CAN WE PROVOKE DISC HERNIATIONS IN THE CERVICAL SPINE IN AN IN VITRO EXPERIMENT?
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Introduction
Although disc herniations in the lumbar spine have been widely investigated, only little is known about cervical disc herniations. Previous studies refer mostly to clinical aspects such as pain or treatment. But, there is also a need to investigate the mechanical cause of cervical disc herniations and to develop recommendations to minimize the risk.

Purpose of this Study
The purpose of this in vitro study was to provoke cervical disc herniations under complex mechanical loading in order to understand the failure mechanisms and identify risk factors during daily-life activities.

Materials and Methods
In this study, 6 cervical motion segments (C4-5, C6-7) from 4 human donors (age: 19-48 years) with degeneration grades of 2-4 (Miyazaki [1]) were included. A new test method was developed to simulate neck motions during typical daily-life activities with complex motion and loading conditions such as extensive use of smartphones, overhead working, head rotations or driving heavy cars. In a dynamic disc loading machine, cervical motion data [2] and axial loadings [3] were replicated to simulate these activities. We tried to simulate long-time effects by exaggerating and combining those activities. The specimens were loaded with this dynamic loading protocol (n = 3000 cycles) in the intact state, after injuring (1 mm cut) the posterior longitudinal ligament (PLL) and after cutting it completely. A flexibility test was performed before and after each testing step using a quasistatic spine tester. A Friedman-Test with Bonferroni Post-Hoc correction was used for statistical analysis (p ≤ 0.05).

Results
With the dynamic loading protocol, no herniation could be provoked in intact specimens. Only
after the PLL was injured (1 mm cut), a clear prolapse with nucleus extrusion through the defect occurred in one specimen after simulating physiologic activities. In the same defect state, a protrusion could be observed in another specimen using the exaggerated load protocol (Fig. 1). Both specimens were from young, minor degenerated donors. The extrusion led to a slight increase in range of motion by about ±1° in each motion direction.

Conclusion
With this new test method, it was possible to replicate physiological motions of the cervical spine and simulate long-time effects on the cervical disc. In general, an intact cervical disc does not seem to herniate due to daily-life activities, even under long-term complex motions. The PLL appears to have a main protective effect on the cervical disc, because a herniation only happened after a small defect was made. Furthermore, the risk of a cervical herniation might be highest in young patients.


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NO PAIN BUT SOMETHING TO GAIN. CLINICAL RESULTS OF MICROSURGICAL EXCISION OF THE C2 NERVE ROOT GANGLIONS DURING INSTRUMENTED FUSION BETWEEN C1/C2 VERTEBRAE

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Introduction: Instrumented treatment of pathologies across cranio-cervical junction can be technically challenging. Currently, two established surgical techniques, Magerl and Harms,
are used for instrumentation of C1 and C2 vertebrae with preserving the C2 nerve roots. On the contrary, Goel described bilateral microsurgical resection of C2 nerve roots during instrumentation of C1 and C2 vertebrae. It allows visualization the C1 lateral masses and provides access to C1/C2 joints for the arthrodesis. We present our clinical results after C2 nerve root excision during instrumented fusion in C1/C2 cervical segments in comparison to control group operated with instrumented fusion with C2 nerve root preservation.

Purpose: To investigate clinical outcome, postoperative pain control and incidence of C2 radiculopathy after posterior instrumented fusion in the cranio-cervical junction with C2 nerve root ganglion excision in comparison to instrumented fusion with C2 nerve root ganglion preservation.

Material and Methods: This retrospective, cohort study enrolled 60 patients (35 males and 25 females), mean age 69.9 years (range 26-90). Patients underwent posterior, instrumented fusion across C1/C2 segments with or without C2 nerve root ganglion excision. Investigated cohort, with excision of bilateral C2 nerve root ganglion (NG), enrolled 26 patients was compared to a control group with preserved C2 nerve roots (PG) that enrolled 34 patients. Pre-, peri- and postoperative data as well as postoperative pain and incidence of postoperative C2 radiculopathy were collected from digital medical and operative records.

