of two vectors. To cover the full GC (0 to 100%), PRV_x and RV_x were computed in increments of 5% of the GC (KSI: kinematic similarity index, R: right. L: left, GC: gait cycle, S: sagittal plane, F: frontal plane, T: transverse plane with all 24 channels (12 for each side), LBP: low back pain).

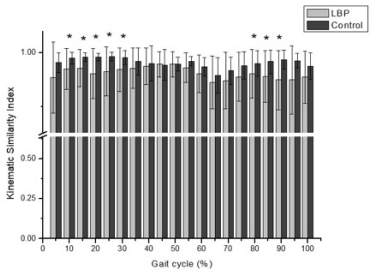


Figure 2. The Kinematic Similarity Index (KSI) values were obtained from the control and LBP groups at each 5% interval of the gait cycle (GC). The mean of the KSIs calculated for a whole GC from the control group (0.99 ± 0.01) was higher than the LBP group (0.91 ± 0.05). However, the standard deviation of the KSI was less than 0.01 in the control group, which supports that the prototype represents similar kinematic patterns within the group.

1205

Lower limb reaction times with tray usage following a slip perturbation between subjects with and without chronic low back pain

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Introduction: Although delayed onsets of trunk muscle activations were present in response to external perturbations, there is currently no convincing evidence for the altered ankle muscle activations in regards to tray usage and limb dominance between subjects with and without low back pain (LBP) following a perturbation. The aim of this study was to compare the functional mobility and reaction times of the ankle muscles in regards to tray usage between subjects with and without chronic LBP following a treadmill-induced slip perturbation.

Methods: Thirty-seven right limb dominant subjects with LBP and 37 subjects without LBP participated in the study. Functional mobility was compared based on the duration of the Timed Up and Go test (TUG). Each subject was introduced to slip perturbations (1.37 m/sec velocity for 8.22 cm) with and without a handheld tray in random order (Figure 1). This treadmill-induced slip allowed subjects to recover by stepping forward for a 0.12 second duration while bilateral tibialis anterior (TA) and gastrocnemius (GA) muscle reaction times were measured by electromyography (Figure 2).

Results: Functional mobility was significantly different between groups ($t = -2.33$, $p = 0.02$). The groups demonstrated significant interactions on the lower limb sides and muscles ($F = 4.86$, $p = 0.03$). The dominant TA reaction time was significantly faster in the LBP group ($t = 2.14$, $p = 0.03$) while holding a tray.

Discussion: Although functional mobility decreased in the LBP group, their reaction time on the dominant TA was faster with tray usage in order to enhance step propulsion and control. Clinicians need to consider dominance-dependent compensatory ankle strategies in LBP patients to help them avoid potential fall risks and to enhance dynamic balance.

Key words: kinematics; perturbations; low back pain; motor learning; compensatory motion.

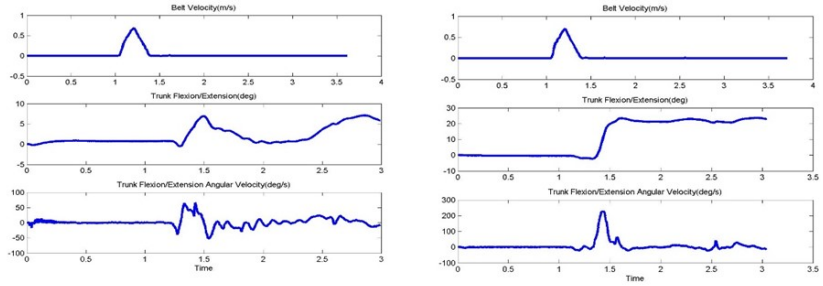

Figure 2. An example of angle and velocity changes following a slip perturbation (duration: 0.12 sec, velocity: 1.37 m/sec, displacement: 8.22 cm) for the control subject (A). The subject with low back pain demonstrated greater angular displacement and velocity changes (B). The positive values of the y-axis correspond to trunk flexion, and the negative values correspond to trunk extension.

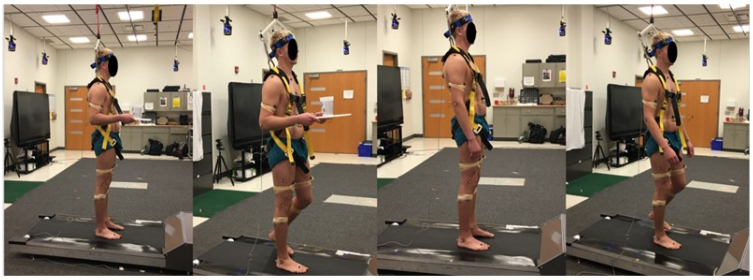

Figure 1. The experimental protocol used a treadmill to produce a perturbation while a subject with low back pain was in a quiet standing posture. Each subject was protected by a full-body safety harness during trials on the treadmill. A: a subject holding a tray, B: a subject not holding a tray during the perturbation trial.

Asymmetrical reactions in the arm-trunk muscles and symmetry indices between subjects with and without chronic low back pain

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Introduction: Individuals with chronic low back pain (LBP) often adapt trunk and pelvis coordination from altered muscular control. However, there is a lack of understanding on the symmetry of trunk muscle reactions relative to the bilateral limbs following a treadmill-induced perturbation. This study was conducted to investigate the reaction times and symmetry index (SI) of the bilateral trunk and limb muscles between control subjects and subjects with LBP for two months or longer.
Methods: Fifty-seven right limb dominant subjects (31 healthy control subjects and 26 subjects with LBP) participated in this study. The subjects were exposed to a slip perturbation (0.24 m/sec velocity for 1.20 cm), which caused them to move forward for 0.10 seconds in standing while holding a tray (Figure 1). The electromyography (EMG) electrodes were placed on the bilateral erector spinae (ES), rectus abdominis (RA), rectus femoris, hamstring, tibialis anterior, gastrocnemius, biceps brachii (BB), and triceps brachii muscles. The reaction times were analyzed, and the SI was used to compare the bilateral trunk and limb muscles for the degree of asymmetry between groups.
Results: The ES reaction time was significantly delayed in the control group (0.33 ± 0.22 vs. 0.22 ± 0.17; t = 2.25, p = 0.03). The SI of reaction times was significantly different on the RA (t = -2.28, p = 0.03), ES (t = -2.36, p = 0.04), and BB (t = -2.15, p = 0.04) muscles between groups (Figure 2).
Discussion: The delayed non-dominant ES reaction time might indicate a freedom of pain recurrence in the control group. Although the asymmetry increased on the RA and BB muscles in the LBP group, it decreased on the ES muscle. The asymmetrical reactions in the arm-trunk muscles need to be considered for rehabilitation strategies, although not all asymmetry causes LBP.

Key words: limb dominance; EMG; low back pain; symmetry index; reaction times.

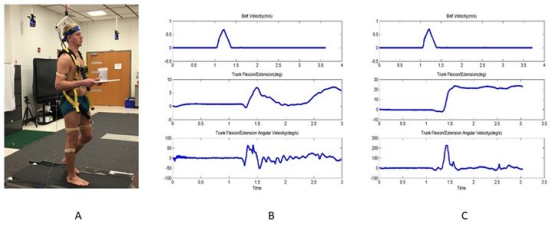

Figure 1. An experimental protocol was utilized to produce treadmill-induced slip perturbations in standing. (A) Each subject was protected by a full-body safety harness during repeated trials. The angle and velocity changes were calculated following the slip (0.24 m/sec velocity for 1.2 cm) for 0.1 seconds in standing while holding a tray. (B) The positive values of the y-axis correspond to trunk flexion, and the negative values correspond to trunk extension. The subject with low back pain (C) demonstrated greater angle and velocity changes compared with the control subject (B).

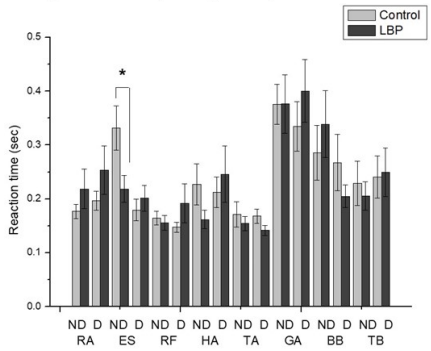

Figure 2. The reaction time differences between limbs and groups with and without low back pain (LBP). The repeated measure ANOVA results indicated that the group demonstrated a significant interaction with sides (F = 5.08, p = 0.02). The group was significantly different between the non-dominant ES muscle (t = 2.25, p = 0.03). (* < 0.05, ND: non-dominant side, D: dominant side, RA: rectus abdominis, ES: erector spinae, RF: rectus femoris, HA: hamstring, TA: tibialis anterior, GA: gastrocnemius, BB: biceps brachii, and TB: triceps brachii)

The limb reaction and recovery step times following repeated perturbations in subjects with recurrent low back pain.

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Introduction: Individuals with recurrent low back pain (LBP) exhibit neural changes that underlie dynamic balance deficits, and continuous pain episodes may relate to postural control. The aim of this study was to investigate adaptive changes on the lower limb reaction, swing, and step times, as well as step length changes, following repeated trip perturbations in individuals with and without recurrent LBP.

Methods: There were 30 subjects with LBP and 40 control subjects who participated in the study. The lower limb reaction, swing, and recovery step times (sec) and step lengths (cm) were analyzed following three repeated random trips (velocity: 0.31 m/sec, displacement: 0.62 m) in standing. The treadmill-induced trip caused subjects to walk forward for 4.90 sec (Figure 1).

Results: There was no group interaction on the lower limb reaction ($F = 2.15$, $p = 0.15$), swing time ($F = 0.79$, $p = 0.38$), or step length changes ($F = 0.51$, $p = 0.48$). However, the groups demonstrated a significant interaction on the recovery step times following trips ($F = 4.04$, $p = 0.04$). The LBP group demonstrated faster recovery step time ($t = 2.68$, $p = 0.01$) only at the first perturbation (Figure 2).

Discussion: The limb reaction, swing time, and step lengths were not sensitively reflected by the trips; however, the novelty of the first perturbation substantially enhanced recovery step times. Although the recovery step times were not significantly correlated with the reaction times, the fast recovery step time suggests the likelihood of a fall prevention strategy to improve dynamic stability from the trip-induced instability in the LBP group.

Key words: reaction time; recovery step time; perturbations; low back pain; compensation.

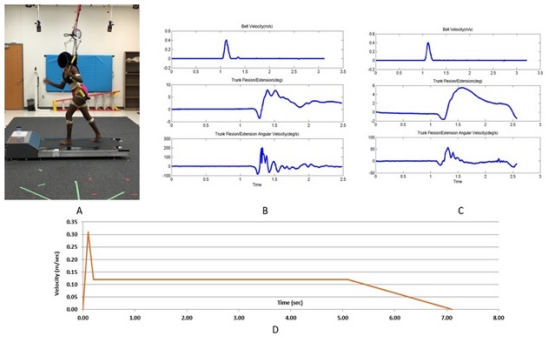

Figure 1. An example of the treadmill-induced trip perturbation (A) The angle and velocity changes (y-axis) on time (x-axis) following a perturbation while not holding a tray. The positive values of the y-axis correspond to trunk flexion, and the negative values correspond to trunk extension. B indicates a control subject, and C indicates a subject with recurrent low back pain (LBP). The subject with LBP demonstrated greater angular displacement and velocity changes compared to the control subject. D indicates a perturbation that caused subjects to walk forward for 4.90 sec after the perturbation velocity (0.31 m/sec) and displacement (0.62 m).

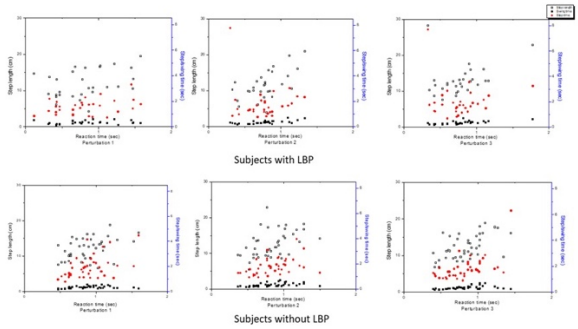

Figure 2. The scatter plots for the reaction times with step and swing times and step length changes following three repeated trips between groups. Following the repeated perturbations, the recovery step times were positively associated (correlation coefficient r: ranged 0.42 – 0.51) with reaction times in the control group. However, these relationships were not significant in the LBP group. (LBP: low back pain)

1208

Is paravertebral muscle a risk factor for recurrent disc herniation?

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Study Design: A nested case-control study

Objectives: Lumbar herniated disc recurrence is common and might be related to the strength of paravertebral muscles. To explore if paravertebral muscle properties (volume and degeneration) are associated with recurrent herniated disc following full-endoscopic discectomy.

Methods: This is a case-control study nested in the Bumrungrad Spine Cohort. In this study, data of 545 international patients who underwent full endoscopic discectomy between 2011 and 2015 were reviewed. Patients were considered a case if he/she experience a recurrent herniated disc. Age- and gender-matched controls were randomly selected from the non-case group. Physiologic measures were used to quantify the paravertebral muscle volume with the lumbar indentation value (LIV) technique and degeneration with the Goutallier classification.

The LIV and Goutallier classification measurements were compared between the clinical and control groups using the kappa statistic and Fisher's exact test.

Results: Of 545 patients, 60 with recurrent herniated disc and 60 age- and gender-matched controls were examined. The overall mean age of the patients was 47.38 years, and 30.83% of patients were female. The mean LIV was 14.59, with no significant difference between the case and control groups (14.93 vs. 14.25 mm; p=0.5021). The Goutallier classification showed a similar distribution between groups (p=0.25).

Conclusions: Based on our data, paravertebral muscle volume and degeneration were not associated with herniated disc recurrence after full-endoscopic discectomy.

1209

Values for the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire in the general elderly population: A Japanese cohort survey randomly sampled from a basic resident registry

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Introduction: Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ) is widely used as a patient-based evaluation tool for lumbar spine disease in Japan. However, there are currently few established JOABPEQ reference values for the general population.

This study proposes population-based reference values for JOABPEQ using a randomly sampled Japanese cohort.

Methods: Registered citizens of 50 to 89 years old were targeted for this survey. We established 8 groups based on age (50's, 60's, 70's, and 80's) and gender (male and female) after random sampling from the basic resident registry of Obuse town in 2014. A total of 414 participants (202 males and 212 females) were enrolled for calculations of average JOABPEQ scores for each age and gender group. We also evaluated for correlations between JOABPEQ domain scores and visual analogue scale (VAS) scores for low back pain.

Results: Median reference JOABPEQ scores stratified by age and gender were determined in this study. Lumbar function, walking ability, and social life function deteriorated significantly with age in both genders, with remarkable declines for the social life function domain. VAS scores for low back pain were not significantly correlated with JOABPEQ item scores.

Discussion: In the present cohort study of over 400 subjects randomly selected from a rural Japanese town registry, we were able to calculate median reference JOABPEQ scores by age and gender of seniors over 50 years old. The scores for lumbar function, walking ability, and social life function all decreased steadily with age in men and women, with notable declines for social life function. These scores were also significantly lower for subjects in their 70's and 80's than in subjects in their 50's and 60's for both genders (all $p<0.05$) apart from men in their 70's for lumbar function and social life function versus men in their 50's. The median value for walking ability in octogenarian women was similar to that in octogenarian men ($p=0.28$).

1210

The prevalence and impacts of low back pain, as well as associated factors in Chinese female adolescents

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4. Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark

INTRODUCTION

Although prior studies revealed high prevalence of low back pain (LBP) among adolescents, little is known regarding the impact of LBP on various aspects of adolescents. The objectives of the current study were to determine the prevalence of LBP, its impact, and factors associated with a high prevalence of LBP among Chinese female adolescents.

METHODS

An online survey was distributed to secondary school students (aged 11-18 years) in two girls' schools who obtained parents' consent for their study participation. The survey comprised four parts: (1) a modified Nordic Musculoskeletal Questionnaire; (2) KIDSCREEN; (3) Rosenberg Self-esteem Scale, and (4) Pediatric Daytime Sleepiness Scale (PDSS). KIDSCREEN evaluated the health-related quality of life (HRQOL) of teenagers, while Rosenberg Self-esteem Scale and PDSS assessed adolescents' self-esteem and daytime sleepiness, respectively. The lifetime prevalence of LBP, the 12-month prevalence of LBP and chronic LBP (CLBP) that lasted for at least 3 months in the last 12 months were calculated. Characteristics of adolescents with and without LBP/CLBP were compared by separate independent t-tests. Factors associated with LBP/CLBP were analyzed by separate stepwise logistic regression models. The significance level was set at 0.05.

RESULTS

229 participants completed the survey (mean age: 14.5+1.7 years; 53.3% response rate). The lifetime prevalence of LBP was 27.5%, while the 12-month prevalence of LBP and CLBP were 25.8% and 5.2%, respectively. Adolescents with LBP reported significantly poorer HRQOL (KIDSCREEN: 34.9 vs 38.6), more daytime sleepiness (PDSS: 26.4 vs 24.1) and greater pain-related interferences of recreational activity (3.6/10 vs 2.6/10) than non-LBP counterparts. Similarly, adolescents with CLBP had significantly poorer HRQOL, more daytime sleepiness, and more pain-related interferences of daily activities (3.8/10 vs 2.8/10) or recreational activities (4.7/10 vs 2.7/10) than non-CLBP students. Laptop/desktop usage for >3 hours per weekday, age > 15 years, and an additional painful region in the last 12 months were all significantly associated with a higher 12-months prevalence of LBP with odds ratios (OR) above 2. Interestingly, only an additional painful region in the last 12 months was significantly related to a higher prevalence of CLBP (OR=1.23).

DISCUSSION

Both LBP and CLBP not only are prevalent among Chinese adolescents but also adversely impact multiple aspects of their lives. While older age is a non-modifiable risk factor for LBP, both sedentary lifestyle and multi-site pain may be modified to lower the risk of LBP/CLBP occurrence. Since LBP in adolescence is a well-known risk factor for LBP in adulthood, early interventions (including education) are warranted to alleviate LBP in adolescents.

Within- and between-day intra- and inter-rater reliability of using shear-wave elastography and myotonometry to assess erector spinae muscle stiffness in asymptomatic individuals

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INTRODUCTION

Although separate studies have used shear wave elastography (SWE) and myotonometry to objectively quantify soft tissue stiffness, the within- and between-day intra- and inter-rater reliability of novice examiners in using these technologies to measure the paraspinal muscle stiffness remains unknown. Importantly, no studies have determined the sensitivity of SWE and myotonometry in detecting temporal changes in paraspinal muscle stiffness, which may limit their clinical applications. Therefore, the current study aimed to: (1) determine the within- and between-day intra- and inter-rater reliability of SWE and myotonometry in quantifying resting erector spinae (ES) stiffness; (2) measure changes in ES stiffness immediately after a back extensor fatigue regimen; and (3) estimate the correlation between ES stiffness estimated by the two methods.

