ALTERATION OF BRAIN NEURAL NETWORK IN CERVICAL SPONDYLOTIC MYELOPATHY USING RESTING-STATE FUNCTIONAL CONNECTIVITY MRI

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BACKGROUND: The diagnosis of spinal diseases, such as cervical spondylotic myelopathy (CSM), relies on neurological examinations and anatomical images of spinal local lesions (e.g., by X-ray, CT scanning or MRI). However, often the severity of the injury shown on anatomical images does not properly explain the clinical symptoms, and this type of mismatch may cause a later misdiagnosis or unsuccessful surgery. The image-symptom mismatch is in part ascribed to compensatory changes seen in neural functions, and this has recently been shown through neuroimaging techniques in patients with spinal cord injury or scoliosis. Thus, it is necessary to assess neural functions for CSM. Functional MRI (fMRI) is an effective tool for visualizing and measuring neural signals noninvasively. In particular, resting-state functional connectivity MRI (rsfc-MRI) not only allows for the detection of spontaneous neural activities but also can be used to reveal changes in “brain networks” at rest and to ascertain changes in neural plasticity in patients with neurodegenerative diseases. Here, we sought to reveal how brain neural networks are altered in CSM and investigate the therapeutic effect of surgery on early brain function during recovery using rsfc-MRI.

METHODS: Six patients who underwent decompression surgery were enrolled in this study (mean age at surgery, 74.7 years). fMRI data were acquired on a 3-T MRI scanner before and at 1 month after surgery. To reveal the specific neural networks that were affected by CSM, the data were preprocessed and computed using CONN software (NITRC, funded by NIH). We then investigated changes to the cerebral networks after surgery. The Japanese Orthopaedic Association (JOA) score was used to confirm the surgical outcome, and recovery rate was calculated according to Hirabayashi’s method.

RESULTS: Expansive open-door laminoplasty was performed for all patients, and the mean recovery rate was 43.4% (JOA score). After surgery, stronger functional connectivity was observed in the medial prefrontal cortex and the posterior cingulate cortex (PCC), which constituted the “Default Mode Network (DMN)”; i.e., a network supporting “a default mode” of brain function to organize and synchronize neural activities in preparation for cognitive and motor tasks. Notably, stronger functional connectivity was observed in the PCC and the nucleus accumbens (NAc), which regulates “motivation-driven efforts”.

CONCLUSION: Using rsfc-MRI, we show that there are changes to the cortical neural network in patients with CSM. Notably, decompression surgery for CSM improves and reinforces the neural connectivity of the DMN. Furthermore, our results demonstrate that the NAc may upregulate the DMN during early recovery after surgery in patients with CSM. These findings can provide clinical information to monitor the progress of neurorehabilitation, and provide prognostic parameters for CSM and other spinal diseases after surgery.
Disclosures:
Author 1: none; Author 2: none; Author 3: none; Author 4: none; Author 5: none
REOPERATION RATE REDUCTION BY USE OF AN ANULAR CLOSURE DEVICE: 90-DAY RESULTS FROM A RANDOMIZED CONTROLLED CLINICAL TRIAL IN HIGH-RISK DISC HERNIATION PATIENTS

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Introduction:
Early reoperation is a major concern following lumbar discectomy causing patient dissatisfaction and consumes significant health care resources. The subgroup of patients with large anular defects (>6mm) have reported reoperation rates of 25%, so that anular closure has been aimed for to minimize reherniation. The purpose of this study was to compare survivorship of the index operation out to 90 postoperative days in a high-risk population receiving either limited discectomy or limited discectomy and an anular closure device (ACD).

Methods:
A two-arm, multi-center, 1:1 randomized design was used. Eligible subjects were 21-75 years of age, had a single-level lumbar disc herniation and had failed at least six weeks of conservative treatment. In addition, only subjects at high risk of reoperation, defined as intraoperatively measured defect height 4-6mm and anular defect width 6-10mm, were eligible. Control group subjects underwent standard closure following limited discectomy, while ACD group subjects received the bone-anchored ACD after limited discectomy. Survivorship at 90 days via Kaplan-Meier (KM) was calculated for each group and between-group comparisons were made using log-rank analysis. Statistical significance was set at p<0.05.

Results:
The control group (n=278) and the ACD group (n=272) had a combined follow-up rate >90% for the time period reported herein. KM survivorship at 90 days was 94.9% (95% CI=91.6% - 97.0) for controls and 98.1% (95%CI=95.6%-99.2%) for ACD (p=0.04). Reoperations due to reherniation were 5 times higher in controls (n=15) than in the ACD group (n=3).