Results: There was no incidence of C2 radiculopathy in NG (p=0.264). Incidence of C2 radiculopathy at follow-up in PG was 11.8%. There was no significant difference in postoperative pain control between the groups at follow-up (p=1.000). Patients in NG presented with lesser perioperative bleeding (mean 213 versus 295 millilitres; p=0.014) despite the longer operation time (mean 219 versus 180 minutes; p=0.032). Grafting from iliac crest was performed in fewer patients in NG (p=0.008) and they also required less frequent postoperative use of hard collar (p=0.028). Furthermore, patients in NG were mobilized faster with shorter hospitalization time and lower rate of severe complications in comparison to PG. Unfortunately, these parameters were not statistically significant.

Conclusions: Our results indicate that excision of C2 nerve root ganglions during posterior instrumented fusion in the cranio-cervical junction does not cause C2 radiculopathy. Moreover, this technique contributes to a better pain control, faster mobilisation, shorter hospitalization and lesser usage of hard collar after the surgery. Our results should be validated by larger, prospective, randomized trial.
Introduction: Degenerative cervical radiculopathy (DCR) is commonly associated with severe neck pain (NP), in addition to arm pain and moderate levels of disability. Many studies have demonstrated improved arm pain following surgery; however, axial neck pain is generally not felt to improve. The purpose of this study was to determine whether surgery for DCR improves NP.

Materials and Methods: We conducted an ambispective cohort study utilized data from the Canadian Spine Outcomes and Research Network (CSORN) registry for patients who received surgery for DCR. Subgroups were comprised of patients that underwent 1-level, 2-level, 3-level ADCF (anterior cervical discectomy and fusion) or cervical disc arthroplasty (CDA). The primary outcome was 12-month postoperative reduction in Visual Analogue Scale for Neck Pain (VAS-NP). Secondary outcomes included Neck Disability Index (NDI), Visual Analogue Scale for Arm Pain (VAS-AP), Short-Form Physical Health Composite Scale (SF-36-PCS), and Mental Health Composite Scale (SF-36-MCS).
Results: We identified 603 patients with DCR. CDA patients were the youngest (ANOVA; p<0.001). Patients reported similar pre-operative mean AP, NP, NDI, and health-related quality of life, regardless of procedure (ANOVA; all P>0.05). All procedures offered a statistically significant mean reduction in VAS-NP, VAS-AP, and NDI (ANOVA; all P<0.001). Mean change from baseline in NP, AP, and disability, were similar across procedures. At 12 months, mean reduction in VAS-AP, VAS-NP, and NDI exceeded minimal clinically important differences for nearly all procedures.

Conclusion: Patients undergoing surgery for degenerative cervical radiculopathy can expect a clinically significant, approximate 50% improvement in neck pain, arm pain, and neck-related disability.

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12
KINEMATIC MRI ANALYSIS OF REDUCIBLE ATLANTOAXIAL DISLOCATION FOR DECOMPRESSION
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Background and Objective: Reducible atlantoaxial dislocation, as one of atlantoaxial dislocation types, has been described in many articles. Atlantoaxial reduction can be achieved by posterior atlantoaxial reduction and fixation. However, many doctors ignore the possibility of spinal cord compression (SCC) after complete atlantoaxial reduction. Several articles have reported there was still SCC caused by soft tissue mass, such as retro-odontoid pseudotumor. Retro-odontoid pseudotumor would be likely to cause SCC directly, but some pseudotumors lead to slight or no compression after atlantoaxial reduction, decompression isn’t necessary in this situation. Nevertheless, it is difficult to assess that SCC is induced by retro-odontoid pseudotumor or atlantoaxial dislocation on neutral MRI. Dynamic MRI can be performed to analyze the condition of SCC after atlantoaxial reduction. our study aims to analyze the role of dynamic MRI in determining whether to perform atlantoaxial decompression for reducible atlantoaxial dislocation.