METHODS

Left ES resting stiffness values of 30 prone lying volunteers (average age:21±0.69 years; 50% females) were measured twice by 2 newly trained examiners using a SWE device and a handheld myotonometer each. Volunteers then performed back extension in prone until experiencing subjective fatigue. Both examiners immediately repeated the muscle stiffness measurements. The volunteers returned 3-4 days later to undergo the same procedure. The within- and between-day intra- and inter-rater reliability of using both devices to measure ES stiffness were evaluated by intra-class correlation coefficients model 3 ($ICC_{3,3}$). Temporal changes in ES stiffness as measured by SWE and myotonometry were assessed by separate paired t-tests. The correlation between the measured baseline ES stiffness by SWE and myotonometry was assessed by the Pearson product-moment coefficient (r)

RESULTS

Within-day intra- and inter-rater reliability estimates for SWE and myotonometry stiffness measurements were $ICC_{3,3}$>0.87 and $ICC_{3,3}$>0.97, respectively ($p<0.05$). Between-day intra- and inter-rater reliability estimates for ES stiffness measurements using SWE and myotonometry were from 0.50 to 0.68 and >0.92, respectively. Both devices showed significant increases in post-fatigue resting ES stiffness ($p<0.05$). Baseline ES stiffness values measured by SWE were significantly correlated to those by myotonometry ($r = 0.28$).

DISCUSSION

Novice examiners showed excellent within- and between-day intra- and inter-rater reliability in using myotonometry to measure stiffness. However, the between-day intra- and inter-rater reliability estimates of ES stiffness measured by SWE was fair to moderate. Given the high reliability, portability, and relatively low cost of handheld myotonometers, they can be handy tools for quantifying back muscle stiffness in clinical practice and research. Future studies should establish the within- and between-day intra- and inter-rater reliability of using the two technologies to measure ES stiffness in people with low back pain.

1212

Using analytic software to understand relevant experiences and information about spinal stenosis from Twitter users

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INTRODUCTION

Spinal stenosis is a narrowing of the spinal canal that may compress neurological tissues leading to pain and disability. Although previous qualitative studies have attempted to solicit data regarding the life experience of patients with spinal stenosis or their opinions towards non-surgical treatments for spinal stenosis, their data was collected from participants in a controlled setting. Therefore, it remains unclear whether patients' or caregivers' concerns/opinions about spinal stenosis would be different in a non-experimental environment. Given that Twitter is a popular online platform for people to share information and interact instantaneously, the analysis of relevant tweets from Twitter may help reveal people's thoughts and attitudes about spinal stenosis. As such, the current study aimed to identify tweets that were relevant to spinal stenosis on Twitter, and to categorize them into common themes.

METHODS

A social media monitoring and analysis software program (TalkWalker) was used to search relevant tweets using the keywords 'spinal stenosis' and 'stenosis' between 29 May 2019 and 24 June 2020. Two independent reviewers screened and conducted content analysis of the tweets and classified the tweets into different themes.

RESULTS

Three hundred sixty-two out of 510 identified tweets met the selection criteria. Five themes were identified: (1) compromised physical, psychological, and social wellbeing (n=173); (2) diverse treatment options (n=69); (3) coping strategies (n=30); (4) dissemination of scientific information (n=86); and (5) health policy (n=4). Most of the tweets revealed negative impacts of spinal stenosis on patients' physical and psychosocial wellbeing. People with spinal stenosis were eager to share their experiences and sought helps from others on Twitter, while it was not uncommon for clinicians or researchers to disseminate relevant information and research findings on Twitter.

DISCUSSION

This is the first study to reveal the feasibility of using Talkwalker to categorize tweets into themes related to spinal stenosis. The approach not only helps understand people's concerns about spinal stenosis in an uncontrolled environment, but also can be adopted to monitor influences of diseases or public health education on Twitter users. Collectively, Twitter can be a novel channel for researchers to understand the impact of different diseases on various aspects of patients, conduct research (e.g., online surveys), and disseminate research findings.

Determining the prevalence of dance-related lumbar injury and associated factors among dancers – a large-scale study

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INTRODUCTION

Previous prevalence research shows that lumbar injury is one of the most prevalent dance injuries among dancers. Unfortunately, no large-scale, population-based studies have investigated the risk factors for dance-related lumbar injury among dancers. A better understanding of the prevalence of such injury and related risk factors can help develop and implement effective dance prevention strategies. This study aimed to investigate the 12-month prevalence of dance-related lumbar injury and the associated risk factors among dancers.

METHODS

Identical web- and paper-based questionnaires were sent to professional and recreational dancers through local dance associations, dance schools, and interschool dance competitions. The questionnaire collected data regarding demographics, dance experiences, dance injury within the last 12 months, and history of dance-related lumbar injury. Factors associated with dance-related lumbar injury in the last 12 months were expressed as odds ratios (OR), Factors that demonstrated reasonable differences between dancers with and without dance-related lumbar injury ($p < 0.10$) were entered as potential factors in a multivariate logistic regression model. The associations were expressed as ORs and 95% confidence interval (CI).

RESULTS

Information from 1,416 respondents (mean age: 19.5+10.2 years) were used for analyses. Approximately 87.4% and 30.0% of the respondents were females and professional dancers, respectively. Scoliosis was reported by 16.8% of respondents. The 12-month prevalence rate of lumbar injury in dance instructors and dancers was 23.5% and 10.3%, respectively. The regression model showed that dancer instructors (OR=2.49; 95% CI: 1.59 to 3.74), prior history low back dance injury (OR=2.32, 95% CI: 1.48 to 3.64), and the presence of scoliosis (OR=1.92; 95% CI: 1.78 to 3.87) were independently related to dance-related lumbar injury in the last 12 months.

DISCUSSION

This is the first large-scale, population-based study to investigate the 12-month prevalence of lumbar injury and associated risk factors for dancers practicing different genres. The results highlight that dance instructors, prior history of lumbar injury, and spinal deformity are significantly related to lumbar dance injury in dancers. Future clinical trials should investigate whether the provision of proper education/rehabilitation can lower the risk of new/recurrent lumbar dance injury in these high-risk individuals.

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The effectiveness of antibiotic treatment in patients with chronic low back pain and Modic changes: a state-of-the-art systematic review

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Introduction

Chronic low back pain (CLBP) affects more than one billion people worldwide. Despite the high prevalence, many treatments for CLBP only display small-to-moderate effects on pain and disability. Subchondral vertebral bone marrow non-neoplastic lesions, known as Modic changes (MCs), have been associated with CLBP. It is hypothesized that MCs are related to low-grade discitis caused by *Cutibacterium acnes*. Although some trials reported that three months of Amoxicillin-clavulanate treatment was effective in treating patients with CLBP, the findings remain controversial. Therefore, this systematic review aimed to summarize evidence regarding the effectiveness of oral antibiotic intervention for CLBP.

Methods

Five databases (AMED, CINAHL, Cochrane Library, Embase, and Medline) were searched from inception to November 15, 2021. Randomized controlled trials (RCTs) or non-RCTs that investigated the effectiveness of oral antibiotics in treating patients with CLBP were eligible for inclusion. Two independent reviewers screened titles, abstracts, and full-text articles, as well as extracted data. They also independently evaluated the methodological quality of the included RCTs and non-RCTs using RoB 2 and ROBINS-I, respectively. The quality of evidence for the treatment effectiveness was appraised by GRADE.

Results

A total of 148 potential articles were identified. After removing duplicates, 135 abstracts and 13 full-text articles were screened. Five RCT articles (from three cohorts) and four case series were included. Strong evidence supported that Amoxicillin-clavulanate or Amoxicillin was significantly better than placebo in reducing Roland Morris Disability Questionnaire or Oswestry Disability Index scores, and improving quality of life in patients with CLBP and concomitant type 1 MCs (as determined by T1/T2 or STIR sequences) at the 1-year follow-up. Limited evidence from non-RCTs suggested that three months of oral Amoxicillin-clavulanate significantly improved LBP and leg pain intensity, number of days with LBP, and LBP-related disability. Likewise, moderate evidence from a RCT suggested that three months of oral Amoxicillin-clavulanate was significantly better than placebo in improving pain and global perceived health at the 1-year follow-up. Conversely, moderate evidence found that three months of oral Amoxicillin alone was not significantly better than placebo in improving LBP intensity or global perceived health in patients with CLBP at the 1-year follow-up. A cost-effectiveness trial revealed that the healthcare cost of the Amoxicillin group was at least double that of the placebo group. Some patients receiving oral antibiotics also reported significantly more adverse effects.

Discussion

This is the first systematic review, to our knowledge, performed on this topic. While strong evidence supports that oral Amoxicillin-clavulanate or Amoxicillin are superior to placebo in reducing LBP-related disability in a subgroup of patients with CLBP and concomitant type 1 MC, it remains uncertain whether oral antibiotics can improve clinical symptoms in patients with CLBP. Since antibiotics-related side effects might cause participants' bias and different magnetic resonance imaging sequences might affect how MCs phenotype was assessed, the existing findings should be interpreted with caution. Given the high-cost and potential adverse effects/antibiotic resistance of antibiotics, future high-quality RCTs should replicate the results before changing clinical practice and guidelines.

Spinal Injuries in Elite Greek Gymnasts - A 10 year study

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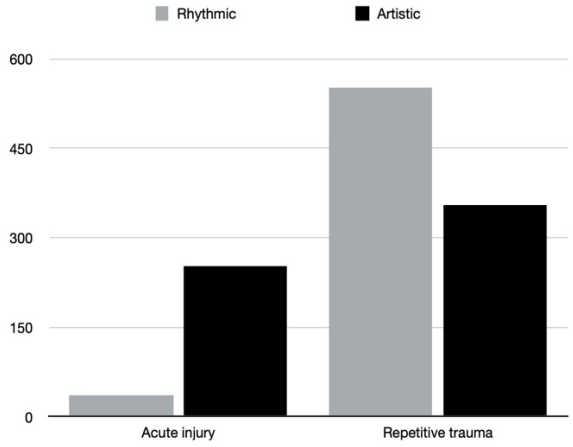
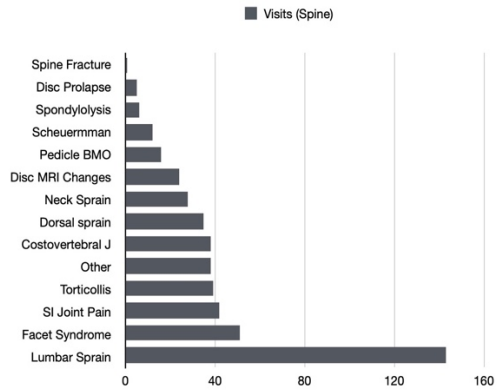
INTRODUCTION Gymnastics is a highly demanding sport with high impact and repetitive stresses on the musculoskeletal system and in particular the spine.

METHODS A retrospective analysis of the injuries recorded over a period of 10 years (2007-2018) in 156 elite Greek Gymnasts competing in international level was performed. A total of 2390 injuries were recorded for a rate of 1,5 new injuries per athlete per year.

RESULTS Acute low back pain that kept the athlete out for an average of 3 training sessions was the most common pathology (20%). Degenerative disk changes (end plate changes, disc dehydration) were found in 25% of 48 lumbar MRI scans performed for persisting low back pain. Established spondylolysis was rare (3%) but MRI detected pedicle bone marrow oedema was more frequent (8%). Hyperextension of the spine during dismount from high bar or floor exercises was reported as mechanism of injury by most athletes. The thoracic spine was least affected (0,7%) but was related with more severe injuries. Neck injuries (mostly muscle sprains) were less frequent (2,8%), but resulted in longer absence from training. Rhythmic gymnasts had significantly more overuse type injuries compared to artistic gymnasts ($p = 0.049$). The majority of injuries were conservatively treated with physiotherapy, core stability and staged return to sport. Spine surgery was necessary only in 3 cases: a T10 fracture with paraplegia after a trampoline accident, a female athlete with severe Scheuermann kyphosis and a male gymnast with lumbar disk herniation.

DISCUSSION Gymnastics is a sport with a high incidence of musculoskeletal pathology - mostly overuse type of injuries. Few studies have addressed the issue of spinal injuries in gymnastics and there is a lack of documentation in order to establish preventive measures. A detailed evaluation of the mechanism of injuries is needed in order to assist sport authorities in revisiting the Code of Points and improve the safety of athletes.





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What is most related to spinal malalignment among various muscle evaluation indices? -The Wakayama Spine Study

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Purpose: Sarcopenia is attracting attention as a cause of spinal malalignment (forward leaning posture) associated with aging. We examined what is most related to spinal malalignment among various muscle evaluation indices.

Method: A cross-sectional analysis was conducted on 737 residents (215 males, 522 females, mean age 63.5 ± 13.1 years old) who participated in the second survey of Wakayama Spine Study conducted in a seacoast town. Evaluation items were C7 SVA of standing X-ray lateral image, existence of low back pain within one month, Oswestry disability index (ODI), trunk muscle mass and limb skeletal muscle mass by impedance method, paraspinal muscle (PVM = multifidus + erector spinae muscle) and psoas major muscle cross-sectional area (CSA) and the fat infiltration ratio (FIR) of lumbar MRI. In addition, grip strength, walking speed, and 5 times chair rise time were also measured, and sarcopenia was judged according to the criteria of the Asian Working Group for Sarcopenia (2019). In this study, C7 SVA ≥ 50 mm was defined as the "spinal malalignment".

Statistics: We examined (1) the relationship between spinal malalignment and low back pain / ODI, (2) the relationship between spinal misalignment and sarcopenia using a multiple logistic model, (3) the correlation between trunk muscle mass and CSAs of paraspinal muscle / psoas major muscle (both non-fat areas). Finally, we created multiple regression models with C7 SVA as the objective variable, sex, age, BMI, and one of the muscle evaluation indices (alternately input) as the explanatory variable and determined which muscle evaluation index has the greatest influence by comparing the standardized β.

Results: The spinal malalignment was significantly related with the existence of low back pain and ODI. Age, obesity, and sarcopenia were all significantly associated with the spinal malalignment. Trunk muscle mass and CSAs of paraspinal muscle / psoas major muscle showed a strong correlation. On the other hand, the degree of influence on C7 SVA is in the order of “L1/2 PVM FIR (β 0.33) > L1/2 PVM CSA (0.24) ≒ L4/5 PVM FIR (0.24) > L4/5 PVM CSA (0.20) ≒ trunk muscle mass (0.20) > psoas major muscle FIR (0.10). Limb skeletal muscle mass was not a significant factor for C7 SVA.

Conclusion: From the results of the cross-sectional survey, we believe that the muscle evaluation index most related to the spinal malalignment is the FIR of PVM at the upper lumbar region. Since limb skeletal muscle mass and C7 SVA did not correlate, it is necessary to establish diagnostic criteria for "paraspinal muscle sarcopenia" in order to predict spinal malalignment.

Association of Diffuse Idiopathic Skeletal Hyperostosis with Vascular Calcification and Cardiovascular Disease

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INTRODUCTION

Diffuse idiopathic skeletal hyperostosis (DISH) occurs mainly as an ossification form around the vertebrae and causes pseudoarthrosis and delayed neuropathy after vertebral fracture. It is known to be associated with obesity and metabolic abnormalities, but the cause is unknown, and the relationship with medical diseases is also largely unknown. We hypothesized that this disease is associated with vascular calcification and the occurrence of cardiovascular events.

METHODS

First, we randomly selected 400 patients who underwent surgery at the Department of Cardiovascular Surgery in our hospital from 2016 to 2008 (cardiovascular event group) and 400 patients who were transported to the Emergency Department for non-cardiovascular events during the same period (non-event group), respectively, and investigated the incidence of DISH. The presence or absence of DISH was assessed by CT imaging based on the criteria proposed by Resnick et al. Second, in the non-event group, we evaluated the degree of calcification in coronary arteries and aorta using coronary artery calcification score (CACS) and aortic calcification index (ACI) to determine the association with DISH incidence. We used workstation software, VINCENT, for image analysis.

RESULTS

The incidence of DISH was 30.2% in the cardiovascular event group and 14.1% in the non-event group. The incidence of DISH was 30.2% in the cardiovascular event group and 14.1% in the non-event group, and was higher in the cardiovascular event group. In terms of vascular calcification, DISH patients in the non-event group (39 patients) had CACS 673.2 ± 124.7 and ACI 9929.6 ± 1492.0, while those without DISH (237 patients) had CACS 174.2 ± 70.8 and ACI 3555.8 ± 545.0. The values were significantly higher in DISH cases.

DISCUSSION

The incidence of DISH was higher in patients with cardiovascular events, and patients with DISH had more calcification of coronary arteries and aorta. These results are important for understanding the pathophysiology and developmental mechanism of this disease. The findings may also be useful for early detection and treatment of untreated cardiovascular diseases.

Short-term clinical results of Balloon kyphoplasty combined with percutaneous pedicle screw fixation for painful and unstable osteoporotic vertebral body fracture and compare it with percutaneous vertebroplasty with HA block combined with percutaneous pedicle screw fixation. -Minimum 2 years follow up-

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INTRODUCTION

Case controlled study. The purpose of this study is to clarify the short-term clinical results of Balloon kyphoplasty combined with percutaneous pedicle screw (PPS) fixation (BKP+PPS) for painful and unstable osteoporotic vertebral body fracture (OVF) and compare it with percutaneous vertebroplasty with HA block combined with PPS fixation (HA+PPS).

METHODS

The clinical study proposal was approved by the medical ethical committee of our institution. From May 2013 to November 2019, out of 31 cases (4 males, 26 females, average age at surgery 75.5 years) who performed vertebroplasty and posterior fixation with PPS by the same operator for painful OVF, the subjects were 24 patients (3 males, 21 females, mean age at surgery 78.0 years) who could be followed up more than 2 years after surgery. The surgical procedure is percutaneous vertebroplasty for 1 vertebral body and posterior stabilization with PPS (without direct neural decompression procedure) for unstable OVF with intra- or inter-vertebral instability. We divided these into 12 cases of HA+PPS (group H) and 12 cases of BKP+PPS (group B), and investigated the clinical results. We evaluated time from injury to surgery, pre- and post-operative visual analogue scale (VAS) of low back pain, wedging angle of fractured vertebra, duration of operation, intraoperative blood loss, number of instrumented vertebra, and length of stay at hospital.

RESULTS

Number of instrumented vertebra is 3.1 ± 0.8 in H and 2.8 ± 1.2 in B , there was no difference between the two groups. The average operation time was 95.3 ± 22.9 minutes in H, 72.6 ± 33.2 minutes in B ($P = 0.016$), and the average intraoperative blood loss was 99.2±42.5 g in H and 47.6±9.9 g in B ($P = 0.001$). The average hospital length was 17.8±9.0 days in H, 8.8±4.6 days in B ($P = 0.003$). The VAS immediately after surgery was significantly lower ($P < 0.005$) than that of before surgery in two groups. The VAS at 1 and 2 years after surgery was significantly decreased ($P < 0.05$) in two groups. The wedging angle of fractured vertebra was significantly lower ($P < 0.005$) than that of before surgery in two groups. The wedging angle of fractured vertebra immediately after surgery was 7.3 ± 5.8 degrees in H and 4.3 ± 3.6 degrees in B, but no difference was observed. The wedging angle of fractured vertebra 2 years after surgery was 12.3 ± 6.8 degrees in the H and 4.6 ± 3.6 degrees in the B, showing a significant correction loss in the H group ($P = 0.002$). In both groups, bone union was obtained in all cases 1 year after surgery. None of the patients were found to have any postoperative neurological complications.