Conclusion:
Successful early outcome is crucial for patient satisfaction and is jeopardized by a reoperation rate >5% in the high-risk discectomy population. Additionally, the 90-day global period has become an important benchmark for measuring cost effectiveness of surgical care. Implantation of an ACD following limited discectomy provides statistically and clinically meaningful disc durability when compared to limited discectomy alone and thus drives clinical and financial success of surgical care.

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DOES SCREW MATERIAL AND AUGMENTATION AFFECT PEDICLE SCREW LOOSENING?

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Background: There is an ongoing debate on how to improve pedicle screw anchorage and prevent screw loosening. Novel pedicle screws manufactured of carbonfiber-reinforced PEEK (CF/PEEK) may be desirable, as a reduction of micromotion at the screw-bone-interface due to their different material properties is considered to be a viable strategy.

Purpose of the study: (1) To test the hypothesis that non-metallic CF/PEEK pedicle screws loosen later (i.e. endure a higher number of load cycles until screw loosening) than standard titanium screws, and (2) to evaluate whether PMMA-cement augmentation further improves screw anchorage of CF/PEEK pedicle screws.

Materials and Methods: In the first part of the study, left and right pedicles of ten isolated lumbar vertebral bodies (L1-L5; BMD: 70.8mg/cm3±14.5; age: 67.8±6.8ys) were randomly instrumented with either CF/PEEK or standard titanium pedicle screws of identical size and design (icotec AG, Switzerland). In the second part, left and right pedicles of ten vertebrae (TH12-L5; BMD: 56.3mg/cm3±15.8; age: 79.2±13.0ys) were randomly instrumented with either PMMA-augmented or nonaugmented CF/PEEK pedicle screws. Each pedicle screw was subjected to cyclic loading in cranio-caudal direction (initial +50N to -50N) with an increasing load magnitude (-5N every 100 cycles). Screw motion within the vertebra was measured with a 3D motion analysis system every 100 cycles and after every 500 cycles x-rays were taken at the minimal and maximal load. Screws were considered loose if the overall screw tilt exceeded eight degrees or screw motion increased more than one degree within 100 load cycles.

Results: The non-metallic CF/PEEK pedicle screws did not resist significantly more load cycles until loosening than the contralateral standard titanium screws (3701±1227 (corresponding to 235N) vs. 3751±1614 load cycles (corresponding to 237.5N), P=0.89). Moreover, angular screw motion measured on x-rays at 100N, last cycle before failure and after failure did not significantly differ between the two screw materials.

PMMA-cement augmentation of CF/PEEK pedicle screws, however, significantly increased the number of load cycles until loosening (5100±1933 (corresponding to 305N) in augmented vs. 3130±2132 load cycles (corresponding to 206.5N) in nonaugmented CF/PEEK screws, P=0.015). Angular screw motion did not significantly differ at 100N and 150N, but was significantly smaller in augmented than in nonaugmented CF/PEEK screws before (2.2°±1.0 vs. 3.9°±0.8; P=0.009) as well as after failure (10.6°±3.4 vs. 17.1°±2.9; P=0.005).

Conclusion: Using a novel non-metallic CF/PEEK screw shank material instead of standard titanium did not significantly reduce pedicle screw loosening in the chosen test setup, whereas cement augmentation enhanced screw anchorage of CF/PEEK screws. While comparable to titanium screws, CF/PEEK pedicle screws offer the advantage of not interfering with postoperative imaging and radiotherapy.

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Development and validation of a stratification scheme for surgical care of spinal disorders as a guide for improved resource utilisation in underserved areas of the world: A Delphi study
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Summary: A Delphi consensus study was performed to stratify the health care facilities for surgical care of spinal disorders in order to provide an optimal guideline for resource utilisation in underserved areas of the world. Diagnostic and therapeutic procedures that can be safely and effectively performed at each level were identified.

Background: The increasing burden, in terms of disability and healthcare costs of spinal disorders is a major global issue. In developed countries, resources are allocated geographically depending on population density and need, however underserved areas often lack necessary resources. As the primary health care personnel in these regions are often untrained to treat spinal disorders, an effective care/referral system that would optimise resource utilisation would benefit both patients and healthcare systems.