Methods: 36 patients with atlantoaxial reduction on preoperative kinematic MRI in extension postures were enrolled retrospectively. grouping was based on the condition of SCC after atlantoaxial reduction preoperatively. Group A: patients with SCC after atlantoaxial reduction on dynamic cervical MRI were treated with C1 laminectomy for decompression and atlantoaxial fixation. Group B: patients with no significant SCC, according to dynamic MRI, underwent only atlantoaxial fixation. Clinical outcomes were evaluated using JOA score for spinal cord function. Radiological outcomes were assessed by measuring spinal cord diameter on MRI.

Results: All 36 patients were achieved atlantoaxial reduction on postoperative X-rays. At last follow-up, there was no screw loosening, all patients obtained atlantoaxial fusion except 1 patient. Postoperative JOA score in both groups was significantly better than preoperative JOA score. Compared with the group A, the group B had significantly better JOA score preoperatively, and at 1-month after surgery (P<0.01). Nevertheless, there were no significant statistically differences in JOA score at 12-month after surgery and JOA improvement rate between the groups at 12-month after surgery. All patients in two groups
had a lower percentage of SCC on extension MRI before surgery (P< 0.01), compared with that on neutral MRI. The percentage of SCC in group A significantly decreased from 63.6±14.5% preoperatively to 9.1±3.4% at 12-month after surgery (P<0.01). Similarly, the percentage in group B also decreased from 51.8±9.7% preoperatively to 5.1±3.1% at 12-month after surgery (P<0.01). No significant statistically differences in spinal decompression improvement rate were observed between two groups at 12-month after surgery.

Conclusion: Decompression should be performed in patients who still have significant SCC after atlantoaxial reduction. Kinematic MRI could be used to assess SCC and decide whether to perform decompression preoperatively.
CORRELATION BETWEEN TRAUMATIC CENTRAL CORD SYNDROME AND CERVICAL DISCOLIGAMENTOUS INJURIES: IS CONSERVATIVE OR LATE SURGICAL TREATMENT STILL JUSTIFIED?

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Background: Central cord syndrome (CCS) is the most common type of incomplete spinal cord injury. Natural history of the condition shows often good potential for spontaneous recovery with and without surgery, so treatment is heterogenous and late surgery is still performed. An indication for early surgery is an accompanying unstable discoligamentous injury (DLI). We examined all our patients with traumatic CCS for DLI with imaging and surgical inspection to reveal the prevalence of DLI in this patient cohort.

Methods: 51 consecutive patients (39 male, 12 female) from a prospective database between 2010 - 2019 with surgery for central cord syndrome of the cervical spine were retrospectively analyzed. Preoperatively age, sex, neurological deficits, diagnostic and functional imaging as well as surgical treatment were recorded for each patient. In all patients a preoperative MRI was performed to exclude/confirm a DLI including STIR sequences.

Results: Mean age at surgery was 64.1 ± 11.3 years (range 41-86 years). Low-velocity accidents were main trauma mechanism in 36 (70.6%) cases. 44 Image-based contusions were detected. 33 (62.1%) had an image-based suspected and 29 (56.9%) had an intraoperatively confirmed DLI. Three patients had AIS grade E, 18 (35.3%) grade D and 18 (35.3%) grade C or worse. Anterior cervical discectomy and fusion with ventral plating was performed in all cases, combined dorsoventral approach was done twice.

Conclusions: Instability due to DLI in patients with traumatic SCI on the basis of preexisting spinal stenosis is seen in 2/3 of patients with adequate MRI. Segmental instability can lead to neurological deterioration or incomplete recovery in these patients and needs to be treated surgically. Therefore, early surgery intervention should be considered and is mandatory if DLI is suspected by MRI.

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14
INCIDENCE OF REVISION SURGERY FOR ADJACENT SEGMENT DEGENERATION (ASD) AFTER PRIMARY CERVICAL FUSION SURGERY WITH 10 YEAR FOLLOW UP
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Introduction: Cervical spine fusion surgery was described nearly 60 years ago for the treatment of various degenerative spondylotic conditions. There are increasing concerns that the spinal fusion surgeries have contributed to significant complications like ASD. The study investigated the demographics and the survivor-ship after the primary cervical fusion surgery with regards to ASD.