DISCUSSION

BKP+PPS for unstable OVF was suggested to be minimally invasive in the elderly patients. In addition, there is no correction loss of the fractured vertebral body 2 years after BKP+PPS, which is considered to be a useful surgical procedure. Further long-term follow-up and further verification are necessary, including the necessity of implant removal.

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Incidence of congenital scoliosis estimated from a nationwide health insurance database

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Objective: To investigate the epidemiology of congenital scoliosis (CS) and treatment trends.
Study Design: An age-matched, nationwide, population-based study was conducted using the National Health Insurance and Health Insurance Review and Assessment databases from 2010 to 2015. Data regarding the diagnosis and treatment of scoliosis were extracted using International Classifications of Diseases, 10th revision codes. The age-matched normal population was determined from the Korean Statistical Information Service database. We analyzed the incidence of CS according to age and sex, as well as the proportion of surgically treated patients.
Results: A total of 2338 patients (aged 0-19 years) were diagnosed with CS. The overall average incidence of CS over the 6-year period was 3.6 per 100,000 persons, with the highest and second highest rates at 0 years and 14–16 years of age, respectively. The incidence stratified by age ranged from 1.8 to 20.9 per 100,000 persons among the age-matched normal population and showed a bimodal pattern, with peaks at 0 years of age and the second growth spurt in adolescence (12–16 years for males; 10–14 years for females). Anterior surgery was rarely performed; posterior surgery was performed in 131 patients (5.6% of all patients), with the highest prevalence (60%) in patients diagnosed at 10–14 years of age.
Conclusions: This study is the first Korean epidemiological study on CS and provides information regarding the latest trends in surgical treatment for CS. Only 5.6% of patients underwent surgery within 6 years after the initial diagnosis.

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A Study on the Treatment of Very Early Stage Lumbar Spondylolysis Patients

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I

INTRODUCTION: Very early stage lumbar spondylolysis is thought to be pre-fracture condition, which can be detected only by high signal change on MRI STIR images. Most of them don't feel pain in daily life but sports activities. We had treated them with bracing and pausing sports activity in order to prevent from progressing to fracture. However, some of them didn't want to pause the sports and they continued sports withuout severe pain in short term. The purpose of this study was to compare the difference between the case of continuing sports and bracing for bone union.

SUBJECTS and METHODS: We included 44 patients (36 boys and 8 girls), who were diagnosed as very early stage, and had unilateral or bilateral spondylolysis. Pseudo-bilateral (contralateral side was already terminal stage) patients were excluded in this study (average age: 14.5 years; range: 11–17 years). We have followed them for at least one year (Mean follow-up periods: 17 months; 12-32 months). Twelve patients continued sports activities (Group S). Remaining 32 patients (Group B) were instructed to put on soft brace, start exercise after the pain subsided and return to sports when MRI showed no signal change. We compared these two groups about bone union rate, recurrence rate and sports activity. We rated their sports activity into four ranks: 1) Excellent; no pain, full activities, 2) Good; occasional pain, full activities, 3) Fair; occasional pausing of sports activities due to low back pain, 4) Poor; pain on daily living, or quit sports.

RESULTS: In Group S, 4 out of 12 patients progressed to fracture. On the other hand ,in Group B, no one failed to union ($p<0.01$). Recurrence occurred 1 patient in addition to the above 4 patients in Group S, 5 in Group B ($p=0.544$). As to sports activity during follow-up period, in Group S ,5 patients were rated "excellent", 3 "good", 5 " fair". In Group B, 25 "excellent", 4 "good", and 5 "fair" ($p<0.01$). Group B patients returned to sports within 4 week to 9 week, average of 6.5 week. Two patients in Group S resulted in bilateral spondylolysis. There was no significant difference as to age and level of affected laminae.

DISCUSSION: All patients in this study were able to return to sports with or without pain. However, even very early stage patients had risk of fracture if they continued sports, and had to pause their activity for a while because of pain. Therefore, we recommended all patients with very early stage spondylolysis to wear soft brace and to pause their sports activity until high signal change diminishing on MRI. As a result, it often can return faster. Not a few recurrences were observed regardless of the treatment. We believe that tightness of the body, such as thorax, shoulder girdle and hip joint, which is thought to be main causes of spondylolysis, had not been resolved in these cases.

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Short-term outcome of lumbosacral lordotic angle acquired using oblique lateral lumbosacral fusion (OLIF51) technique brought by two different intervertebral cages

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Background

Oblique lateral interbody fusion for L5/S lumbosacral junction (OLIF51) is one of the viable options for degenerative spine and/or discopathy at the level to provide significant postoperative results and reduced loss of correction of the lumbosacral vertebral angle in conjunction with bony fusion. However, the acquired lordosis angle can be different due to the intervertebral cage: general-purpose titanium cage for anterior interbody fusion (ALIF; Teijin Nakashima Medical minalif®) with a slight kyphosis angle of 6˚, that can be undersized/angled, resulting in the correction loss and cage subsidence. Another PEEK cage for OLIF51 (Medtronic Sovereign®), introduced to Japan in 2019, has a kyphosis of 8˚ to 14˚, which is more adaptable to the intervertebral space. The purpose of this study was to compare the change in correction angle of lumbosacral intervertebral fusion by using different cages.

Materials and Methods

In the present study, 15 patients (mean age 68.3 years, six males and nine females) underwent an anterior lumbosacral fusion with OLIF51 for lumbosacral diseases (lumbosacral spondylolisthesis, degenerative lumbar spondylolisthesis, etc.). We compared the intervertebral angle, correction rate of the L5/S intervertebral space, and presence of subsidence (more than 1 mm to the adjacent endplate) for each intervertebral cage. The significance level of the p-value was set at 0.05 for statistical examination.

Results

The mean kyphosis angle was 6° and 12.3±2.9°, and the mean cage height was 9.14±1.1 mm and 11.3±1.6 mm, respectively. The L5/S intervertebral kyphosis was 4.2˚/16.8˚ immediately after surgery (M group/S group, same as below). One patient in the M group underwent additional posterior decompression due to postoperative leg pain, but no additional surgery was performed in the S group, and no intraoperative complications were observed.

There was no additional surgery in the S group, and there were no intraoperative complications. Eight (80%)/1 (20%) patients had postoperative subsidence, and in the M group, subsidence at the cephalic endplate was significantly observed with one case with mild anterior backout of the cage.

Conclusion: Minimally invasive lumbosacral anterior fusion OLIF51 with a dedicated kyphosis cage provides relatively good kyphosis correction and significantly reduces subsidence and correction loss compared with a general ALIF cage.

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Effect of contrast media on the enzyme activity of condoliase for lumbar disc herniation

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Introduction

Condoliase is an enzyme that degrades glycosaminoglycans, specifically chondroitin sulfate (CS) of proteoglycans abundant in nucleus pulposus of intervertebral disc (IVD). Condoliase was approved as novel chemonucleolytic agent for lumbar disc herniation (LDH) by Japanese authority in 2018, and its efficacy and safety have been reported. When injected into IVD, condoliase effectively reduced intradiscal pressure and volume of herniated mass soothing compressed nerve roots without affecting surrounding nerves and vessels, because it completely lacks proteolytic activity. Its best indication is subligamentous extrusion lying beneath posterior longitudinal ligament. MRI is standard imaging modality to establish diagnosis of LDH. However, Lumbar discography is especially useful in discriminating whether LDH is subligamentous or transligamentous by depicting consistency of posterior longitudinal ligament. However, use of condoliase together with contrast media is not allowed, because there are no data on stability, efficacy and safety of condoliase when mixed with other agents. Purpose of current study is to evaluate condoliase activity when mixed with contrast media to test if these can be used together in clinical settings.

Methods

Condoliase was mixed with two different types of iodine contrast media, ionic (amidotrizoic acid) and non-ionic (iohexol, iotrolan), under two different settings; 1) with CS, and 2) without CS. With CS, condoliase was mixed with different volumes (equal, 2x, 3x) of each contrast medium and mixture was incubated at 37°C for 10 min. To investigate long-term effect, condoliase was mixed with equal volume of each contrast medium and mixture was incubated at 37°C for 120 min. Without CS, condoliase was mixed with equal volume of each contrast medium without adding CS and was stored at room temperature. Condoliase activity in mixture was measured by Morgan-Elson method, in which N-acetylgalactosamine cleaved from CS by condoliase was quantified by absorbance at 585nm using spectrophotometer. The absorbance of sample without contrast medium was set as 100%.

Results

In presence of CS, condoliase activity was maintained over 90% even after incubation with 3x volume of non-ionic media, and up to 120 min. However, equal volume of ionic medium significantly reduced condoliase activity within 10 min of incubation. In absence of CS, condoliase activity was almost completely diminished when mixed directly with ionic medium and was also reduced to 35-65% with non-ionic media.

Discussion

Two settings; with and without CS, were used to mimic clinical scenarios, 1) condoliase was injected into IVD after discography where condoliase and contrast media coexist with CS; and 2) condoliase was mixed directly with contrast media before injection. With CS, condoliase activity was maintained by non-ionic but was reduced by ionic contrast medium. When condoliase was mixed directly without CS, both ionic and non-ionic medium reduced its activity. High inhibitory effects of ionic medium may be due to its high osmolarity, which is three to six times higher than non-ionic media. Intradiscal injection of condoliase may be feasible after establishing diagnosis of subligamentous extrusion by discography, if non-ionic iodine contrast medium were used. Condoliase should not be mixed with any type of contrast medium prior to injection.

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Analysis of the brain activity of patients with chronic low back pain

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[Objective]

To analyze the brain activity of patients with low back pain using functional magnetic resonance imaging (fMRI).

[Subjects and Methods] The study involved 11 patients (6 men and 5 women, mean age: 60.0 years) with low back pain that persisted for more than 3 months [numerical pain rating scale (NPRS) score ≥ 5: low back pain group] and 14 individuals (7 men and 7 women, mean age: 50.1 years) without low back pain (control group). Using audio triggers, fMRI was performed while the subjects were asked questions both related to low back pain (pain condition) and not related to low back pain (neutral condition), and their brain activity was measured.

A questionnaire survey using the Pain Catastrophizing Scale (PCS) was conducted for all the subjects. Based on the fMRI data, the brain activity (β values) was calculated using analytical software, SPM and MarsBaR.

Evaluation items comprised the activated brain areas and the β values of those areas.

The β values obtained for the control and low back pain groups in three conditions—neutral, pain, and pain–neutral (P–N) conditions—were compared.

[Results] In both the control and low back pain groups, the posterior insula cortex and the superior and transverse temporal gyri were activated. Meanwhile, the left amygdala was activated only in the low back pain group. Thus, the control and low back pain groups were compared in terms of the β values of the left amygdala. In the neutral condition, the β value of the control group was 0.041 ± 0.332 and that of the low back pain group was −0.047 ± 0.279; no significant differences were observed (P = 0.78). Similarly, with the β value of −0.030 ± 0.358 and −0.007 ± 0.337 in the control and low back pain groups, respectively, no significant differences were noted in the pain condition. In the P–N condition, however, the β value was −0.071 ± 0.161 and 0.040 ± 0.149 in the control and low back pain groups, respectively; therefore, the low back pain group exhibited a significantly higher value (P = 0.04).

Assuming that catastrophic thinking might be associated with the activation of the amygdala, the low back pain group was divided into two subgroups—the N subgroup with PCS score < 30 (n = 8) and the P subgroup with PCS score ≥ 30 (n = 3. The brain activities were then analyzed for these two subgroups and the control group. However, when compared in terms of the β values obtained for the left amygdala in the neutral, pain, and P–N conditions, no significant differences were observed between the control group and the N and P subgroups.

[Conclusion]

These results suggest the possibility that patients with chronic low back pain are susceptible to the activation of negative emotions regarding low back pain regardless of the presence/absence of catastrophic thinking.

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Spine-SegLoop: A Deep Learning Framework for Multi-tissue Segmentation in Lumbar MRI with No Manual Annotations

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Publish consent withheld

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Chronic Non-specific Low Back Pain: Disease Burden, Management Status, and Clinical Course Prediction with Machine Learning

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Is There Benefit to Increasing Number of Rods (4-, 5-, and 6-) Across a Lumbar PSO?: A Finite Element Analysis

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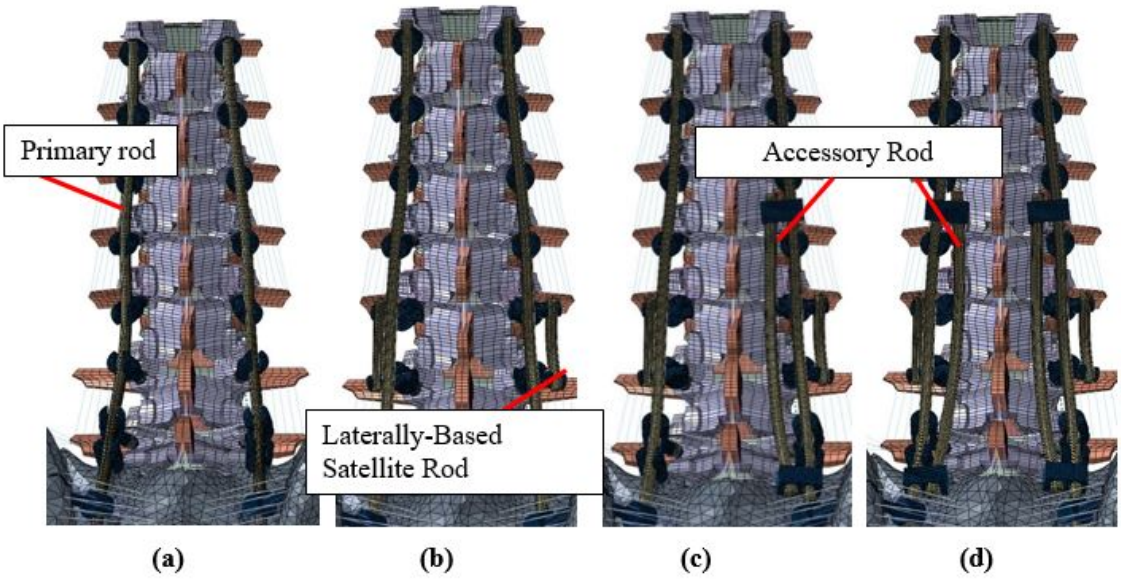
Introduction. Pedicle subtraction osteotomies (PSO) are powerful techniques to correct sagittal and coronal malalignment. As PSOs are associated with high rates of nonunion and rod fracture, multi-rod constructs (4-, 5-, 6-rods) are commonly used to stabilize PSOs. Multi-rod configurations can be created using “satellite” rods (not connected to primary rod) and/or "accessory" rods (connected to primary rod). This study aimed to assess biomechanics of laterally-based satellite rods, with and without additional accessory rods.

Methods. A previously validated 3D spinopelvic finite element model (T10-pelvis) with a 30° PSO at L3 was used (1). In the control model (2-Rods), two bilateral rods connected all levels (T10-pelvis) (**Fig. 1**). Three multi-rod techniques were modeled and analyzed: (1) laterally-based satellite rods with no accessory rods (4-Rods), (2) laterally-based satellite rods with one medial accessory rod (5-Rods), and (3) laterally-based satellite rods with two accessory rods (6-Rod) (**Fig. 1**). Global and PSO range of motion (ROM) were recorded. Rods’ von Mises stresses and PSO forces were recorded and the percent differences from Control were calculated.

Results. Laterally-based satellite rods decreased global ROM in flexion-extension in 4-Rod (8.6%-39.4%), 5-Rod (15.5%-43.7%), and 6-Rod constructs (22%-47.7%). Increasing rods from four to six led to reduction in global ROM in all motions. Compared to 2-Rods, laterally-based satellite rods increased PSO flexion and extension ROM by 18.8% and 211.6%, respectively. Lower ROMs at the osteotomy site were observed for 5- and 6-Rods compared to 4-Rods. Laterally-based satellite rods (4-Rods) showed higher PSO force than 2-Rods (347.1N vs. 336N). However, additional accessory rods reduced the PSO force further to 327.8N (5-Rods) and 309.7N (6-Rods). All multi-rod models decreased von-Mises stresses on the primary rods at the PSO site. 5- and 6-Rods led to lower von Mises stresses in these areas. In 4-Rods, two critical stress locations were observed: adjacent to the PSO site and L5-S1. Adding the accessory rods (5- and 6-Rods) shifted the critical stress locations to connection points between primary rods and W-connectors in some motions.

Discussion. Laterally-based satellite rods across a lumbar PSO reduced stresses on primary rods. Adding accessory rods increased the construct’s rigidity and led to a lower global and PSO ROM. Moreover, 5- and 6-Rods resulted in forces on the posterior instrumentation being distributed across more components, which decreased von-Mises stresses at the PSO site compared to 4-Rod and 2-Rods. Although increased rigidity afforded by 5- and 6-Rods may be beneficial in reducing chances of rod breakage, it should be highlighted that due to higher stiffness, load may be transferred posteriorly and less load would be carried by the anterior vertebral column, which may not be most favorable for healing of the anterior column.

Fig. 1



1. (1) Vosoughi A.S., et al. The Spine Journal, 2019; 19(5): 931-94.

Satellite Rod Configuration and Screw Type Spanning a Lumbar Pedicle Subtraction Osteotomy: A Biomechanical Evaluation with a Finite Element Analysis

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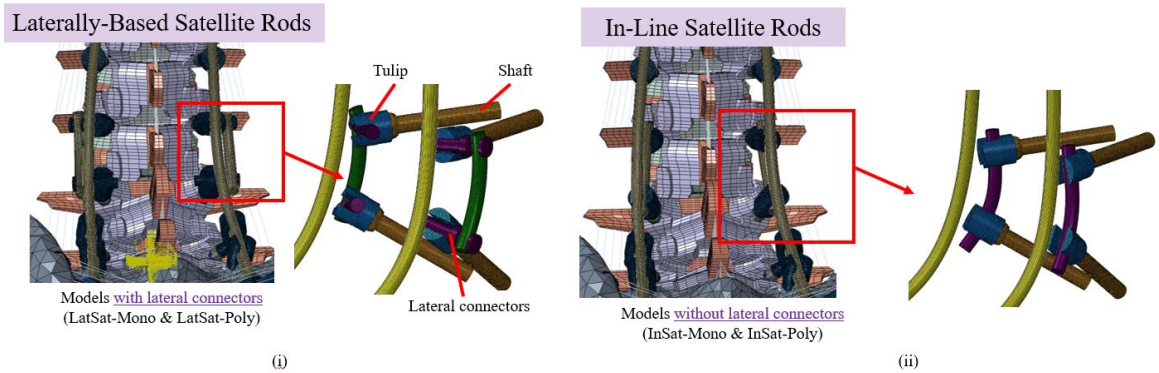
Introduction. While pedicle subtraction osteotomies (PSO) in the lumbar spine are powerful techniques to correct sagittal and coronal spinal malalignment, they are fraught with high complication rates, including nonunions and rod fractures due to motion at the PSO site. Multi-rod constructs are used commonly to decrease rates of pseudarthrosis and can be achieved with "satellite" rods (not connected to primary rod) placed in-line or laterally to the primary rod. This study aimed to assess the biomechanical properties of laterally-based satellite rods as well as evaluate effects of screw-type (polyaxial v. monoaxial) spanning the PSO.