Aim: To introduce and validate a 5 level stratification scheme of surgical spinal care to serve as a framework for referrals and distribution of patients with spinal disorders through a Delphi process

Methods: A computerised database search was run from 1960 to 2015 to identify experts to be included in the Delphi panel. In addition, the expert panel was further populated by inviting spine surgeons known to be opinion leaders globally. Following the delineation of 5 hierarchical levels of care (from a rural clinic setting to a specialised center, Fig 1), a 4 step Delphi process (question validation, collection of factors, evaluation of factors, re-evaluation of factors) was performed.

Results: A total of 78 experts were invited. Nineteen participated in round I, 14 in II and 12 in III and IV. Points of consensus were fairly heterogeneous especially in regard to levels 2 to 4 (institutions with moderate resources). Only simple assessment methods (clinical history, physical exam) based on the clinical skills of the medical personnel are considered to be feasible and safe in low resource settings. There is 100% consensus that no invasive procedures may be deemed feasible and safe in this setting. On the other extreme, everything (for diagnosis, staging and treating spinal disorders) appears to be feasible and safe in a specialised spine center. Accurate diagnostic work-up is deemed feasible and safe in lower levels of complexity (from level 3 upwards) compared to non-invasive procedures (level 4) and the full range of invasive procedures (level 5).

Conclusions: This study introduces and has validated a 5 level surgical care stratification for spinal disorders. Diagnostic and therapeutic procedures that can be safely and effectively performed at each level were identified through a Delphi consensus process. This stratification is expected to provide invaluable guidance to health care providers especially in underserved areas of the world.

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Fig 1: Five levels of surgical care for spinal disorders as developed and validated through the Delphi process in this study.

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Example Location</th>
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<tbody>
<tr>
<td><strong>Level 1</strong></td>
<td>You are in a clinic located in a village in an underserved area of the World</td>
<td>Central Botswana, 22 km from a District Hospital Area</td>
</tr>
<tr>
<td><strong>Level 2</strong></td>
<td>You are in a Level 1 District Hospital in an underserved area of the World</td>
<td>Central Botswana, 200km from capital city-Gaborone.</td>
</tr>
<tr>
<td><strong>Level 3</strong></td>
<td>You are in a Level 2 Referral Hospital in a reasonably served area in the World</td>
<td>Gaborone, Capital City Tertiary institution Largest public hospital in the country.</td>
</tr>
<tr>
<td><strong>Level 4</strong></td>
<td>You are in a Level 3 Private/University Referral Hospital in a reasonably served area of the World</td>
<td>Location: 200-bed private hospital in Ankara, Turkey</td>
</tr>
<tr>
<td><strong>Level 5</strong></td>
<td>You are in a Spine Centre of Excellence / Reference in any country</td>
<td></td>
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A NOVEL SURGICAL LATERAL APPROACH AVOIDING PSOAS DIVARICATION AND IN PRONE POSITION: TECHNIQUE AND SURGICAL COMPLICATIONS

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Introduction and purpose of the study: The retroperitoneal lateral approach is largely used for the anterior stabilization of the spine; however, it is associated to several postoperative complications. Here, we describe TALPA (Transpsoas Atraumatic, Lateral, Prone Approach), a new minimally invasive retroperitoneal technique that, through a lateral access and an appropriate instrumentation, allows to insert large interbody cages into the spine, with the patient in prone position and avoiding psoas divarication.

Material and Methods: We retrospectively reviewed medical records of 109 patients underwent TALPA, with preoperative diagnosis of degenerative disc disease, spondylolisthesis, instability, sagittal imbalance, post laminectomy, low back pain post discectomy, degenerative scoliosis, pseudarthrosis. An apposite medical report for lumbar plexopathies and nerve injury evaluation was employed. Patients were divided into different subsets in according to (i) the level treated and (ii) the level in which the cage was implanted. The surgical technique contemplated patient on surgical table in prone position and with pendoulus abdomen. The usual access to retroperitoneal space was performed. We used a last generation equipment (totally atraumatic probe and instruments), supported by neuromonitoring, to implant a large cannulated titanium cage inside the disc, avoiding psoas divarication.

Results: The 109 patients underwent TALPA were followed for a mean of 18 ± 7.5 months (range, 4-33 months). During the surgery always we carried out a posterior instrumented arthrodesis; 2 cases were treated with stand-alone anterior surgery. We observed only 1 bowel perforation (ileal loop), as major complication, during the initial experience with TALPA, promptly recognized and treated without sequele for the patient. We hadn’t any motor nerve lesions (femoral and obturator nerves) nor vascular complications. Among minor complications, we noticed 7 cases of lumbar sensitive nerves plexopathies: 1 case for ileoypogastic nerve, 5 cases for anterior and medial sensitive branche of femoral nerve and 1 case for ileoinguinal nerve. We also observed 2 cases of hip flexor weakness. All these symptoms disappeared after 4 months from the surgery.