Methods: The Retrospective case study looked at all the consecutive patients who underwent cervical spine fusion surgery using both anterior and posterior approaches from the year 2000 to 2010 at a single center. Only those patients undergoing surgery for spondylosis and myelopathic conditions were assessed. The patient’s data was analysed using windows R. The Kaplan-Meier survivor-ship analysis was used to calculate survivor-ship.

Results: 346 patients underwent surgery and the average age of patients was 54.14 years. 311 patients had anterior cervical spine surgery. 193 single level fusion surgery compared to 118 multilevel surgery. The overall prevalence of revision surgery for ASD was found to be 11%. The survivor-ship for ASD was found to be 84.5% [CI 95% 78.1-91.5] at 17 year follow up. The median survival time was 11.5 years. There were 95 % survival rates for three level surgery compared to 87% for a single level surgery.

Conclusions: Compared to the previous studies the survivor-ship of these fusion surgeries was much better when compared at 5 years, 10 years and 15 years follow up. This study helps in predicting the occurrence of revision surgery for ASD and is one of the largest studies till date.

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Ossification of the posterior longitudinal ligament (OPLL) is a pathologic hyperostotic condition whose pathogenesis remains poorly understood. Progression of OPLL requires surgery for treatment of myelopathy or radiculopathy. C5 palsy is one of most common complication after treatment of OPLL. Although it is known to resolve spontaneously, its duration varies that might even take several years and sometimes complete recovery is impossible. Prediction of C5 palsy would be helpful for treatment decision of OPLL. Machine learning is increasingly used in medicine. We aim to investigate whether machine learning can perform better than conventional logistic regression in predicting postoperative C5 palsy in OPLL patients. Nine hundred one OPLL patients who underwent operation on our institute from January 1998 to January 2012 were analyzed. Area under curve (AUC) of prediction model Twenty five variables of each patient including demographic, clinical radiologic and operation profiles were used to make a prediction model. Target outcome was development of postoperative C5 palsy. Preoperative prediction model was made with first 24 variables. Postoperative prediction model was developed adding presence of immediate postoperative shoulder pain as new variable. Five different preprocessed dataset were made applying one of the sampling method (original data, upsampling, downsampling, synthetic minority over sampling technique (SMOTE), random over sampling examples (ROSE)). Seven different kinds of prediction models were developed from each preprocessed dataset applying conventional logistic regression or one of the following six machine learning methods: Decision Tree (DT), Random Forest (RF), Artificial Neural Network (ANN), Reinforcement learning (Gradient Boosting Machine (GBM), Adaptive reinforcement learning (ada)), Support Vector Machine (SVM) using radial kernel. Accuracy of each model was assessed by receiver operating characteristics (ROC) curve analysis and area under curve (AUC). All statistical analyses were performed by R software (version 3.5.2). Among 901 OPLL patients, 26 patients developed postoperative C5 palsy, which counted for 2.8% of the total patients. Comparison of the C5 palsy group and the control group showed age, operation method, involvement of C1 or C2 or C3, presence of immediate postoperative shoulder pain are significantly associated with C5 palsy. Preoperative prediction model using down sampling method and Adaptive reinforcement learning showed highest AUC of 0.812 (0.683-0.941). Postoperative prediction model using down sampling method and adaptive reinforcement showed highest AUC of 0.876 (0.789-0.964). In both model, machine learning outperformed conventional logistic regression. Machine learning was superior to conventional logistic regression in terms of better AUC. Our model demonstrated immediate postoperative shoulder pain is closely associated with postoperative C5 palsy of OPLL patient.
IS THERE AN ASSOCIATION BETWEEN CERVICAL SAGITTAL ALIGNMENT PARAMETERS AND NECK DISABILITY BEFORE SURGERY?

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Background:
To identify whether cervical alignment is related to health-related quality of life (HRQOL) outcomes in patients with cervical spine conditions prior to surgical treatment.