Materials and Methods. A validated 3D spinopelvic finite element model with a 30° PSO at L3 was used. To evaluate 5 models: (1) Control (T10-pelvis+2 rods); (2) lateral satellite rods connected via offsets to monoaxial screws (LatSat-Mono) or (3) polyaxial screws (LatSat-Poly); (4) in-line satellite rods connected to monoaxial screws (InSat-Mono) or (4) polyaxial screws (InSat-Poly) (Fig. 1). Global and PSO range of motion (ROM) were recorded. Rods' von Mises stresses and PSO forces were recorded and the percent differences from Control were calculated.

Results. Multi-rods constructs with satellite rods in any configuration (in-line and laterally) decreased global ROM in flexion, extension and lateral bending. Compared to the control, PSO flexion and extension ROM increased for all satellite rods, except for InSat-Mono that decreased flexion ROM at the PSO. Laterally based satellite rods increased PSO forces (347.1N in LatSat-Mono, 348.6N in LatSat-Poly) compared to control (336N). Conversely, in-line satellite rods decreased PSO forces (280.1N in InSat-Mono, and 330.7N in InSat-Poly). Locations of maximal von-Mises stress on the primary rods were adjacent to the PSO site and L5-S1 (2). Both satellite rod configurations (in-line and lateral) decreased von-Mises stresses on the primary rods at the PSO site. Von-Mises stress on satellite rods were lower on laterally-based satellite rods than in-line satellite rods. There were relatively high stresses on "satellite rods in the InSat-Mono model.

Discussion. Multi-rod constructs using in-line and lateral satellite rods across a lumbar PSO reduced stresses on primary rods via different mechanisms. Lateral satellite rods, irrespective of screw type, provided more favorable biomechanics, as they increased PSO forces and had lower von Mises stresses (lower posterior instrumentation stress shielding) compared to in-line satellite rods that had a high degree of posterior instrumentation stress shielding and lower PSO forces. Additional clinical studies are warranted to confirm these biomechanical findings.

Figure 1



1. (1) Vosoughi AS, et al. The Spine Journal, 2019; 19(5): 931-94. (2) Smith JS, et al. Neurosurgery 2012; 71(4): 862-868.

Radiographic Comparison of L5-S1 Lateral ALIF Cage Subsidence and Displacement by Fixation Strategy: Anterior Plate vs. Integrated Screws

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Introduction. Lateral anterior lumbar interbody fusion at L5-S1 (LatALIF) is an attractive surgical technique to achieve interbody support at the lumbosacral junction. LatALIF cages can be secured within the interbody space using an anterior buttress plate or integrated screws. The purpose of this study was to perform a radiographic comparison of cage subsidence and displacement between L5-S1 LatALIF cages secured with an anterior buttress plate to cages secured with integrated screws.

Methods. Consecutive patients who underwent a L5-S1 lateral ALIF with supplemental posterior fixation by a single surgeon (6/2016-1/2021) were reviewed. Radiographs were analyzed and compared between two groups based on type of fixation used to secure the L5-S1 LatALIF cage: (1) anterior buttress plate (+PLATE) and (2) integrated screws (+SCREWS). The following measurements at L5-S1 were analyzed on radiographs obtained pre-operatively, before discharge, and at latest follow-up: (1) anterior disc height, (2) posterior disc height, and (3) segmental lordosis. Cage subsidence was determined by measuring the distance between the cages' cranial surfaces to the L5 inferior endplate and between the cages' caudal surfaces to the S1 superior endplate on first post-operative radiographs and latest follow-up radiographs. Anterior cage displacement was determined by measuring the distance between the cage's anterior surface to L5's anterior-inferior endplate on first post-operative and latest follow-up radiographs.

Results. Presented in Table 1. One hundred thirty-nine patients (average age 60.0 ± 14.3 years) were included for analysis. Sixty-eight patients were treated with +PLATE (follow-up: 12 ± 5 months) and 71 were treated with +SCREW (follow-up: 9 ± 3 months). Average age, gender distribution, pre-op L5-S1 lordosis, pre-op L5-S1 anterior disc height, and pre-op L5-S1 posterior disc height were statistically similar between the two groups. After surgery, segmental L5-S1 lordosis and L5-S1 anterior disc heights significantly improved for both groups and each respective measurement was similar between the groups at final follow-up. Posterior disc heights significantly increased after surgery for +SCREW, but not for +PLATE. As such, posterior disc heights were significantly greater at final follow-up for +SCREW. Significantly more +PLATE patients had cage subsidence cranially (through L5 endplate: 20.6% *v.* 2.8%; $p<0.01$), cage subsidence caudally (through S1 endplate: 27.8% *v.* 0%; $p<0.01$), and anterior cage displacement (22.1% *v.* 0%; $p<0.01$) compared to +SCREW patients.

Discussion. In this radiographic analysis of 134 patients who underwent lateral L5-S1 ALIFs supplemented by posterior fixation, L5-S1 cages secured with an anterior buttress plate demonstrated significantly higher rates of cage subsidence and anterior cage displacement compared to cages secured with integrated screws. The more durable stability afforded by cages secured with integrated screws makes them a more viable fixation strategy for L5-S1 LatALIFs.

Table 1. Cohort Comparisons

	Anterior Buttress Plate	Integrated Screws	*p*
N	68	71	n/a
Age	59.7 ± 12.9	60.2 ± 15.6	0.82
Gender			
Male	27	35	0.26
Female	41	36	
L5-S1 Lordosis (deg)			
Pre-op	11.0 ± 6.5	9.2 ± 7.3	0.12
Immediate Post-op	15.0 ± 5.1	16.2 ± 8.3	0.30
Last Post-op	17.5 ± 9.1	16.2 ± 9.2	0.41
p	**<0.01**	**<0.01**	
L5-S1 Anterior Disc Height (mm)			
Pre-op	10.5 ± 5.0	9.2 ± 5.0	0.16
Last post-op	13.6 ± 6.6	15.4 ± 8.4	0.16
p	**<0.01**	**<0.01**	
L5-S1 Posterior Disc Height (mm)			
Pre-op	4.82 ± 2.71	4.45 ± 2.56	0.40
Last post-op	4.00 ± 2.61	5.76 ± 3.84	**<0.01**
p	0.13	**0.02**	
L5-S1 Cage Subsidence (superior endplate)			
N	14 (20.6%)	2 (2.8%)	<0.01
Magnitude (mm)	1.85 ± 0.70	0.81	0.06
p	**<0.01**	**0.03**	
L5-S1 Cage Subsidence (inferior endplate)			
N	19 (27.9%)	0 (0%)	<0.01
Magnitude (mm)	1.60 ± 0.66	n/a	n/a
p	**<0.01**	n/a	
L5-S1 Anterior cage displacement			
N	15 (22.1%)	0	<0.01
Magnitude (mm)	3.52 ± 2.10	0	0.33
p	0.59	n/a	

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Impact of knee osteoarthritis on surgical outcomes of lumbar spinal stenosis

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【INTRODUCTION】Lumbar spinal stenosis (LSS) and knee osteoarthritis (KOA), both of which are age-related degenerative diseases, are independently correlated with increased pain and dysfunction of the lower extremities. However, there have been few studies to investigate whether LSS patients with KOA exhibit poor clinical recovery following lumbar spinal surgery. The aim of this study is to elucidate the surgical outcomes of lumbar spinal surgery for LSS patients with KOA using multiple health-related quality of life (HRQOL) parameters.

【METHODS】A total of 865 consecutive patients who underwent posterior lumbar spinal surgery for LSS were retrospectively reviewed. Patients with failed back syndrome, past history of orthopaedic surgery at other sites, major postoperative complications and medical history of hip osteoarthritis were excluded. Following the initial identification of KOA based on medical history, cases with radiographic KOA of Kellgren-Lawrence grade ≥ 2 were included in this study. Baseline characteristics, radiographic parameters, visual analog scale (VAS) and multiple HRQOL parameters were analyzed preoperatively and at 1-year follow-up. HRQOLs included Zurich Claudication Questionnaire (ZCQ), Oswestry Disability Index (ODI), Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36), and Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ). Statistical analyzes were performed using Student t-test, Mann-Whitney U-test, Pearson's chi-square test, and Wilcoxon signed-rank test.

【RESULTS】A total of 32 LSS patients with KOA were identified; 128 age- and sex-matched LSS patients without KOA were selected as controls. There were no differences in the baseline characteristics between the two groups. In the preoperative radiographic parameters, pelvic tilt was significantly higher in the KOA group than in the control group (27.3° ± 8.6° vs. 24.1° ± 9.2°, $P = 0.046$). Although there were no significant differences in postoperative ZCQ and ODI scores between the two groups, all HRQOL parameters markedly improved at the 1-year follow-up compared with preoperative scores in both groups ($P < 0.01$). Postoperative VAS scores for pain in buttocks and lower limbs were significantly higher in the KOA group than in the control group (3.8 ± 3.3 vs. 2.4 ± 2.8, $P = 0.007$). In SF-36, the postoperative mean score for physical functioning (59.7 ± 25.7 vs. 69.9 ± 23.9, $P = 0.035$), role physical (61.1 ± 28.0 vs. 72.7 ± 24.1, $P = 0.034$) and vitality (49.0 ± 20.5 vs. 56.9 ± 16.3, $P = 0.048$) was significantly lower in the KOA group than in the control group. The effective rate of social life domain in the JOABPEQ was lower in the KOA group than in the control group (22.6% vs. 62.2%, $P < 0.001$).

【DISCUSSION】The surgical outcomes of LSS patients with KOA are favorable, although poorer than those of LSS patients without KOA, particularly in terms of social life and activities. These results indicate that LSS patients with KOA experience difficulty in routine work or ordinary activities due to knee pain or restricted knee ROM even after lumbar spinal surgery. Hence, preoperative KOA status warrants consideration when planning lumbar spinal surgery and estimating surgical outcomes of LSS.

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Radiographic parameters for the lumbar spine of L1 axis sacral distance and sacral slope angle are associated with low back pain

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【Introduction】Degenerative changes in the lumbar spine increase with aging. To date, many radiological parameters have been published that indicate the progression of adult spinal deformity. However, the relationship between radiological parameters and symptoms has yet been unclear. The purpose of this study is to investigate the relationship between L1 axis sacral distance (LASD) and sacral slope angle (SS), which are indices on lumbar spine X-ray lateral views, and low back pain (LBP).

【Methods】This was a cross-sectional study, using a database of community health check-ups conducted in rural areas of Fukushima Prefecture in 2004 (Minami-Aizu Study). The participants were 514 residents (170 males and 344 females, mean age were 65.1 years) who were evaluated for the presence of LBP and underwent X-ray photography of the lumbar spine on the standing lateral view. We defined LBP as "LBP lasting more than 24 hours" and included acute and chronic pain. Patients after lumbar fusion surgery were excluded. LASD (horizontal distance between the vertical line from the center of the L1 vertebra and the superior posterior angle of the sacrum) and SS were measured from the radiographs, and each index was categorized into three groups: low, middle, and high. Several candidate cutoff values were created for each group, and the set that maximized the F value by one-way analysis of variance with the presence of LBP as a factor was adopted. In addition, logistic regression analysis was conducted to analyze the relationship with LBP. The presence of LBP was the dependent variable; gender, age, and BMI were adjusted variables; and LASD and SS were independent variables. A p-value of less than 5% was used as statistical significance in this study.

【Results】One-way analysis of variance showed that LASD had the largest F values at cutoffs of less than 20 mm, 20-30 mm, and greater than 30 mm, and SS had the largest F values at cutoffs of less than 30°, 30-40°, and greater than 40°. Logistic regression analysis showed that the odds ratio of having LBP was significantly higher in the low and high groups compared to the LASD middle group (low group: odds ratio 3.71, 95% CI 1.11-12.4, p=0.033; high group: odds ratio 8.12, 95% CI 2.01-33.2, p=0.003). In SS, the odds ratio of having LBP was significantly higher in the low group than in the high group; no significant difference was observed in the middle group (low group: odds ratio 4.68, 95% CI 1.46-15.0, p=0.009; middle group: odds ratio 2.69, 95% CI 0.87-8.30, p=0.085).

【Discussion】This study revealed that LASD and SS were associated with LBP, and the odds ratio for the presence of LBP was lowest when LASD was 20-30 mm, and SS was greater than 40°. Numerous reports have shown that sagittal imbalance of the spine is involved in LBP, and LASD also could be one of the indices in radiographic lumbar lateral views.

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The Risk Factors for Early-onset Adjacent Segment Disease in Patients With Spondylolytic Spondylolisthesis Who Underwent Single-level Posterior Lumbar Interbody Fusion

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Background

The risk factors for radiographical adjacent segment disease (ASD) in patients with degenerative spondylolisthesis have been reported. However, reports on patients with spondylolytic spondylolisthesis who underwent single-level posterior lumbar interbody fusion (PLIF) are few.This study aims to investigate the risk factors for radiographical ASD in patients with L5-S1 spondylolytic spondylolisthesis who underwent single-level PLIF.

Methods

This study retrospectively reviewed 135 consecutive symptomatic L5-S1 spondylolytic spondylolisthesis (91 males and 44 females) who underwent single-level PLIF. The mean age at surgery and mean follow-up period were 58.5 ± 15.0 years and 30.3 ± 10.1 months, respectively. Radiographical ASD was defined as disc height loss (>3 mm), posterior angulation increase (>5°), or progression of slippage for anterior translation (>3 mm) between the pre- and postoperative radiographs. Disc degeneration was evaluated using Pfirrmann's classification. The changes between the pre- and postoperative values were evaluated in each non-ASD and ASD group. We compared radiographical parameters between non-ASD and ASD group. A binary logistic regression model was conducted to evaluate the adjusted associations between each potential explanatory variable and ASD development. The pre- and postoperative (at the final follow-up) global sagittal alignment, % slip, sacral slope (SS), lumbar lordosis (LL), pelvic tilt (PT), pelvic incidence (PI), PI minus LL (PI-LL), lumbosacral angle (LSA), C7 sagittal vertical axis (C7-SVA), and thoracic kyphosis (TK) on the standing radiographs were measured.

Results

Radiographical ASD incidence was 11%. Also, 60.0% of the patients with ASD had radiographical ASD at 1 year after the initial surgery and all cases of radiographical ASD in this follow-up period occurred within 3 years after the initial surgery. The mean period of ASD occurrence after initial surgery was 21.7 ± 12.6 months. No patients required reoperation for radiographical ASD. Multivariate analysis revealed that preoperative pelvic incidence (PI) minus lumbar lordosis (LL) ≥ 15° (odds ratio [OR], 5.9; 95% confidence interval [CI], 1.2–28.9; p = 0.03) and postoperative PI-LL ≥ 15° (OR, 6.5; 95% CI, 1.2–34.5; p = 0.03) were the risk factors for radiographical ASD.

Conclusions

the current study identified that the pre- and postoperative PI-LL mismatch ≥ 15° were the independent risk factors for early-onset radiographical ASD in patients with L5-S1 spondylolytic spondylolisthesis who underwent single-level PLIF. Therefore, the sagittal alignment, particularly the risk factor identified in the present study, should be taken into consideration when surgeons decide the surgical approach for L5-S1 spondylolytic spondylolisthesis.

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Evaluation of spinal alignments and clinical findings and the usefulness of one-stage surgery in tandem spinal stenosis

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【Introduction】

TSS (Tandem Spine Stenosis) is increasing, but the pathophysiology and pathogenesis are unclear, and there is no consensus on the surgical procedure as to whether it is one-stage or 2-stage. We compared spinal alignments, clinical symptoms, skeletal muscle mass, and surgical results between TSS patients who underwent simultaneous cervical and lumbar decompression and lumbar spinal stenosis (LSS) patients who underwent lumbar decompression, and the characteristics of the TSS patient and the usefulness of one-stage surgery were examined.

【Methods】

The subjects were 82 patients who visited our outpatient department of orthopedics, received surgical treatment. Of the 82 cases, TSS was 13 cases and LSS was 69 cases. Regarding the evaluation of spinal alignments, Lumbar scoliosis (LS), Sagittal vertical axis (SVA),Lumbar lordosis (LL), Pelvic tilt (PT), Pelvic incidence (PI), and Sacral slope (SS) were evaluated. Regarding the evaluation of clinical symptoms, the visual analogue scale (VAS) score for low back pain (LBP) and leg pain and leg numbness, the Japanese Orthopedic Association scoring system (JOA score), the Roland-Morris Disability Questionnaire (RDQ), the Japanese Orthopedic Association Back Pain Evaluation Questionnaire (JOABPEQ), and Oswestry Disability Index (ODI) were evaluated. A bioelectrical impedance analyzer (BIA) was used to measure systemic skeletal muscle mass and phase angle, which is an index of cell membrane aging. Preoperative skeletal muscle mass, phase angle, clinical symptoms, and surgical results were compared and examined in both groups.

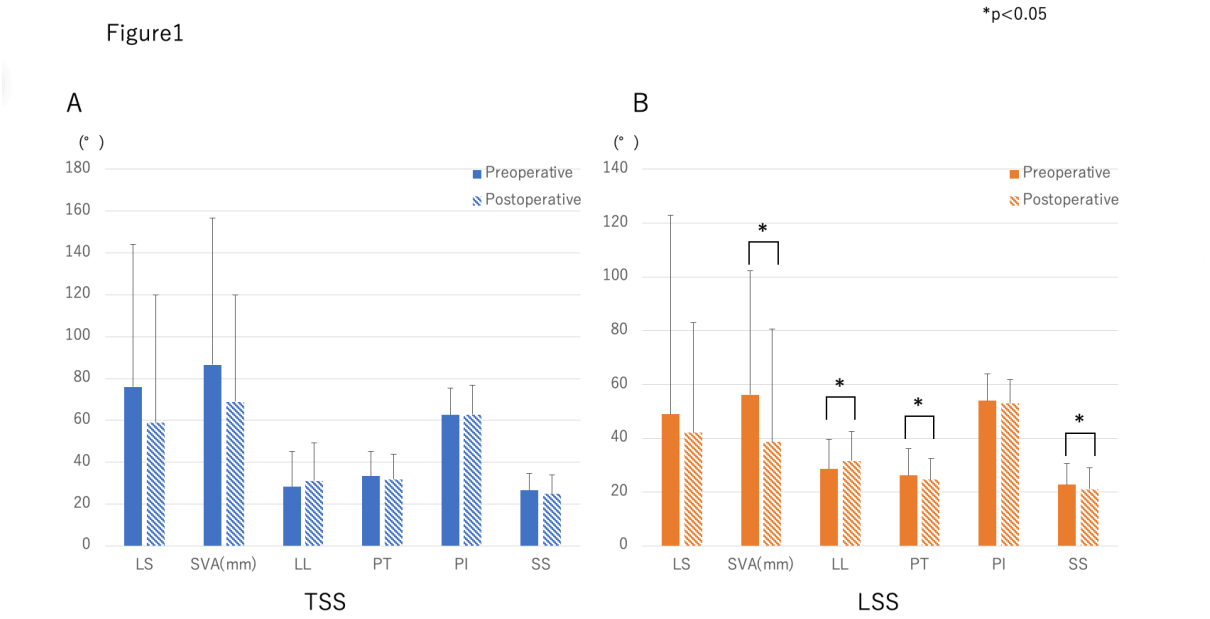
【Results】

The operation time was significantly longer in the TSS group than in the LSS group ($p < .05$), but the amount of bleeding was not significantly different between the two groups ($p > .05$). In addition, phase angle of the trunk and both lower limbs were significantly lower in the TSS group than in the LSS group ($p < .05$). Postoperative SVA, LL, PT, and SS in the TSS group were insignificantly improved and in the LSS group were significantly improved. Regarding preoperative clinical symptoms, the proportion of JOABPEQ gait dysfunction that was difficult to climb stairs was 83% in the TSS group, and social life disturbance that was difficult to engage in ordinary activities was 67% in the TSS group, which were significantly higher than that in the LSS group ($p < .05$). Although clinical symptoms improved by surgery in both groups ($p < .05$), there was no significant difference in the degree of clinical symptom improvement ($p > .05$).

【Discussion】

TSS decreased in the phase angle of the trunk and both lower limbs, suggesting the progression of trunk muscle atrophy and aging due to the decrease in activity. About 85% of TSS cases are characterized by difficulty in climbing stairs, and it was shown that TSS should be treated with TSS in mind in LSS cases where it is difficult to climb stairs. Spinal surgery significantly improved SVA, LL, and PT in LSS, and TSS also showed a tendency to improve spinal alignment. A one-stage operation was performed on TSS, and the amount of intraoperative bleeding was equivalent to that of LSS alone and minimally invasive. The one-term approach seems to be effective.

Figure1



Reduced leg muscle mass and lower grip strength in women are associated with osteoporotic vertebral compression fractures

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INTRODUCTION

Lower limb muscle mass and grip loss may be risk factors for vertebral compression fractures in women.We examined the relationship between bone mineral density, bone strength, skeletal muscle mass, grip strength, and skin autofluorescence (SAF) in women with osteoporotic vertebral compression fractures (VCF).

METHODS

1039 women (mean age 73.3 years) were included in our study. These included 222 cases of VCF (mean 77.8 years), and 817 controls (mean 72.0 years). Lumbar and femur BMD were measured for all participants using dual-energy X-ray absorptiometry (DXA). Bone strength surrogates, such as cross-sectional area (CSA) of the proximal femur, were evaluated using Advanced Hip Assessment software. SAF was measured with an autofluorescence reader. We used a bioelectrical impedance analyzer (BIA) to analyze body composition, including appendicular skeletal muscle mass index (SMI; appendicular lean mass (kg)/(height (m))^2. We measured bone density, geometric parameters related to bone strength, skeletal muscle mass, grip strength, and SAF in both groups. We also examined factors related to vertebral fracture using logistic regression analysis.

RESULTS

Women with vertebral fractures had lower SMI (5.55 vs 5.76 kg/m^2, p = 0.0006), smaller femoral cross-sectional area (97.20 vs 100.09, p = 0.014), lower grip strength (16.81 vs 19.16 kg, p < 0.0001) and increased skin autofluorescence (2.38 vs 2.25, p = 0.0002) compared to women without fractures. The prevalence of sarcopenia (SMI < 5.75) was 63.51% in VCF subjects and 52.02% in controls, revealing a high prevalence in VCF (p=0.002). Skeletal muscle mass and grip strength were not significantly different between patients with acute and old VCF, suggesting that low skeletal muscle mass and muscle weakness may exist before fracture. From the logistic regression analysis, lower femoral density (p=0.0025), CSA (p=0.0123), leg muscle mass (p=0.015), and left arm grip strength (p=0.0173) were risk factors for vertebral compression fractures; all were negatively correlated with increased vertebral fractures.

DISCUSSION

Lower limb muscle mass and grip loss may be closely related to the onset of vertebral compression fracture.

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Hounsfield Unit for Assessing Asymmetrical Loss of Vertebral Bone Mineral Density and its Correlation with Curve Severity in Adolescent Idiopathic Scoliosis

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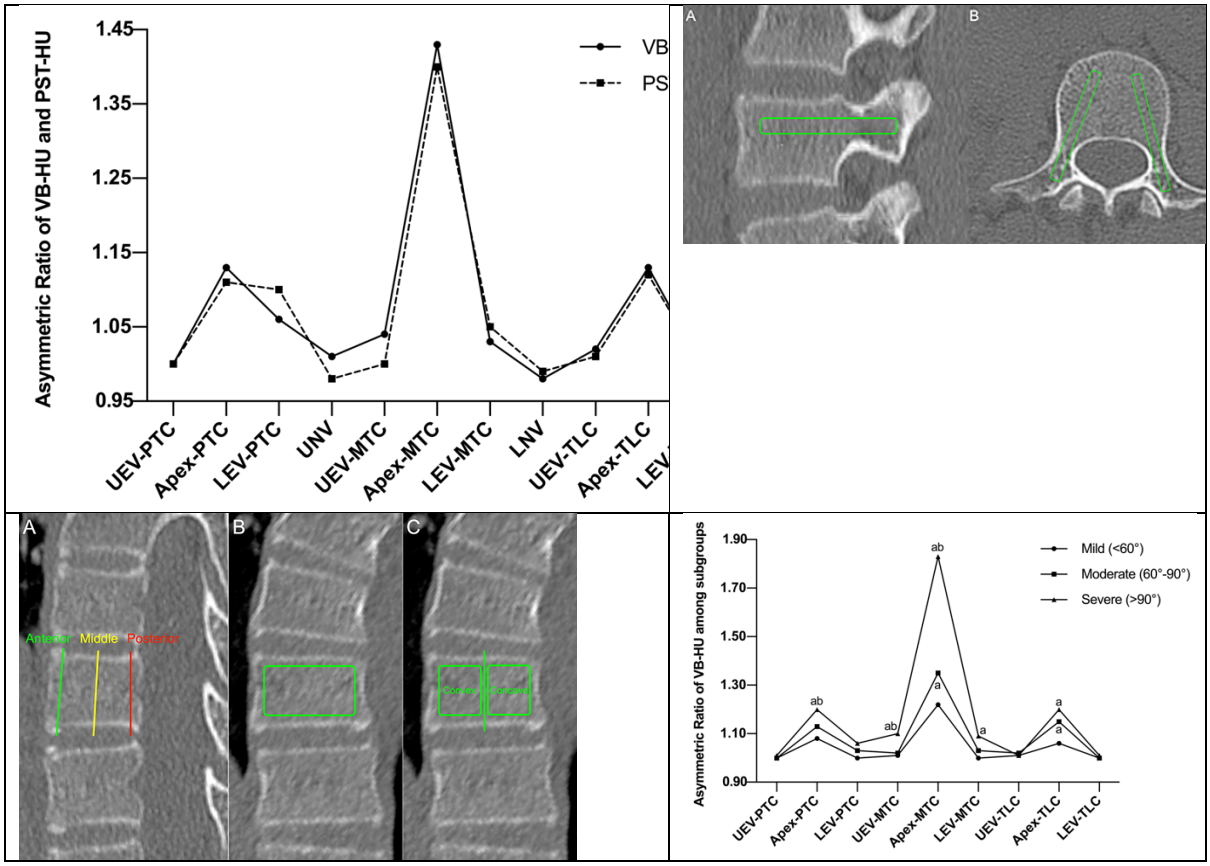
Introduction: The low bone mass concomitantly occurred in patients with adolescent idiopathic scoliosis (AIS) and could still persist after skeletal maturity. The purpose of this study was to assess the asymmetrical loss of vertebral bone mineral density (vBMD) and its correlation with curve severity in patients with AIS using Hounsfield unit (HU) values measured from computed tomography (CT) scans.

Methods: Nighty-three AIS patients were retrospectively recruited. The HU values of vertebral body (VB-HU) and pedicle screw trajectory (PST-HU) were measured from 4 vertebras above (Apex-4) to 4 below (Apex+4) the apical vertebra (Apex) of the major curve. The VB-HU and PST-HU at UEV, Apex, LEV within concave and convex sides of major and minor curves, and stable vertebras were also obtained.

Results: Significant correlation was detected between Cobb angle and VB-HU at periapical levels of major curve. VB-HU and PST-HU at periapical levels were significantly greater within concavity than convexity of both major and minor curves. The asymmetric ratio of VB-HU and PST-HU were significantly correlated to the major curve Cobb angle, and peaked at Apex and gradually diminished from Apex to end vertebras. The asymmetrical loss of vBMD aggravated with the progression of curve severity, presenting as VB-HU significantly decreased within convexity and insignificantly decreased within concavity of the major curve.

Discussion: The asymmetrical loss of vBMD was associated with the progression of curve severity in AIS. For patients with severe AIS, distraction of the pedicle screws at concave side should be a priority to correct the major curve, and supplemental anchors as well as larger sized screws should be placed within convex side around Apex of major curve, in order to reduce the risk of screw loosening after surgery.



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The Risk of Aorta Injury During Correction Surgery in Patients with Severe and Rigid Scoliosis

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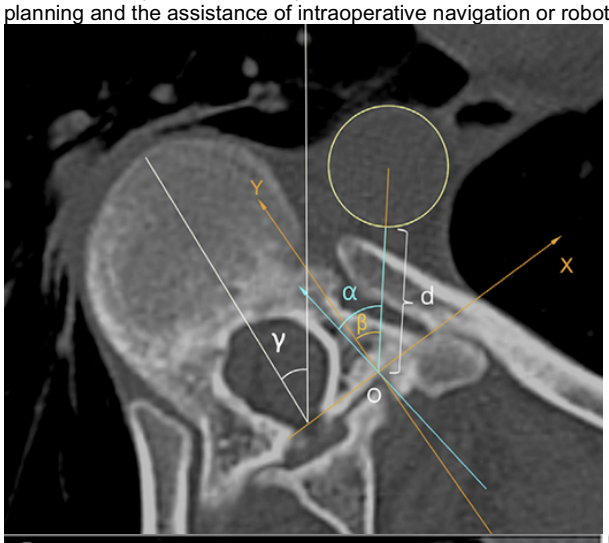
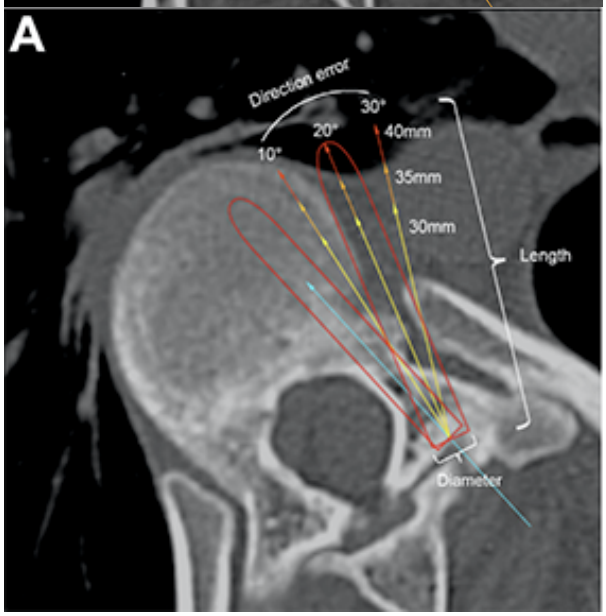
Introduction: To evaluate the position of the aorta relative to the spine and the risk of aortic injury during correction surgery in patients with idiopathic severe and rigid scoliosis (main curve Cobb angle >90° and flexibility <30%).

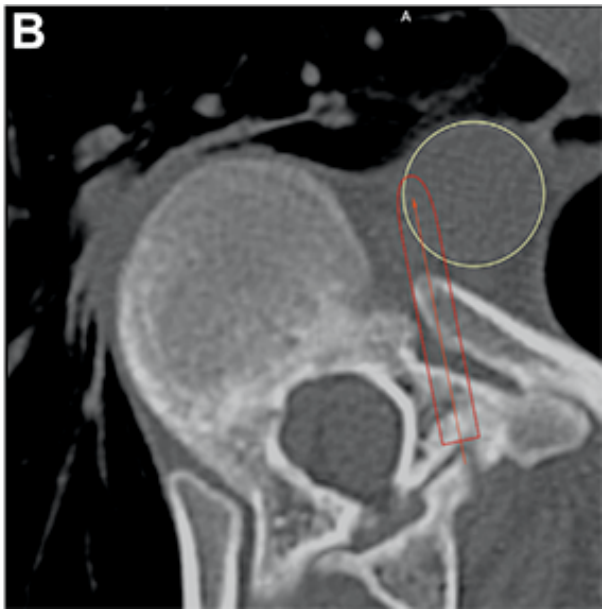
Methods: Twenty-seven patients with severe right thoracic/thoracolumbar scoliosis were recruited. The entry point-aorta distance (EAD), the left pedicle-aorta angle (α), the left aorta angle (β), and the vertebral rotation angle (γ) were measured from 4 vertebrae above (A4) to 4 below (B4) the apical vertebra (Apex) to quantify the spatial relationship between aorta and spine. We simulated the pedicle screw misplacement with variable direction error, length, and diameter to analyze the potential risk of aortic injury.

Results: The aorta shifted laterally and posteriorly as it descended from A4 and moved back medially and anteriorly from Apex. The potential risk of aortic injury increased with the augment of direction error and/or length of the screw, but the tendency was not significant with the augment of diameter. The risk peaked at A4, A3, and B2, when the screw length was 40 mm and diameter was 5.0 mm, and the direction error was 30°, whereas the risk was lowest at the apical level 14.3% (0%-40.7%) in any scenarios.

Discussion: In patients with severe and rigid scoliosis, the aorta shifted more laterally and posteriorly, and the injury risk was lower at the apical level, compared with moderate scoliosis. Most potential risks can be minimized by careful preoperative planning and the assistance of intraoperative navigation or robotics.







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Advantage of Single-Position Oblique Lumbar Interbody Fusion with Percutaneous Pedicle Screw Instrumentation

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Purpose: To evaluate the technical feasibility and advantage of single-position oblique lumbar interbody fusion (OLIF) and the subsequent clinical and radiologic outcomes

Materials and methods: Among the 93 patients that underwent OLIF from January 2017 to January 2019, those that with single-level pathology and followed up for at least a year were enrolled. Deformity, stenosis due to trauma, and patients that underwent additional direct posterior decompression were excluded. Patients were divided into those that underwent the whole surgical procedure on lateral position (Group A) and those that underwent cage insertion on lateral position and subsequent percutaneous pedicle screw fixation after changing the patient to prone position (Group B). Demographics, operative and anesthesia time, clinical outcome, and postoperative complication were compared between the two groups.

Results: Total of 97 patients were enrolled in this study, 36 patients in Group A and 57 patients in Group B. The mean age, and sex ratio, did not differ between the two groups ($p>0.05$). However, the index levels were more in Group A, which showed a significant difference between two groups ($p=0.012$). The preoperative diagnosis included degenerative and isthmic spondylolisthesis, and foraminal stenosis. The mean operative and anesthesia time were 291.1 and 402.6 minutes in Group A, and 232.9 and 297.5 minutes in Group B, respectively. Clinical outcome of VAS back and leg did not show significant difference between the two groups. No complication including pedicle screw malposition occurred in both groups.

Conclusion: Single-position OLIF on lateral position is a feasible procedure that can decrease anesthesia time without complication compared to the conventional position changing method.

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Facet joint degeneration preceding the intervertebral disc: an epidemiological study in the community

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【Introduction】

The facet joints constitute a joint complex with the intervertebral discs and contribute to load distribution and control of excessive rotation. In most cases, degeneration of the lumbar spine occurs in the discs before the facet joints at the same spinal level, however, in a few cases, the facet joints degeneration (FJD) precedes the disc degeneration (DD) (FJD > DD). The purpose of this study was to investigate the characteristics of individuals with FJD > DD and their association with low back pain (LBP) using epidemiological data.

【Methods】

This was a community-based cross-sectional study. The subjects were 437 community residents (142 males and 295 females, mean age 65.0 years) who underwent lumbar spine MRI. We evaluated the left and right FJD from L1-L2 to L5-S using the Weishaupt classification (4 grades from 0-3). DD was measured by the Schneiderman classification (4 grades from 0-3). FJD > DD was defined as Weishaupt grade ≥ 2 in either the left or right facet joint and a Schneiderman grade = 0 in the disc at same spine level. Furthermore, subjects underwent blood and urine sampling, blood pressure measurement to assess for hypertension, diabetes, hepatic and renal dysfunction. Arteriosclerosis was assessed by cardio-ankle vascular index (CAVI) and osteoarthritis (OA) of the hip and knee joints were evaluated by the ARA classification (Altman 1986, 1991). LBP was assessed with a self-administered questionnaire and defined as pain requiring treatment lasting at least 1 month. We compared age, gender, BMI, prevalence of comorbidities and LBP between FJD>DD (+) and (-) groups. Statistical analysis was performed using the chi-square test, Mann-Whitney U test, and multiple logistic regression analysis, with a p-value of <5% considered statistically significant.

【Results】

A total of 219 subjects were enrolled, excluding those with compression fractures, scoliosis or degenerative spondylolisthesis. There were 16 (7.3%) subjects in the FJD>DD (+) group and 203 (92.7%) in the (-) group. There were statistically significant differences in only age (57.5±12.0 in FJD>DD (+) group vs. 65.5±109 in (-) group, p=0.004). On the other hand, there were no significant differences in gender (female/male 0.60 vs. 0.42, p=0.32), BMI (23.2±3.6 vs 23.3±3.2, p=0.68), hypertension (31.3% vs 56.2%, p=0.05), diabetes (0.0% vs 4.4% p=0.39), abnormal hepatic(37.5% vs 34.5% p=0.81) and renal function (18.8% vs 41.4% p=0.08), dyslipidemia (16.7% vs 32.5%, p=0.25), arteriosclerosis (16.7% vs 32.5%, p=0.25), knee (12.5% vs 32.6%, p=0.09) and hip OA (0.0% vs 6.9%, p=0.28) , LBP (18.8% vs 11.3%, p=0.38). Finally, multiple logistic regression analysis adjusted for age, gender, and BMI showed no significant differences between FJD > DD and LBP (OR=1.61, 95%CI: 0.39-6.65, p=0.51).

【Discussion】

In the present study, FJD > DD was more common in younger age groups, but there was no association with gender, BMI, or comorbidities including lower extremity OA. In addition, FJD>DD was not associated with LBP. Further studies with longitudinal data are needed to validate these results.

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Associations between treatment and health-related quality of life in patients with symptomatic lumbar spinal stenosis: a retrospective propensity score-matched analysis in the Locomotive syndrome and health outcome in Aizu cohort study (LOHAS) database

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INTRODUCTION:

Since prospective cohort studies that have to follow symptomatic lumbar spinal stenosis (LSS) patients who do not receive treatment must not be planned due to ethical considerations, the natural course for the untreated LSS patients was uncertain. The purpose of the present study was to investigate the association between treatment and health-related quality of life (HR-QOL) in patients with symptomatic LSS.

METHODS:

We analyzed treatment effects on the Medical Outcomes Study 12-Item Short-Form Health Survey (SF-12) in patients with symptomatic LSS focused on our Locomotive Syndrome and Health Outcomes in Aizu Cohort Study (LOHAS) dataset from 2008 and 2009. Symptomatic LSS was assessed using a validated LSS diagnostic support tool (Konno et al. 2007). Exclusion criteria comprised a history of spinal surgery. The one-to-one nearest-neighbor propensity score matching technique was used between patients who did and did not receive conservative treatment. The potential confounders considered in the present study were age, gender, height, weight, smoking, difficulty in walking 100 meters, urinary incontinence during walking, comorbidities, and history of treatment for musculoskeletal diseases. None of the patients received public health intervention such as secondary health examinations throughout the observational period. The medical care that the patients received was recorded for one year.

RESULTS:

The baseline prevalence of symptomatic LSS was 376 (16.3%) of 2302 participants. Within the year of follow-up, eleven and 114 patients were treated by lumbar spinal surgery and conservatively, respectively (treated group), whereas 251 patients were not treated (untreated group). The conservative treatment group had a lower health-related quality of life than the untreated group at baseline and one-year follow-up. After propensity-matched analysis, the median change in mental health sub-scale score was significantly lower in the conservative treatment group than in the untreated group.

DISCUSSION:

The degree of LSS might be more severe among conservatively treated than untreated patients because their HR-QOL scores were lower than those of untreated patients at all observational periods. There was no apparent deterioration in the HR-QOL of untreated LSS patients within the one-year follow-up period, even when the patients were left to their natural medical consultation behaviors.

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Can Wall-Occiput distance and Rib-Pelvis distance be used to assess sagittal spinal alignment?

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【Introduction】Wall-Occiput distance (WOD) and rib-pelvis distance (RPD) in female patients treated for osteoporosis are estimates of the presence of thoracic and lumbar vertebral fractures. However, it is unclear whether it is useful for global spinal alignment evaluation. The purpose of this study was to assess the relationship between WOD or RPD and sagittal spinal alignment in the general population, and to assess whether WOD or RPD was useful for estimating the sagittal spinal alignment.

【Methods】The subjects were 910 local residents (344 men, 566 women, average age 68 years, most age group 70s) who agreed with the purpose of this survey and submitted a written consent to participate. Thoracic kyphosis angle (T1-T12, TK), lumbar lordosis angle (L1-S1, LL), and sagittal vertebral axis (SVA) were measured on a standing whole-spine lateral radiograph. SVA was classified into 3 groups: less than 40 mm, 40-95 mm, and more than 95 mm. In addition, WOD was measured while the patient stands straight with his/her back against the wall and heels touching the wall. While the head face forward so that an imaginary line connecting the lateral corner of the eye to the superior junction of the auricle of the ear was parallel to the floor, the distance between the occipital prominence and the wall was quantified. In this study, the inability to touch the wall with the back of the head was judged as WOD positive. RPD was measured while the subject stand straight with arms outstretched at 90 degrees. The examiner stand behind the subject and inserted his or her fingers into the space between the inferior margin of the ribs and the superior surface of the pelvis in the midaxillary line. The rib-pelvis distance was the closest whole number of fingerbreadths between these structures. Two and less than two fingerbreadths were judged as RPD positive.

【Results】1. There was a statistically significant difference between WOD positive / negative and TK or LL. However, the difference between the average values was about 3-4 degrees in each case. On the other hand, in SVA, WOD positive was 41 mm on average and 25 mm negative, and the frequency of WOD positive was 16.5% for less than 40 mm, 23.1% for 40-95 mm, and 60.5% for the group over 95 mm.

2. There was a statistically significant difference between RPD positive / negative and TK or LL. However, the difference in the average values was about 2-3 degrees in each case. On the other hand, in SVA, RPD positive was 39 mm on average and 24 mm negative, and the frequency of RPD positive was 42.8% for less than 40 mm, 55.6% for 40-95 mm, and 67.5% for the group over 95 mm.

3. The sensitivity and specificity of WOD and RPD when detecting SVA 40 mm or more were 72.0% and 83.4% for WOD and both of 57.2% for RPD.

【Conclusion】WOD was convenient for detecting SVA 40 mm or more by a simple method, and its sensitivity was 72.0% and its specificity was 83.4%.

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Combination of preoperative frailty and postoperative serological markers can be a feasible predictor of surgical site infection after spinal surgery

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Introduction: To detect surgical site infection (SSI) at early time point after spine surgeries, we previously reported the efficacy of postoperative lymphopenia (PL) [1] and our original scoring system (SSI score)[2], which consists of a combination of four postoperative serological markers. Frailty has also been highlighted as a preoperative risk factor for postoperative adverse events including SSI in patients undergoing spine surgeries. The purpose of this study was to investigate if the combined use of preoperative frailty and postoperative serological assessments would be further effective to predict SSI after spine surgery.

Methods: A total of 419 patients who underwent spine surgeries at National Defense Medical College Hospital from 2012 to 2016 were retrospectively reviewed. Excluding patients with unplanned antimicrobial agents use and those with missing serological data, 327 patients were included. Nine patients who required reoperations due to SSI were grouped into the SSI group and the other 318 patients into the non-SSI group. Using 11-item modified Frailty Index (mFI-11), preoperative frailty was determined by dichotomous definition, frail (mFI-11 ≥3) or not frail (mFI-11 <3). Patients' characteristics at baseline (sex, age, preoperative frailty), use of metal implants, PL<1000/mL at 7 days after surgery (PL7D)[1], and SSI score were compared between the two groups. SSI score is the number of items matching the following four criteria, and SSI score ≥3 was found to be a strong indicator of SSI[2]: (1) neutrophil count at 7D >5095/mL; (2) increase in neutrophil-to-lymphocyte ratio from preoperative baseline to postop 7D >1.27-fold; (3) change in lymphocyte count from postop 2D to 7D <1.05-fold; (4) change in CRP level from 2D to 7D after surgery >0.39-fold.

Results: There were no significant differences in age, sex, and use of implants between the two groups. The SSI group were likely to show higher incidence of PL7D (44.4% in the SSI group vs 17.9% in the non-SSI group, p=0.07) and significantly higher percentage of frail patients (mFI-11] ≥3; 33.3% vs 8.8%, p=0.04) and those with SSI score ≥3 (88.9% vs 7.9%, p＜0.001) compared to the non-SSI group. Univariate logistic regression analysis identified the combination of mFI ≥3 and SSI score ≥3 as the strongest predictor of SSI among the variables examined in this study: PL7D (OR 4.61, 95%CI 1.20-17.81, p=0.27); mFI-11 ≥3 (OR 5.18, 95%CI 1.23-21.84, p=0.025); SSI score ≥3 (OR 93.76, 95%CI 14.39–595.36, p<0.001), mFI-11 ≥3 and SSI score ≥3 (OR 180.67, 95%CI 12.68–2573.77, p<0.01).

Discussion: Preoperative frailty determined by mFI-11 ≥3 showed similar predictive value for SSI with PL7D. Preoperative assessment of frailty might be useful to label patients with higher risk of SSI and to modify surgical plans. Combination of preoperative frailty and postoperative SSI score can be a feasible and reliable predictor of SSI at early postoperative time point to optimize patients care for the prevention / early detection of SSI.

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Prophylactic administration of denosumab for spinal metastases

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Introduction:

Skeletal-related events (SREs) in spinal metastases dramatically affect the activities of daily living and qualities of life. Prophylactic administrations of bone modified agents including denosumab are recommended for patients with bone metastases. The aim of this study was to evaluate the efficacy of prophylactic administrations of denosumab for advanced cancer patients with spinal metastases.

Methods:

We retrospectively reviewed medical records of patients who treated with denosumab for spinal metastases between January 2012 and December 2020 in our institution. Exclusion criteria were defined as switching from zoledronic acid, usage for hematologic disease and bone/soft tissue tumor, and less than three months follow-up. The rates of SREs excluding irradiation under denosumab treatment and surgeries for spinal metastases were evaluated. Moreover, spinal instability neoplastic scores (SINS) were analyzed between patients with SRE and those who with Non-SRE.

Results:

Two hundred twenty-two patients including 138 men and 84 women were eligible for this study. The median age was 62.8 years old. The median follow-up period was 35.1 months. Cancer origins consisted of lung (27.0%), prostate (12.1%), breast (10.9%), colorectal (9.0%), and kidney (8.4%) mainly. Thirteen patients (5.9%) developed SREs even under denosumab treatment. Of 13 patients, eight patients (3.6%) underwent palliative surgery for SREs. Regarding SINS, Patients with SREs had significantly higher points, averaged 10.7±3.8 compared to 7.4±3.8 in those who with non-SRE ($p<0.01$).

Discussion:

Prophylactic administration of denosumab could achieve favorable clinical outcomes. However, prophylactic surgery may need for patients with spinal metastases who have more than 10 points in SINS even under denosumab treatment.

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SYSTEMATIC LITERATURE REVIEW AND META-ANALYSIS ON THE CLINICAL OUTCOMES OF SPINE SURGERIES IN PATIENTS WITH CONCURRENT OSTEOPOROSIS

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INTRODUCTION

Osteoporosis is common in elderly patients and could be increased the risk of revision surgery in surgical treatment with spinal instrumentation.

The primary objective of this systematic literature review is to assess the effect of poor bone quality on surgical outcomes in such patients, including clinical and safety performance (both device- and patient-related), and economic outcomes of surgical management of spine fractures caused in patients with concurrent osteoporosis.

METHODS

A systematic review and meta-analysis were conducted to identify the characteristics of patients with compromised bone quality undergoing spinal surgeries. The systematic review was conducted in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Studies appearing in ProQuest (searched on 29 March 2021) and PubMed (searched on 27 May, 2021) databases up to past five years were queried using key words like spine surgery, osteoporosis, osteopenia or spinal implant.

The results were presented and synthesized qualitatively and quantitatively. Qualitative synthesis included summarization of individual studies and description of their results with respect to the relevant outcomes. For the quantitative synthesis, data on proximal junctional kyphosis (PJK)/proximal junctional failure (PJF) and revision surgery were analyzed using RevMan 5.4 according to PRISMA guidelines.

RESULTS & DISCUSSION

From 2,262 initial matches, a total of 62 studies met the inclusion criteria and were included in this systematic literature review. Overall, 540,289 patients were reported in the included studies. The number of patients varied from 18 to 182,519 and the follow-up period ranged from 1.2 to 51.7 months.

The overall prevalence of patients with compromised bone quality undergoing spinal surgery was found to be 21.79%. It was also reported that the rates of occurrence of the outcomes for the osteoporotic/osteopenic population was found to be higher when compared to those of the normal population. Regarding surgery related clinical and safety outcomes, patients presenting with compromised bone quality reported higher rates (33.44% vs. 29.05%) of PJK and PJF, when compared to normal population. Similarly, patients with compromised bone quality not only reported higher rates of implant-related complications (9.97% vs. 6.24%), but also revision surgeries (5.59% vs. 2.28%), readmissions (38.38% vs. 33.03%), reoperations (20.06% vs. 13.24%), and other adverse events (11.85% vs.7.69%). In addition, the meta-analysis also revealed that the risk of PJK/PJF (RR=1.89; 95%CI=1.22-2.92, p=0.004), but also revision surgeries (RR=1.65; 95%CI=1.13-2.42, p=0.010) was higher in osteoporotic patients when compared to normal patients. In a sub-analysis, the rates of outcomes were also provided for studies published in Asian countries. Among Asian patients, the prevalence of osteoporotic patients undergoing spinal surgeries, was higher (43.70%) than the overall prevalence (21.79%) in all included studies. Similarly, compared to non-Asian patients, Asian patients exhibited higher rates of PJK and PJF (32.10% vs. 30.30%), higher implant-related complications (42.80% vs. 16.20%), revision surgery (24.00% vs. 17.6%), and readmission (38.60% vs. 33.30%).

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Dynamic Spinopelvic Alignment on Walking is Associated with Quality of Life in Patients with Degenerative Lumbar Spinal Canal Stenosis; Kinematic study using three-dimensional motion analysis.

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INTRODUCTION: In patients with lumbar spinal canal stenosis (LCS), postural collapse has been observed in many cases, and its relation to quality of life (QOL) has been pointed out. Although previous studies have examined the relationship between QOL and the parameters measured on X-ray images in a static standing position, it must be taken into account that symptoms in patients with LCS often occur in a dynamic condition such as walking. The purpose of the current study was to investigate the relationship between QOL and dynamic spinopelvic alignment on walking in LCS patients.

METHODS: This is a cross-sectional study in a single hospital. We examined patients who admitted to our hospital as a surgical candidate between December 2016 and April 2021. This study was approved by institutional review board (approval number: general 29263). The Oswestry Disability Index (ODI) was used to evaluate QOL. The ODI consists of 10 items related to functional impairment. Then, trunk flexion/ extension and hip extension/ abduction muscle strength were measured as physical function using Mobie (Sakai Medical Co., Ltd., JAPAN) which is a hand-held dynamometer (HHD). Spinal mouse® (Index Ltd., Japan), a device which can calculate the curvature and inclination of particular segments of the spine, was used to measure the static alignment of the spine. A three-dimensional (3-D) motion analysis system, VICON MX (Vicon Motion Systems, Oxford, UK) was used to measure the dynamic spinopelvic alignment on walking. The data were collected for one gait cycle. For statistical analysis, we examined the relationship between the ODI score and above-mentioned items using Spearman's rank correlation coefficient. Furthermore, in order to investigate the influential factors on the ODI score, a stepwise multiple regression analysis was performed. SPSS statistics 26 (IBM, Chicago, IL, USA) was used for statistical processing. Statistical significance was set at $p < 0.05$.

RESULTS: A total of 30 subjects with LCS were participated in this study. ODI score significantly correlated with trunk extension strength ($r = -0.559$, $p = 0.002$), hip extension strength ($r = -0.473$, $p = 0.011$), maximum flexion angle of spine on walking ($r = -0.551$, $p = 0.002$) and maximum anterior tilt angle of pelvis ($r = 0.528$, $p = 0.004$). Multiple regression analysis showed that trunk extension strength (standardized β; - 0.35), maximum spinal flexion angle (standardized β; - 0.51) and hip extension strength (standardized β; - 0.40) significantly affected the ODI score, with adjusted coefficient of determination of 0.62.

DISCUSSION: The current study was the first to investigate the relationship between dynamic spinopelvic alignment and QOL in LCS patients. Our study suggested that both physical function and dynamic spinopelvic alignment play an important role to affect the QOL in the patients with LCS. Our findings may provide many insights to manage the symptom such as neurogenic intermittent claudication in the patients with LCS.

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Efficacy of Posterior fixations for middle or lower lumbar pyogenic spondylitis.

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INTRODUCTION:

Most cases of pyogenic spondylitis can be treated non-surgically, but some cases require surgical intervention. Although there are some reports minimally-invasive posterior fixation is effective for refractory cases, in patients with lumbar spine disease, treatment could be difficult due to inadequate fixation of the caudal side. In this study, we report five cases of lumbo-iliac fixation with sacral alar iliac (SAI) screws as the distal anchors for middle or lower lumbar pyogenic spondylitis refractory to conservative treatment.

PATIENTS AND METHODS

We reviewed medical charts of consecutive five cases of lumbar spondylitis treated surgically using SAI screws. We collected data involving sex, age, follow-up period, time to surgery from initial diagnosis, complicated disease associated with pyogenic spondylitis, the level of infection site, surgical procedures, postoperative complications, and the presence of postoperative infection recurrence.

RESULTS:

All cases treated surgically are male. The average age was 62.2 (range, 49–72) years old. The average follow-up period was 12.4 (range, 10–21) months. Time to surgery from initial diagnosis was averaged 100.6 (range, 58–175) days. All cases have underlying illness, mainly diabetes mellitus in three patients, liver cirrhosis in two patients, and rheumatoid arthritis in one patient. The level of infection site were L3/4 in two patients, L4/5 in one patient, and L5/S in two patients. Among five cases, one patient underwent L3-S1 posterior fixation with percutaneous pedicle screws previously. However, 6 months after surgery, S1 screws were loosened and the infection could not be healed. All cases were treated surgically with posterior fixation using SAI screws. Th12-iliac fixation in two patients, L1-iliac fixation in one patient, and L3-iliac fixation in two patients were performed, respectively. Time required for C-reactive protein levels to return to normal was averaged 95.6 (range, 27–300) days. No additional surgical interventions such as anterior debridement nor postoperative complications developed at final follow-up.

RESULT AND DISCUSSION:

In our series, minimally invasive lumbar-pelvic posterior fixation using SAI screws were very effective for the treatment of pyogenic spondylitis refractory to conservative treatment. All patients who underwent surgery were free to move and signs of infection improved dramatically after surgery. Spinal fixation using SAI screws could be beneficial for refractory pyogenic spondylitis of the middle or lower lumbar spine.

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Mid-term clinical results of spinal endoscopic decompression for lumbar degenerative spondylolisthesis with spinal stenosis: Does facet joint orientation affect the postoperative results?

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INTRODUCTION: We have performed endoscopic decompression for lumbar degenerative spondylolisthesis (DS) regardless of the degree of slippage and instability. Sagittalization of the facet joint (FS) has been reported to be a risk factor for lumbar spondylolisthesis, but few reports have been published on the relationship between FS and the postoperative results of endoscopic decompression. This study aimed to clarify the relationship between FS in DS and the medium-term results of endoscopic decompression.

METHODS: Of the 35 patients who underwent endoscopic decompression with a diagnosis of DS (slippage of ≥3 mm on the X-ray standing view) from April 2013 to October 2018, 32 patients whose images could be evaluated 2 years after surgery were investigated. The mean postoperative follow-up period was 3 years and 7 months. Bilateral facet joint angles were measured at the height of the lower margin of the slip level on preoperative CT, and the mean value was taken as the facet joint angle. The following items were compared based on the presence or absence of FS. The primary endpoint was the change in slippage rate at the decompressed level. As a secondary endpoint, the reoperation rate caused by the decompressed level was investigated. Age, sex, preoperative facet joint width, and postoperative joint survival rate were also investigated as adjusting factors. Regarding the presence or absence of FS, it was judged that the risk factor for DS in the previous study was ≥58 degrees with FS, and <58 degrees without FS.

RESULTS: There were 22 patients with FS (11 males, 11 females, mean age at surgery 67.9 years) and 11 without FS (2 males, 9 females, mean age 65.7 years). There were significantly more females without FS. The mean preoperative facet joint angle was 67.2 ± 6.6 degrees with FS and 47.4 ± 8.5 degrees without FS. No significant differences in preoperative facet joint width or the postoperative facet joint survival rate were observed between the groups. The postoperative % slip change was 1.9 ± 1.1% with FS and 1.6 ± 1.6% without FS, showing no significant difference, and the progression of slip was less than 2% with or without FS. There was one reoperation without FS. That is, FS is unlikely to affect postoperative slip progression or the reoperation rate.

CONCLUSION: Endoscopic decompression is useful for DS because it is not affected by sagittalization of the facet joint.

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Preoperative dysfunction of hip joint can be a risk factor for rod fracture after posterior corrective surgery in the patients with adult spinal deformity; a retrospective cohort study

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Introduction: Rod fracture (RF) after posterior corrective fusion surgery in patients with adult spinal deformity (ASD) is one of the most frequent and serious complications. Many reports have been published to investigate the pathomechanism of RF and to resolve this devastating problem. However, the association between RF and preoperative hip joint function after corrective fusion surgery in ASD patients is unknown. The purpose of this study was to investigate the association between the occurrence of RF and hip joint function in ASD patients who underwent corrective fusion surgery.

Methods: A retrospective cohort study was conducted at a single hospital for ASD patients who underwent corrective fusion surgery between September 2014 and May 2019. The surgery was performed on a pedicle-screw basis posteriorly. Lateral lumbar intervertebral fusion (LLIF) was accompanied in some patients. Only autogenous bone graft was used in all the patients. Any bone morphologic proteins were not grafted concurrently. All the surgeries were performed by the same single attending orthopaedic spine surgeon (OS). Using the SRS-Schwab Classification, the ASD was defined as the following: 1) sagittal vertical axis (SVA) was 40 mm or more, 2) pelvic incidence minus lumbar lordosis (PI-LL) was 10 degrees or more. Preoperative demographic and radiological characteristics, as well as surgical characteristics, were assessed. In addition, hip function (hip extension range of motion [ROM] and hip extensor strength) was measured. The outcome in this study was the occurrence of RF within one year postoperatively. The association between hip function and occurrence of RF within one year postoperatively was assessed by multivariable analysis. Multivariable analysis was adjusted for several confounding factors (gender, age, body mass index, SVA, PI-LL, number of fusion levels, rod diameter, and material). The level of significance was set at $P<0.05$.

Results: A total of 37 subjects with ASD (34 women, three men; age range 56-79 years) had a full set of all data and were included in this study. Preoperative radiological characteristics were SVA, 139.2±78.4mm; PI-LL, 37.3±9.1 degrees. Postoperative RF occurred in 16 patients (43%). Multivariable analysis showed that hip extension ROM was an independent risk factor for the occurrence of RF after corrective fusion surgery (OR, 0.82; 95%CI, 0.70-0.95).

Discussion: The current study found that hip extension ROM is an independent risk factor for the development of postoperative RF in ASD patients after corrective fusion surgery. The hip joint is most adjacent to the spine and is considered important as a compensatory mechanism for sagittal imbalance. This plays an important role to complement the dysfunction of the fixed spine, especially after corrective fusion surgery. The result in this study is useful for many health care providers who are responsible for ASD patients scheduled for corrective fusion surgery. Maintaining adequate hip extension ROM in ASD patients scheduled for corrective fusion surgery may be a strategy to prevent postoperative RF.

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Short-segmental spinal fusion for chronic low back pain with bone marrow edema adjacent to the vertebral endplate in adult spinal deformity

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Introduction:
Corrective long spinal fusion is a widely accepted surgical method for the management of patients with adult spinal deformity. However, instrumented long-fusion for the treatment for elderly patients has been associated with a significant risk of complications and high cost of medical care. The purpose of this study was to assess the success of short-segmental spinal fusion specifically for bone marrow edema (BME) adjacent to the vertebral endplate in patients with chronic low back pain and spinal deformity.

Methods:
A cross-sectional observational study was performed at our hospital, whereby we analyzed patients with spinal deformity and accompanying chronic low back pain. For inclusion in this study, the required patient age was at least 50 years old, with a minimum LBP severity score of 40mm on the visual analogue scale (VAS). Refractory to standard conservative medical treatment was performed. We included patients with lumbar BME on magnetic resonance imaging (MRI) and a lumbar tenderness point on the BME lesion. We defined BME as an area of high signal intensity on T2-weighed fat-saturated MRI. Short spinal fusion was performed on segments of BME. Clinical evaluations of low back pain on VAS, the Oswestry Disability Index (ODI), the radiological parameter for sagittal vertical axis (SVA), pelvic incidence (PI), lumbar lordosis (LL) and pelvic tilt (PT) were carried out. To analyze the clinical and radiological data, we used the Paired t-test, and statistical significance was defined as $P < 0.05$.

Results:
There were 27 patients (19 men and 8 woman), with a mean age of 64.6 years (range: 51 to 78 years). The mean VAS and ODI scores were 70.2 ± 2.5 mm and 48.4 ± 3.3% before surgery, 20.4 ± 2.5 mm and 31.2 ± 3.1% 1 month after surgery, and 33.4 ± 4.8 mm and 29.3 ± 3.5% 12 months after surgery, respectively. The mean VAS and ODI scores significantly improved after surgery. The mean spinal fusion ranges were 1.3 segments. The SVA, PI-LL, and PT scores were 60.7 ± 10.6 mm, 20.5 ± 3.9 degrees, and 23.8 ± 2.0 degrees before surgery, respectively. These spinal alignment parameters did not change significantly after surgery. MRI showed the BME to decrease after surgery.

Discussion:
Short-segmental spinal fusion is an effective procedure for chronic low back pain and spinal deformity with BME adjacent to the vertebral endplate.

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Spinous process fractures in osteoporotic vertebral fractures: a cross-sectional study of patients with low back pain

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Introduction:
Osteoporotic vertebral fractures (OVFs) are becoming a significant socio-economic problem as the percentage of older people in the population increases. Although there have been some studies which have focused on the fractured vertebral body, there have been few reports of spinous process fractures (SPFs) in the osteoporotic spine. The purpose of this study was to assess the radiological and clinical outcomes of OVF accompanied by SPF.

Methods:
A cross-sectional observational study was performed at our hospital. We evaluated patients who were suffering pain due to single-level OVF and an intravertebral cleft. For inclusion in the study, the requisite duration was at least 12 weeks and the severity of low back pain (LBP) was greater than 40/100 mm on the visual analogue scale (VAS). Refractory to standard medical treatment was administered. SPF was detected using magnetic resonance imaging (MRI) and computed tomography (CT). The outcomes of the plain radiograms of the vertebral fractures were evaluated from the wedging angle of the fractured vertebrae, intravertebral instability and the presence of ankylosing spinal hyperostosis. As clinical parameters, we investigated age, gender, VAS score for LBP, Oswestry Disability Index (ODI), and the period from the onset of acute fracture. To analyze the clinical and radiological data, we used the Mann-Whitney U test and statistical significance was defined as $P < 0.05$.

Results:
Our study included 195 patients with chronic pain (50 men, 145 women) due to single-level OVF with an intravertebral cleft. The mean age and the mean time-period from the onset of acute LBP were 77 years (range, 57-93 years) and 38 weeks (range, 12-144 weeks), respectively. In 195 OVF patients with LBP, 41 patients (20.5%) showed SPFs on MRI and CT. SPFs were observed just 1 level above the fractured vertebral body in 35 patients (85.4%), with the same results as the fractured vertebral body in 6 patients (14.6%). The rate of incidence of SPF in the thoracic spine was higher in the SPF(+) group than that in the SPF(-) group. Regarding the presence or absence of APFs, there were no significant differences in age, gender, VAS, ODI, the time-period from the onset of acute LBP, wedging angle, intravertebral instability, or in the presence of ankylosing spinal hyperostosis.

Discussion:
SPFs occurred in 20.5% of elderly OVF patients with long-lasting LBP. In addition, SPFs often occurred just one level above the fractured vertebra, and SPFs with OVF tended to be located in the thoracic spine.

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Multidimensional evaluation of the effects of psychosocial factors on postoperative lumbar spinal stenosis -A 3-year retrospective cohort study using the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ) -

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Introduction

Psychosocial factors are associated with poor postoperative outcomes in lumbar spinal stenosis (LSS). The purpose of this study was to investigate the effect of psychosocial factors on the postoperative outcome of LSS in a multidimensional manner using the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ).

Methods

The subjects were 118 patients (65 males and 53 females, mean age 64.7 years) who underwent LSS surgery at our hospital. Preoperatively, the patients were classified into two groups, normal and abnormal, using Brief scale for evaluation of psychiatric problems in orthopedic patients (BS-POP). They were evaluated preoperatively and at three months, one year, and three years postoperatively using the JOABPEQ. Mann-Whitney's U test was used for the statistical study ($p < 0.05$).

Results

JOABPEQ scores (normal group/abnormal group; preoperative, 3 months, 1 year, 3 years postoperative) were as follows: pain-related disability (28.6/42.9, 78.6/71.4, 100/71.4, 100/64.3), lumbar dysfunction (50.0/50.0, 83.3/58.3, 83.3/33.3, 100/70.8) gait impairment (28.6/21.4, 71.4/28.6, 75.0/46.4, 92.9/64.3), social impairment (43.2/32.4, 56.8/45.9, 64.9/51.4, 78.4/54.1), and psychological impairment (41.7/45.6, 60.2/47.6, 57.3/52. 4, 69.4/42.2). The BS-POP abnormal group had significantly lower scores for lumbar spine dysfunction at three months and one year postoperatively. For social disability, the score was significantly lower at one year postoperatively. Low back pain, lower extremity pain, and numbness were significantly lower at three months postoperatively.

Discussion

When considering surgery for LSS in patients with psychosocial factors, it would be necessary to select a treatment method after providing adequate explanations to patients based on the characteristics shown in this study.

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Clinical Results of Combined Interlaminar and Transforaminal Endoscopic Discectomy for Central Lumbar Disc Herniation

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Introduction

Herniated nucleus pulposus of the lumbar spine is the most common indication for surgery [1]. The herniated nucleus pulposus can be classified into 3 types: central, paramedian, foraminal herniation according to location [2]. The incidence of central large disc herniation is about 3.6% [3]. However, central large disc herniation type is the most common cause of cauda equina syndrome, resulting in severe disability [4].

The use of endoscopy has been extensively expanded to other areas rather than simple lumbar discectomy e.g., large central disc herniation [4], migrated lumbar disc herniation [6], Lumbar endoscopic fusion etc. Some studies have used the benefits and overcome the limitation of each approach by combining transforaminal and interlaminar in one patient but at different levels [5,6].

Methods

From January 2015 to December 2020, 9 cases were diagnosed with Central large disc herniation and treated with combined interlaminar and transforaminal approach were retrospectively reviewed.

Results

The study revealed 7 men and 2 women. The average age of patients was 42.33 ± 19.8 years old (18 - 83). The level of surgery reveal L3-4 2 cases, L4-5 7cases. The VAS Back and Leg were improved from pre-operative score from 5.0 ± 2.0, 4.42 ± 2.93 to 2.18 ± 1.97 and 2.55 ± 2.84 retrospectively at 1 week. The ODI score was improved pre-operative from 46.85 ± 15.61% to 14.94 ± 19.08% at 3 month follow up. There were 2 cases (2/9) diagnosed of recurrent disc herniation. No case of epidural hematoma, infection or permanent neurological deterioration.

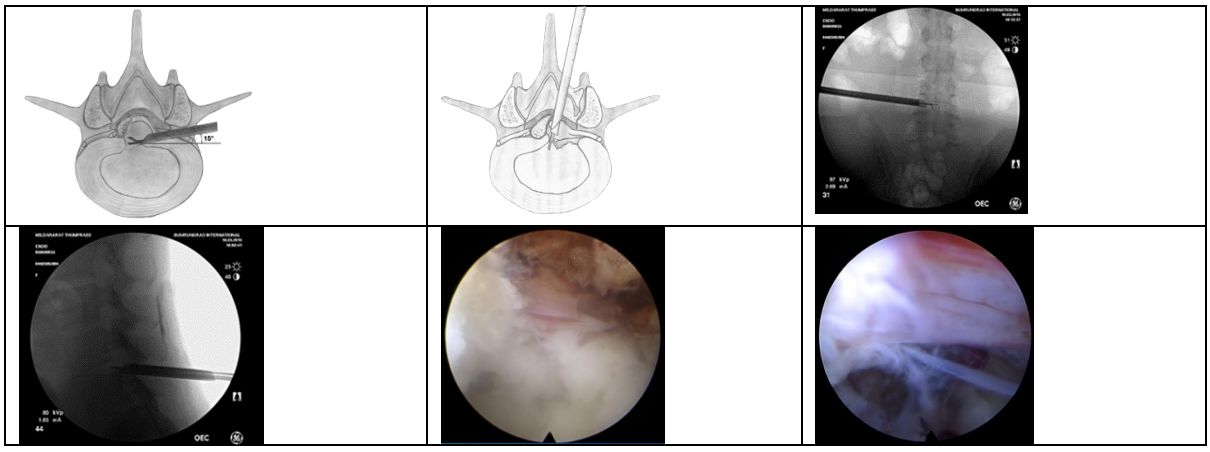
Discussion

The Incidence of central disc herniation reported, varied from 1.2% to 44% [7]. The symptoms reported in previous study were different e.g. present of quada equina syndrome, bilateral radicular symptoms. In our study, all patients' symptoms were not cauda equina syndrome but only bilateral radiculopathy.

The surgical technique combines the advantage of transforaminal approach and interlaminar approach. Via the transforaminal approach which is considered less invasive,we aim to gently remove some part of large disc to loosen the epidural tissue and widen space for the interlaminar approach discectomy. The interlaminar approach purpose to remove the remnant of herniated disc, remove the intra discal free fragments and manage the annular defect with eletrocoagulation(figure 1).

The VAS back, leg ODI score were improved significantly after surgery. The recurrent rate was 22.22% (2/9 cases), one of two cases needed surgery while the other was treated conservatively after recurrent symptoms. We assumed that the annular defect may be larger than paramedian or posterolateral herniation therefore after surgery recurrent is more likely.

Complications of the combined approach were similar to general endoscopic discectomy[8]. There were 2 cases of postoperative weakness and numbness which was completely resolved at 3 months follow up. The excessive nerve retraction was considered the cause of the temporary weakness in both cases. There are 2 cases diagnosed of recurrent disc herniation as patient had recurring symptoms on post-operative day 155 and 225. However, those two cases have improved postoperative VAS back and leg and ODI score.



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The correlation between the change of Hounsfield units value and Modic changes in the lumbar vertebral endplate

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Abstract

INTRODUCTION

A lot of studies in current literature described the etiology, epidemiology and clinical relevance of MCs. However, there are few studies on the correlation between MCs and Hounsfield units value of vertebral marrow and endplate.

Objectives: To evaluate the changes of Hounsfield units (HU) value in different types of Modic changes (MCs) and to analyze the correlation between the change of HU value and area ratio of MCs region, bone mineral density (BMD), and degree of intervertebral disc degeneration.

Methods: One hundred fifty-eight endplates with MCs were included and analyzed. HU values of MCs regions and adjacent vertebral corresponding regions without MCs were measured. The area ratio of MCs region was defined as the area of MCs divided by the area of endplate or the vertebral sagittal plane. BMD was measured by Dual-energy x-ray absorptiometry (DXA). Degree of intervertebral disc degeneration was evaluated based on Pfirrmann classification. According to the types of variables, descriptive statistics, Kolmogorove-Smirnov test, paired t-test, Wilcoxon signed-rank test, Independent-Samples T Test, and Pearson correlation analysis were used.

Results: The HU values in any types of MCs are significantly higher than that of adjacent vertebral corresponding regions without MCs ($P < 0.001$). The HU value of the type III MCs is higher than that of the type I and type II MCs.HU value was positively correlated with BMD. In the levels with Grade V disc degeneration, the area ratio of MCs region was significant increased.

DISCUSSION

In our study, all types of MCs were included to evaluate the change of HU values in different types of MCs. Our findings show that the HU values of MCs regions were significantly higher than those of the corresponding regions in adjacent vertebra without-MCs, regardless of the endplate region and bone marrow region. The HU value in type III was higher than that in type I and II. In type I and type II, we found HU values slight decreased in very few cases. As we all know, higher HU value is associated with more severe endplate sclerosis. Our results showed that osteosclerosis may coexist with fat deposition and inflammatory reactions. In addition, the consistency between axial plane and sagittal plane suggested the error of our measurement was negligible. Our study was a quantitative measurement and provided accurate information. We could infer that the pathological process of MCs might be osteosclerosis. We think that as the area ratio of MCs region gets larger, chronic lower back pain will become more severe. We also found that there was a positive correlation between the area ratio of the endplate and the area ratio of the sagittal plane, which proved that the diffusion of MCs was simultaneous to the endplate and the vertebral body.

Conclusions: HU values of the vertebral endplate and bone marrow were increased in most MCs regions with all types of MCs. HU value of endplates had a significantly positive correlation with BMD. Higher area ratio of MCs region is associated with more severe intervertebral disc degeneration.

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Skeletal muscle mass and clinical findings to evaluate the effectiveness of one-stage surgery in tandem spinal stenosis

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【Purpose】

The incidence of TSS (Tandem Spinal Stenosis) is increasing rapidly as society ages but its pathophysiology and pathogenesis are not clear. There is no consensus whether a one-stage or two-stage procedure is better. We compared preoperative skeletal muscle mass, clinical symptoms, and surgical results between TSS patients who underwent simultaneous cervical and lumbar decompression and lumbar spinal stenosis (LSS) patients who underwent lumbar decompression. The characteristics of the TSS patients and the surgical outcomes of one-stage surgery were examined.

【Methods】

There were 118 patients (mean age 66.34 years, 71 men) who received surgical treatment. Of these, 9 patients had TSS (mean age 74.33 years, 4 men) and 109 had LSS (mean age 65.70 years, 67 men). A bioelectric impedance analyzer (BIA) was used to measure systemic skeletal muscle mass and phase angle, an index of cell membrane aging. The visual analogue scale (VAS) score for low back pain (LBP) and leg pain and leg numbness, the Japanese Orthopedic Association scoring system (JOA score), the Roland-Morris Disability Questionnaire (RDQ), the Japanese Orthopedic Association Back Pain Evaluation Questionnaire (JOABPEQ), and the Oswestry Disability Index (ODI) were used to evaluate clinical symptoms. Preoperative skeletal muscle mass, phase angle, clinical symptoms, and surgical results were compared between groups.

【Results】

Operative time was significantly longer in the TSS group than in the LSS group ($p < 0.05$), but the amount of bleeding was not significantly different between the groups. The height, trunk muscle mass, and phase angle of the trunk and both lower limbs were significantly lower in the TSS group than in the LSS group ($p < 0.05$). JOA scores were significantly lower in the TSS group ($p < 0.05$), and 88% of TSS patients had difficulty climbing stairs, significantly more than in the LSS group (28%, $p < 0.05$). Although clinical symptoms in both groups improved with surgery, there was no significant difference in the degree of clinical improvement ($p > .05$).

【Discussion】

TSS was associated with decreased trunk muscle mass and decreased phase angle of the trunk and both lower limbs, suggesting the progression of trunk muscle atrophy due to decreased activity. In addition, about 90% of TSS patients had difficulty climbing stairs. A one-stage minimally invasive operation was performed for TSS and the amount of intraoperative bleeding was equivalent to that of LSS alone. The one-stage approach seems to be effective.

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A study on bone union promoting effect by Romosozumab administration in a rat posterolateral lumbar fusion model

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This study investigated the effect of romosozumab on bone union in a rat posterolateral lumbar fixation model. Posterolateral lumbar fixation was performed on 8-week-old male Sprague Dawley rats (n=20). For bone grafting, autogenous bone (40 mg) was harvested from the spinous processes of the 10th thoracic vertebra until the 2nd lumbar vertebra and implanted between the intervertebral joints and transverse processes of the 4th and 5th lumbar vertebrae on both sides. Rats were matched by body weight and equally divided into two groups: R group (Evenity®, 25 mg/kg) and control (C) group (saline). Subcutaneous injections were administered twice a week until 8 weeks after surgery. Computed tomography was performed at surgery and week 8 after surgery. The area and percentage of bone trabeculae in the total area of bone fusion were calculated. Statistical analysis was performed using unpaired t-test ($P<0.05$). We found that the R group rats had significantly higher mean bone union rate and volume than the C group rats at all time courses starting week 4 after surgery. The R group had significantly higher increase rates than the C group at weeks 4 and 6 after surgery. The percentage of bone trabeculae area of the R group was approximately 1.7 times larger than that of the C group. Thus, we demonstrated that romosozumab administration has stimulatory effects on bony outgrowth at bone graft sites. We attribute this to the modeling effect of romosozumab.

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Kitchen elbow sign is one of the surrogate markers that predict good surgical outcomes in adults with spinal deformity: A retrospective cohort study

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Introduction: Kitchen elbow sign (KE-Sign) is a skin abnormality on the extensor side of the elbow and forearm that is often observed in patients with adult spinal deformity (ASD). The KE-Sign is a skin change that runs from the elbow to the forearm in patients with intractable low back pain in the standing position, and is caused by supporting oneself using the elbows in a standing position during housework. The KE-Sign is not specific to ASD patients, but may act as a surrogate marker of maintaining and continuing an independent lifestyle even with intractable low back pain due to sagittal plane imbalance if the population is limited to patients with ASD. Therefore, we hypothesized that the KE-Sign correlates with health-related quality of life (HRQOL) and can be used to predict surgical outcomes or patient satisfaction in ASD. This study aimed to investigate the significance of KE-Sign in surgical cases of ASD.

Methods: Overall, 114 patients with ASD treated with long spinal fusion were reviewed and divided into KE-Sign positive and negative groups. The preoperative and 1-year follow-up evaluations included radiographic parameters (C7 sagittal vertical axis [SVA], pelvic incidence [PI] and lumbar lordosis [LL]), the Oswestry Disability Index (ODI), visual analog scales (VASs) for low back pain, leg pain, and satisfaction, and Short Form 36 questionnaire (SF-36).

Statistics: To compare data between the KE-Sign positive and KE-Sign negative groups, Fisher's exact test/chi-square test was used for proportional variables. Analysis of variance (ANOVA) was performed for continuous variables. First, baseline characteristics and postoperative outcomes at 1 year after surgery were compared between the two groups. Second, multi-regression analysis was performed to identify predictors of patient satisfaction and improvement in ODI as dependent variables, and sex, age, BMI, presence or absence of KE-Sign, preoperative C7 SVA, PI-LL, ODI (%), lumbar VAS, and component summary scales of SF-36 as independent variables.

Results: Preoperative characteristics showed no significant difference between both groups (Fig.1). Improvement in the ODI and VAS for satisfaction were significantly superior in the KE-Sign positive group (Fig.2). Multiple regression analysis showed that KE-Sign positivity and preoperative ODI score were the significant factors predicting the ODI improvement (Fig.3). Again, multiple regression analysis showed that age, KE-Sign positivity, and preoperative VASs of low back pain and leg pain were the significant factors in predicting the patient's satisfaction at 1-year post-surgery (Fig. 4).

Conclusion: Both groups with and without KE-Sign showed similarly good recoveries of SVA, PI-LL, lumbar VAS, and component summary scales of SF-36 postoperatively. However, improvement in ODI (%) and the VAS for satisfaction were significantly superior in KE-Sign positive patients. Thus, the KE-Sign may be useful as a surrogate marker of increased postoperative satisfaction in ASD patients with respect to the preoperative inability to perform household chores.

a. Multiple regression analysis for improving of ODI

Preoperative factor	p value	Std. β	VIF
Sex	0.374	0.068	1.066
Age (years)	0.064	-0.156	1.263
BMI (kg/m^2)	0.664	-0.034	1.088
KES (+)	<0.001*	0.300	1.121
SVA (mm)	0.411	-0.076	1.572
PI-LL (°)	0.382	-0.082	1.604
ODI (%)	<0.001*	0.608	1.339
VAS (low back pain) (mm)	0.099	-0.147	1.426
VAS (leg pain) (mm)	0.862	-0.016	1.552
SF-36 (PCS)	0.154	0.111	1.101
SF-36 (MCS)	0.343	0.074	1.116

b. Multiple regression analysis for patient satisfaction VAS

Preoperative factor	p value	Std. β	VIF
Sex	0.981	0.002	1.066
Age (years)	0.003*	0.287	1.263
BMI (kg/m^2)	0.332	-0.089	1.088
KES (+)	<0.001*	0.426	1.121
SVA (mm)	0.431	0.083	1.572
PI-LL (°)	0.446	-0.081	1.604
ODI (%)	0.501	-0.065	1.339
VAS (low back pain) (mm)	0.025*	-0.228	1.426
VAS (leg pain) (mm)	0.039*	0.218	1.552
SF-36 (PCS)	0.301	0.091	1.101
SF-36 (MCS)	0.766	-0.028	1.116

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Revision surgery for symptomatic adjacent segment diseases after lumbar fusion based on patient-based questionnaire

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Introduction: Although the number of symptomatic adjacent segment disease (ASD) after lumbar fusion surgery is increasing, there is no definitive strategy of surgical selection for symptomatic ASD, and a few study discussed based on Health-Related QOL evaluation. The purpose of this study was to investigate the outcome of revision surgery for ASD using Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ) .

Methods: 51 patients (23 male, 30 female, mean age of 68.9 years) who underwent surgery for symptomatic ASD and were assessed using JOABPEQ before and one year after the surgery were included in this study. We divided the patients into two groups, that is decompression alone (D group) and the other is decompression with fixation (F group), and evaluated in demographic data (age, sex, BMI, past history), surgical factor (surgical procedure, rate of complications and re-operation), preoperative X-ray parameters and instability of the affected level (segmental slip > 20%, dynamic slip >10%, segmental angulation > 5 degrees, and lateral translation > 3mm), and JOABPEQ effectiveness rate.

Results: There were 19 cases in group D (spinous process-splitting laminoplasty), 34 cases in group F (PSF: 1 case, PLIF: 31 cases, XLIF + PSF: 2 cases). No significant differences were observed in age, preoperative X-ray parameters between the two groups, however, the frequency of female was significantly higher in the F group than in the D group (78.4% vs 19.2% ; p = 0.01). BMI was significantly lower in the F group than D group (23.1 vs 25.6 ; p = 0.01). The rate of complications and re-revision surgery did not show significant differences (p=0.62, 1.00, respectively). Preoperative instability of the affected level was observed in 5 patients in the group D (25.0%) and 28 patients in the Group F (84.8%), which was significantly higher in the group F (p<0.01).The JOABPEQ effective rate for each domain were Social life function (p=0.84), Low back pain (p=0.70), Lumbar function (p=0.82), Mental health (p=0.70), and walking ability (p=.0.70), indicating that there were no significant differences between the two groups.

Discussion: From our study, symptomatic ASD was dominant in female. With regard to surgical outcome based on patient-based questionnaire for symptomatic ASD, there were no significant differences between the two procedures, suggesting that ASD patients without instability could be treated by decompression alone.

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Sciatic scoliosis in lumbar disc herniation patients: radiological characteristics and recovery following posterior endoscopic transforaminal discectomy

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Introduction

Sciatica scoliosis could be observed in lumbar disc herniation patients. Posterior endoscopic transforaminal discectomy is recommended to treat such situation. However, there are only a few reports about the evolution of the curve after lumbar surgery. The purpose of this study was to analyze the radiological characteristics of sciatica scoliosis and to further characterize the curve evolution after posterior endoscopic transforaminal discectomy.

Methods

LDH patients with sciatic scoliosis who underwent posterior endoscopic transforaminal discectomy from 2020 to 2021 and were followed up for at least 2yrs were retrospectively reviewed. Radiographic parameters were measured on standing whole spine radiographs including the apical vertebral translation (AVT), distance from the C7 plumb line to the central sacral line (CSVL-C7PL). Patients with the preoperative AVT ≥20mm were enrolled in present study. The AVT was measured on serial radiographs taken at 1, 6 months, and last follow-up to evaluate the curve evolution. The resolution of scoliosis was defined as AVT≤10 mm during follow-up. Coronal balance was defined as CSVL-C7PL≤10 mm.

Results

A total of 42 LDH patients were included in this study. The incidence of scoliosis secondary to LDH was 23.8%. All patients had a short lumbosacral curve accompanied with a long thoracic or thoracolumbar curve toward the opposite side. At the postoperative 2 yrs follow-up, all patients recovered to normal sagittal and coronal balance. 83.3% of the LDH patients achieved resolution of scoliosis within 6 months after surgery. 92.8% of the LDH patients achieved resolution of scoliosis within 1 yrs after surgery.

Discussion

The incidence of sciatica scoliosis secondary to LDH is 23.8%. Spontaneous correction of sciatica scoliosis could be achieved when sciatica was relived after posterior endoscopic transforaminal discectomy and well-maintained during follow-up.

Safety and efficacy of single-position computer navigation assisted oblique lumbar interbody fusion and percutaneous pedicle screw fixation (Synergy OLIF 360) for treatment of degenerative lumbar disease

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Introduction

Traditional OLIF combined with posterior pedicle screw placement requires patients to perform the procedure in two different positions, which greatly increases the operation time and the risk of radiation exposure. In addition, due to the limitations of X-ray fluoroscopy, screw misplacement rate is also higher.

Methods

From August 2020 to October 2021, a total of 3 patients with degenerative lumbar disease were enrolled in our study. All patients underwent single-position computer navigation assisted oblique lumbar interbody fusion and percutaneous pedicle screw fixation. The total operation time, blood loss, pedicle screw placement time were recorded. Radiological examinations and Visual analogue scale (VAS), Oswestry disability index (ODI) were used to evaluate the radiological and clinical efficacy.

Results

A total of 3 patients were included in this study. The average followed-up was (9.6±1.2) months. All surgeries were successfully completed. The average total operation time was (116.2±20.5) min, the average blood loss was (84.2±20.3) ml. Average total pedicle screw placement time was (43.0±2.6) min. The VAS and ODI decreased significantly at each follow-up. Imaging showed no loosening or rupture of internal fixation at each follow-up. The intervertebral fusion rate was 100% by the latest follow-up, and the accuracy of pedicle screw placement was 100% .

Discussion

Synergy OLIF 360 for treatment of degenerative lumbar disease is feasible, safe and effective, which can optimize suigical procedures, avoid reposition and save operation time.

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Is Anterior Lumbar Interbody Fusion (ALIF) alone sufficient to treat Grade Ⅰ lumbar degenerative spondylolisthesis in L4? A comparison between stand-alone ALIF and Transforaminal Lumbar Interbody Fusion (TLIF) with a 5-year follow up

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Introduction: Lumbar fusion for spondylolisthesis, which includes ALIF (anterior lumbar interbody fusion), PLIF (posterior lumbar interbody fusion), and TLIF (transforaminal lumbar interbody fusion) are commonly used for symptomatic spondylolisthesis with failed conservative treatment. PLIF and TLIF is powerful in reduction and decompression but is blamed for postoperative axial back pain and the possible dura and nerve root injury [1-3]. ALIF limits the postoperative axial back pain by sparing the exposure of posterior structures, provides excellent exposure to discectomy and the implantation of a large, lordotic device, which restores intervertebral height, resulting excellent realignment of the lumbar spine. In the past, stand-alone ALIF was not stable without pedicle screws, and often used as a complementary fusion after posterior reduction and decompression in spondylolisthesis [4-7]. However, combined anterior-posterior surgery was highly traumatic and costly. Besides, there were few comparisons between stand-alone ALIF and TLIF in spondylolisthesis. In this study, we retrospectively compared cases of single-level grade spondylolisthesis that were treated with stand-alone ALIF with self-anchored cages and TLIF, in which clinical and radiologic outcomes are presented.

Methods: Sixty-eight patients with L4 lumbar degenerative spondylolisthesis I° underwent surgery between January 2014 and January 2016 were included. Among them, 32 patients were treated with ALIF and 36 were treated with TLIF. All patients received follow-up for at least 5 years. Data of patient demographics, intraoperative parameters, perioperative complications were collected. Clinical outcomes included visual analog scale (VAS) of leg and back pain, Oswestry disability index (ODI) and radiological outcomes included fusion, lumbar lordosis (LL), disc height (DH) and lordotic angle of the surgical segments (SLA), and slip percentage (Slip%) were also evaluated.

Results: All cases achieved fusion at the final follow-up. No major vascular injury and other approach-related complications were found. The Average blood loss and operation time in ALIF group were significantly lower than TLIF group ($P<0.05$). Significant improvements were observed with respect to the VAS and ODI scores postoperatively. There was no significant difference on postoperative VAS and ODI score at each time points between the two groups. Radiologically, significant improvements in DH, LL, SLA and Slip% were found postoperatively. There was no significant difference in postoperative Slip% at each time points between the two groups. The postoperative DH, LL, and SLA at each time point were significantly higher in ALIF group than the ones in TLIF group($p<0.05$). Five cases (15.6%) in ALIF group subsided postoperatively. There was no major complication of neurological deficit, visceral organ injury, fixation or implant failure in both groups. There was one case of external iliac vein tear and one intraoperative peritoneal injury in ALIF group which were both repaired without postoperative symptoms. There was one dura tear in TLIF group, who was successful treated with prolong drainage until the incision of the skin was healed at the 12th day after surgery.

Discussion: ALIF alone achieved excellent clinical and radiological results in Grade Ⅰ lumbar degenerative spondylolisthesis in L4 with 5 year follow up, making it an alternative treatment option in selected patients.

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Clinical outcome of minimally invasive lumbar posterior decompression for lumbar spinal stenosis with prevalent vertebral fracture -Propensity score-matched analysis with the cases without prevalent vertebral fracture

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Introduction

It is often difficult to select the surgical method for cases of lumbar spinal stenosis (LSS) with complex pathologies. For the cases of LSS with old vertebral fracture, fusion surgery may be generally preferred, but we have selected minimally invasive decompression surgery for those cases without instability or the symptom due to foraminal stenosis in our institution. However, there has not been few reports about the influence of prevalent vertebral fracture on the clinical outcome of decompression surgery for LSS. The purpose of this study was to investigate the feature of LSS with old vertebral fracture and the clinical results of minimally invasive posterior decompression.

Methods

In this study, we retrospectively reviewed prospectively collected data of 773 cases who underwent minimally invasive posterior decompression for LSS and followed up for more than 2 years. We extracted the cases with old prevalent fracture in the decompression level. The cases with fresh fracture were excluded in this study. To evaluate the feature of the pathology, we investigated the presence of anterior/posterior spondylolisthesis, lateral- slip, and coronal wedging on preoperative X-ray. For the clinical outcome, we investigated additional surgery/reoperation, and preoperative and postoperative (2years) visual analogue scale (VAS) for low back pain, leg pain and leg numbness, and JOA score for low back pain. We also extracted the twice number of control cases without fracture by using propensity score-matching based on age, sex, the number of decompression level, and the operative method (under microscope or micro-endoscope) and compared the items between the two groups.

Results

Twenty-six out of 773 cases (3.4%) had one or more prevalent vertebral fracture in the decompression level. L4 fracture was the most common, and multiple fractures were found in 7cases. In the intervertebral level with prevalent fracture, anterior/posterior spondylolisthesis was found in 54%, lateral slip in 27%, and coronal wedging in 42%, but there was not significant difference in the prevalence compared with the control group (anterior/posterior spondylolisthesis 38%, lateral slip in 23%, and coronal wedging in 42%). Pre-operative VAS for low back pain, leg pain and leg numbness and JOA score were significantly improved at 2years after surgery in both groups, and there was not significant difference in the degree of improvement. The rate of additional surgery in 2yrs was 15% in the group with old fracture and 10% in the control group. There was not significant difference in the rate, but all the additional surgery were fusion surgery in the group with old fracture whereas 20% in the control group.

Discussion

The clinical outcome of minimally invasive posterior decompression for lumbar spinal stenosis with prevalent vertebral fracture was similar with that for lumbar spinal stenosis without fracture. Minimally invasive decompression surgery offers favorable outcome also for LSS with prevalent vertebral fracture without instability or foraminal stenosis, and not all the LSS cases with prevalent fracture require fusion surgery.

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Quantitative assessment of bone marrow edema in lumbar spondylolysis using contrast ratio on magnetic resonance imaging in adolescent athletes

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Introduction:

Spondylolysis, a stress fracture of the pars interarticularis, is a common occurrence in adolescent athletes with low back pain. It has been reported that T2-weighed fat-saturated magnetic resonance imaging (MRI) is useful for the detection of bone marrow edema (BME) in the pedicle in the early stage of spondylolysis, however quantitative assessment of BME in spondylolysis has not been reported. The purpose of this study was to quantitatively evaluate BME in the pedicle on MRI for adolescent athlete patients with spondylolysis.

Methods:

Adolescent athletes with spondylolysis, including the symptom of low back pain, were enrolled in this study. The sporting activity of patients was restricted, and a hard brace was attached to the spine. BME were defined as the area of increased signal intensity (SI) around the pars interarticularis on T2-weighed fat-saturated MRI. The BME range of interest was taken on T2-weighed fat-saturated MRI, and the SI of the BME (SI_{edema}) was measured. The contrast ratio (CR) between the SI of the BME and SI of the spinal cord (SI_{cord}) was calculated ($CR_{edema}=(SI_{edema}-SI_{cord})/(SI_{edema}+SI_{cord})$). The CR of the normal pedicle was measured as a control ($CR_{control}=(SI_{control}-SI_{cord})/(SI_{control}+SI_{cord})$).

Results:

There were 32 men and 1 woman, and the mean age was 15.2 years (range: 12 to 18 years). The athletic events comprised 18 football, 10 baseball, 2 basketball and tennis, and 1 volleyball. The level of sporting activity was school or club team. The spinal level of spondylolysis was L2 in 2 patients, L3 in 3 patients, L4 in 7 patients, and L5 in 21 patients. The laterality of spondylolysis was right in 10 patients, left in 7 patients and both in 16 patients. Staging based on computed tomography (CT) showed early stage in 21 patients, progressive stage in 12 patients, and no terminal stage. The mean duration from onset of low back pain to the first MRI was 2.2 weeks (range: 1 to 8 weeks). After the treatment with spinal hard brace and restriction of sporting activity, 25 patients (75.8%) showed bone union on CT at 3 months. The mean CR of the edema and normal pedicle at the first visit was 0.506 (range: 0.097 to 0.804) and 0.137 (range: -0.741 to 0.572), respectively. The CR of the edema was significantly higher than that of the normal pedicle ($P<0.01$). On MRI one month after the first visit, the CR of the edema decreased to 0.204 (range: -0.152 to 0.517). The CR of the edema one month later was significantly lower than that at the first visit ($P<0.01$).

Discussion:

Quantitative assessment of BME using CR on MRI is useful for evaluating the healing process of spondylolysis.