Conclusion
TALPA is the first lateral retroperitoneal approach with patient in prone position, avoiding the use of blade retractors inside the psoas. This technique is reliable and reproducible; we observed mainly minor complications, without permanent motor nerve lesions, with only few cases of transient and reversible sensitive nerve lesions. Although these preliminary findings are very encouraging, especially for the few complications, further investigations with randomized, perspective and double blind clinical studies, are needed to confirm these initial results.

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INCIDENCE OF LUMBAR PLEXOPATHY UTILIZING MECHANOMYOGRAPHY FOR TRANSPSOAS LATERAL INTERBODY FUSION

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Summary
Studies have questioned the reliability of EMG to detect nerve injury. MMG may be a useful addition to traditional intraoperative monitoring (IOM) techniques for transpsoas lateral interbody fusion (LIF). Using MMG, our data demonstrates an overall rate of 21.2% (18/85) of ipsilateral thigh symptoms. Most patients with thigh symptoms (16/18) had multi-level procedures performed for degenerative scoliosis, all of which included L45. MMG is a safe alternative to EMG to monitor the lumbar plexus when performing transpsoas lateral interbody fusion.

Introduction:
Reported incidences of thigh complications during transpsoas lateral interbody fusion (LIF) range from 0.7% to 75%. The reliability of electromyography (EMG) has been questioned due to false-positives and false-negatives, and also secondary to interference from common operating-room equipment. Mechanomyography (MMG) may provide an alternative to EMG. In this study, we evaluated the incidence of thigh complications of transpsoas LIF using MMG.

Methods:
A retrospective review of prospectively collected data was completed at four institutions. Eighty-five consecutive patients (175 levels fused) who underwent transpsoas LIF surgery (L1-L5) during a one-year period were included. Immediate postoperative and routine follow-up clinical exams were obtained.

Results:
The rate of all ipsilateral thigh symptoms (pain, numbness, and weakness) was 21.2% (18/85). Eight patients (9.4%) had iliopsoas or quadriceps weakness (3/5 motor strength). Ten patients (11.8%) had anterior thigh pain and/or numbness. Most patients with postoperative thigh symptoms (16/18) had 3 or 4 level procedures performed for degenerative scoliosis and included L45. All thigh symptoms resolved within 3 months.

Discussion and Conclusion:
MMG is the mechanical signal seen from the surface of a muscle when it contracts after stimulation. MMG is an effective alternative to EMG for nerve mapping during lateral transpsoas surgery and overcomes deficiencies related to electrical interference and high rates of false-positives and false-negatives inherent to EMG. With the use of MMG, the rate of ipsilateral thigh symptoms was 21.2%, which is consistent with currently reported rates for transpsoas procedures utilizing EMG. Most thigh symptoms occurred in multi-level procedures; direct trauma to the psoas may have contributed to our results. All symptomatic patients had L45 included in their construct. MMG is a safe alternative to EMG to monitor the lumbar plexus when performing transpsoas LIF.

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RADIOGRAPHIC COMPARISON OF PATIENT-SPECIFIC (PS) AND MANUALLY CONTOURED CONVENTIONAL (C) RODS IN ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) SURGERY

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Summary
We retrospectively studied 41 consecutive AIS patients of an experienced surgeon with either PS rods (digitally-planned prefabricated) or C rods (manually contoured during surgery). Change of rod contour was comparable in both groups at 1-year follow-up but spinal thoracolumbar (TL) junction angle was significantly hyperlordotic in C group. This finding can have potential implications in terms of risk of future junctional disorder.

Hypothesis
PS rods are associated with more physiologic sagittal alignment and less rod contour change when compared to C rods.

Design
Retrospective single-surgeon study of consecutive patients before and after use of PS rods

Introduction
In AIS surgery, it is unclear if prefabricated PS rods (based on digital planning using preoperative x-rays) are associated with an alignment advantage compared to manually contoured C rods.

Methods
Operative AIS cases with either PS rods (n=21) or manually contoured C rods (n=20) and 1-year follow-up were included. Calibrated digital pre and postoperative x-rays were assessed for spinal alignment and rod contour change (Δ: 1-year-immediate postoperative x-rays for maximal rod deflection distance [MRDD] and angle of tangents to rod endpoints [AT]) using t-tests.

Results
There was no significant difference between PS and C groups in terms of age (mean: 15 vs 14.8 years), female gender (76 vs 85%), body mass index (21.7 vs 21.4 kg/m2), Cobb angle (57.1 vs 54.8°), pelvic incidence (49.5 vs 50.0°), sagittal parameters, surgery duration (201 vs 206 minutes), number of fused levels (10.2 vs 9.4), rod material (Titanium alloy rods: 81 vs 65%), rod diameter (6.0 vs 5.8 mm) and surgical complications (1 wound dehiscence vs none), respectively (all p values > 0.05). Postoperative x-rays showed no statistically significant difference in Cobb angles (13.7 vs 13.6°), thoracic kyphosis (27.1 vs 24.4°), lumbar lordosis (55.8 vs 57.6°) and rod contour change (ΔMRDD: 1.1 vs 1.4 mm; ΔAT: 1.8 vs 3.1°), respectively (all p values > 0.05). In patients with thoraco-lumbar (TL) fusion (n=13 in each group), postoperative TL angle (T10-L2) was significantly lordotic in C group (-7.3°) compared to PS group (-0.3°, p<0.001).

Conclusion
In this study PS and C rods were generally associated with comparable sagittal spinal alignment and rod contour change 1 year after AIS surgery. The only exception was spinal TL junction, which was hyperlordotic in C group due to suboptimal positioning of thoracic and lumbar curves during manual rod contouring. This finding can be considerable in terms of its potential contribution to...
long-term risk of junctional disorders in AIS patients.

Disclosures:
Author 1: none; Author 2: none; Author 3: none; Author 4: consultant: medicrea, stock/shareholder: nocimed
NON-FUSION GROWTH MODULATION WITH ANTERIOR VERTEBRAL BODY TETHERING FOR ADOLESCENT IDIOPATHIC SCOLIOSIS: A PROMISING MINIMAL INVASIVE ALTERNATIVE TO TRADITIONAL TREATMENT.

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Background
Anterior vertebral body tethering (VBT) is a thoracoscopic minimal-invasive approach where screws are inserted on the convexity of vertebral bodies and tightened using a polyethylene tether. As such, VBT modulates spinal growth according to Heuter-Volkmann principle thus providing additional spontaneous curve correction during follow-up in patients with remaining growth potential.

Purpose
The aim of this study was to report the single surgeon experience of the first 12 cases that had undergone VBT.

Methods
This study was a descriptive analysis on prospectively collected data. VBT indications were; <60° progressive major thoracic curves and Risser ≤3. Coronal and sagittal measurements were done in pre-operative and post-operative first-erect, 6-weeks, 3, 6, 9, 12, 18, 24 and 36-months follow-up radiographs. Surgical correction percentage, additional follow-up correction percentage and final follow-up correction percentage were calculated. HRQoL was analyzed using SRS-22 questionnaire.

Results
12 female patients with minimum 6-months follow-up were included. 9 patients had progression despite bracing while 2 were incompliant and one was not convenient due to severe hypokyphosis. Mean follow-up was 14.9 months (7-36). Mean age was 12.2 years (11-13). Mean pre-operative thoracic and lumbar Cobb angles were 46° (35°-59°) and 27.6° (8°-35°) respectively. Post-operative first-erect x-rays showed 52% main thoracic curve correction with a mean Cobb of 22° (12°-26°) (p<0.05). An average of 3.9° (-6° - 14°) additional correction was obtained during follow-up resulting in an average of 61% correction. Compensatory lumbar curves showed a similar pattern averaging 43% surgical and %7 follow-up correction adding up to an average of 50% correction (mean 14°, range 2°-27°). Mean pre-op kyphosis was 34.8° (15°-59°). The mean early post-operative thoracic kyphosis showed slight decrease after surgery (mean 27.1°, range 10°-57°), but reached back to initial values during follow-up (mean 30.1°, range 19°-49°). Average length of hospital stay was 3.5 days (3-5). Average return to school was 11 days (7-15). No neurologic, infectious, or hardware-related complications were recorded. Two patients experienced atelectasis that resolved with pulmonary physical therapy. Mean SRS subtotal score was 3.7 (3-4.2) preoperatively and 4.3 (3.6-4.8) at final follow-up.

Conclusion
VBT is a growth- and motion-sparing minimal-invasive technique that modulates spinal growth with a significant correction in both major and compensatory curves. Remaining growth potential of the child urges more growth on the concavity thereby lessening the deformity. Therefore, the initial correction is tailed by additional correction attained during follow-up. VBT is a promising alternative to instrumented fusion for immature adolescent idiopathic scoliosis.

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