Methods:
Patients admitted in the outpatient department of our institution between June 2016 and June 2018 were prospectively studied. In all patients, NDI (Neck Disability Index) scores were recorded at the time of admission, and the following radiographic parameters were measured: occiput-C2 angle (C0-2 lordosis), C2-C7 angle (C2-7 lordosis), cervical lordosis (CL, sum of C0-2 and C2-7 lordosis), T1 slope (TS), T1 slope minus C2-C7 angle (TS-CL, cervicothoracic mismatch), and C2-C7 SVA. Patients were grouped: a) depending on whether presenting or not indications for surgery; b) depending on disability levels, based on NDI scores [no disability; mild to moderate; and severe to complete]; and c) by gender. The independent samples t-test was used for statistical analysis among groups of patients. Pearson correlation coefficients were calculated between pairs of alignment parameters and NDI scores. The level of significance was set to 0.05.

Results:
In total, 252 patients [106 men and 146 women; mean age 54.5±12.5 (range, 27-91) years] were included in our study after strict inclusion criteria. Surgery was indicated in 86 cases (myelopathy, radiculopathy, stenosis, instability), and non-surgical treatment in 166 patients. Patients indicated for surgery presented only greater C0-2 lordosis (23.2°±9° vs 19.4°±7.9°, p=0.017), while NDI scores did not differ significantly. Based on disability levels, again no differences were found in the radiographic measurements among groups of patients. When patients were grouped by gender, men presented significantly lower NDI scores (32±17.4% vs 39.8±19.3%, p=0.023) and were significantly younger (51.3±14.1 vs 56.8±10.6, p=0.02), while a difference regarding the studied parameters was not found. Correlation analysis revealed that NDI was not associated with any of the radiographic parameters either in patients indicated for surgery, or in those indicated for conservative treatment. Nonetheless, significant relationships were found between the alignment parameters.

Conclusions:
Cervical alignment does not seem to have a significant impact on patients’ quality of life, at least before surgery. NDI scores and cervical alignment parameters do not differ significantly among patients indicated for surgical and non-operative management. However, significant relationships between alignment parameters do exist, indicating the complicate interactions and mechanisms existing in cervical sagittal alignment.

Disclosures:
INTRODUCTION: Postoperative dysphagia and dysphonia are prevalent complications after anterior cervical spine surgery. Previous dysphagia and dysphonia risk factor studies demonstrated conflicting results. One possible reason is the lack of a standardized measurement method. The Hospital for Special Surgery Dysphagia and Dysphonia Inventory (HSS-DDI) is a patient-derived survey instrument that assesses dysphagia and dysphonia after anterior cervical spine surgery. The HSS-DDI is a patient-reported survey about swallowing and speaking function with a scale ranging from 0 (worst) to 100 (normal). The purpose of this study is to identify the perioperative risk factors for postoperative dysphagia and dysphonia utilizing the HSS-DDI.

METHODS: Patients undergoing anterior cervical discectomy and fusion (ACDF) from 2015 to 2018 were prospectively enrolled in this study. The HSS-DDI was administered 4 weeks, 8 weeks, and 4-6 months after surgery. As potential risk factors, the data on demographic factors, preoperative sagittal alignment, surgical factors, and preoperative diagnoses and function (myelopathy, radiculopathy, degenerative disc disease, preoperative Neck Disability Index (NDI) score, and symptom duration) were collected. Univariate and multivariate regression analyses utilizing the Tobit model were conducted.

RESULTS: 291 patients were included in the final analysis. The median [IQR] age was 55.3 [47.00, 63.8] and 60.8% of patients were men. The median [IQR] HSS-DDI at 4-weeks was 80.7 [61.3, 93.2]. Multivariate analysis including all significant and trending variables in univariate analyses demonstrated that previous cervical spine surgery (β = -9.3 (-18.0, -0.64), p=0.035), upper level surgery defined as C3/4 and C4/5 surgery (β = -9.8 (-15.3, -4.3), p=0.001), multilevel surgery (β = -7.8 (-14.2, -1.3), p=0.018), current smoking(β = -12.2 (-23.0, -1.4), p=0.027), preoperative C2-7 angle (β = -0.3 (-0.5, 0.0), p=0.026), opioid use (β = -6.6 (-12.0, -1.2), p=0.017), and a high (over 50%) preoperative NDI score (β = -12.7 (-18.1, -7.2), p<0.001), were independent contributing factors to a low HSS-DDI score at 4-weeks follow-up. Among these factors, upper level surgery, opioid use, and high preoperative NDI score remained significant factors for a low HSS-DDI score at 4-6 months follow-up. Upper level surgery, current smoking, opioid use, and high preoperative NDI score were significant factors for both dysphagia and dysphonia, whereas multilevel surgery, C2-7 angle, and prior cervical surgery were significant for dysphagia only.

CONCLUSIONS: Our results showed that preoperative opioid use and a high preoperative NDI score are independent risk factors for postoperative dysphagia and dysphonia, as well as other well-known risk factors such as current smoking, upper level surgery, prior cervical surgery, and multilevel surgery. Our study also suggests that potential risk factors are not the same for dysphagia and dysphonia in anterior cervical fusion patients.
HYOID POSITION AS A PREDICTIVE MARKER FOR POSTOPERATIVE DYSPHAGIA AND DYSPHONIA AFTER ANTERIOR CERVICAL DISCECTOMY AND FUSION

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Introduction: Pre-vertebral soft-tissue (PVST) swelling is associated with postoperative dysphagia/dysphonia (PDD) after anterior cervical discectomy and fusion (ACDF). However; the vertebrae below C5 are often difficult to visualize in obese or short-neck patients. The hyoid, however, is visible on a lateral radiograph regardless of a patient’s body habitus. Currently, no study has investigated the association between PDD and the position of the hyoid. We hypothesized that the horizontal positional change of the hyoid is associated with the severity of PDD and conducted a comparative study between PVST and the hyoid.

Material and Methods: We utilized data of consecutive patients undergoing ACDF from 2015 to 2018 and PDD was assessed utilizing the Hospital for Special Surgery Dysphagia and Dysphonia Inventory (HSS-DDI). The HSS-DDI consists of 31 patient-reported questions about swallowing and speaking function with a scale ranging 0-100. The hyoid horizontal position (H-Hy: the distance between the posterior margin of the hyoid body and the anterior wall of the closest vertebra) and PVST [the averages of all operative levels (PVSTOP) and C2 to C7 levels (PVSTC2-7)] were assessed utilizing lateral cervical radiographs. The associations between postoperative changes of H-Hy and PVST and patients’ 4-week HSS-DDI score were evaluated. As part of a validation study for the H-Hy measurement, we randomly chose 52 patients who had preoperative cervical flexion and extension lateral images and measured H-Hy in both the flexion and extension position then calculated the interclass correlation coefficient as the measure of agreement.

Results: 209 patients had pre- and post-operative radiographs. Mean age was 54.2 and 60.3% were male. Mean (SD) changes of H-Hy, PVSTOP, and PVSTC2-7 were 1.64 (4.46), 5.82 (2.71), 5.19 (2.44) mm, respectively. The median [IQR] HSS-DDI score was 81.45 [61.3-92.7]. H-Hy and PVSTC2-7 changes demonstrated significant correlations with HSS-DDI (H-Hy: coefficient = -0.157, p= 0.023; PVSTC2-7: coefficient=-0.212, p=0.003), whereas PVSTOP showed no significant association. After adjusting with gender and operating level, the changes in H-Hy (p=0.019) and PVSTC2-7 (p=0.009) showed significant associations and PVSTOP showed no significant association. PVSTC2-7 could not be calculated in 12.0% of patients due to difficulty with measuring PVST at lower levels. For the validation study, the positional change of H-Hy with neck movement showed no systematic error and the agreement of both measurements was good (ICC 0.80, 95%, CI 0.68-0.88).

Conclusion: In this study, we introduced a novel potential predictive marker for PDD after ACDF. Our results suggest that H-Hy is reproducible and can be utilized for the risk assessment of PDD, especially in cases where PVST is unmeasurable, which accounts for...
over 10% of ACDF patients. Our study also demonstrated that PVST at the operating level was not a sensitive marker for PDD severity.

Disclosures: