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ABSTRACTS

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Mario Boni Grant nominated orals

O1

Maintaining range of motion after cervical arthroplasty does not prevent adjacent segment degeneration

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Question: Many previous research reported that adjacent segment degeneration (ASD) was prevented in patients with cervical arthroplasty by means of maintaining range of motion (ROM) and restoring disc height. However, baseline information of ASD and progression of ASD were rarely reported, and methods to assess ROM are insufficiently precise in most studies. This study aims to investigate the correlation between ASD and ROM.

Methods: Patients that underwent anterior discectomy for cervical radiculopathy due to a herniating disc were analyzed for segmental and global cervical ROM and the presence of ASD, both preoperatively, 12 and 24 months postoperatively. 253 patients were included in two randomized, double-blinded trials (RCT) comparing anterior cervical discectomy with arthroplasty (ACDA), anterior cervical discectomy with intervertebral cage (ACDF), or anterior cervical discectomy without intervertebral cage (ACD) for one level disc herniation. ROM was defined by a custom developed image analysis tool. ASD was defined by decrease in disc height and anterior osteophyte formation on X-rays. Clinical outcome was evaluated by means of the Neck Disability Index (NDI).

Results: Two-year postoperatively, the ACDA group had a higher ROM at the index level and a larger global cervical ROM than the other two groups. The incidence of ASD was comparable in the three groups though, being circa 34% at baseline, and circa 58% at 2-year follow-up. Likewise, ASD progression was comparable in the three treatment arms. No correlation was demonstrated between ROM and ASD, and neither was there a correlation between ROM and NDI or ASD and NDI.

Conclusions: ROM is better preserved in the patients that were subjected to arthroplasty, however, this did not result in less ASD, nor in better clinical outcome. Although follow-up of two-year may be too short to draw firm conclusions, data tend to indicate that the clinical relevance of persisting ROM at the target level is absent.

O2

Is upper cervical involvement in female patients with RA associated with neck pain, dysfunction and QOL?

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Question: The most important indications for surgery in the presence of cervical spine involvement in rheumatoid arthritis (RA) are resistant pain and neurological deficits. On the other hand, patients with cervical spine subluxation are often asymptomatic in clinical experience. The aim of this study is to investigate the relationship between upper cervical lesions and neck pain, cervical dysfunction and quality of life (QOL) in female patients with RA.

Methods: We enrolled 1047 female RA patients in this cross-sectional study. Upper cervical lesion (atlantoaxial subluxation [AS], and vertical subluxation [VS]) were evaluated on plain radiographs. Visual analogue score (VAS) for neck pain, Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ) for neck dysfunction and Short Form-8 (SF-8) for QOL were assessed. One-to-one propensity score matching was performed to control demographic (including age, body mass index (BMI), onset year and age of RA, and disease duration) and clinical (surgical history, Steinbrocker stage, use of corticosteroid, methotrexate (MTX), and biological agent (BIO)) imbalances. Multivariate logistic regression analysis of unadjusted and propensity score-matched cohorts were performed to examine the influence of upper cervical lesions.

Results: The propensity score-matching procedure yielded scores of 146 pairs of matched patients with upper cervical lesions and without those. The multivariate analysis of propensity score-matched population found upper cervical lesions to show no significant association with any of the outcome analyzed, including neck pain ($p=0.448$), cervical dysfunction ($p=0.336$) and QOL ($p=0.092-0.933$).

Conclusions: For female RA patients, upper cervical lesions were not associated with neck pain, cervical dysfunction and QOL.

O3

Intraoperative neuromonitoring for ossification of posterior longitudinal ligament in nationwide prospective multicenter study

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Question: Surgical treatment for cervical/thoracic ossification of posterior longitudinal ligament (OPLL) is one of the most challenging spinal procedures because of high neurological complication rate. Intraoperative spinal neuromonitoring (IOMN) may have a role in identifying and preventing neural damage for high risk spine surgery.

Methods: We prospectively analyzed the incidence of neurological deterioration and details of IOMN alert, and clarified how to prevent neural damage in case of IOMN alert in OPLL surgery from 2010 to 2016. The surgical techniques used for cervical OPLL were posterior laminoplasty/ laminectomy with fusion, or anterior cervical discectomy/corpectomy and fusion, and those used for thoracic OPLL were posterior decompression and fusion. Tc(E)-MEPs were monitored under uniform monitoring conditions at 16 hospitals.

Results: OPLL surgeries were consisted of 622 cervical OPLL and 249 thoracic OPLL. Totally, TP, FP, TN, FN and rescue cases of Tc-MEPs were 7, 33, 550, 0 and 32 in cervical OPLL and 30, 28, 170, 1 and 20 in thoracic OPLL, respectively. Alarm and neurological deficit rate were 6.3% and 1.1% in cervical OPLL, and 20.1% and 12.0% in thoracic OPLL, respectively. In cervical OPLL, 61.5% of the alerts occurred during lamina opening for laminoplasty. Among these patients, 73.3% were rescued by suspension surgery, irrigation, or additional decompression/foraminotomy. However, suspension surgery in corpectomy cases were mostly ineffective. In thoracic OPLL, 54.0% of alerts occurred during posterior decompression for OPLL. For these patients, suspension surgery and steroid injection after the alarm were also ineffective. However, posture change, bilateral rodding, or additional dekyphosis after alarm were effective.

Conclusions: This study indicates totally 58.4% rescue cases by Tc-MEPs. Although neurological deficit of OPLL was high, appropriate intervention for protecting spinal cord and blood supply immediately after IOMN alert was effective even in high risk OPLL surgery.

O4

Degenerative cervical myelopathy: Chronic trauma leads to alterations of endogenous inflammatory and angiogenetic mediator concentrations in CSF

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Question: Endogenous immune mediated reactions of inflammation and angiogenesis is a component of the secondary injury of the spinal cord in patients with degenerative cervical myelopathy. Aim of this study is to detect and identify the alteration of certain mediators in the cerebro-spinal fluid (CSF) in patients with chronic spinal cord injury (SCI) compared control group.

Methods: Patients with DCM (n=28; 14 female; mean age 62.3±10.8) and indication for surgery were included. CSF samples were taken preoperatively. A control group of patients (n=38; 13 female; mean age 65.0±15.0), with abdominal aortic aneurysm (AAA), requiring surgery was established. Patients of this group received a CSF drainage for intrathecal pressure monitoring, samples were taken preoperatively. The neurological status of patients and controls was evaluated prior surgery including NDI and mJOA. Controls with any neurological deficit or history of neurological diseases were excluded. Samples were examined via ELISA tests. Protein-concentrations of inflammatory and angiogenic factors were measured in CSF pg/ml: Angiopoietin-2, VEGF-A and C (Vascular Endothelial Growth Factor), RANTES (Regulated And Normal T cell Expressed and Secreted), Interleukin (IL) 1 beta and IL 8.

Results: Patients and controls did not differ in terms of age and gender distribution. The groups clearly distinguished in their neurological status (mJOA: DCM 10.8±3.3, AAA 17.3±1.2, p

Conclusions: Proangiogenetic mechanisms (Angiopoietin 2 and IL-8) were significantly reduced in patients with DCM. Comparable with known angiogenetic reactions in SCI, however these immune mediated reactions seem to be suppressed over a longer period of time in chronic SCI. Furthermore Angiopoietin 2 alterations are associated with the clinical severity of DCM.

O5

Minimal clinically important difference and substantial clinical benefit using PROMIS CAT in cervical spine surgery

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Question: PROMIS allows for improved psychometric properties with reduced questionnaire burden through computer adaptive testing (CAT). The purpose of this study is to establish minimal clinically important difference (MCID) and substantial clinical benefit (SCB) thresholds for PROMIS use in patients with cervical spine pathology

Methods: Adult patients undergoing cervical spine surgery at a single institution between 2016-2018 were prospectively enrolled. Patients completed questionnaires (SF-36, NDI, VAS arm/neck, and PROMIS PI, PF) preoperatively and at 6 months postoperatively. MCID was calculated using distribution-based and SCB using anchor-based methods. The Health Transition Item of the SF-36 was utilized as an anchor with the cut-off values chosen using receiver operating characteristic (ROC) curve analysis

Results: There were 139 patients meeting inclusion criteria, with a mean age of 56.4 years and diagnoses of myelopathy (n=36), radiculopathy (n=48) and myeloradiculopathy (n=49). There were significant improvements in PROMIS PF, PROMIS PI, NDI, and SF-36 MCS and PCS pre- to post-operatively (p <0.001). The test-retest reliability of all tests was excellent (ICCs = 0.87-.094). Using these values, we calculated the standard error of measurement (SEM) and MCID for all tests. PROMIS, SF-36 and NDI scores were all correlated with our anchor question ($|r| = 0.34-0.48$, p<0.001). MCIDs were 8.5 (NDI), 11.1 (SF-36 PCS), 9.7 (SF-36 MCS), 4.9 (PROMIS PI), and 4.5 (PROMIS PF). SCB was 13 (NDI), 24 (SF-36 PCS), 11.8 (SF-36 MCS), 6.85 (PROMIS PI), 6.75 (PROMIS PF). MCIDs were greater than the SEM for all measures

Conclusions: We report an MCID of 4.9 for the PROMIS PI and 4.5 for PF. SCB threshold for PI and PF was closer to 6.8. These data support the use of PROMIS in cervical spine patients and support the use of the CATs as a method to reduce questionnaire burden. Lastly, our results provide important reference as PROMIS reporting becomes more widespread in the literature

O6

Neuropathic pain after spinal cord injury relieves in CCL21 knockout (plt) mouse through decreasing of M1 type microglia/macrophage and inflammatory cytokines at the injured site and lumbar enlargement

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Question: Activated microglia are thought to contribute to neuropathic pain symptoms through their release of modulators of neuronal excitability. In this study, spinal cord injury (SCI) models by using mutant (plt) mice that have deficient CCL19/CCL21 (microglia-activating factor) expression, we assessed the post-SCI chronic neuropathic pain and the expression of microglia/macrophage (M/M) and inflammatory cytokines in the injured site and lumbar enlargement.

Methods: C57BL/6 and plt mice were subjected to SCI at T9-T10 level. EGFP+ bone marrow cells were obtained from C57BL/6-transgenic mouse. Behavioral and sensory testing were recorded at times indicated post-SCI. To evaluate the expression of M1 and M2 types M/M, immunohistochemistry (CD11b, iNOS, CD206), flow cytometry analysis and western blotting (TNF- α , IFN- γ , IL-4) were performed.

Results: SCI-induced hypersensitivities to mechanical and thermal stimulation relieved in plt mice. CD11b positive cells increased from 4 days up to more than 14 days post injury in both mice. In the results of immunohistochemistry and flow cytometry analysis, the phenotype of M/M was M1 type-dominant in both mice at the lesion site and lumbar enlargement. The decrease of M1 type M/M was seen in plt mice compared with wild type, while the number of M2 type M/M was not different in both mice. The expression of TNF- α and IFN- γ was decreased in plt mice and that of IL-4 was not different in both mice.

Conclusions: CCL21 is reported as chemokine to recruit M1 type M/M and induce allodynia by microglia activation. The suppression of inflammatory cytokines by decreasing the number of M1 type M/M in the injured site and lumbar enlargement was associated with reduction in inhibitory scar tissue/cavity formation in the subacute/chronic phase, and the provision of a permissive environment for reduction of neuropathic pain.

Mario Boni Grant nominated ePosters

O23

[Surgical navigation technology using a combination of augmented and virtual reality for minimally invasive spine surgery](#)

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Question: To evaluate whether an augmented reality surgical navigation [ARSN] system with automatic instrument tracking, yielding feedback of instrument position in relation to deep anatomy, is feasible and accurate for pedicle cannulation.

Methods: Background: Minimally invasive spine surgery [MISS] has the possibility of reducing the length of hospital stays, and reducing blood loss and infection rates compared to open surgery. However, it limits the view for the surgeon, leading to an increased use of ionizing radiation during surgery.

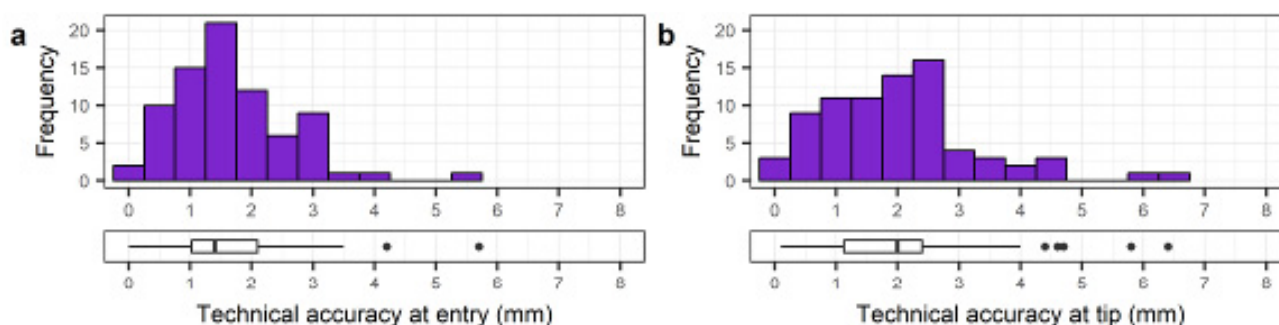
Design: Cadaveric animal laboratory study

Methods: A hybrid OR equipped with a robotic C-arm with integrated optical cameras for augmented reality instrument navigation was used. In two pig cadavers, cone beam computed tomography [CBCT] scans were performed and pedicle screw insertions were planned. In total, 78 insertions were performed. Technical accuracy was assessed on post-insertion CBCTs by measuring the distance between the navigated device and the corresponding pre-planned path. Drilling and hammering into the pedicle were also compared. An independent reviewer assessed a simulated clinical accuracy according to Gertzbein.

Results: The technical accuracy was 1.7 ± 1.0 mm at bone entry point (Figure 1). Angular deviation was $1.7 \pm 1.7^\circ$ in the axial and $1.6 \pm 1.2^\circ$ in the sagittal plane. There was no difference in accuracy between hammering and drilling. The clinical accuracy was 97.4-100% depending on the screw size considered for placement. No ionizing radiation was used during navigation.

Conclusions: Discussion: The addition of instrument tracking to ARSN improves feedback on deep anatomical structures and facilitates accurate navigation, with close to 100% accuracy, while abolishing staff radiation exposure. Further studies will be needed to confirm our initial results in human subjects.

Figure 1



O24

[Another solution in order to increase accuracy of cervical pedicle screw placement: a new aiming probe for CPS](#)

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Question: Cervical pedicle screw (CPS) malposition has high risk of neurovascular injury. In order to increase accuracy, many systems such as navigation systems using CT or O-arm and template systems have been developed, however, there are limitations in cost or preparation time. The first author developed a new aiming probe for accurate CPS placement. The purpose of this study is to estimate the accuracy of CPS placement using this probe and to compare to that of navigation system or template system.

Methods: A patent probe is designed to aim at the safety zone of the pedicle in order to avoid the spinal canal and transverse foramen. CPSs were inserted into C3, C4, C5, and C6 pedicles using this aiming probe and fluoroscopy. Screw misplacement was evaluated with postoperative CT and classified as either screw exposure (under 50% of the screw diameter outside of the pedicle) or pedicle perforation (over 50% of the screw diameter).

Results: From 2015 to 2018, 68 consecutive cervical trauma cases treated with posterior instrumentation using CPS and LMS. There are 70 male and 8 female, and the average age is 67 years old (from 17 to 90 years). A total of 79 CPSs were inserted into pedicle safely using this probe. Postoperative CT demonstrated that 3 screws (3.8%) showed "screw exposure" and 0 screws (0%) showed "pedicle perforation". There was no neurovascular complication in all cases.

Conclusions: The reported CPS malposition rate is from 3.5 to 11.1% in O-arm navigation system studies and from 2.5 to 4.5% in template system studies. That accuracy is quite high, however, O-arm is extremely expensive and template system need long time. This probe has an equivalent accuracy to navigation or template systems and advantages of low cost and without loss of time, which are favorable for emergency surgery such as trauma cases.

O25

Intramedullary tumors of the cervical spine

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Question: Intramedullary tumors are rare benign lesions in the overwhelming majority. Radiation and chemotherapy are of limited value. Early surgery is considered as treatment of choice. This study provides data on surgical morbidity and long-term results.

Methods: All spinal cord pathologies have been entered into a spinal cord register since 1991. 60 intramedullary tumors of the cervical cord were operated by the author. Apart from tumor resection rates data on permanent surgical morbidity and progression-free survival were determined. Clinical data were classified according to McCormick.

Results: There were 31 ependymomas, 11 angioblastomas, 9 astrocytomas, 5 cavernomas, 2 gangliogliomas, 1 dermoid cyst and 1 metastasis. 93% were removed completely while the remainder underwent subtotal resections (4 astrocytomas grades II or III). Permanent morbidity was determined as 9.4%. 96.6% kept their preoperative McCormick grade after rehabilitation, while 3.4% lost one grade with surgery permanently. 54 patients were able to walk before surgery. Of these, one patient lost his walking capacity permanently. Among patients undergoing a complete tumor resection no adjuvant therapy was required. Overall, progression-free survival for 10 years was observed for 80% of all patients. Tumor recurrences were observed after incomplete resections and in patients with von Hippel Lindau disease (VHL).

Conclusions: Compared to intramedullary tumors of the thoracic spine, cervical intramedullary tumors can be removed completely with lower morbidity. All histologies except some astrocytomas grades II or III were amenable to complete resection. Therefore, surgery should be recommended as soon as these tumors become symptomatic.

O26

Surgical site infection after cervical laminoplasty using hydroxyapatite spacer

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Question: Surgical site infection (SSI) is an important complication in spinal surgery that leads to significant morbidity; however SSI cases after cervical laminoplasty have been rarely reported. Especially those of including superficial SSI have never been reported. The object of this study was to analyze the incidence of SSI after cervical laminoplasty.

Methods: We analyzed a consecutive cohort of 453 adult patients who underwent spinous process splitting cervical laminoplasty using ceramic spacer by a same surgeon from October 2006 to December 2018. Antibiotics (cefazolin, CEZ) administered at operation day and post-operative day 1. The epidural drainage tube was removed at post-operative day 2. SSI was based on the CDC criteria and was clinically reviewed. We analyzed age, gender, treated lamina, operation time, the amount of intraoperative bleeding and post-operative drainage, comorbid disorder, isolated pathogens, reoperation, and hospitalization day. The statistical analysis was performed with Mann-Whitney U test and chi-square test, and differences with $P < 0.05$ was considered significant.

Results: From a total of 453 patients, 18 developed SSI (4.0%) including 2 deep SSI (0.4%). Pathogens were only isolated in two of deep SSI (MRSA, *Serratia marcescens*) and one of superficial SSI (*Serratia marcescens*). Debridement was required two in both SSI groups respectively. Removal of the spacer was required only in deep SSI group. The patient age, gender, treated lamina, operation time, the amount of intraoperative bleeding and postoperative drainage observed for SSI group were not significantly different from those for non-SSI group. SSI was only associated with prolonged hospitalization.

Conclusions: An infection rate of 4.0% implied that SSI after cervical laminoplasty is not rare. SSI was only associated with prolonged hospitalization.

Randomized, placebo-controlled, double-blinded trial of granulocyte colony stimulating factor-mediated neurotection for acute spinal cord injury

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Question: Granulocyte Colony Stimulating Factor (G-CSF) is generally used for neutropenia. Our experimental studies revealed that G-CSF promoted neurological recovery after SCI via various mechanisms. Next we moved to early phase of clinical trials. In a phase 1/2a trial, no adverse events were observed. Next, we conducted a non-randomized, non-blinded, comparative trial, which suggested the efficacy of G-CSF for promoting neurological recovery. We are now performing a phase 3 trial to confirm G-CSF treatment efficacy for acute SCI.

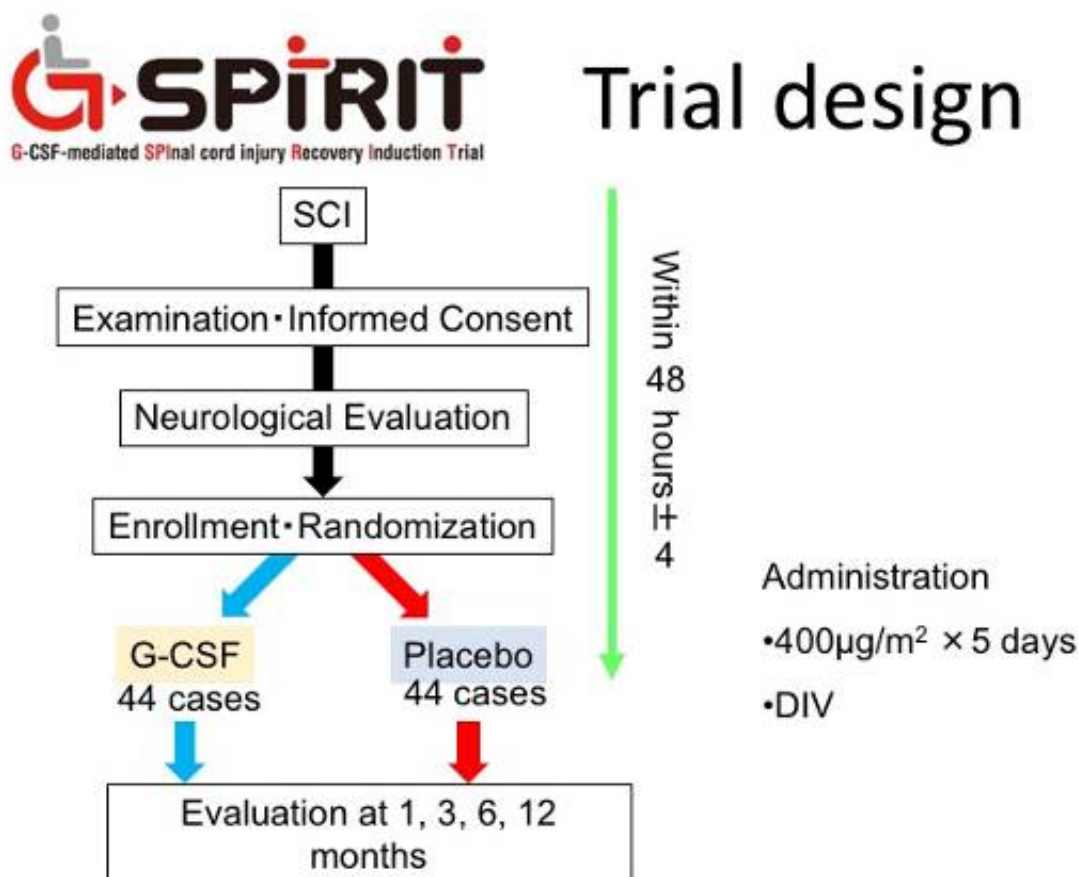
Methods: The current trial includes cervical SCI (AIS B/C) within 48 hours after injury. Patients are re-assessed for neurological status at 48 hours after injury, and those whose palsy is AIS B/C are enrolled. Patients are randomly assigned to G-CSF and placebo groups. The G-CSF group is administered 400 µg/m²/d×5d of G-CSF in normal saline via intravenous infusion for 5 consecutive days. The placebo group is similarly administered a placebo. Allocation is concealed between blinded evaluators of efficacy/safety and those for laboratory data, as G-CSF markedly increases white blood cell counts that can reveal patient treatment. Efficacy and safety is evaluated by blinded observer.

Our primary endpoint is changes in ASIA motor scores from baseline to 3 months. Each group includes 44 patients (88 total patients). Our protocol was approved by the Pharmaceuticals and Medical Device Agency and this trial is funded by the Center for Clinical Trials, Japan Medical Association.

Results: All the patients (total 88 cases) had been enrolled to the current trial. Results of the current trial will be disclosed after the 1-year follow-up of all the patients.

Conclusions: G-CSF is one of possible candidates for novel therapeutic agents for SCI.

Figure 1



Oral presentations

O7

Radiological outcomes following hyperlordotic cage insertion in anterior cervical discectomy and fusion

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Question: Cervical alignment is associated with myelopathy and quality of life. Kyphosis correlates with increased neck pain and poor post operative neurological outcomes. Anterior cervical discectomy and fusion (ACDF) aims to decompress neural structures and optimise cervical alignment. This study examines the quantitative impact of the hyperlordotic 15° ACDF cage on cervical alignment. If post operative radiographical parameters are improved to a greater extent than the standard cage, its wider utilisation can be statistically justified, and its impact on disability scores further explored.

Methods: A retrospective analysis of radiographical parameters of cervical alignment was conducted in 80 consecutive ACDF patients from two institutions between 2013 and 2017. 40 received 15° cages, 40 received standard cages. Pre and post-operative Cobb angles and C2-7 sagittal vertical axis (SVA) were generated from radiographical imaging utilising the Surgimap program. Changes in lordosis and SVA were compared within and between groups, and the significance of the change evaluated using the student t-test.

Results: In both groups, post-operative device level, segmental, and global Cobb angles were superior to pre-operative values ($p < 0.05$), especially among patients with pre-operative kyphosis ($p < 0.05$). Trends suggested greater changes in lordosis in the 15° group, but they did not reach statistical significance ($p = 0.06-0.23$). However, subgroup analyses indicated greater device level Cobb angle change in patients less than 65yo ($p < 0.049$), and those with pre-operative lordosis ($p < 0.003$). Neither standard nor hyperlordotic cages significantly improved SVA in this study.

Conclusions: Hyperlordotic and standard cages both improve cervical lordosis segmentally and globally. Hyperlordotic cages were not shown to be statistically superior to standard cages in this study. Prospective studies featuring consistent imaging modalities are necessary to further delineate their utility.

O8

Is right side anterior cervical approach a risk factor of recurrent nerve injury?: From the point of the frequency of aortic arch anomaly

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Question: There is still controversy between right- and left-side anterior cervical approach. Although right-side approach is easier for right-handed surgeon, it is postulated that right-side approach has higher risk of recurrent laryngeal nerve (RLN) palsy, since the frequency of non-RLN is higher in right-side. RLN originates from vagus nerve, turns at subclavian artery in right side or aortic arch in left side, and ascends to larynx. Though in the aberrant origin of right subclavian artery (AORSA), the right-side LN is non-RLN. The safety of right-side anterior cervical approach is discussed from the point of AORSA.

Methods: Consecutive 534 cases' 3D-CT angiography (3D-CTA) of aortic arch were analyzed retrospectively. The purposes of taking CTA were dissection aneurysms, vascular disorder in lower extremity, coronary artery, etc. They were 336 male and 198 female, age range was 0-92 yrs (69.5 ± 12.5 yrs). The types of aortic arch were divided using Adachi, Williams and Nakagawa classification.

Results: They were type A in 447 cases (84%), type B in 70 cases (13%), type C in 11 cases (2.1%). These relatively usual types account for 528 cases (99%). Type M, mirror image of type A, were in 2 cases (0.37%). Type G, the AORSA with both sides carotid artery originates separately, was in 1 case (0.19%). And type H, the AORSA with bilateral carotid arteries originates as common trunk, were in 3 cases (0.56%). In short, AORSA were 4 in 534 cases (0.74%).

Conclusions: The frequencies of AORSA and non-RLN are equivalent since the report that all non-RLN accompany AORSA. This study suggests the frequency of non-RLN is rare as 0.74%. Right-side approach is still attractive method. Although rare, preoperative diagnosis of AORSA could be beneficial. Chest X-ray is useless, the finding of artery situating posterior to esophagus in CT is characteristic of AORSA. Though contrast-enhanced CT is excessive, it can be an option to enlarge area to caudal in routine preoperative CT for cervical surgery.

Posterior foraminotomy versus anterior decompression and fusion in patients with cervical degenerative disc disease with radiculopathy – 5-Year outcome from a national spine register

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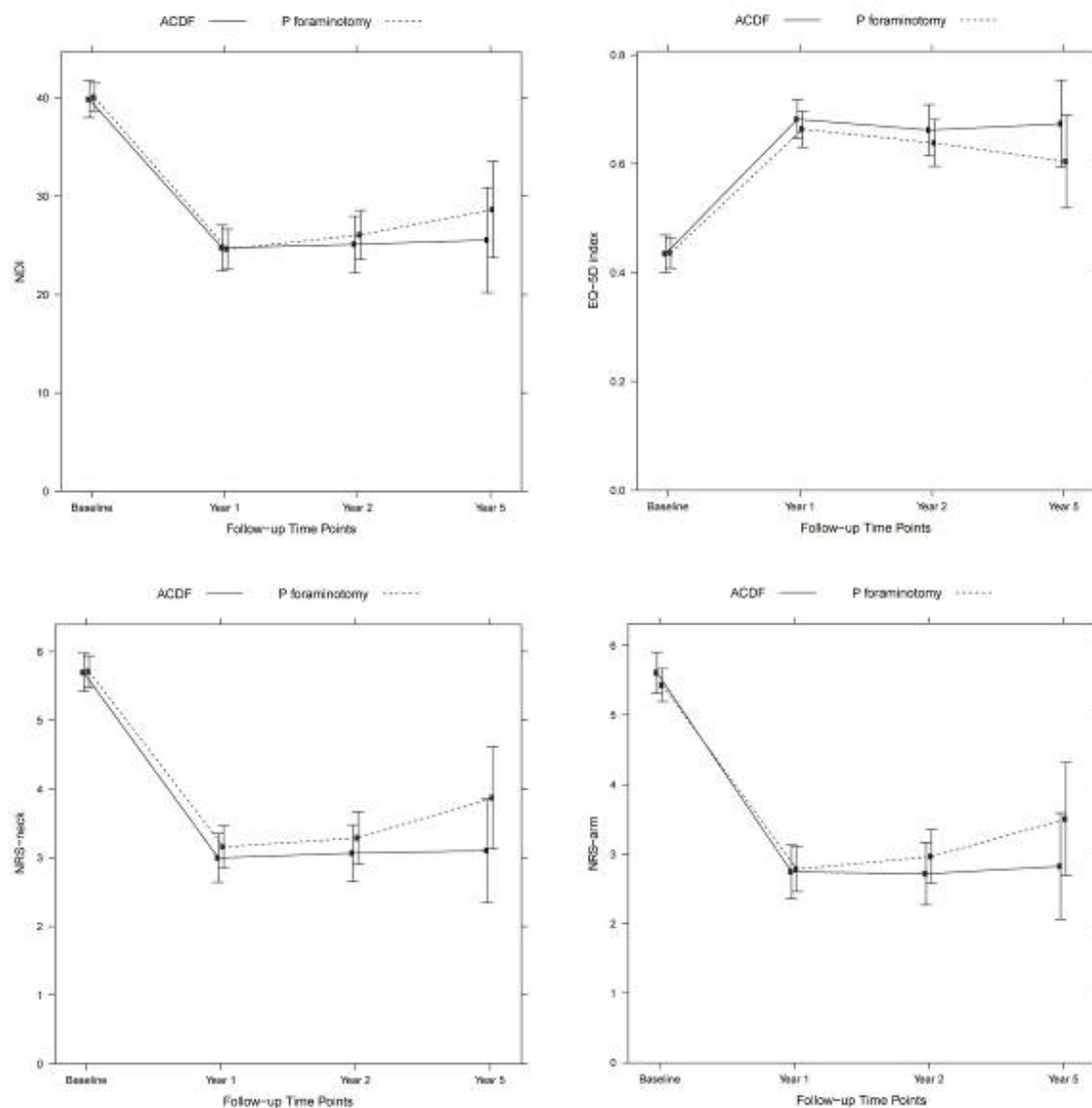
Question: The long-term efficacy of posterior foraminotomy compared with anterior cervical decompression and fusion (ACDF) for the treatment of degenerative disc disease with radiculopathy has not been previously investigated in a population-based setting.

Methods: All patients in a national register from January 1, 2006 until November 15, 2017, with cervical degenerative disc disease and radiculopathy, were assessed. Using propensity score matching, patients treated with posterior foraminotomy were compared with those undergoing ACDF. The primary outcome measure was the Neck Disability Index (NDI) with a minimal clinically important difference defined as >15%. Secondary outcomes were assessed with additional patient reported outcomes measures (PROMs).

Results: A total of 4,368 patients (2,136/2,232 women/men) met the inclusion criteria. Posterior foraminotomy was performed in 647 patients and 3,721 patients underwent ACDF. After meticulous propensity score matching, 567 patients with a mean age of 54 years remained in each group. Both groups had substantial decreases in their NDI scores; however, after 5 years, there was not a significant difference (2.4%; 95% CI, -4.3 to 9.0; $P=0.48$) between the groups. There were no significant differences between the groups in EQ-5D or numeric rating scale (NRS) for neck and arm pain.

Conclusions: In patients with cervical degenerative disc disease and radiculopathy, both groups demonstrated clinical improvements, at 5-year follow-up, which were comparable and did not achieve a clinically important difference from one another. This study design obtains population-based results, which are generalizable.

Figure 1



Disc height narrowing does not affect the intervertebral stability in cervical spondylolisthesis: Analysis of CT and X-rays of 101 spondylolisthesis patients

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Question: The concept of degenerative cascade in lumbar spondylolisthesis was broadly recognized, and vertebral body is thought to be stabilized by disc height narrowing. However, degenerative cascade in cervical spondylolisthesis is not fully understood. The purpose of this study is to examine whether the cervical disc height narrowing causes the stability of the intervertebral space in cervical spondylolisthesis.

Methods: This study was conducted to analyze cervical X-rays and CT-myelography of 731 patients with cervical spine disorders between 2008 and 2013. We defined cervical spondylolisthesis as antero-posterior vertebral slipping of more than 2mm identified on lateral X-rays in neutral position or sagittal CT. On lateral X-rays, considered parameters were neck alignment, C2-7 angle, range of flexion-extension neck motions (ROM), C2-7 sagittal vertical axis (SVA) and change of translation in flexion-extension from neutral position. Anterior translation was defined to be plus value in anterior spondylolisthesis, while posterior translation was defined plus value in posterior spondylolisthesis. On sagittal CT, we classified disc height at slipped level into 5 grades. High disc height grade indicates more narrowed disc height.

Results: Anterior and posterior spondylolisthesis was detected in 81 disc levels and 43 disc levels respectively. The change of translation in flexion-extension examined according to the disc height grade, and results are on figure 1. The change of translation was not statistically different among groups of 5 disc height grades. There was no statistical significant difference in neck alignment, C2-7 angle, ROM, C2-7 SVA and mean age among groups of 5 disc height grades.

Conclusions: From the results of this study, disc height narrowing did not affect the change of translation in flexion and extension at slipped level. Disc height narrowing was difficult to contribute the stability in cervical spondylolisthesis.

Figure 1

		Flexion(mm)	Extension(mm)	Number of disc levels
Anterior listhesis	Grade 0	0.09	-1.3	9
	Grade 1	0.48	-1.19	40
	Grade 2	0.94	-1.86	14
	Grade 3	0.33	-1.43	9
	Grade 4	0.39	-1.01	9
Posterior listhesis	Grade 3	-1.19	0.06	9
	Grade 4	-0.8	0.24	34

Morphological changes in the intervertebral disc post trauma: any impact of preexisting segment degeneration?

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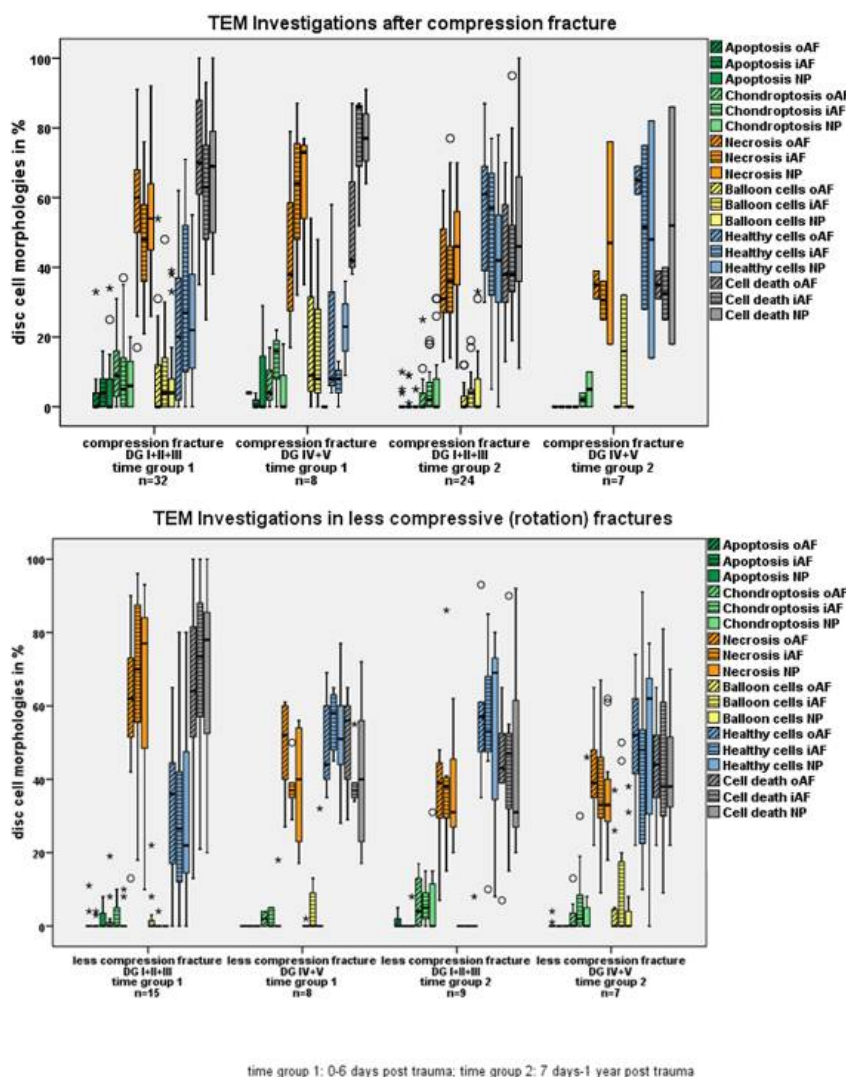
Question: In the first 24 hours post intervertebral disc (IVD) trauma, up to 75% cell death has been reported. The aim of the study was to assess histological changes and cell-death over a time period of up to one year after trauma, with particular regard to the impact of preexisting degeneration grades.

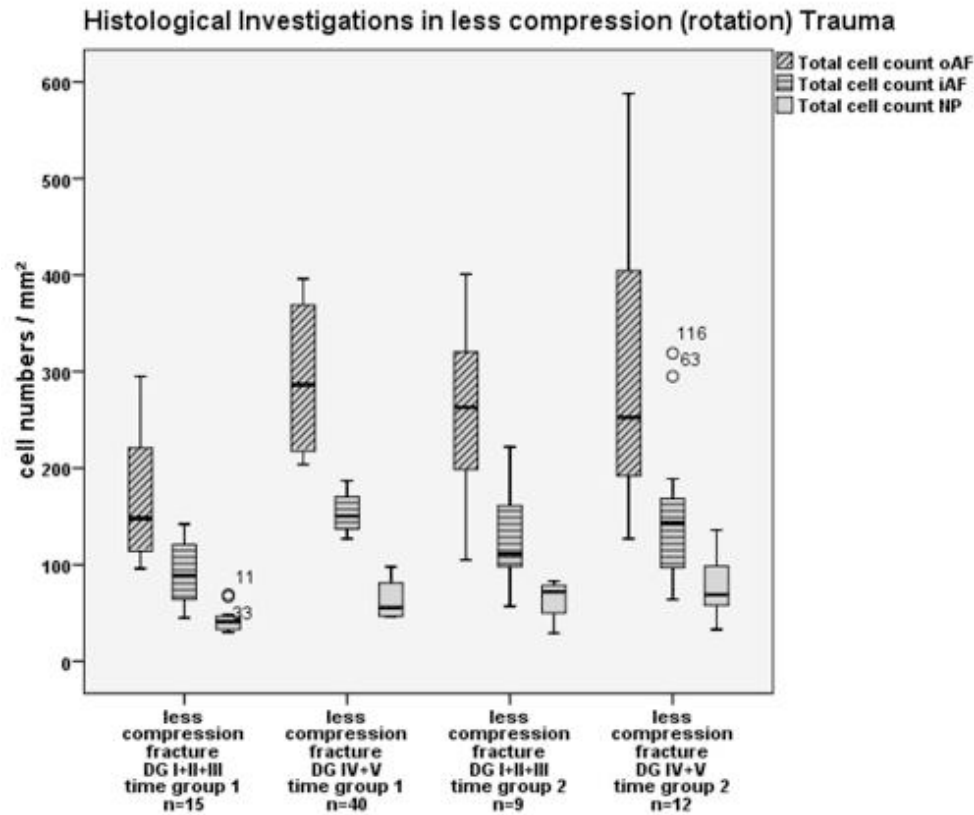
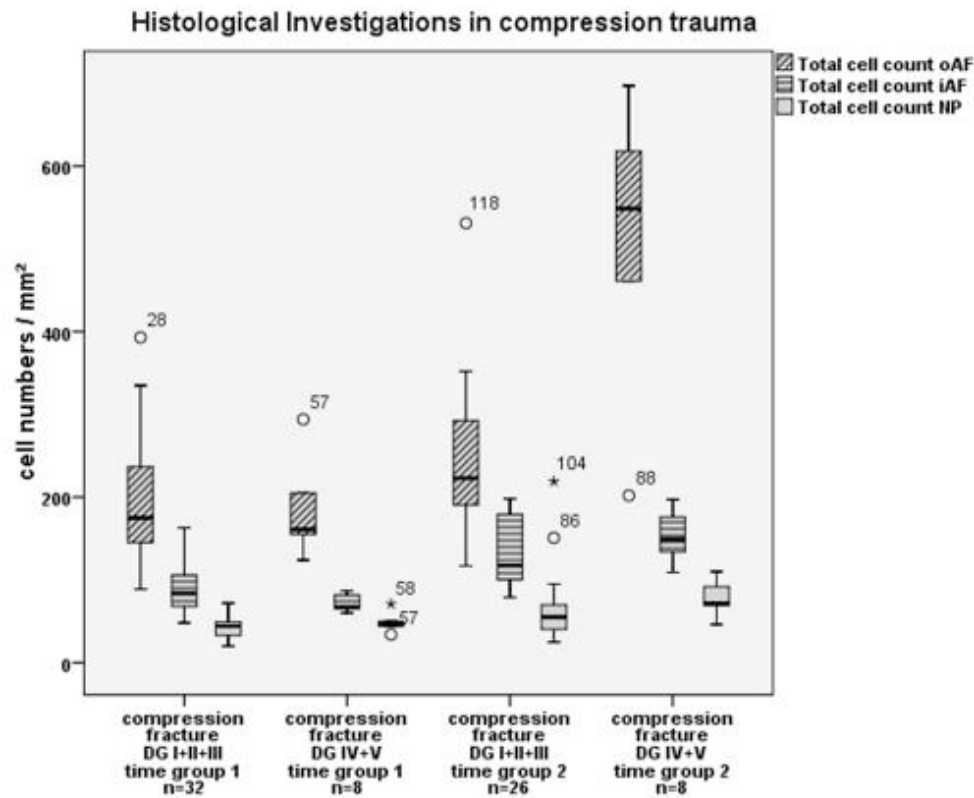
Methods: 111 anterior portions of IVDs of the cervical spine were studied histologically by light microscopy and ultrastructurally by transmission electron microscopy (TEM). The group was investigated with regard to two parameters: fracture mechanism (compression vs. rotation fractures) and degeneration grade (low vs. high). Disc architecture (e.g. ruptures) was studied histologically. Cell morphology was examined ultrastructurally to quantify cell-death, healthy and balloon cells. According to ultrastructural observations, two time-groups (up to 6 days vs. later) were established. Statistical analyses (SPSS) were carried out within the time-groups.

Results: Histological changes were obvious in the annulus fibrosus where ruptures with haematoma were replaced by granulation tissue. Significantly higher cell numbers per mm² were found in highly degenerated segments after compression fractures (time group 2) than in all other investigated groups. Necrotic cell death was obvious with significant differences in time group 1 (acute trauma) comparing both degeneration groups according to compression and rotation fractures. Apoptosis was significant higher in low degenerated segments after compression fractures. No difference was found between groups after the sixth day (time group 2). Cell-death (mean 44% for all groups) remained high after day 6 post-trauma.

Conclusions: Interestingly, alterations post trauma of the different cell morphologies according to low and high degenerated discs were only present in the early phase after trauma (up to 6 days), but not later on.

Figure 1





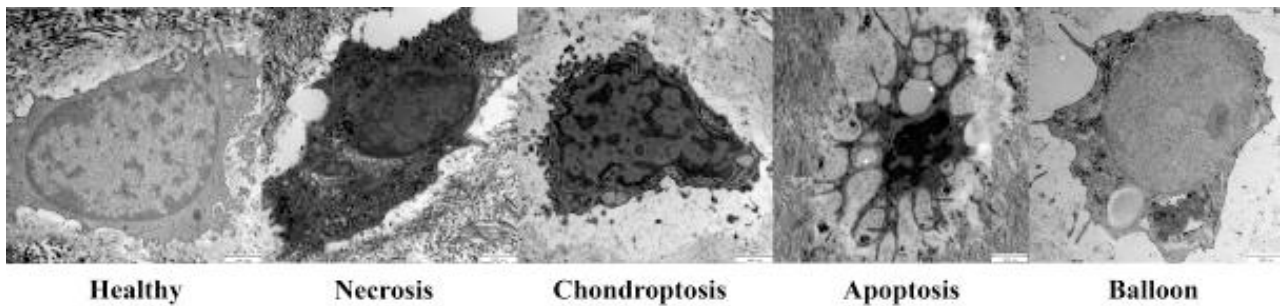
time group 1: 0-6 days post trauma; time group 2: 7 days-1 year post trauma

Figure 3

Statistical analysis undertaken in the different time groups

	Timegroup 1 compression fractures	Timegroup 2 compression fractures	Timegroup 1 less compression fractures	Timegroup 2 less compression fractures
	DG I II III <> DG IV V	DG I II III <> DG IV V	DG I II III <> DG IV V	DG I II III <> DG IV V
apoptosis	oAF: $P=ns$ iAF: $P=0.028$ NP: $P=ns$	ns	ns	ns
chondroptosis	ns	ns	ns	ns
necrosis	oAF: $P=0.022$ iAF: $P=0.001$ NP: $P=0.018$	ns	oAF: $P=ns$ iAF: $P=ns$ NP: $P=0.029$	ns
healthy cells	ns	ns	oAF: $P=ns$ iAF: $P=ns$ NP: $P=0.022$	ns
balloon cells	ns	ns	ns	ns
Total cell death			oAF: $P=ns$ iAF: $P=ns$ NP: $P=0.022$	
total cell count	ns	oAF: $P=0.015$ iAF: $P=ns$ NP: $P=0.047$	oAF: $P=0.028$ iAF: $P=0.007$ NP: $P=0.044$	ns

Figure 4



O12

Adjacent segment pathology after cervical laminoplasty

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Question: In cervical spine surgery, it is generally supposed that adjacent segment pathology (ASP) is an important problem associated with fusion surgery. In contrast, there is a consensus that cervical laminoplasty (CLP) is a motion preservation surgery. Consequently, there had been only a few case reports of ASP after CLP. The aim of this study was to evaluate the prevalence and clinical features of ASP after CLP.

Methods: Seventy-four patients of cervical myelopathy, who underwent CLP and could be followed for minimum 2 years after surgery, were retrospectively reviewed. The ASP was assessed using a radiographical grading system described by Hilibrand et al. We evaluated radiological findings on standing lateral radiographs and MRI. The postoperative follow-up duration was mean 4.3 years. We conducted a comparative study between patient group with ASP (group-A) and that without ASP (group-C) to evaluate clinical features of ASP after CLP.

Results: The ASP was found in 7 patients (9.5%); 1 patient within 2 years after surgery and 6 patients at over 4 years after surgery. The ASP developed at proximal segment (Oc-C2) in 3 patients and at distal adjacent segment in 6 patients. There were no significant differences between two groups on preoperative demographic details and radiological findings. A significant decrease of cervical ROM with unexpected postoperative interlaminar bony fusions was observed in group-A, postoperatively. In patients with proximal ASP, the C2-7 lordosis decreased and Oc-C2 lordosis increased with significant differences after CLP.

Conclusions: The ASP after CLP might occur more frequently than previously thought. Patients with unexpected interlaminar bony fusions and decrease of cervical ROM after CLP have a higher risk of ASP. The proximal ASP (Oc-C2 level) was connected with increase of Oc-C2 lordosis after surgery, which resulted from compensation for postoperative loss of lordosis at the C2-7. Meanwhile, the relevant factors of distal ASP could not be found in this study.

O13

The spinal cord "back shift" concept in posterior decompression and stabilization in lordosis for cervicalspondylotic myelopathy: favorable clinical outcomes

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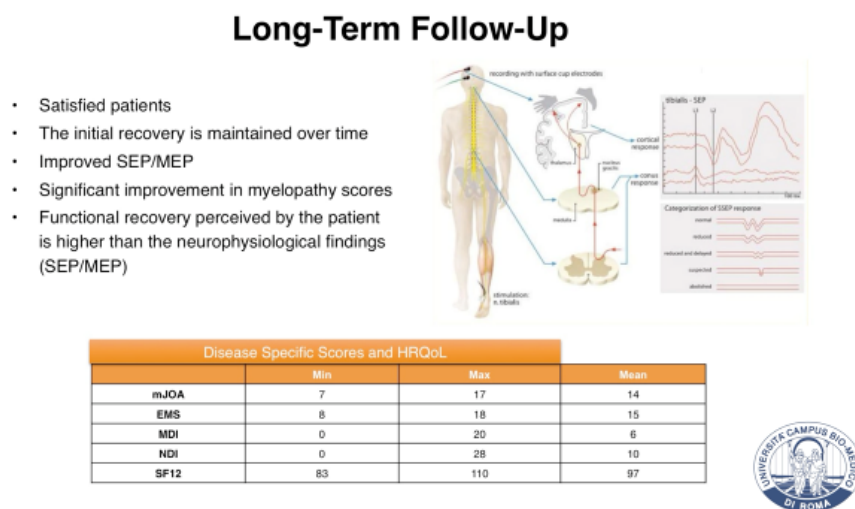
Question: Surgical management of patients with multilevelcervicalspondylotic myelopathy (CSM) aims to decompress the spinal cord and restore the normal sagittal alignment. The literature lacks of high level evidences about the best surgical approach. The purpose of this study was to investigate the efficacy of posterior decompression and stabilization in lordosis for multilevel CSM.

Methods: 36 out of 40 patients were clinically assessed at a mean follow-up of 5, 7 years. Outcome measures included EMS, mJOA Score, NDI and SF-12. Patients were asked whether surgery met their expectations and if they would undergo the same surgery again. Bone graft fusion, instrumental failure and cervical curvature were evaluated. Spinal cord back shift was measured and correlation with EMS and mJOA score recovery rate was analyzed.

Results: All scores showed a significative improvement ($p < 0.001$), except the SF12-MCS ($p > 0.05$). Ninety percent of patients would undergo the same surgery again. There was no deterioration of the cervical alignment, posterior grafted bones had completely fused and there were no instrument failures. The mean spinal cord back shift was 3.9 mm (range 2.5-4.5 mm). EMS and mJOA recovery rates were significantly correlated with the postoperative posterior cord migration ($P < 0.05$).

Conclusions: Posterior decompression and stabilization in lordosis is a valuable procedure for patients affected by multilevel CSM, leading to significant clinical improvement thanks to the spinal cord back shift. Postoperative lordotic alignment of the cervical spine is a key factor for successful treatment.

Figure 1



O14

Clinical feature of the revision cases due to symptomatic adjacent segment degeneration after the anterior cervical decompression and fusion surgery

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Question: We have indicated anterior decompression and fusion surgery for every degenerative cervical spine, usually with myelopathy. Re-worsening due to adjacent segment degeneration/ASD is advocated often as negative side of the anterior cervical fusion surgery. To prevent recurrence due to ASD, we have preferred to indicate multilevel fusion surgery for younger patients with developmental narrow spinal canal, which is not rare in Japanese population. Purpose of this study is to clarify the incidences of revision surgeries due to symptomatic ASD and to examine the validity of our indication of the first surgery.

Methods: Subjects include 248 patients(177male/71female, avg.62.7yo), who underwent anterior decompression and fusion surgery for cervical degenerative disease including 56 OPLL cases in 2007-11. Average fusion segments are 2.0. Average F/U period is 5.4 years. We assessed incidences of revision surgeries due to symptomatic ASD, duration between two surgeries and etiology up to each revision surgery.

Results: In the 248 cases, 11 cases have experienced revision surgeries for symptomatic ASD. Duration between 1st and 2nd surgery is 33-120(avg.68) months. Symptomatic segment is C7/T1 in 4 cases, C5/6 in 3 cases, C4/5 in 2 cases and 2 others. Etiology up to the revision surgeries includes CSM/4 cases, C8 root/4 cases and 3 others. For revision surgery, anterior surgery had indicated again except for an OYL case. (table 1)

Conclusions: Incidence of revision surgeries for symptomatic ASD was 4.4%(11/248) in avg. 5.6 years F/U. This frequency, relatively lower than reported literally, represents validity of indication on the 1st surgery, which avoids short fusion for younger developmental narrow canal cases. However, C8 palsy due to C7/T1 ASD recognized considerably in younger patients after multilevel surgery, which should be newly taken account when choosing multilevel surgery for younger cervical spine.

Figure 1

Age	Sex	Diag.&1 st .op.	Duration /months	Symptomatic level	Etiology	2 nd . op.
43	M	OPLL, 5-7	33	7/1	C8	7-1 ant.
44	M	CSM/CP, 3-6	71	7/1	C8	7-1 ant.
45	M	CSM, 3-6	72	7/1	C8	7-1 ant.
48	M	CSM, 3-7	69	7/1	C8	7-1 ant.
55	F	CSM, 4-5	46	5/6	CSM	3-6 ant.
59	M	CSM, 3-4	85	4/5	CSM	4-6 ant.
61	M	CSM, 3-5	52	5/6	CSM	5-6 ant.
67	M	CSM, 3-6	89	6/7	CSA	6-1 ant.
71	F	CSM, 3-4	120	2/3	CDH	2-5 ant.
79	F	CSM, 3-5	72	5/6	CYL	5-7 post.
81	F	CSM, 3-4	44	4/5	CSM	4-6 ant.

O15

A dynamic multi-segmental finite element model of rear-impact cervical whiplash: Role of spine morphological variations and head inertial properties on segmental rotations

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Question: To investigate the role of variations in spine morphology and head inertia properties on cervical spine segmental rotation in rear-impact whiplash loading.

Methods: A multi-segmental (C2-C7) cervical spine finite element model, with its morphology parametrized using mesh morphing, was used to study the influence of disc height, anteroposterior vertebral depth, and segmental size, as well as variations in head mass, moment of inertia, and center of mass locations. The influence of these variations on the characteristic S-curve formation in whiplash response was evaluated using the peak C2-C3 flexion marking the maximum S-curve formation and time taken for the formation of maximum S-curve.

Results: The peak C2-C3 flexion in the S-curve formation was most influenced by disc height and vertebral depth, followed by anteroposterior head center of mass location. The time to maximum S-curve was most influenced by the anteroposterior location of head center of mass and segmental size.

Conclusions: The role of gender-dependent vertebral depth and segmental size may explain the pronounced S-curve formation for females reported in both post-mortem human subjects and volunteer experiments in whiplash type mechanisms of injury; and hence, may help explain why women are clinically more predisposed to whiplash injury than men.

O16

Comparison of surgical results of C-arm versus O-arm in C1-2 transarticular screw fixation

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Question: C1–2 transarticular screw (TAS) is technically demanding. Traditionally, C-arm has been used to place TAS. O-arm based navigation system (O-arm) has been implemented to help some of the technical difficulties of screw placement in the upper cervical spine. The purpose of this study is to compare the surgical outcomes of TAS using C-arm and O-arm.

Methods: The present study was conducted in 71 patients who underwent TAS in our hospital between 2006 and 2018. The mean age at surgery was 61 years. Fifty three patients underwent surgery with C-arm (C-group) and 18 patients with O-arm (O-group). Additional surgery, such as C3-7 laminoplasty (LP), was performed in 8 patients in C-group and 3 patients in O-group. Total of 91 TAS were inserted: 62 in C-group and 29 in O-group. Unilateral and bilateral TAS was performed in 51 and 20 patients, respectively. Operative time, intraoperative bleeding, accuracy of screws, perioperative complications and bone union were evaluated. Screw accuracy was assessed using Neo classification: grade (G) 0: no perforation, G1: perforation 4mm.

Results: The mean operative time was 183 (105–349) min in C-group and 207(116-266) min in O-group. The mean blood loss was 132 (20–382) g in C-group and 360 (20-2684) g in O-group. The operative time without additional surgery was 170 (105-249) min in C-group and 179 (116-266) min in O-group. The mean blood loss without additional surgery was 132(20-382) g in C-group and 163 (20-480) g in O-group. The accuracy of TAS was G0:44, G1:17, G2:3, G3:3 in C-group, and that was G0:28, G1:1 in O-group. Bone union was completed 100% (20/20pts) with bilateral TAS, though 78.7% (37/47pts) with unilateral TAS. Deep wound infection was observed in a case in C-group.

Conclusions: O-arm dramatically improved accuracy of TAS. Bone union rate was 100% with bilateral TAS. Therefore, TAS should be performed with bilateral TAS if O-arm is available.

O17

Time course of respiratory dysfunction in the cervical spinal cord injury without bony injury: respiratory function restore around 12 weeks after injury

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Question: Cervical spinal cord injury without bony injury (SCIWOBI) is a common cervical injury in the elderly population, and is most likely to occur at the C3/4 level. Respiratory dysfunction (RD) related to damage of the spinal respiratory center, which is close to the C4 segment, is one of the greatest challenges to improving activities of daily life in cases of severe paralysis. We evaluated the time course of RD and motor function in cervical SCIWOBI with a view to selecting effective medical strategies.

Methods: We followed 54 patients (49 men, 5 women; mean age 65 years) who were treated for SCIWOBI at our medical center from 2011 to 2014, were evaluated within 72 hours of injury, and were followed at least 12 weeks. Whether treated conservatively or surgically, all patients began respiratory-muscle training the day after admission. The percent vital capacity (%VC), forced expiratory volume in one-second/forced vital-capacity ratio (FEV 1.0%), and American Spinal Injury Association motor score (MS) were recorded at admission and again at weeks 4 and 12. We calculated the %VC rate of change and the MS improvement rate over the entire period.

Results: Fifty patients (92.6%) had restrictive ventilatory impairment at admission. The %VC correlated with the upper- and lower-limb MS at admission, and the %VC and upper- and lower-limb MS had improved at weeks 4 and 12 after injury. The %VC rate of change was significantly correlated with the rate of improvement in lower-limb MS throughout the entire period.

Conclusions: Lung capacity decreased in SCIWOBI due to respiratory-muscle paralysis and on the same level with upper- and lower-limb motor paralysis. Lung capacity improved as the lower limbs recovered motor function. Respiratory rehabilitation should be continued for at least 12 weeks after SCIWOBI.

O18

Relationship between the timing of reduction for cervical spine dislocations and neurological recovery

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Question: Although many studies have reported that it is desirable to perform reductions for cervical spine dislocation injuries as early as possible, the ideal timing remains unclear. The purpose of this study was to clarify the relationships between the interval from injury to reduction (referred to as "reduction time") and the neurological prognosis.

Methods: A total of 206 patients with cervical spinal cord injury were treated at our hospital from 2007 to 2018. In those patients, there were 54 cases with distractive flexion dislocation according to the Allen classification (42males, 12 females; average age, 60.0 years). Their ASIA Impairment scale (AIS) grade at the arrival at the hospital ranged from A to D. We evaluated the reduction time and the transition of paralysis after one month from the injury.

Results: The distribution of AIS grade at the time of injury was as follows: A, 24 cases; B, 13 cases; C, 8 cases; and D, 9 cases. The mean reduction time was 7.0 hours (range, 2.0 hours to 21 days). Twenty one cases (38.9%) were performed reduction within the determined cut-off value of 6 hours, which included 9 grade A, 4 grade B, 4 grade C and 4 grade D. Among these 21 patients, all 12 patients with initial AIS B, C and D improved significantly by one or more AIS grade. On the other hand, in 18 AIS B, C and D patients whose reduction time was over 6 hours, only 9 patients (50.0%) showed improvement by one or more AIS grade.

Conclusions: In our case series, patients with AIS grade B, C and D showed neurological improvement in case the reduction time was less than 6 hours. These results indicate an aiming reduction time and transportation time for the acute treatment. We should make an effort to shorten the reduction time by transferring the patients to a hospital that can perform reduction and diagnose the dislocation injury as soon as possible.

O19

Clinical outcomes of acute cervical spinal cord injury depending on the timing of surgery

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Question: There have been lots of prior studies that show optimal surgical time for acute SCI. Most studies reported that early surgery had better results than late surgery. However, the timing of surgery remains controversial. We tried to evaluate the clinical outcomes of acute cervical spinal cord injury (SCI) depending on the timing of surgery.

Methods: We analyzed patients whose surgery was performed for acute cervical spinal cord injury from 2007 to 2017. We analyzed change in AIS(ASIA Impairment Scale) and ASIA motor subscore depending on the timing of surgery and analyzed the relation of clinical outcomes and age, gender, neurologic level of injury and type of spinal cord syndrome by multivariate analysis. Secondary outcomes were analyzed with complication and mortality.

Results: A total of 154 patients with acute cervical SCI were enrolled. Of these, 49 patients (group A) underwent early surgery (≤ 24 hr), 54 patients (group B) underwent intermediate surgery (24~72hr) and 48 patients (group C) underwent delayed surgery (≥ 72 hr). AIS improvement was shown as 44.8% in group A, 31% and 24.1 % in group B and C respectively (A vs B&C; $p=0.041$). In the multivariate analysis, with steroid administration, the rate of AIS improvement were 33% in early surgery group and 16% in the other group (odds ratio=2.6, $p=0.061$). Age, gender, and NLI had no relation with AIS statistically. Mortality during hospitalized period was 2 in group A and 1 in group B. The complication rate was 34.6% in group A, 28.5 and 24.4 % in group B and C respectively.

Conclusions: Surgery prior to 24 hours after acute cervical SCI could improve clinical outcome.

The effect of rod pattern and multiple screw-rod constructs for surgical stabilization of the 3-column destabilized cervical spine – Presentation of biomechanical analysis and clinical rationale

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Question: Supplemental posterior cervical instrumentation can improve construct stability after corpectomy procedures (CE), particularly in the 3-column deficient spine. Among standard screw-rod instrumentation using CoCr-rods, advanced constructs including the use of outrigger rods (OGR) and 6-screws/3-rods constructs (6S3R) with additional lamina screws are available (Fig.1). The biomechanical characteristics of each construct are yet to be compared.

Methods: Based on reconstructed human CT-scans, 3-column deficient PVC cervical models were created. The CE-level distances were calculated and reconstructed using titanium mesh cages. Biomechanical testing was performed with the use of different rod materials (Ti vs. CoCr), different rod diameters (3.5 vs. 4.0mm), \pm constrained anterior plating, \pm cross-links, and the use of different construct pattern. All motion tests were performed in a customized 6-degree of freedom spine tester (2Nm). Stability was expressed in ROM changes (°).

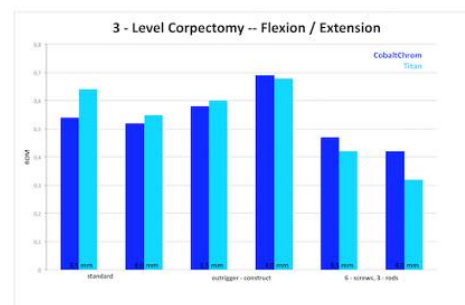
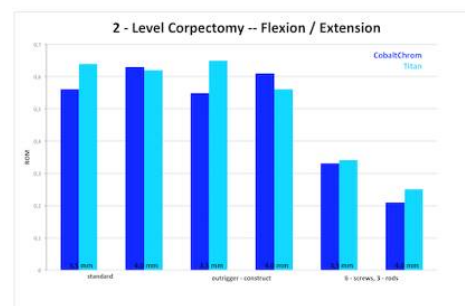
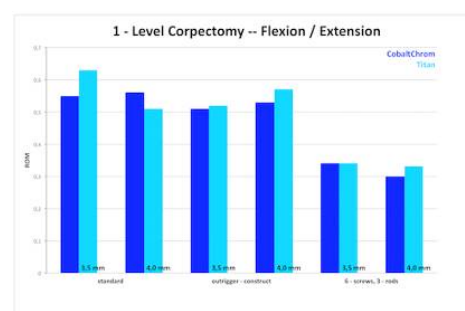
Results: A total of 432 tests were performed. The largest reduction of ROM was noticed for the 6S3R-group, while the addition of an outrigger rod caused moderate advantage (Fig.2). For all simulated 1-, 2- and 3-level CE constructs, the use of CoCr rods initiated a substantial ROM reduction in all planes. The use of 1 cross-link lowered ROM mainly in AR. In the OGR-group, a decreased ROM was recorded for all motion directions compared to the Standard-Group. Differences observed were increased with the number of CE-levels resected and without anterior plating.

Conclusions: A PVC model allow us to benchmark the mechanical effect of different screw-rod construct pattern of the 3-column destabilized spine. The 6S3R-group outperformed all other constructs and might resemble the standard of reference for advanced posterior fixation of 3-column destabilized cervical spine, particularly in multilevel CE. The use of CoCr-rods improves construct endurance in patients with posterior-only instrumentation without anterior plating.

Figure 1



Figure 2



Type II odontoid fracture in elderly patients treated conservatively: is bony union the goal?

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Question: Independently from radiological outcome, hard collar immobilization represent a safe and effective treatment choice when facing type II geriatric odontoid fractures

Methods: 50 geriatric patients with type II odontoid fractures were treated with Aspen/Vista collars. On admission, each patient was assessed assigning ASA score, modified Rankin scale (mRS-pre) and Charlson Comorbidity Index (CCI). 12-15 months after treatment, functional evaluations were performed employing a second modified Rankin scale (mRS-post) together with Neck Disability Index (NDI) and Smiley Webster Pain Scale (SWPS). Radiological outcome was evaluated through dynamic cervical spine x-rays at 3 months and cervical spine CT scans 6 months after treatment. Three different conditions were identified: stable union, stable nonunion, unstable nonunion. Surgery was preferred whenever a fracture gap >2 mm, an antero-posterior displacement >5 mm, an odontoid angulation >11° or neurological deficits occurred.

Results: Among the 50 patients, 24 reached a stable union while 26 a stable nonunion. Comparing the two groups, no differences of ASA ($p=0.60$), CCI ($p=0.85$) and mRS-pre ($p=0.14$) were noted. Similarly, no differences of mRS-post ($p=0.96$), SWPS ($p=0.85$) and NDI ($p=0.51$) were observed between patients who reached an osseous fusion and those with a stable fibrous non-union. No effects of age, sex, ASA, mRS-pre, fracture dislocation and radiological outcome were discovered on functional outcome. At logistic regression analysis, female sex and high values of CCI emerged associated with worse NDI.

Conclusions: In geriatric type II odontoid fractures pre-injury clinical status and comorbidities overcome imaging in determining post-treatment level of function. Hard collar immobilization led to a favourable functional outcome whatever a bony union or a fibrous nonunion was obtained.

Figure 1

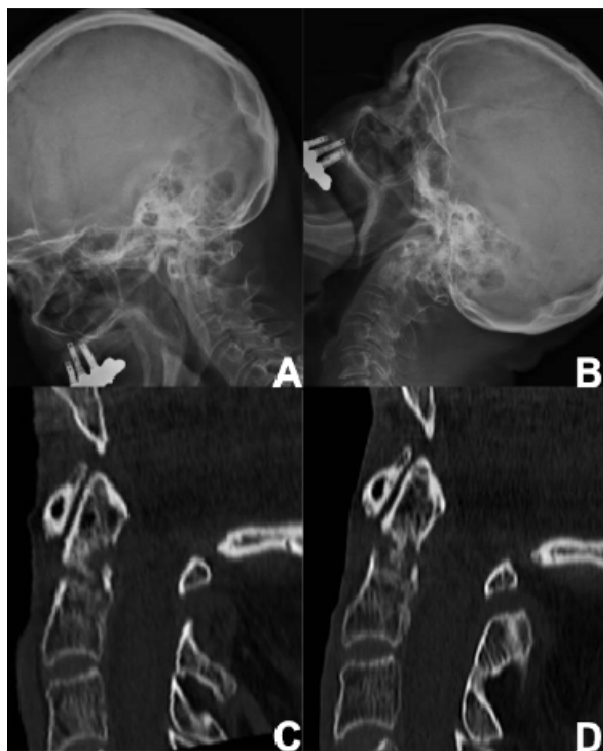


Figure. Dynamic cervical spine x-rays (flexion, A; extension, B) at 3 months and dynamic cervical spine CT-scan (flexion, C; extension, D) settling any doubts on evolutionary instability 6 months after injury.

Question: Knowledge about the so-called crowned dens syndrome (CDS) is reduced to the seldom published reports on one or a few cases. These authors state that this entity would not be a very rare condition but mentions some doubts on the possibility of being also an eventual radiological finding. The propose of this study was to search a possible distinction of ossifications around the apex of the odontoid process as early as degeneration signs, normal findings in old people and the so-called CDS (Figure 1).

Methods: For this preliminary study, we reviewed retrospectively 843 consecutive CT studies of the upper cervical spine. Four out of these studies were indicated by CDS suspicion, 18 in patients with sub-axial neck pain, 43 in general medical checking in patients with no cervical pain, 144 in studies of the facial bones, 292 in studies of neck structures and cavum and 348 in studies of the brain. Data about age, sex, nuchal pain and fever were taken on every patient as well as the presence of lumpy (Figure 2) or lineal (Figure 3) calcifications in the CT, associated or not to degenerative signs at disc spaces or zygapophyseal joints (Figure 4).

Results: Twenty seven (3,2%) out of the 843 CT scan studies disclose some kind of calcification around the odontoid process. The average age was 80.4 (57 to 98); 59% were men and 41% were women. No patient had fever and only the four under suspicion of having a CDS, complained of suboccipital pain. Two of these patients were finally diagnosed of CDS and 2 had degenerative signs - simple arthritis- at C1C2 level. Only two 2 of the 27 patients had chondrocalcinosis in the extremities.

Conclusions: The so-called CDS has to be better defined. Nuchal pain may be caused by C1C2 arthritis and similar images may be found in asymptomatic people over fifty years. This study is the largest study conducted on the prevalence of periodontoid calcifications and will continue in order to better define the options for diagnosis in case of facing patients with suboccipital pain.

Figure 1

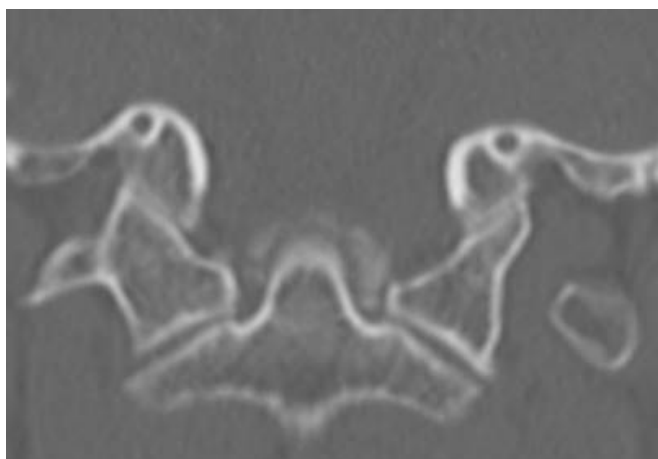


Figure 3

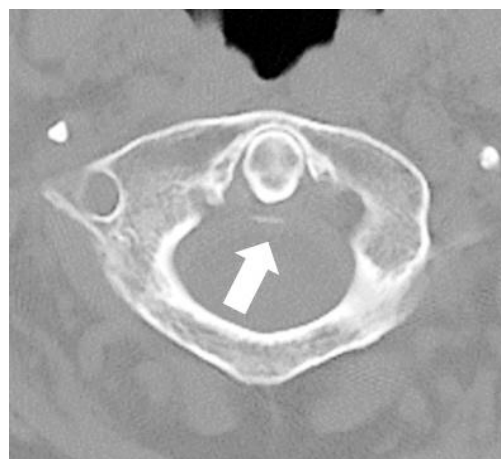
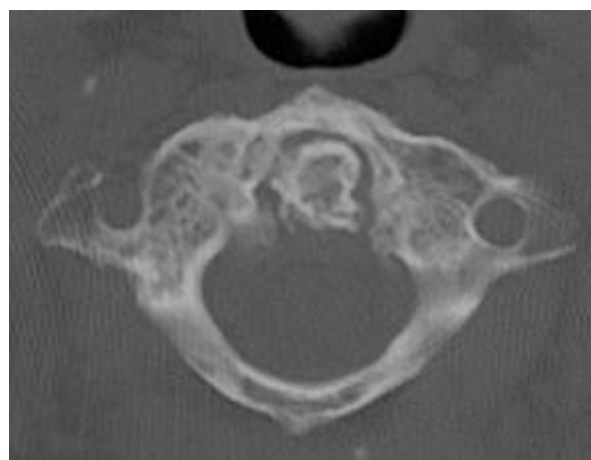


Figure 2



Figure 4



O28

The role of non-rigid cervical collar in pain relief and functional restoration after whiplash injury: a systematic review and pooled analysis of randomized controlled trials

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Question: Whiplash injury (WI) represents a common diagnosis at every emergency department. Several investigations have been conducted to compare the different medical management for non-surgical cases. Although active-mobilization (PhT) protocols have demonstrated good clinical outcomes, patients' compliance and PhT service availability are needed. Furthermore, the role of a non-rigid cervical collar (nRCC) for pain management and range of motion (RoM) preservation has not been completely clarified. Accordingly, we designed this systematic review and pooled analysis of randomized control trials to investigate any role of nRCC when PhT protocols are not pursuable.

Methods: We performed a systematic review of the randomized control trials (RCTs), according to PRISMA guidelines, and a pooled analysis in order to investigate the role of the nRCC for pain management, scored through the visual analogue scale (VAS) and the RoM, by comparing the use of a nRCC versus a non-immobilization protocols, regardless the association with physical therapy (PhT). Due to a certain heterogeneity across the RCTs, follow-up times time-range re-setting was necessary in order to pool the data.

Results: A total of 141 papers were reviewed, 6 of them matched the inclusion criteria and were admitted to the final study. Pooled-analysis showed that nRCC does not improve the outcome in term of VAS score and RoM trends along the follow-up. Moreover, VAS and RoM trends seem to further improve at long-term follow-up in non-immobilization associated with PhT group.

Conclusions: This pooled analysis of the available RCTs shows the absence of an advantage using nRCC after a WI. On the contrary, non-immobilization protocols show an overall better trend of pain relief and neck mobility recovery, regardless their association with PhT. Thus, nRCC prescription should be always avoided in WI management.

O29

The Odom's criteria validated at last: a clinimetric evaluation in cervical spine surgery.

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Question: The Odom's criteria are, since 1958, a widely used 4-point rating scale for assessing the clinical outcome after cervical spine surgery. Surprisingly, the Odom's criteria have never been validated.

Research question: The aim of this study was to investigate the reliability and validity of the Odom's criteria for the evaluation of surgical procedures of the cervical spine.

Methods: **Methods:** Patients with degenerative cervical spine disease were included. Reliability was assessed with inter-rater and test-retest design using a quadratic weighted Kappa coefficient. Construct validity was assessed by means of hypothesis testing with related constructs. To evaluate if the Odom's criteria could act as a global perceived effect (GPE) scale, we assessed concurrent validity by comparing the areas under the curves (AUCs) of the receiver operating characteristic curves (ROCs) with the set of questionnaires.

Results: A total of 110 patients were included in the study. Overall inter-rater reliability was $\kappa=0.77$ and the test-retest reliability $\kappa=0.93$. Inter-rater reliability for the radiculopathy patients was $\kappa=0.81$ and for myelopathy patients $\kappa=0.68$. More than 75% of the hypotheses were met. The AUCs showed similar characteristics between the Odom's criteria and GPE.

Conclusions: The Odom's criteria meet the predefined criteria for reliability and validity. Therefore, the Odom's criteria may be used to measure surgical outcome after a cervical spine procedure, specifically for patients presenting with radicular symptoms. Results of previous studies that have been deemed less trustworthy, because of the use of the Odom's criteria, should be reconsidered.

O30

Combination of 10-s Grip and Release test and 10-s Step test can distinguish thoracic myelopathy from cervical myelopathy

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Question: Thoracic myelopathy is a relatively rare disease and occasionally difficult to diagnose. In the diagnosis of thoracic myelopathy, nor objective or quantitative evaluation method was reported. The ten-second step test (Step test) measures how many times a foot stepping can be performed in 10 seconds to raise each thigh alternately parallel to the floor at the same place. This test can evaluate the motor function of the trunk and lower extremities quantitatively. Also the ten-second grip and release test (G&R test) was considered to examine the motor function of the upper extremities objectively. We investigated whether combination of Step test and G&R test can distinguish thoracic myelopathy from cervical myelopathy.

Methods: Thirty three thoracic myelopathy (TM) patients and 123 cervical myelopathy (CM) patients, who were diagnosed by clinical symptoms and MR images without other level stenosis, were enrolled. Those cases with neuromuscular diseases of other parts such as lumbar spinal canal stenosis and cases of joint diseases in which it is difficult to appropriately implement Step test are excluded. The test was conducted preoperatively and 1year after surgery

Results: Their mean age (TM / CM) was 61.8 ± 14.3 / 63.3 ± 12.1 . They included 19 males / 14 females in TM group, and 74 / 49 in CM group. The Step test (TM / CM) was 9.0 ± 6.2 / 10.4 ± 5.9 preoperatively and improved to 14.0 ± 5.2 / 14.0 ± 5.4 postoperatively. The G&R test (TM / CM) was 20.3 ± 4.8 / 16.3 ± 6.1 before surgery and 21.5 ± 4.0 / 19.3 ± 4.9 after surgery. The average number of Step test and G&R test in 1230 healthy subjects were 19.7 ± 3.4 and 21.5 ± 5.5 .

Conclusions: Both TM and CM patients showed marked decrease preoperatively and postoperative increase in Step test. However CM patients alone demonstrated significant decrease of G&R test before surgery and prominent increase after surgery. The combination of Step test and G&R test are useful to diagnose thoracic myelopathy and cervical myelopathy.

Figure 1

	Step test	G&R test
Cervical myelopathy	9.0 ± 6.2	16.3 ± 6.1
Thracic myelopathy	10.4 ± 5.9	20.3 ± 4.8
Healthy subjects	19.7 ± 3.4	21.5 ± 5.5

O31

Blood-spinal cord barrier disruption in patients with degenerative cervical myelopathy

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Question: Disruption of the blood spinal cord barrier (BSCB) is associated with several acute and neurodegenerative diseases causing secondary injuries to the spinal cord. Aim of this study is to prove the presence of BSCB disruption in patients with degenerative cervical myelopathy (DCM) and give a possible explanation for the onset of secondary injuries.

Methods: Twenty-one patients (mean age 63.3 ± 11.6 years) with DCM were prospectively included. All patients had an indication for neurosurgical decompression. As controls 33 patients (mean age 62.3 ± 15.2 years) with abdominal aortic aneurysm (AAA) and indication for surgery were included. These Patients (AAA) routinely received CSF drainage prior surgery for intraoperative intrathecal pressure monitoring. Samples of CSF and blood serum were taken simultaneously from each participant. All participants underwent neurological examination including mJOA and NDI. Regarding BSCB disruption and intrathecal immunoglobulin (Ig) concentrations the samples were examined for Albumin (mg/dl), IgG (mg/dl), IgA (mg/dl) and IgM (mg/dl). Quotients (CSF/serum) were standardized calculated according to the Reiber diagnostic: QIgG ($n \times 10^{-3}$), QIgA ($n \times 10^{-3}$), QIgM ($n \times 10^{-3}$) and QAlb ($n \times 10^{-3}$) 21. The individual age related references ranges of QAlb for patients and controls were calculated: $QAlb = (4 + age/15) \times 10^{-3}$.

Results: Patients and controls distinguished significantly in their clinical status (mJOA: DCM 10.1 ± 3.1 , AAA 17.6 ± 1.2 , $p=12$) and patients with severe clinical status ($n=14$, mJOA

Conclusions: Patients with DCM seem to have an increased permeability and disruption of the BSCB. The severity of BSCB disruption (QAlb) and the diffusion of Ig are related to the clinical status of the patients. Similar to the acute SCI, BSCB disruption could be the initiation for secondary harm of the spinal cord in DCM. Having documented this particular pathomechanism in patients with DCM for the first time, we suggest that this diagnostic tool cloud be an important addition to surgical decision making in the future.

Question: Cervical roots supply fibers to form brachial plexus and branches to individual peripheral nerves. Thus sometimes we encounter difficulties to distinguish cervical radiculopathy from peripheral nerve neuropathy. The purpose of this study was to retrospectively review cases of cervical radiculopathy that were referred to our hospital that were diagnosed as peripheral neuropathy at the previous hospital.

Methods: Retrospective case series. 878 cases who were referred to our department suspected for peripheral neuropathy from 1999 to 2016. All the patients were examined for their neurological symptoms, physical test, radiographic examination or MRI and underwent electrophysiological study. The patients with normal conduction velocity (NCV) and abnormal cervical MRI findings corresponding to the muscle weakness area were diagnosed as cervical radiculopathy. Finally 39 cases were included in this study. We investigated the diagnosis at previous doctor, clinical symptoms and distribution of the paralyzed muscles in these patients.

Results: Average age was 58 years old. All cases had no neck pain. Distribution of harmed nerve roots were as below, C5:2(5%), C5 and 6:3(8%), C6:5(13%), C7:3(8%), C7 and 8:3(3%), C8:24(62%), T1:1(1%). C8 radiculopathies were most frequently misdiagnosed. The diagnoses at previous doctor were shown. Four axillary nerve paralysis in the C5 or C5, 6 combined radiculopathy, one carpal tunnel syndrome in the C6 radiculopathy, two radial nerve paralysis in C7 radiculopathy, three posterior interosseous nerve palsy, 4 ulnar nerve palsy, 4 cubital tunnel syndromes in C8 radiculopathy. C8 palsy showed various distributions of muscle weakness area. In almost C8 radiculopathy patients, muscle weakness area were presented in two or more peripheral nerve areas.

Conclusions: The most common muscle weakness differences between peripheral neuropathy and C8 radiculopathy was present in the muscles innervated by the radius and the median nerve so a detailed evaluation of the muscle strength is required.

O34

The corticospinal reserve: reversible reorganization of motor area and excitability in degenerative cervical myelopathy

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Question: We have recently shown a compensatory reorganization of the corticospinal network in patients with degenerative cervical myelopathy which led to the concept of the "corticospinal reserve capacity". In patients suffering from mild symptoms (JOA>12) and thus preserved reserve an increased motor area due to a higher recruitment of supplementary motor areas (M2) was observed. We now investigated how the status of the reserve impacts postoperative outcome and whether these compensatory changes are reversible.

Methods: 20 patients with a cervical degenerative myelopathy were examined preoperatively and in a 9 months follow up with navigated transcranial magnetic stimulation (nTMS). Based on the initial JOA score two patient groups were established (JOA<12/>12). We determined the resting motor threshold (RMT), recruitment curve (RC), cortical silent period (CSP) and motor area for the FDI muscle.

Results: The RMT showed no difference in the follow up measurement for both groups (p=.06) Operative decompression led to a reconstitution of motor area size in the severely symptomatic patient group (p=.03). In patients with preoperatively mild symptoms (JOA>12) and preserved corticospinal reserve no significant change in motor area size was detected. However the compensatory increased recruitment of supplementary motor areas and disinhibition diminished after 9 months (M2 area pre/postop p=.02; CSP pre/postop p=.03). Patients who clinically didn't benefit from surgery also didn't present a reconstitution of corticospinal excitability.

Conclusions: Based on these results, we could detect reversible adaptive mechanisms on the cortical and spinal level, i.e. corticospinal reserve capacity. Changes in these nTMS parameters might therefore serve as a valuable pre-and postoperative tool in these patients.

O35

The three sagittal morphotypes that define the normative cervical spine

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Question: The alignment of the c-spine allows for forward gaze and the aim of this study was to describe cervical alignment and how it varies amongst asymptomatic volunteers

Methods: We examined cervical/standing radiographs from adult volunteers. We examined volunteers with a previously published normal limit of chin-brow vertical angle (CBVA). A 2-step cluster analysis was used to find natural groups among volunteers. We performed a post hoc ANOVA analysis for a deeper analysis of the differences between groups

Results: Overall, 84/119 of volunteers met inclusion criteria of CBVA (age: 49.0±17.1 y/d, 73.8% Female, BMI 27.7kg/m²±6.1). We found 3 alignment groups based on cervical curvature and T1S (silhouette measure >0.6). Group 1 was "kyphotic cervical" [KC] spine (N = 27, C2-C7: -8.6°±7.3, T1S: 17.4°±6.6), group 2 was "Medium Curve" [MC] (N = 43, C2-C7: 8.7°±7.3, T1S: 26.6°±4.0), group 3 was "Large Curve" [LC] (N = 14, C2-C7: 21.2°±7.2, T1S: 39.5°±6.4) (all p<0.001). There was a difference in C0-C2 alignment (17.9° for KC, 12.9° for MC, 10.9° for LC, p = 0.019). These cohorts demonstrated a double compensation: change in C2-C7 to compensate for T1S increase to maintain cSVA (cSVA: 31mm vs 25mm vs 26mm p = 0.174) and reciprocal change in C0-C2 to maintain a horizontal gaze (CBVA: 5.7° vs 2.7° vs 4.6° p = 0.066). Examination of vertebra orientation demonstrated that C4 had a constant orientation vs horizontal (C4S: 23.8 vs 21.5 vs 22.5 p = 0.665). Correlation analysis between C2-C7 and vertebra orientations demonstrated C4 orientation is independent of C2-C7

Conclusions: These results show cervical alignment is complex with compensation of cervical curvature and C0-C2 for differences in T1S. C4 is constant in terms of orientation and may be the center of rotation of the cervical spine

O36

Complications following cervical spine surgery in patients with Parkinson's disease – an analysis of 21 patients.

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Question: Spinal surgery in Parkinson's disease (PD) is challenging with high complication rates reported. The aim of this study is to evaluate outcome and complications occurring in cervical spinal surgery in patients with PD.

Methods: Analysis of prospectively collected data of all patients with PD undergoing cervical spine surgery between 1999 and 2018; evaluation of epidemiological, clinical and outcome data as well as complications.

Results: Five female and 16 male patients with PD for 8.3 ± 7.2 years (median Hoehn & Yahr stage: 3) were identified. The \bar{x} age was 71.8 (range 56-83) years; predominant indication for surgery was myelopathy in 9 and radiculopathy in 6 cases. In 10 patients index surgery was performed from anterior and in 9 patients primarily from posterior. In 2 cases an anterior-posterior approach was necessary. 3.2 ± 2.7 (range 1-12) levels were fused. Construct failure in 3 patients led to 6 revisions. Postoperative weaning failure necessitated tracheostomy in 5 cases. Dysphagia in 5 patients required a PEG in 4 cases (of which one was treated by posterior approach only). One patient suffered from esophageal injury. SSI occurred in 2 cases which resulted in multiple revisions in one patient. Overall, 8 patients (38%) needed reoperation after index surgery. Pneumonia complicated the outcome in 4 cases. Mean hospital stay was prolonged in comparison to other patient population with 34 ± 22 (range 3-71) days. At the time of last FU (mean 22.5 ± 28.4 , range 1-113 month) 7 patients showed improved neurology while in 1 case deterioration was detected.

Conclusions: Beside increased risk for construct failure after cervical spine surgery in patients with PD the surgeon should be aware and the patient informed of possible deterioration of disease related dysphagia, even after posterior-only approach, and prolonged hospital stay due to weaning failure, pneumonia and SSI with overall increased rate of revision surgeries. In contrast neurologic improvement can be achieved in the majority of patients.

O37

A comparison of cervical disc arthroplasty and anterior cervical discectomy and fusion in patients with two-level cervical degenerative disc disease: 5-year follow-up results

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Question: Present the long-term clinical and radiographic comparison between the Prestige-LP cervical disc replacement and the Zero-p spacer cervical disc fusion in treatment of patients with symptomatic two-level cervical degenerative disease.

Methods: 36 patients in the ACDF group and 24 patients in the CDA group were analyzed before surgery and at 1 week, 3, 6, 12, 24 and 60 months after surgery. Clinical assessments included JOA, VAS, and NDI scores. Radiographic assessments included CL, ROM of the total cervical spine, FSU, superior and inferior adjacent segments. Complications including HO and ASD at 5-year follow-up were collected as well.

Results: Mean follow-up period was 65.6 months. Both ACDF and CDA groups showed significant clinical improvements in terms of JOA, VAS and NDI ($P < .05$), but there was no significant difference between groups at the last follow-up period. A significant increase of cervical lordosis (CL) was observed in the CDA group after surgery while significant difference was not observed between groups. ROM of the total cervical spine and FSU were maintained during the follow-up and significant decrease was observed in ACDF group after surgery ($P < .05$). The ROM of the superior adjacent segment did not show any difference while the ROM of the inferior adjacent segment in the ACDF group was observed a significant increase at 6 months and 1 year after surgery and a significant decrease at the last follow-up period. A total of 8 (33.3%) patients in the CDA group were observed an occurrence of HO. ASD was observed in 2 (8.3%) patients underwent CDA surgery and 8 (22.2%) patients underwent ACDF surgery.

Conclusions: Both the use of the Prestige-LP and Zero-P spacer implantations are safe and effective. At 5 years after surgery, CDA with Prestige-LP is superior in terms of ROM of the total cervical spine, FSU and inferior adjacent segment. It also has a relatively low ASD occurrence rate. This procedure may be a suitable choice for the treatment of contiguous two-level CDDD.

Figure 1

Variable	ACDF Group (N = 36)	CDA Group (N = 24)	P*
Age, years			
Mean ± SD	58.6 ± 9.5	54.7 ± 6.6	0.094
Sex, n			
Male	22	15	0.914
Female	14	9	
Height, cm			
Mean ± SD	161.9 ± 7.4	163.8 ± 8.5	0.400
Weight, kg			
Mean ± SD	61.1 ± 10.0	64.8 ± 10.5	0.245
Clinical diagnosis, n			
Radiculopathy	26	15	0.428
Myelopathy	10	9	
Level implanted, n			
C3–4–5	4		0.141
C4–5–6	17	16	
C5–6–7	15	8	
Blood loss, mL			
Mean ± SD	91.1 ± 105.2	77.8 ± 63.6	0.613

ACDF, anterior cervical discectomy and fusion; CDA, cervical disc arthroplasty; SD, standard deviation.
 *For contiguous variable, P values are from analysis of variance or Mann–Whitney U test and for categorical variables, they are from χ^2 analysis.

Figure 2

	ACDF (N=36)	CDA (N = 24)	P*
VAS scores			
Preoperative	5.6 ± 3.5	4.8 ± 3.4	0.133
Last follow-up	2.4 ± 2.6	1.9 ± 2.0	0.515
P†	<0.001	0.016	
JOA scores			
Preoperative	9.5 ± 3.6	10.1 ± 2.7	0.419
Last follow-up	16.0 ± 1.3	14.9 ± 2.4	0.728
P†	<0.001	0.006	
NDI scores			
Preoperative	32.3 ± 17.5	26.3 ± 11.8	0.677
Last follow-up	10.1 ± 7.8	9.6 ± 6.3	0.832
P†	<0.001	<0.001	

ACDF, anterior cervical discectomy and fusion; CDA, cervical disc arthroplasty; VAS, visual analogue scale; JOA, Japanese Orthopaedic Association; NDI, Neck Disability Index.
 *Mann–Whitney U test.
 †Paired t test.

Figure 3

	Preoperative	1 Week	3 Months	6 Months	1 Year	2 Year	Last Follow-up
CL							
ACDF	9.6 ± 14.8	12.5 ± 8.4	11.5 ± 9.5	11.2 ± 10.2	11.7 ± 10.4	10.4 ± 12.5	10.0 ± 9.6
CDA	7.5 ± 10.2	12.9 ± 12.2*	11.9 ± 12.4*	11.4 ± 11.7*	12.5 ± 8.7*	11.2 ± 10.2*	10.7 ± 10.4*
P†	0.567	0.830	0.931	0.828	0.874	0.362	0.243
ROM of C2–C7							
ACDF	44.1 ± 13.8		31.1 ± 8.6*	34.2 ± 7.7*	32.7 ± 9.1*	31.5 ± 10.5*	28.1 ± 11.8*
CDA	51.1 ± 14.2		41.8 ± 13.0*	44.8 ± 13.9	45.8 ± 15.3	46.9 ± 12.3	46.5 ± 13.3
P†	0.110	28.5 ± 16.4*	<0.001	0.009	0.003	<0.001	<0.001
ROM of FSU							
ACDF	22.4 ± 7.1		3.2 ± 2.6*	4.1 ± 3.1*	4.0 ± 2.8*	3.9 ± 2.2*	3.4 ± 2.7*
CDA	26.5 ± 10.3		17.7 ± 7.5*	19.4 ± 9.3*	20.6 ± 10.4	19.7 ± 8.6	20.1 ± 7.5
P†	0.097	12.5 ± 7.5*	<0.001	<0.001	<0.001	<0.001	<0.001
ROM of superior adjacent segment							
ACDF	10.4 ± 6.1		8.1 ± 5.2	8.2 ± 5.6	8.4 ± 3.3	10.4 ± 6.0	9.8 ± 5.8
CDA	10.7 ± 5.0		8.0 ± 4.7	10.8 ± 5.3	10.1 ± 4.5	9.0 ± 5.0	8.8 ± 3.8
P†	0.905	4.7 ± 3.1*	0.921	0.167	0.436	0.445	0.630
ROM of inferior adjacent segment							
ACDF	7.2 ± 3.6		7.8 ± 4.6	8.8 ± 2.9*	9.0 ± 1.9*	6.2 ± 2.5	5.3 ± 3.5*
CDA	8.4 ± 3.2		9.8 ± 2.4	10.2 ± 2.9	10.0 ± 3.0	10.4 ± 3.8	9.4 ± 3.8
P†	0.359	5.1 ± 3.3*	0.279	0.450	0.627	0.033	0.016

CL, cervical lordosis; ACDF, anterior cervical discectomy and fusion; CDA, cervical disc arthroplasty; ROM, range of motion; FSU, functional spinal unit.
 *Significant different from preoperative parameter analyzed by paired t tests.
 †Mann–Whitney U test.

Figure 4

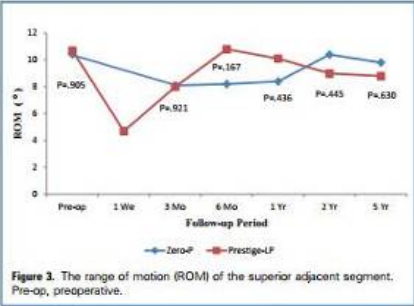
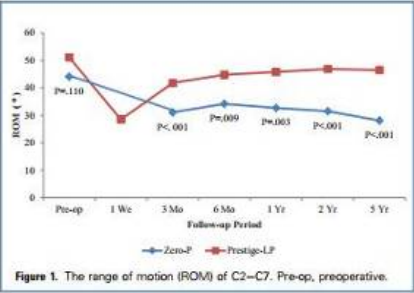


Figure 5

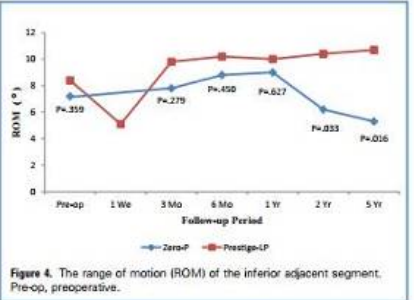
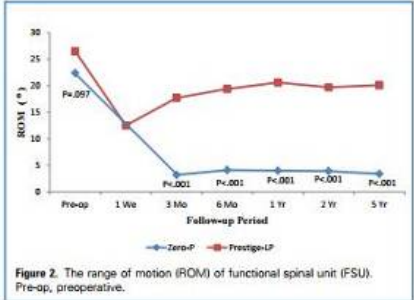
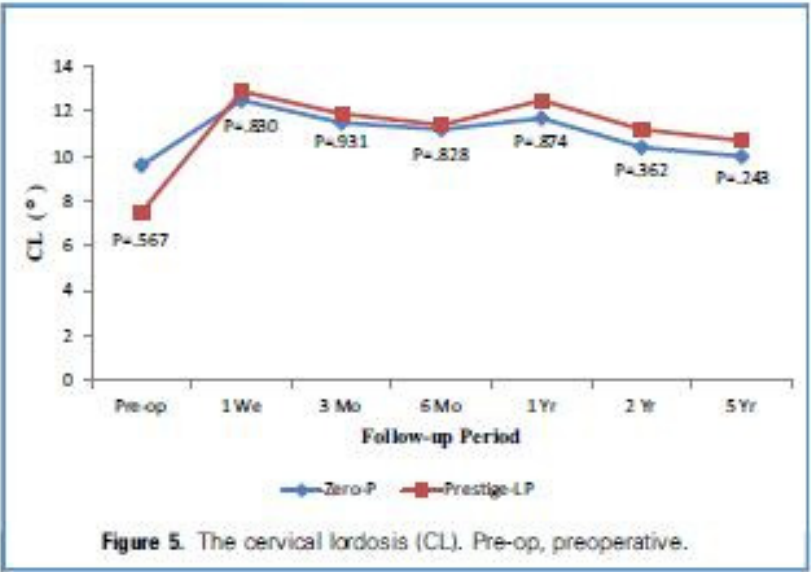


Figure 6



O38

Cervical and spinal sagittal alignment deviation in the general elderly population: A Japanese cohort survey randomly sampled from a basic resident registry

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Question: There are presently no clear benchmarks for such values or those for the cervical spine in the general population. Quality epidemiological studies are needed to establish standards for spinal alignment deviation. In this study of an aged Japanese population, we employed random sampling from the basic resident registry of a rural town for subject selection to determine reference values of sagittal spinal alignment including the cervical spine.

Methods: We established 8 groups based on age (50's, 60's, 70's, and 80's) and gender after random sampling from the resident registry. A total of 413 people were enrolled. Radiographic parameters of sagittal spinal alignment of the cohort were measured and analyzed. Comparisons between age groups on the basis of 50's age group reference values were performed using multiple comparisons based on the Dunnett test.

Results: Each spinal alignment parameter stratified by age and gender was presented. Global spinal alignments became more misaligned with age for both genders. Sagittal vertical axis (SVA) forward shift was significantly more frequent in 80's males and 70's females, and SVA in 80's females was a mean of 66 mm forward of that of 50's females. Forward movement of the cervical spine was especially prominent in men. Cervical protrusion was markedly greater in 60's males onwards. C2-7 SVA was large at all ages in males, and T1 slope increased from their 60's. In women, lumbar lordosis and posterior pelvic inclination were noticeable from a younger age than in men. The amount of pelvic tilt misalignment in female subjects was approximately 10 years earlier than their male counterparts.

Conclusions: This first resident cohort of Japanese individuals determined average spinal alignment parameters by age and gender. Spinal balance generally shifts forward as age increases. A forward shift in the upper cervical spine occurs first in men, while lumbopelvic alignment shift occurs first in women.

O39

The clinical relevance of the cervical disc prosthesis: combining clinical results of two RCTs

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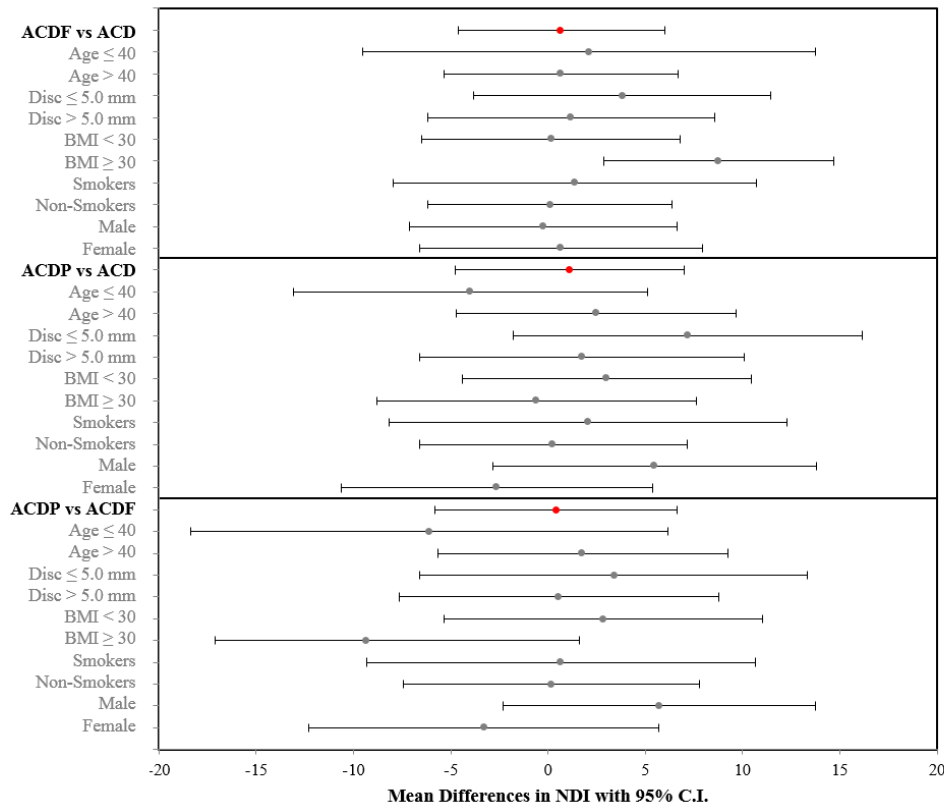
Question: Is ACDA clinically superior to either ACDF or ACD in the entire group of patients or in a particular subgroup of patients?

Methods: Individual patient data of two prospective, double-blind, randomised clinical trials were combined. Both trials were independently conducted in University Medical Centers in the Netherlands. Participants were randomly assigned to receive anterior cervical discectomy either followed by placing a prosthesis (ACDA), placing a cage (ACDF) or placing nothing (ACD) in the intervertebral space after the cervical disc space was cleared out. The individual patient data from 109 (X trial) and 142 (X trial) patients were combined: allocating 83 patients to ACD, 83 patients to ACDF and 85 patients to ACDA. Both trials included patients with radicular signs and symptoms in one or both arms due to a single level cervical disc herniation with or without an osteophyte. Data was available on 159 patients after two-year follow-up. Neck Disability Index, SF36 and McGill pain score were evaluated during two years post-operatively. A pre-specified subgroup analysis was performed for age, disc height, BMI, smoking and gender; according to the X trial protocol.

Results: The NDI decreased comparably in all treatment arms to circa 50% of baseline value and mean NDI differences varied from 0.4 to 1.1 on a 100 point NDI scale, with confidence intervals never exceeding the 20-point Minimal Clinical Important Difference (MCID). Secondary outcome parameters were comparable too. Subgroup analysis could not demonstrate clinically relevant differences in NDI between treatments after two years.

Conclusions: Combining data of RCTs provides sufficient statistical power to conclude that a difference in clinical outcome between the three groups is absent. Neither is there evidence that a specific subset of patients based on age, BMI, smoking, gender or preoperative disc height of the involved level would benefit more from one of the treatment strategies.

Figure 1



O40

Is C1/2 fusion required for all patients with Chiari I Malformation or basilar invagination?

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Question: C1/2 fusion has been proposed as standard treatment for Chiari I Malformation (CMI) and basilar invagination (BI). The alignment of C1/2 facettes and the clivus canal angle (CCA) before and after surgery were analyzed as parameters for C1/2 stability and craniocervical sagittal balance.

Methods: All spinal malformations have been entered into a spinal cord register since 1991. The CCA and C1/2 facettes were analyzed in 391 patients with CMI and/or BI. Postoperative results were determined after 3 months and progression-free survival rates calculated with Kaplan-Meier statistics.

Results: In 291 patients with CMI without BI, the CCA was in the normal range ($143 \pm 11^\circ$) in contrast to 12 patients with BI without CMI ($122 \pm 12^\circ$) and 88 patients with CMI+BI ($120 \pm 15^\circ$; $p < 0.0001$). The C1/2 facettes were in normal alignment in 94% in CMI without BI, 58% in BI without CMI and 36% in CMI+BI ($p < 0.0001$). Anterior subluxations of the C1 facette occurred in BI with ventral medullary compression only, posterior subluxations in all groups. In CMI without BI ($n=132$) and CMI+BI without ventral compression ($n=29$) posterior decompressions without fusion left the CCA unchanged ($-0.4 \pm 3^\circ$ and $-0.1 \pm 5^\circ$, respectively) irrespective of facette orientation. In BI with ventral compression ($n=36$) decompressions with realignment and fusion increased the CCA from $113 \pm 16^\circ$ by $6 \pm 7^\circ$ on average. Clinical results after 3 months (improved status for 77% in CMI without BI, 86% with CMI+BI after decompression, 79% with BI after decompression plus fusion) and progression-free survival rates for 10 years (91% for CMI without BI, 77% for CMI+BI after decompression and 84% for BI after decompression plus fusion) showed no significant differences.

Conclusions: Patients with CMI without BI and BI without ventral compression do not require C1/2 fusion and can be managed by posterior decompression alone without compromising sagittal balance. Patients with BI and ventral compression should undergo posterior decompression, realignment and fusion.

O41

Does a disruption of the C2 extensor muscle insertions affect post-operative cervical alignment in cervical laminoplasty?

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Question: It has been reported that post-operative loss of cervical lordosis correlated with poor outcomes in cervical laminoplasty (CLP). The aim of this study was to evaluate a connection between a disruption of the C2 extensor muscle insertions and post-operative alignment changes of the cervical spine in CLP.

Methods: A total of 60 patients, who underwent CLP (C3-6 or C4-6) for cervical myelopathy and could be followed for minimum 1 year after surgery, were reviewed. The C2 extensor muscle insertions were dissected and reconstructed in C3-6 CLP and were completely preserved in C4-6 CLP. The patients were distributed into two groups as follows; C3-6 CLP:32 patients (group D) and C4-6 CLP:28 patients (group P). We conducted a comparative study on the changes of sagittal alignment following each CLP between the two groups. Several radiographic parameters were measured on standing lateral radiographs before surgery and at 1-year FU. In a statistical analysis, t-test and Mann-Whitney U test were used.

Results: There were no significant differences between the two groups on baseline data, such as age, gender, ASA-PS grade, BMI and all of radiographic parameters. At 1-year FU, C2 tilt indicated a significant difference ($p=0.028$) between the two groups and the other parameters demonstrated no significant differences. In group D, C2 tilt increased from 11.9 ± 7.2 to 15.3 ± 8.6 , C2-7 Cobb's angle decreased from 15.4 ± 9.8 to 11.3 ± 10.6 and C2-7 SVA increased from 27.8 ± 14.5 to 31.9 ± 15.3 with statistical differences ($p=0.005$, 0.001 , and 0.007 , respectively) after surgery. Meanwhile, the group P showed no significant changes on the cervical alignment following surgery.

Conclusions: We found that the disruption of C2 extensor muscle insertions might cause a slight increase of the C2 anteversion and consequently lead to loss of cervical lordosis after CLP. We suggest that the most cephalad laminoplasty level should be the C4 rather than the C3 to preserve the C2 extensor muscle insertions in CLP.

O42

The impact of cervical sagittal imbalance on laminoplasty indicated to patients with cervical myelopathy

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Question: Recently, some authors have used a regional definition of "cervical SVA (C2-7 SVA)". However, it is unclear whether the sagittal cervical imbalance that is designated by C2-7 SVA impacts both the clinical status and the surgical outcomes of cervical degenerative diseases including cervical myelopathy. The purpose of this study was to evaluate the influence of C2-7 SVA on laminoplasty for cervical myelopathy.

Methods: Patients with cervical myelopathy ($n = 110$; 39 women, 71 men; mean age, 66.8 years; the follow-up, 2 years) who underwent laminoplasty were included in this study. The relationship between cervical sagittal parameters, including C2-7 SVA, and clinical status was evaluated. The changes in radiographic cervical alignment parameters and clinical status 2 years after surgery were compared between patients with sagittal cervical imbalance (defined as C2-7 SVA ≥ 35 mm; group A, $n = 14$) and those without (group B, $n = 96$). Their clinical status by using the JOA score, the JOACMEQ, the visual analog scale for neck pain and shoulder stiffness, and the SF-36.

Results: Preoperatively, the mean C2-7 SVA of all patients was 19.9 mm. C2-7 SVA significantly correlated with C2-7 angle, T1 slope, and thoracic kyphosis, but did not with lumbar and pelvic sagittal parameters (Table 1). C2-7 SVA did not correlate with defined health-related quality of life evaluation scores (VAS, JOACMEQ, and SF-36). Postoperatively, SF-36 PCS and VAS for neck pain got worse in group A (Table 2). Concerning cervical imbalance, the postoperative change of C2-7 SVA did not significantly differ in 2 groups. Patients with a large C2-7 SVA maintained cervical alignment after laminoplasty but experienced severe postoperative neck pain.

Conclusions: Our patients with cervical imbalance experienced severe postoperative neck pain (axial pain) even though cervical alignment was maintained after laminoplasty. Laminoplasty alone was not suitable for patients with sagittal cervical imbalance.

Figure 1

Table 1. Relationship among the preoperative sagittal alignment parameters

	C2-7 SVA	CL	T1 slope	TK	LL	SS	SVA	PI
C2-7 SVA (mm)	x	-0.28*	0.51*	0.40*	0.07	0.05	0.08	-0.10
CL (°)		x	0.41*	0.32*	-0.18	-0.19	0.11	-0.01
T1 slope (°)			x	0.74*	-0.07	-0.10	0.27	-0.08
TK (°)				x	0.43*	0.02	-0.19*	-0.08
LL (°)					x	0.66*	-0.49*	0.18*
SS (°)						x	-0.08	0.34*
SVA (mm)							x	0.03
PI (°)								x

Value means Pearson correlation coefficient. x = empty space crossing the same parameter on the table. C2-7 SVA = C2-7 sagittal vertical axis, CL = cervical lordosis, TK = thoracic kyphosis, LL = lumbar lordosis, SS = sacral slope, SVA = sagittal vertical axis, PI = pelvic incidence.

* Statistically significant values ($p<0.05$).

Figure 2

Table 2. Change in clinical status/HRQOL in patients after laminoplasty

	Group A (14 cases)			Group B (96 cases)			p value
	Pre-op.	Post-op.	Δ	Pre-op.	Post-op.	Δ	
JOA score (point)	9.1 \pm 1.7	12.8 \pm 1.8	47.3#	8.4 \pm 2.5	12.9 \pm 2.3	53.8#	0.09
VAS for neck pain (mm)	19.9 \pm 23.2	36.1 \pm 28.9	16.2	28.4 \pm 29.5	34.5 \pm 27.3	6.1	0.07
VAS for shoulder stiffness (mm)	26.3 \pm 30.1	34.5 \pm 38.5	12.9	36.4 \pm 31.6	42.6 \pm 29.6	6.1	0.35
JOACMEQ (point)							
cervical spine function	60.9 \pm 34.6	56 \pm 33.4	-4.9	60 \pm 29.5	65.7 \pm 24.1	5.7	$p<0.05$
upper extremity function	75.6 \pm 9.5	74.4 \pm 23.5	-1.2	66.6 \pm 24.1	73.6 \pm 22	7	0.18
lower extremity function	62.4 \pm 24.1	63.5 \pm 24.6	1.2	52.3 \pm 31.3	60.5 \pm 27.9	8.2	0.11
bladder function	79 \pm 16.9	74.8 \pm 20.3	-4.2	66.9 \pm 23.7	72.5 \pm 21	5.6	0.26
Quality of life	40.9 \pm 16.3	48.1 \pm 21.2	7.2	38 \pm 17.6	45.3 \pm 19.5	7.3	0.98
SF-36 (point)							
PCS score	26.3 \pm 13.9	24.8 \pm 17.1	-1.5	19.4 \pm 17.1	26 \pm 18	6.6	$p<0.05$
MCS score	47.2 \pm 9.4	47.9 \pm 9.7	0.7	44.6 \pm 11.2	47.3 \pm 9.7	2.7	0.58
physical functioning	29 \pm 17.2	28.5 \pm 21.9	-0.5	21.7 \pm 19.4	27.2 \pm 18	5.5	0.24
bodily pain	40.6 \pm 11.6	38.3 \pm 10.5	-2.3	34.7 \pm 10	37.9 \pm 10.5	3.2	0.12

JOA score = Japanese Orthopaedic Association score, VAS = visual analog scale, JOACMEQ = the JOA Cervical Myelopathy Evaluation Questionnaire, SF-36 = short form-36, PCS = physical component summary, MCS = mental component summary.

Δ = postoperative parameter value – preoperative parameter value.

#. Value means the recovery ratio (%) calculated using Hirabayashi's method.

p value reflects the significance of the differences in postoperative change of parameter value (Δ) between groups A and B.

O43

The impact of the multifidus muscle swelling on C5 palsy after cervical laminoplasty

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Question: Cervical posterior decompression surgery is an established technique that yields good clinical outcomes, but the risk of C5 palsy (C5P) after surgery has not yet been resolved. Previous studies have reported that lateral stretching and postoperative swelling of multifidus muscles may cause stretching of medial branches and cervical nerves. The present study aimed to identify the effects of posterior neck muscle swelling on C5P by evaluating early postoperative MRI.

Methods: 218 consecutive C5 nerve roots from 109 patients who underwent laminoplasty were examined. We reviewed the demographics, surgical data, X-ray images, and MRI images of each patient, including the axial cross-sectional area (CSA) of posterior neck muscles. The 109 patients and 218 nerve roots were divided into C5P and non-C5P groups. Each parameter and its changes were compared between the two groups, examining correlations with C5P.

Results: In the demographics analysis, existence of OPLL, history of smoking, DM, and preoperative JOA scores were not significantly different between the C5P and non-C5P groups. Only BMI was higher in the C5P group. In terms of surgical and imaging data, numbers of laminoplasty, operating time, laminectomy trough width, accomplishment of C4/5 foraminotomy, C2–C7 Cobb angle, preoperative spinal cord rotation, and posterior shift of the spinal cord were not significantly different in the two groups. Only the multifidus CSA change ratio was significantly higher in the C5P group. Multiple logistic regression analyses revealed that the multifidus CSA change ratio and BMI were significant independent factors.

Conclusions: Our results indicate that multifidus swelling is associated with C5P through traction of the C5 nerve via medial branches of the cervical dorsal rami. The medial branch is the shortest of the dorsal rami and may have the largest effect by traction force. Therefore, a gentle procedure for deep posterior muscles during surgery is a potential countermeasure for the prevention of C5P.

Question: Cervical degenerative disc disease (CDDD) at two noncontiguous is a special type of multilevel CDDD. No study has examined biomechanical differences between anterior cervical discectomy and fusion (ACDF) and hybrid surgery (HS) constructs for noncontiguous CDDD. Differences in the biomechanical changes between the intermediate and adjacent segments are unknown.

Methods: A finite element model of a healthy cervical spine (C2-7) was constructed. Three surgical models were developed: (1) skip-level ACDF at C3/4 and C5/6 (FF), (2) ACDF at C3/4 and cervical disc arthroplasty (CDA) at C5/6 (FA) and (3) CDA at C3/4 and ACDF at C5/6 (AF). A 75N follower load with 1.0N·m moment was applied to the top of the C2 vertebra in the intact model to simulate flexion, extension, lateral bending and axial rotation. Surgical models achieved identical motion angles of the intact model in each direction.

Results: The FF model required much higher moments than did the two HS models. In the FF model, the motion contributions of the unfused segments were unevenly increased. The magnitude of the increased motion, facet contact force (FCF) and intradiscal pressure (IDP) in the intermediate segment was larger than those in the supra-or infra-adjacent segments. In the FA and AF models, the motion contributions of the untreated levels were evenly changed, and the intermediate segment did not experience additive motion, FCF or IDP. The segment adjacent to the level of ACDF had greater FCF and IDP than did the segment adjacent to the level of CDA in the two HS constructs.

Conclusions: ACDF at two noncontiguous levels substantially alters kinematics, FCF and IDP at the unfused levels, and the intermediate segments exhibit additive motion and forces. HS constructs resulted in less altered biomechanics and kinematics of the untreated levels and showed no additive biomechanical effects on the intermediate segments. However, the effects were associated with the relative location of the ACDF and CDA levels

Figure 1

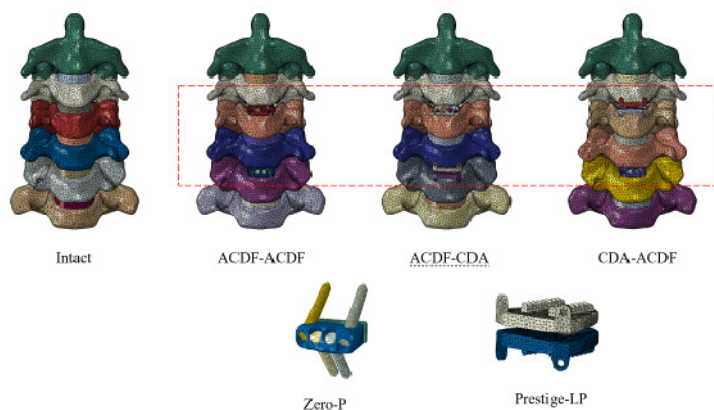


Figure 2

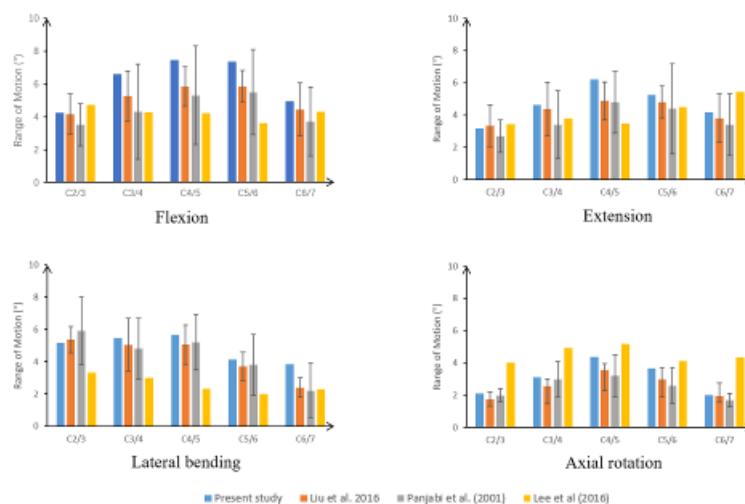


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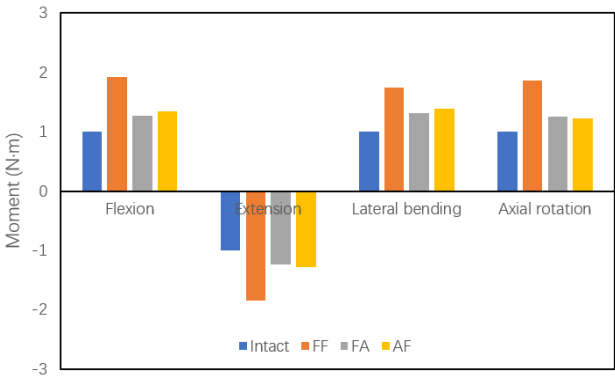


Figure 4

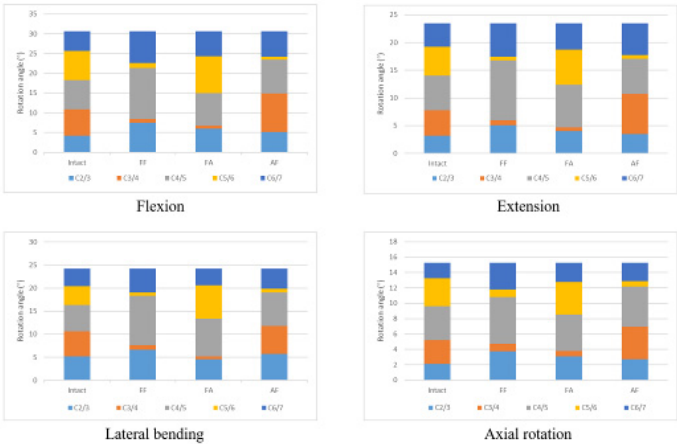


Figure 5

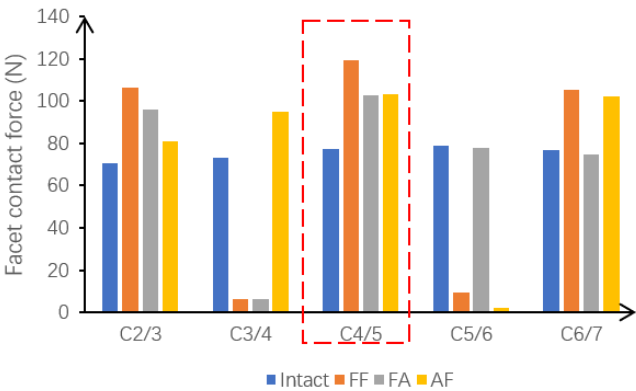
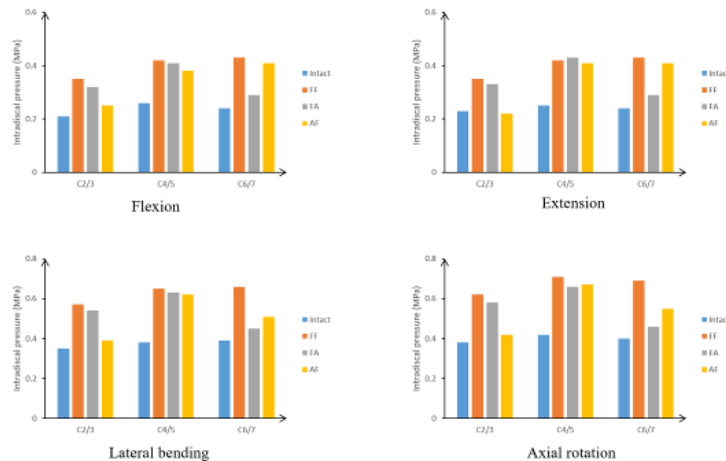


Figure 6



O45

The characteristic of cervical sagittal alignment in patients with chronic low back pain

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Question: Difference in postural control has been identified between people with and without chronic low back pain (CLBP). This difference may affect cervical lesion. However, cervical alignment in patients with chronic low back pain has not been previously described. The purpose of this study was to describe cervical alignment and cervical deformity in patients with CLBP.

Methods: Of the patients who visited an orthopedic clinic due to low back pain lasting more than 3 months, 127 cases [average 71 years old (49 - 91), 48 male and 79 female] who had whole standing spinal screening radiographs were evaluated. (CLBP group) Cervical parameters evaluated included cervical lordosis (CL), C2-C7 sagittal vertical axis (C2-7 SVA), and the T1 slope (T1S) minus the CL (T1S-CL). Cervical deformity was defined as C2-C7 SVA >4 cm, CL<0°, or T1S-CL > 15°. We compared the cervical alignment and prevalence of cervical deformity with that of 127 age and gender matched healthy volunteers (HV group) (average 71 years old (50- 91), 48 male 79 female).

Results: The prevalence of cervical deformity was significantly lower in CLBP group than in HV group (26.4% vs. 74.0%, $P < 0.01$). The mean pelvic incidence was 47.2° vs. 49.1° in CLBP group and HV group, respectively ($P = 0.130$). The mean cervical lordosis was larger in CLBP group than in HV group (16.2° vs. 12.0°, $P = 0.004$). The mean C2-7 SVA was smaller in CLBP group than in HV group (17.6 mm vs. 25.0 mm, $P < 0.001$). The mean T1 slope minus cervical lordosis was smaller in CLBP group than in HV group (9.1° vs. 19.8°, $P < 0.001$). The mean EQ-5D was smaller in LBP than in HV (0.73 vs. 0.83, $P < 0.001$).

Conclusions: This study results suggest that patient with CLBP present better cervical sagittal alignment and lower prevalence of cervical deformity than age and gender matched healthy volunteers, which means that CLBP at least doesn't impact on cervical lesion negatively.

O46

Anterior cervical corpectomy and reconstruction using titanium implants in the surgical treatment of cervical spondylodiscitis: Long term results

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Question: Spinal infections account for 1-7% of pyogenic osteomyelitis. with bony destruction, corpectomy is unavoidable. The use of cages in the presence of infection is still raising the concerns of many surgeons. we evaluated the treatment of cervical spondylodiscitis by means of anterior cervical corpectomy and reconstruction using titanium implants

Methods: A retrospective analysis of data between 1994 and 2015 in our department revealed 42 patients with cervical spondylodiscitis treated by cervical corpectomy and reconstruction using titanium implants. The clinical, laboratory and radiological parameters were analysed preoperatively, postoperatively and for a minimum of two years after surgery

Results: There were 20 females and 22 males with a mean age of 72 years. 23 patients had preoperative neurological deficit. One level corpectomy was done in 24, two levels in 15 and three levels in 3 patients. 17 patients had epidural abscess, five patients had an accompanying lumbar infection. The mean operative time was 187 minutes and the mean blood loss was 450 ml. In 20 patients a stand-alone implant was used and in 22 posterior fixations was added. Followed up was for a mean of 38 months. Mean VAS improved from 8 pre- to 3 postoperatively, and the mean NDI from 18 to 10. The mean CRP improved from a mean of 96 preoperatively to a mean of 20 two weeks after. Cervical lordosis improved from 1.3° preoperatively to 6° (p=0.02). Fusion was achieved in 38 patients. In 4 patients, asymptomatic pseudo-arthritis was documented. A single patient had persisting infection around the implant and underwent cage removal. Reoperation in 2 patients due to hematoma, and oesophageal injury

Conclusions: Anterior corpectomy and reconstruction using titanium implants is safe in the treatment of cervical spondylodiscitis with low rate of infection recurrence. Restoration of the sagittal profile and fusion can be successfully achieved. If the implant design permits and with good bone quality, additional fixation could be spared

O47

Feasibility of the far lateral suboccipital approach to the retroodontoid region: How much bone removal is needed?

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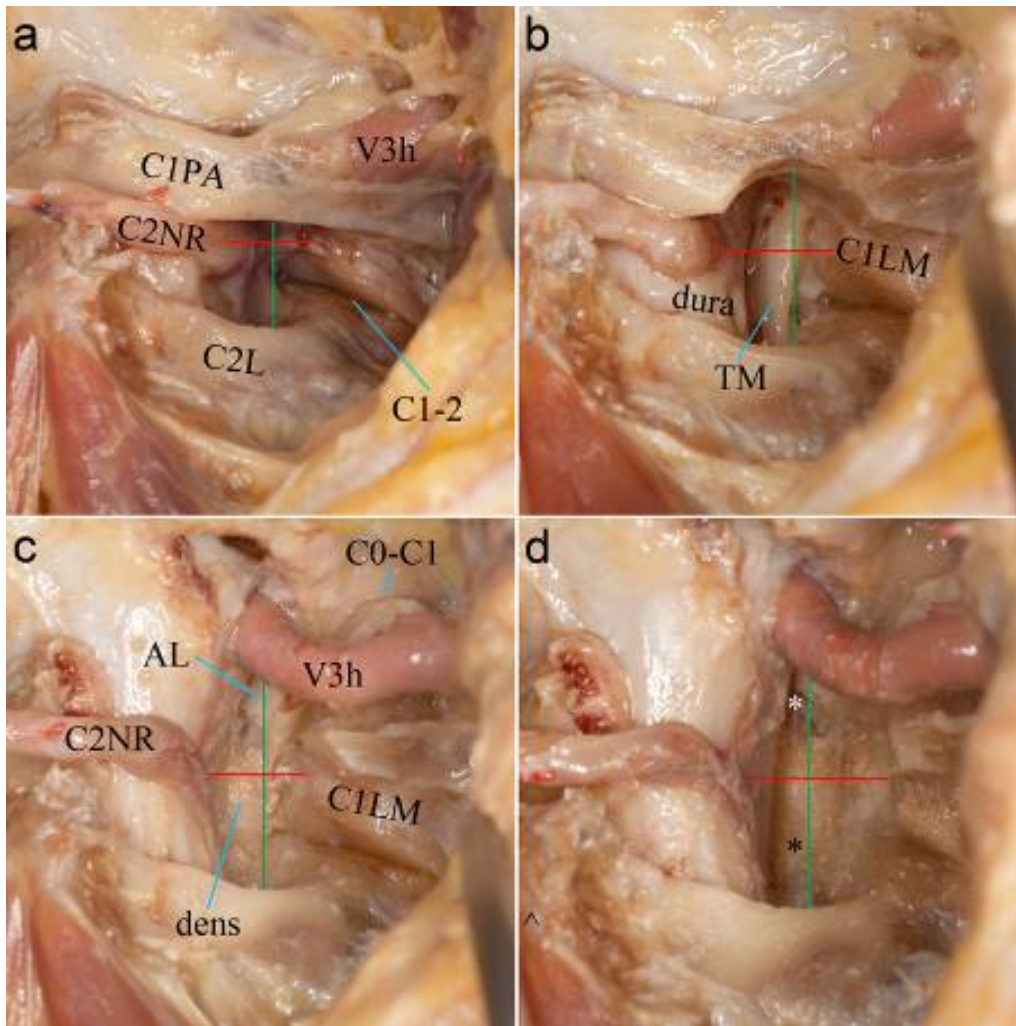
Question: The posterolateral extradural suboccipital approach can be used to reach the anterior epidural space and the retroodontoid regions. The extent of necessary bone removal was not yet studied. We examined the changes of the horizontal and vertical surgical windows using successive bone removal of the atlas during this approach.

Methods: This anatomical study was done bilaterally on 5 Thiel-fixed human cadavers (mean age 83,7 years, range 74-94 yrs). Vertebral arteries were filled with colored silicon. After a wide posterolateral suboccipital approach, the C2 nerve root was identified and sacrificed to gain access to the epidural region in all specimens. Our goal was to reach the epidural space and to dissect the dens free of soft tissues from its base to its tip. We measured the surgical window with a) intact C1 posterior arch, b) after a dome formed laminotomy of C1, c) after resection of the unilateral hemiarch of C1, and d) finally after drilling 3mm of the medial aspect of the lateral mass of C1. Steps of the bone removal are shown on Fig.1.

Results: Intact spines were characterized by a very narrow surgical window of $6,3 \pm 2,1$ mm x $9,7 \pm 1,5$ mm (horizontal x vertical window) as per the area formed by the dura to C1-lateral mass and C2-lamina to C1-arch distances. The vertical window increased to a $13,0 \pm 1,2$ mm in case of laminotomy and to $17,3 \pm 1,1$ mm in case of removal of the ipsilateral C1-posterior arch. Bone removal from the medial aspect of the C1-lateral mass increased horizontal surgical window to $10,3 \pm 0,5$ mm. The final size of the surgical window was $10,3 \pm 0,5$ mm x $17,3 \pm 1,1$ mm (horizontal x vertical window).

Conclusions: The surgical window could be increased significantly through bone removal of the atlas vertebra. If only the anterior epidural space or the base of the dens needs to be reached, the dome formed laminotomy allows for an adequate surgical window. The tip of the dens could only be reached if the ipsilateral posterior arch is resected.

Figure 1



O48

Risk factor of surgical site infection (SSI) in cervical spine surgery – importance of perioperative hygienic status

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Question: Surgical site infection (SSI) after cervical spine surgery can result in increased morbidity and mortality. Since patient factors as well as surgical invasion associate with the incidence of SSI, the risk factors should be investigated exhaustively. This study aimed to investigate the risk factors of surgical SSI in cervical spine surgery in both "patient" and "surgery" aspects.

Methods: A total of 388 cases (258 males and 130 females, mean 67.1 y.o.) who underwent cervical spine surgery from 2015 to 2017 was reviewed. The incidence of SSI within 6 months after surgery and the risk factor of the SSI were investigated from the aspect of "patient" and "surgery".

Results: SSI occurred in 4 cases (3 males and a female, mean 53.8 y.o.). The incidence of SSI was higher in the "patients" with BMI of 30 or more (2/23 cases: 8.7%, control: 0.56%), requiring assistance for daily activity preoperatively (2/58: 3.4%, cont.: 0.6%), cerebral palsy (1/8: 12.5%, cont.: 0.79%), psychological disorder (1/13: 7.7%, cont.: 0.80%), serum level of albumin 3.5mg/dl or less before surgery (2/38: 5.3%, cont.: 0.57%) and 3.0mg/dl or less after surgery (3/90: 3.3%, cont.: 0.34%). In addition, SSI was observed more frequently in the "surgery" with instrumentation (3/114: 2.6%, cont.: 0.37%), 6 or more vertebral levels involved (3/99: 3.0%, cont.: 0.35%), taking more than 180 minutes (4/110: 3.6%, cont.: 0%).

Conclusions: The results of this study demonstrated that obesity (BMI \geq 30), cerebral palsy and psychological disorder increased the incidence of SSI after cervical spine surgery besides nutritional status or surgical invasion. These patients had difficulty in keeping their surgical site clean by themselves, and which can that could be considered as a risk factor of SSI. Therefore, perioperative hygienic status should be tightly taken care around the surgery for cervical spine.

Patterns of short-term and long-term surgical outcomes and prognostic factors for cervical ossification of the posterior longitudinal ligament between anterior cervical corpectomy and fusion and posterior laminoplasty

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Question: During short-term follow-up period, surgical outcomes for cervical ossification of the posterior longitudinal ligament (OPLL) between anterior cervical corpectomy and fusion (ACCF) and laminoplasty (LP) were similar. However, there were several reports that long-term surgical outcomes were superior in the ACCF compared with LP. Therefore the objective of this study is to compare short-term and long-term surgical outcome patterns between ACCF and LP in patients diagnosed with cervical OPLL and identify factors affecting surgical outcomes.

Methods: This study enrolled 70 patients who underwent ACCF and 63 patients who underwent LP between 2005 and 2012. Patterns of surgical outcomes were analyzed in accordance with surgical procedures. Furthermore, these patients were divided into two subgroups on the basis of follow-up duration: the short-term group (less than 48 months) and the long-term group (more than 48 months) group. Occupying ratio, type of OPLL, shape of ossified lesion, cervical sagittal alignment, grade of signal intensity on MRI, and Japanese orthopedic association (JOA) score were examined.

Results: Surgical outcomes of ACCF went into reverse at 48 months follow-up period. In short-term group, JOA recovery rate had no difference between ACCF and LP. In long-term group, the ACCF recovery rate (78.5 ± 31.0) was significantly higher than the LP recovery rate (48.4 ± 54.9) ($P=0.008$). In short-term group, old age ($p=0.011$), hill shape ($p=0.013$), and high grade of MRI signal intensity ($p=0.040$) had negative effects on recovery rate. On the other hand, in long-term group, LP ($p=0.021$) and a high grade of MR signal intensity ($p=0.017$) independently and negatively affected recovery rate.

Conclusions: Long-term surgical outcomes of ACCF became better than those of LP at more than 48 months follow-up period. Furthermore, high grade MRI signal changes and the LP surgical procedure were independent negative factors for long-term surgical outcomes.

Figure 1

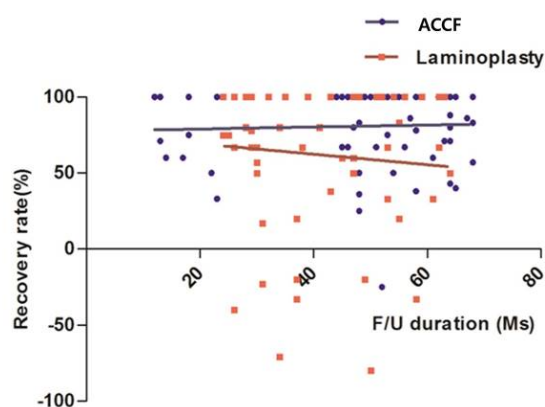


Figure 2

TABLE 1. Demographics and preoperative variables

	ACCF	LP	P
No. of Patients	70	63	
M : F	50:20	48:15	0.533
Age at Surgery (Mean±SD, year)	57.2±9.7	55.3±9.1	0.247
Follow-up duration (Mean±SD, month)	47.9±16.9	40.4±12.3	0.004*
Space available for spinal cord (Mean±SD, mm)	6.2±1.7	6.0±1.9	0.592
Occupying ratio of OPLL (Mean±SD, %)	56.4±10.3	54.8±14.6	0.474
Preop JOA score (Mean±SD)	11.9±2.6	12.3±2.3	0.384
JOA Recovery rate (Mean±SD, %)	75.1±32.3	57.5±49.4	0.015*
Type of OPLL, n (%)			<0.001*
Continuous	11 (15.7)	21 (33.3)	
Mixed	19 (27.1)	25 (39.7)	
Segmental	9 (12.9)	16 (25.4)	
Localized	31 (44.3)	1 (1.6)	
Shape of ossified lesion, n (%)			0.360
Hill	40 (57.1)	31 (49.2)	
Plateau	30 (42.9)	33 (50.8)	
Sagittal alignment, n (%)			<0.001*
Lordotic	17 (24.3)	33 (52.4)	
Straight	37 (51.4)	29 (46.0)	
Kyphotic	17 (24.3)	1 (1.6)	
Grade of ISI on MRI, n (%)			0.004*
0	15 (21.4)	14 (22.2)	
1	44 (62.9)	24 (38.1)	
2	11 (15.7)	25 (39.7)	

ACCF, anterior cervical corpectomy and fusion; LP, laminoplasty; JOA, Japanese Orthopedic Association; OPLL, ossification of the posterior longitudinal ligament; ISI, increased signal intensity; MRI, magnetic resonance imaging.

* $P < 0.05$

Figure 3

TABLE 2. Relationship between recovery rate and preoperative variables according to surgical approaches

		JOA Recovery rate (%)			
		ACCF		LP	
		N.	Mean±SD	N.	Mean±SD
Gender	Male	50	71.4±33.2	48	54.9±52.5
	Female	20	84.3±28.6	15	65.9±38.4
Follow-up duration	≤ 48ms	28	69.9±34.1	44	61.4±47.0
	> 48ms	42	78.5±31.0	19	48.4±54.9
Occupying ratio (%)	<60	43	74.7±33.9	35	60.4±46.7
	≥60	27	75.7±30.3	28	53.9±53.3
Shape	Hill	40	78.4±30.5	31	51.3±49.1
	Plateau	30	70.6±34.5	32	63.5±49.7
Type of OPLL	Continuous	11	87.1±30.1	21	62.5±60.0
	Mixed	19	80.1±24.8	25	60.1±43.3
	Segmental	9	51.8±44.2	16	51.8±47.4
	Localized	31	74.5±31.3	1	-23.0
Grade of ISI on MRI	0	15	90.7±27.1	14	73.6±38.0
	1	44	75.3±29.7	24	70.5±38.7
	2	11	53.0±38.3	25	36.0±57.4
Sagittal alignment	Lordotic	17	79.5±29.1	33	62.5±47.1
	Straight	36	71.4±32.9	29	51.0±52.7
	Kyphotic	17	78.4±34.9	1	80.0

JOA, Japanese Orthopedic Association; ACCF, anterior cervical corpectomy and fusion; LP, laminoplasty; ms, months; OPLL, ossification of the posterior longitudinal ligament; ISI, increased signal intensity; MRI, magnetic resonance imaging.

*P < 0.05

Figure 4

TABLE 3. Relationship between recovery rate and preoperative variables, according to surgical approach

JOA Recovery rate											
		Short-term group (≤ 48 months)				Long-term group (> 48 months)					
		ACCF		LP			ACCF		LP		
		N	Mean±SD	N	Mean±SD	P	N	Mean±SD	N	Mean±SD	P
Gender	Male	19	66.2±32.8	34	58.8±48.7	0.560	3	74.6±33.6	14	45.3±61.6	0.044*
	Female	9	77.8±37.3	10	70.2±41.6	0.683	1 1 1	89.5±19.4	5	57.2±33.6	0.027*
Occupying ratio (%)	<60	20	71.8±32.5	25	66.4±46.4	0.659	2	77.2±35.6	10	45.4±46.2	0.039*
	≥60	8	65.1±39.8	19	54.8±48.2	0.601	1 3 9	80.2±25.2	9	51.8±66.0	0.109
Shape	Hill	16	79.6±27.5	22	66.0±41.4	0.264	2	77.7±33.0	9	15.1±49.8	<0.001*
	Plateau	12	57.0±38.8	22	56.7±52.5	0.988	1	79.7±29.0	10	78.4±41.5	0.925
Type of OPLL	Continuous	5	95.0±11.2	12	66.1±49.9	0.227	6	80.5±40.0	9	57.8±68.2	0.477
	Mixed	6	62.0±28.4	18	75.1±37.2	0.440	1	88.4±18.6	7	21.4±34.3	<0.001*
	Segmental	2	0	13	44.5±49.6	0.240	7	66.6±38.1	3	83.3±16.5	0.495
	Localized	15	74.0±30.8	1	-23	0.009*	1	75.0±32.7	0		
Grade of ISI on MRI	0	5	92.0±17.9	8	76.6±27.0	0.287	1	90.0±31.6	6	69.5±51.9	0.339
	1	17	69.5±36.2	17	73.8±38.5	0.740	2	78.9±24.9	7	62.4±41.0	0.184
	2	6	52.7±31.4	19	43.9±55.7	0.719	5	53.4±49.3	6	11.0±60.4	0.241
Sagittal alignment	Lordotic	8	90.9±17.0	22	69.2±41.4	0.165	9	69.3±34.7	11	49.0±56.5	0.359
	Straight	12	53.9±33.1	21	52.3±52.7	0.926	2	80.2±29.8	8	47.6±56.5	0.043*
	Kyphotic	8	72.9±39.0	1	80	0.868	9	83.2±32.4	0		

JOA, Japanese Orthopedic Association; ACCF, anterior cervical corpectomy and fusion; LP, laminoplasty; N, number; OPLL, ossification of the posterior longitudinal ligament; ISI, increased signal intensity; MRI, magnetic resonance imaging.

*P < 0.05

Figure 5

TABLE 4. Multiple linear regression analysis of recovery rate according to follow-up period

Short-term group (≤ 48 months)			Long-term group (> 48 months)		
JOA Recovery rate			JOA Recovery rate		
Variable	Unstandardized coefficient (B)	P	Variable	Unstandardized coefficient (B)	P
Surgical Approach	-9.933	0.406	Surgical Approach	-31.706	0.021*
Sex	11.682	0.288	Sex	13.212	0.242
Age	-1.385	0.011*	Age	-0.861	0.111
Type of OPLL	-6.786	0.191	Type of OPLL	-2.442	0.640
Alignment	-4.962	0.522	Alignment	7.504	0.378
Shape of lesion	-28.002	0.013*	Shape of lesion	11.389	0.279
MRI grade	-14.761	0.040*	MR grade	-20.97	0.017*
Occupying ratio	-3.632	0.165	Occupying ratio	0.593	0.226
Preoperative JOA score	1.789	0.331	Preoperative JOA score	-3.766	0.133

JOA, Japanese Orthopedic Association; OPLL, ossification of the posterior longitudinal ligament; MRI, magnetic resonance imaging.

*P < 0.05

O50

Trends in posterior cervical fusion in the United States from 2000-2016

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Question: To what extent has the rate of posterior cervical fusion (PCF) increased over the past 16 years and what are the most significant areas of growth?

Methods: Adult patients who underwent PCF from 2000-2016 were identified in the Premier Healthcare Database (PHD) using International Classification of Disease Codes (ICD) 9 and 10. Complexity was defined by concurrent codes within the same admission as index PCF including an osteotomy (PCF+OST), thoracic fusion (PCF+T), anterior cervical fusion (PCF+ACF), or deformity diagnosis (PCF+DEF). Demographics, clinical and hospital characteristics, and healthcare utilization measures were collected. Yearly procedure volumes were projected to the US population using weights based on the American Hospital Association survey data. Rate of PCF procedures were estimated for the overall population undergoing PCF and stratified by age, gender, and surgical complexity.

Results: A total of 60,891 discharges for PCF occurred over the study period. Both the projected volume of patients and the rates of patients undergoing PCF per 100,000 population increased over time. For patients age 65 or older, the compound annual growth rate (CAGR) of PCF was 8.8% with an overall increase of 281% over the study period. Patients age 85 or older had the greatest CAGR (10%) and total growth (361%) over the study period. PCF complexity increased across the study period. The CAGR was 7.9% for PCF alone compared to 19.0% for PCF+T and 15.2% for PCF+DEF, among patients aged 65 or older.

Conclusions: Rates of posterior cervical fusion have increased dramatically over the past 16 years with significant growth among the elderly, particularly over age 85, and among patients with cervical deformity.

O51

Increasing surgical invasiveness relative to frailty status in cervical deformity surgery: A risk benefit analysis

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Question: Investigate the outcomes of CD surgery by frailty status and surgical invasiveness.

Methods: Operative CD(C2-C7 Cobb>10°,CL>10°,cSVA>4cm,CBVA>25°) patients >18yr with surgical and NDI data were included. Invasiveness was calculated using an invasiveness index specific for CD Surgery. Invasiveness scores were calculated within the frail(F,0.3-0.5) and severely frail(SF,>0.5) states. Logistic regression analysis assessed the relationship between increasing invasiveness, no reoperations, and meeting MCID in any HRQL at 1Y. Decision tree analysis assessed thresholds for an invasiveness risk-benefit cutoff point, above which experiencing a reoperation or not reaching MCID were higher.

Results: 159 pts met inclusion criteria. There were 3NF, 34F, and 77SF pts. For all pts, regression analysis found a significant relationship between increasing invasiveness & revision surgery(1.02[1.00-1.03] p=0.03). Within F and SF subgroups, the results were:(1.01[0.99-1.03] p=0.37) and (1.02[1.00-1.04] p=0.045). Defining no reop or meeting MCID for any HRQL at 1Y as a favorable outcome, decision tree analysis established an invasiveness risk-benefit cutoff of 46.8. Pts below this cutoff were 1.75[0.77-3.96](p=0.18) times more likely to meet MCID & no reop. Invasiveness above this cutoff point was a negative predictor,(0.57 [0.25-1.29], p=0.18). For F pts only, risk benefit cutoff was 66.6: (above:3.08[0.73-17.8]p=0.21) vs. below:0.33[0.06-1.88]p=0.21). For SF pts, risk benefit cutoff was 46.8: (above:1.82[0.65-5.06]p=0.25 vs. below:0.55[0.20-1.54]p=0.25).

Conclusions: Increasing invasiveness is associated with increased odds of major complications and reoperations. A risk/benefit cut off for decreasing major complications/reoperations and meeting MCID was found to be 79.3 for NF patients, 111 for F patients, and 53.3 for SF patients. Above these thresholds, increasing invasiveness is associated with increasing the risk of major complications or reoperations and not meeting MCID at 3Y.

Figure 1

Table 1. Factors Included in Cervical Deformity Invasiveness Index.

Surgical Factors	Points Assigned
ACDF	2 points per level
Corpectomy	4 points per level
Levels Fused	1 point per level
Implants	1 point per implant
Posterior Decompression	2 points per level
Smith-Peterson Osteotomy	2 points per level
Three-Column Osteotomy	8 points per level
Fusion to upper cervical spine	2 points
Revision Status	3 points

O52

Does prophylactic foraminotomy reduce the occurrence of postoperative C5 palsy in reconstruction surgery using cervical pedicle screw?

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Question: C5 nerve palsy is an annoying complication in surgery for cervical myelopathy, and the incidence was reported to occur in several percent. However, the precise mechanism is still unclear. Several papers have reported that posterior reconstruction surgery using screw-rod system such as cervical pedicle screw (CPS) causes a higher frequency (12-50%) of postoperative C5 nerve palsy compared with conventional laminoplasty. For preventing the palsy, prophylactic foraminotomy may be performed. However, it is unclear whether the prophylactic foraminotomy at C4/5 reduces the occurrence of postoperative C5 palsy.

Methods: Thirty-seven patients who underwent correction surgery using CPS (21 male, 16 female, a mean of 71 years old) were enrolled. For the cases accompanying with preoperative foraminal stenosis at C4/5 on CT image, prophylactic foraminotomy was performed. The patients were divided into two groups; group P (postoperative C5 palsy occurred) and group NP (no palsy). The duration until the palsy was recovered was investigated. Statistical analysis in respect to correction angle of kyphosis, correction of C2-7 angle, the presence of preoperative foraminal stenosis at C4/5 on CT, and the posterior shift of the spinal cord on MRI between two groups was performed.

Results: Postoperative C5 palsy occurred in seven patients (18.9%). It took a mean of 2 months for complete recovery. The frequency having the incidence was higher in those with bigger correction angle of kyphosis and the presence of preoperative foraminal stenosis at C4/5 with statistical significance.

Conclusions: The prophylactic foraminotomy did not reduce the incidence of postoperative C5 palsy, however, it may reduce the severity of the palsy because it took two months until full recovery. It was also indicated that the bigger kyphosis correction and the presence of preoperative foraminal stenosis are the risk factors of C5 palsy in correction surgery using CPS.

O53

Cortical breach detection in spine surgery: Novel use of diffuse reflectance spectroscopy

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Question: To evaluate whether diffuse reflectance spectroscopy [DRS], at the tip of surgical instruments, is a feasible technology for cortical breach detection when placing vertebral screws.

Methods: Lateral mass and pedicle screws are used in cervical fixation surgery. To avoid misplaced screws that could cause neurovascular damage, a novel technology relying on DRS can be used. This technology can differentiate between different tissues in the human body. If used at the tip of surgical instruments, breach detection could warn the surgeon before placing an inaccurate screw.

Methods: Four cadavers were used to place pedicle screws with typical breaches (inferior, medial, lateral, and anterior). DRS measurements were collected in the wavelength range of 400-1600 nm using a spectroscopic system built into the tip of a pedicle probe. DRS data of the vertebral constituents, such as blood, fat and water, along with photon scattering coefficients were analyzed.

Design: Cadaveric human laboratory study

Results: Four typical pedicle screw breaches were performed. In each case, the technology was able to detect a statistically significant change in fat fraction between cancellous bone, cortical bone, and actualized breach. The mean fat fraction was $58.6 \pm 9.5\%$ in cancellous bone, $8.7 \pm 13.0\%$ in cortical bone, and $46.5 \pm 25.1\%$ when breached. Impending breach could be reliably detected within 3 mm from cortical border.

Discussion: Using DRS technology at the tip of surgical instruments, might be used for accurate spinal screw placement by warning the surgeon before breaching the cortical bone. Further studies are needed to evaluate the technology in human subjects.

ePoster presentations

Biomechanics and basic science

P1

Cervical spine morphology and ligament property variations: a finite element study of their influence on sagittal bending characteristics

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Question: To Investigate the influence of variations in spine morphology on the flexion-extension responses at C5-C6, utilizing mesh-morphing- based parametrization and metamodel-based sensitivity analysis.

Methods: The C5-6 segment was selected for the baseline model due to the higher incidence of degenerative disc disease and trauma frequently seen at this level clinically. Flexion-extension bending was incorporated. Variations of intervertebral disc height, facet joint slope, facet joint articular process height, vertebral body anterior-posterior depth, and segmental size were parametrized. In efforts to make the model more physiologic, material property variations of the ligaments were considered for sensitivity analysis. The influence of these variations on vertebral rotation and forces in the ligaments were analyzed.

Results: The disc height, segmental size, and vertebral body depth were found to be the most influential with respect to morphologic variations. Whereas of the ligament material property variations, the capsular and ligamentum flavum showed more influence on vertebral rotation.

Conclusions: Using this type of finite element analysis to determine a more "physiologic" and dynamic sagittal bending model at C5-C6, we have shown that changes in disc height influence the posterior ligaments; hence, changes in the anterior load bearing column of the spine could have consequences on the posterior column. This has clinical significance and implications when we select interbody disc space implants.

P2

Is it possible to place accurate C2 screws without spinal computerized navigation?

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Question: Is it possible to place accurate C2 screws without spinal computerized navigation?

Methods: Observational cohort of patients to evaluate C2 screw accuracy placement.

Twenty-three consecutive patients treated by a single surgeon were identified. C2 screws were inserted under lateral fluoroscopy guidance. Accuracy was assessed on postoperative CT scans according to Gertzbein and Robbins classification (GRGr). Additionally, the final axis of the screw was compared to an optimal lateromedial trajectory angle, as it could have been defined if navigation system was used. It was also measured the Δ angle (difference between the optimal and the obtained angles). All data was statistically analysed using IBM® SPSS® Statistics 25.

Results: A total of 21 C2 transpedicular screws were placed. The postoperative CT findings showed GRGr A in 52.4% (n=11), GRGr B in 23.8% (n=5), GRGr C in 19.0% (n=4) and GRGr D in 4.8% (n=1). No screw malpositioning GRGr E was observed.

Concerning C2 translaminar screws, a total of 22 were inserted and we obtained GRGr A in 90.9% (n=20) and GRGr B in 9.1% (n=2). In misplaced transpedicular screws (GRGr C or D), the ideal lateromedial angle was significantly higher (p=0.037).

The mean Δ angle was 17.9° (\pm 12.2) in transpedicular screws and 2.4° (\pm 13.6) in translaminar screws. There was no statistically significant difference (p=0.92) between the Δ angle and the screw accuracy. No neurovascular injury occurred.

Conclusions: Without using spinal computerized navigation, C2 screws can be placed effectively and safely. Inserting translaminar screws increases the placement accuracy over transpedicular screws. Even if the screw trajectory is not optimal, as could be afforded by navigation, this does not translate into significant cortical breaches.

Furthermore, C2 pedicle with a more medial angulation are prone to screw defective placement, which demands a more lateral exposure or the use of cannulated screw.

P3

Cervical sagittal balance compensation mechanisms after lower cervical spine total disc replacement (TDR)

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Objective: To study the effect of C5-6-7 TDR on C0-2 and C5-7 functional units under different SVA scenarios

Introduction: Recent biomechanical studies suggest that an increase in SVA leads to compensatory hyperextension at C0-2 and hyperflexion at C5-7 to maintain horizontal gaze. The effect of total disc replacement (TDR) at C5-6-7 on this compensatory mechanism is still unknown.

Methods: **Methods:** Observational cohort study of patients submitted to TDR at C5-6 and/or C6-7. We studied demographic data, sagittal balance parameters (SVA, and T1 slope), C0-2, C5-6, C6-7 and C5-7 functional units angles. Pre/post-OP neutral lateral x-rays were analyzed using the SPECTRA[®] software. Statistical analysis was done with SPSS[®] v23.

Results: **Results:** Thirty-one patients were studied, of which 26 were females. Mean age of 48 years (range 31-64), and a mean follow-up of 30 months. Forty-four levels were treated with TDR.

In all groups there was an increase of lordosis at index level (C5-6: $\Delta 4.7 \pm 5.9^\circ$; C6-7: $\Delta 3.5 \pm 5.6^\circ$) with loss of lordosis at non-operated levels (C6-7: $\Delta -0.4 \pm 4.4^\circ$; C5-6: $\Delta -2.6 \pm 5.1^\circ$). Nevertheless, and increase of lordosis for the C5-7 unit was found ($\Delta 3.4 \pm 5.7^\circ$).

An increase in lordosis at C5-6 index was correlated with C0-2 extension ($p=0.016$, $r=0.41$). A direct linear relationship was found between pre-OP SVA and C0-2 for index C5-6 ($p=0.11$), with a statistical significance for C6-7 as index ($p=0.037$).

Conclusions: **Conclusions:** Cervical TDR at lower cervical spine increased lordosis at index levels and C5-7 functional unit. An increase in pre-operative SVA was associated with compensatory C0-2 hyperextension and with a C5-7 gain in lordosis.

P4

Anatomy of the dens and its implications for fracture treatment: an anatomical and radiological study

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Question: The most common injuries to the upper cervical spine are fractures of the dens axis. Therefore, the purpose of our study was to answer three questions, namely (1) whether the size of the dens is adequate at all levels to accommodate two screws, (2) what the angle of the posterior tilt of the dens is in a healthy individual and (3) compare the measured variables between the sexes.

Methods: The cohort comprised 50 males and 50 females CT examination of the craniocervical junction. We measured the five diameters of the dens and posterior dens angulation angle (PDAA) and screw insertion angle (SIA). The same dimensions were measured in a control group, consisting of 40 non-pathological second cervical vertebrae specimens.

Results: On CT scans, the mean PDAA was 162.7 degrees in males and 160.26 degrees in females; the mean SIA was 62.0 degrees in males and 60.2 degrees in females. On specimens, the mean PDAA was 169.47 degrees in males and 166.95 degrees in females; the mean SIA was 65.42 degrees in males and 64.47 degrees in females. All obtained values were higher in males; regardless of their measuring on either CT scans or specimens, differences between males and females were statistically significant ($p < 0.05$) in a, c, d and e values.

Conclusions: The values of our measurements correlate with the dimensions identified previously in other studies. Based on our clinical experience and measurements, we presume that two 3.5-mm screws can be inserted into the dens of all adult patients, except for those with pronounced anatomical anomalies. Posterior dens angulation angle is slightly larger than we expected. The dens is significantly larger in males almost in all measurement.

Figure 1

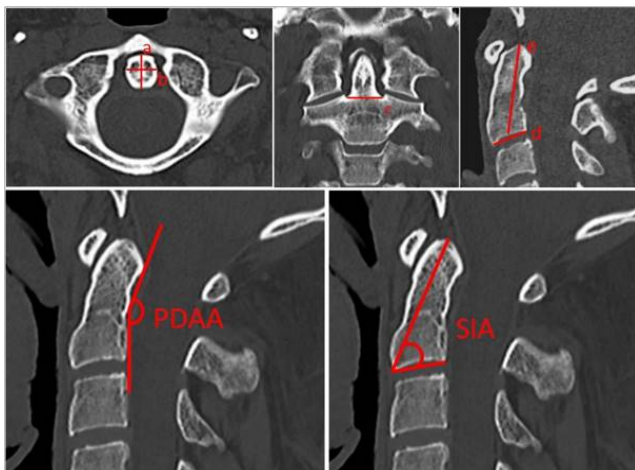


Figure 2

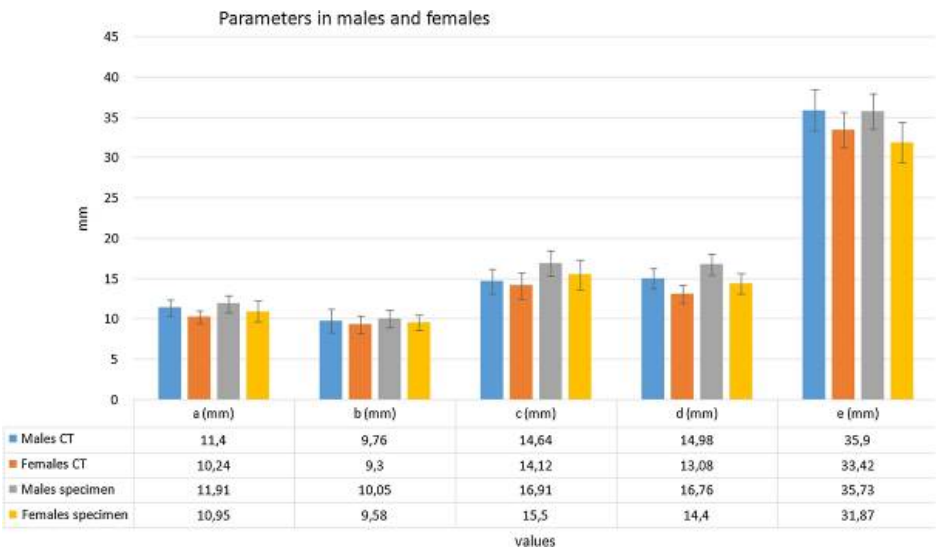
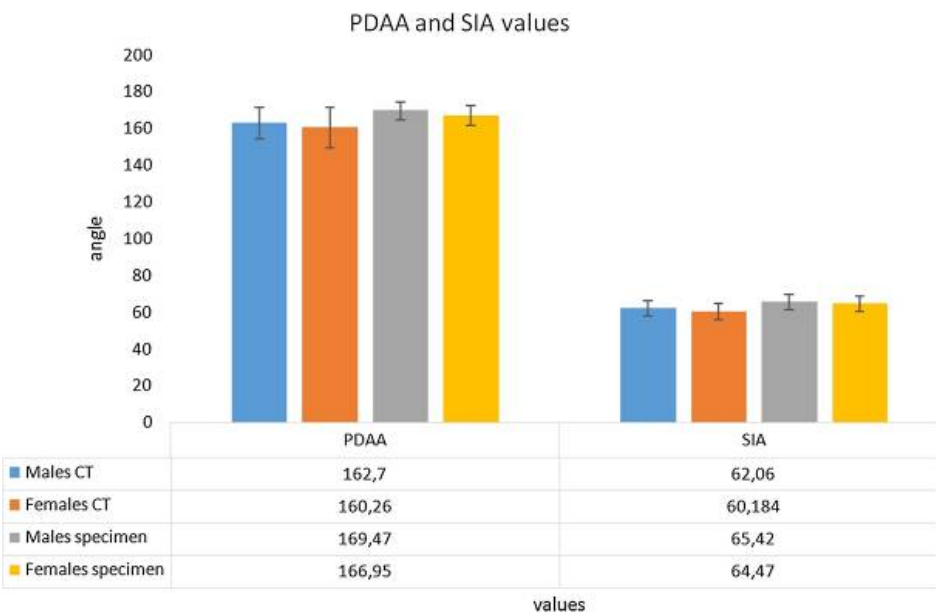


Figure 3



P5

The impact of different artificial disc heights on the facet joint during cervical disc replacement: a finite element study

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Question: The principles of choosing an appropriate height implant remain controversial in cervical total disc replacement (c-TDR). Previous biomechanical studies have shown the impact of implant height on the range of motion and intervertebral disc pressure, while the impact on the posterior column has not been reported specifically. The objective of this study was to explore the impact on facet joint biomechanics and morphology and therefore to offer valid proposals regarding the selection of the appropriate implant height during c-TDR.

Methods: We generated a finite element model of the intact cervical spine (C2-C7) using the CT scans of a cadaveric specimen. Our model predictions were validated by cadaveric biomechanical testing. The validated model was altered to implant semi-constrained artificial discs at the C5/C6 level. The effects of 5mm, 6mm and 7mm-height implants on facet joint pressure, ligament tension, facet joint angle, facet joint area, and facet joint articulation overlap were examined.

Results: 5mm and 6mm-height implants slightly affected the biomechanical and morphological properties of facet joints. 7 mm implant strongly altered the properties of the facet joint at the C5/C6 level. Ligament tension, facet joint pressure and facet joint angle increased along with the increment of implant height, while facet joint area and articulation overlap exhibited an opposite trend. 7mm implant could affect the properties of facet joints at adjacent levels.

Conclusions: This study suggested that an appropriate height artificial disc can achieve near-normal biomechanical and morphological properties and is recommended. We should be very cautious if using artificial discs ≥ 1 mm in height compared with normal. However, implants ≥ 2 mm in height compared to normal significantly altered the properties of facet joints; therefore, it should not be used in clinical practice.

P6

3D printed anatomical models of severe cervical deformity: a new tool for surgical planning and intraoperative surgery guidance

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Question: Surgery for severe cervical deformity is often challenging, even when a navigation system is available, mainly because reference anatomical landmarks can be lost during surgery. This happens because of the altered connection among vertebrae and because of the anatomical deformity of every single vertebral body. Performing a trial surgery (including decompression, stabilization, osteotomies) on a 1:1 scale plastic model is expected to give valuable indication on the feasibility and practicability of the planned procedure. Furthermore corresponding 3D anatomical models, folded in a sterile bag, can be brought in to the OR and can be seen and manipulated by the surgeon whenever required during the procedure.

Methods: Medical imaging analysis was performed by manual semi-automatic segmentation of each single image of the Dicom file to obtain 3D models of the cervical spine, both as a single segment aggregating from C1 to T1, together with the eight isolated vertebrae. These models were printed in 3D in P430 ABS Plus, slicing height 0,25 mm. This represented well the external surface of the bones, in the exact overall spine deformity condition of the patient.

Results: A surgery trial was first performed on the 3D model (including drilling, tapping, screws placement, rods bending and laminectomy). Pre-bent rods were then removed from the model and sterilized the day before surgery to be employed during the operation, this resulting in time saving and great simplification of the surgical procedure. Surgery consisted in double approach decompression and fusion from C2 to T1. The 3D anatomical model was present in OR and used for quick consultation to decide screws direction and extension of laminectomy.

Conclusions: Simulated surgery on a 3D anatomical model resulted to be very helpful both in pre-operative planning and during surgery. The material employed allows to perform a complete surgical procedure on a 1:1 scale model, including decompression and stabilization by metal hardware.

Figure 1

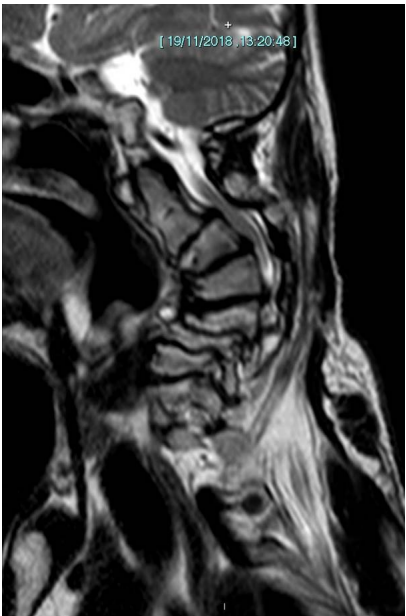


Figure 2



Figure 3

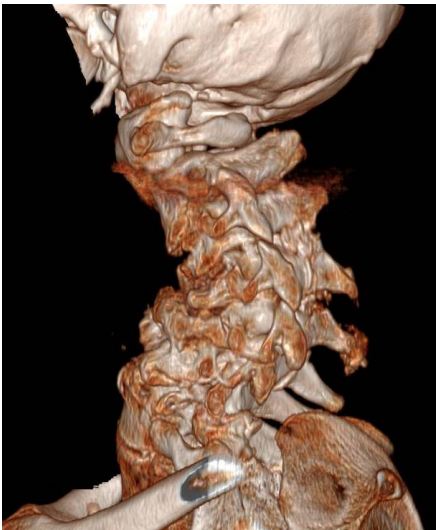


Figure 4

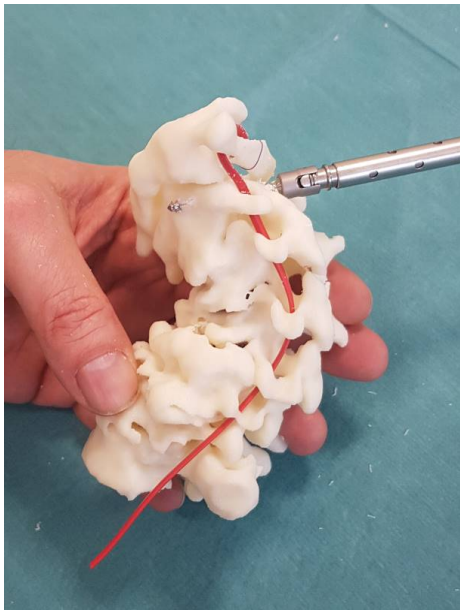
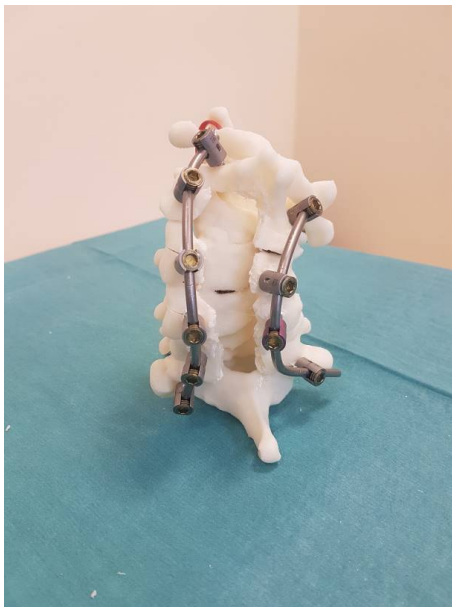


Figure 5



P7

Teriparatide anabolic therapy as potential treatment of type II dens non-union fractures

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Question: Type II odontoid fractures are the most common type in the elderly. Treatment options remain controversial. The aims of treatment in the elderly is the quick recovery while decreasing morbidity and mortality. Several studies reported that administration of Teriparatide (PTH-1,34, 20 ng per day) is able to stimulate bone formation and to induce fracture healing.

How effective is anabolic therapy with Teriparatide in the treatment of type II dens delayed and/or non-union fractures?

Methods: We present a case series of 10 patients with C2 fractures with posterior displacement treated conservatively because of non-eligibility for surgery and/or refusal of it and not healed after 3-6 months. The mean age was 73 years old (64-81). Seven still had an area of contact between the two fragments 3-6 months after injury, they were informed and administered with Teriparatide off label for 3 months (1,34 PTH; 20 ng/day).

All patients showed lack of callus on CT scan images taken at 3-6 months after injury with a mean distance between the fragments of 4mm (3 to 6mm). A further control CT scan was carried out 3 months after the drug administration to evaluate its effect on the healing process.

Results: At 45 days of therapy all patients showed radiologic evidence of callus formation and after 3 months they showed complete consolidation of the fracture on the final CT.

Conclusions: The successful outcome of our study seems to suggest a potential role of Teriparatide in the treatment of the delayed union of C2 fractures in elderly patients. The co-morbidities typical of the elderly population and the complications related to surgery could support the use of the drug as a conservative treatment option. Of course, our exciting preliminary data on a small series of patients need confirmation and further studies based on a larger population and on prospective randomized trials.

Cervical deformity and sagittal balance

P8

Postoperative reciprocal changes in global spinal alignment after occipitospinal fusion and risk factors of horizontal gaze difficulty

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Question: Proximal reciprocal change of global spinal alignment after thoracolumbosacral fixation has been well reported. On the other hand, distal reciprocal change of global spinal alignment after occipitocervical fusion (OCF) are still unclear, nevertheless difficulty in horizontal gaze can occur depending on the change in thoracolumbosacral alignment since neck mobility is completely lost after OCF. The purpose of this study is to investigate reciprocal change of global spinal alignment and risk factors of horizontal gaze after OCF.

Methods: Sixteen patients who underwent OCF and followed over 1 year were included (male/female: 1 case/15 cases, mean age: 69.6 y.o., mean follow-up period: 3.1 years). We measured cervical and global spinal sagittal alignment on preoperative, postoperative and follow-up radiographs and investigate the chronological changes of the alignments after OCF. In addition, the alignments were compared between the cases with the difficulty in horizontal gaze (group NG) and without it (group G).

Results: T1 slope (T1S) and COG-C7 SVA did not show significant change between pre- and postoperative radiogram, but significantly increased in follow-up (T1S: 29.7 degrees to 36.7 degrees, COG-C7 SVA: 28.4mm to 43.9mm) (p

Conclusions: In the cases after OCF, T1S and COG-C7 SVA increased during follow-up, although there had no change of global spinal alignment. This result indicates fixed occiputocervicocervical component tended to be anteverted during follow-up, and compensatory change in thoracolumbar spine was not expected. In addition, postoperative COG-C7 SVA of 35mm or more was shown to be a risk factor of difficulty in horizontal gaze. Therefore, not only occiputocervicocervical alignment but global spinal alignment should be carefully considered at the planning of OCF.

Impact of cervical kyphosis on the results of selective laminectomy in patients with cervical spondylotic myelopathy

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Question: Selective laminectomy (SL) has been reported to minimize the surgical invasiveness for cervical spondylotic myelopathy (CSM) without disturbing the deep extensor muscles and facet joints. However, a limited number of SLs might decrease posterior spinal cord shifting (PSCS) and exacerbate the results of surgery, especially in patients with kyphosis. This study aimed to investigate the features of SL to treat CSM with kyphosis.

Methods: Patients with CSM who underwent SL with a follow-up period of ≥ 2 years were included in this study. The patients who had C2–C7 angle $< 0^\circ$ were assigned to the K group, whereas age-matched patients without this characteristic angle were assigned to the non-K group (Figure 1). Patients who showed kyphotic changes in the C2–C7 angle $\geq 10^\circ$ after surgery were assigned to the KC group, whereas those without these changes were assigned to the non-KC group (Figure 1). Comparison studies were performed between the K and non-K groups, as well as between the KC and non-KC groups. PSCS was calculated at the most stenotic level using sagittal MRI, and its clinical features were investigated (Figure 2).

Results: The K group showed a significantly smaller C2–C7 angle and C7 tilt than the non-K group (Table 1). The KC group showed a significantly lower JOA score and a larger C2–C7 angle and C7 tilt (Table 2). The degree of PSCS was significantly associated with the number of laminectomies without having an impact on the JOA recovery rate (Figures 3 and 4; Table 1).

Conclusions: Preoperative kyphosis in patients with CSM following SL did not affect PSCS, surgical results, or the frequency of kyphotic changes. Conversely, PSCS significantly increased in proportion to the number of laminectomies without clinical impacts. Unexpectedly, a kyphotic change after SL is more likely to occur among patients with a larger cervical lordosis without any effects on surgical outcomes. Thus, the present study suggests that the presence of kyphosis does not preclude the indications for SL to treat CSM.

Figure 1

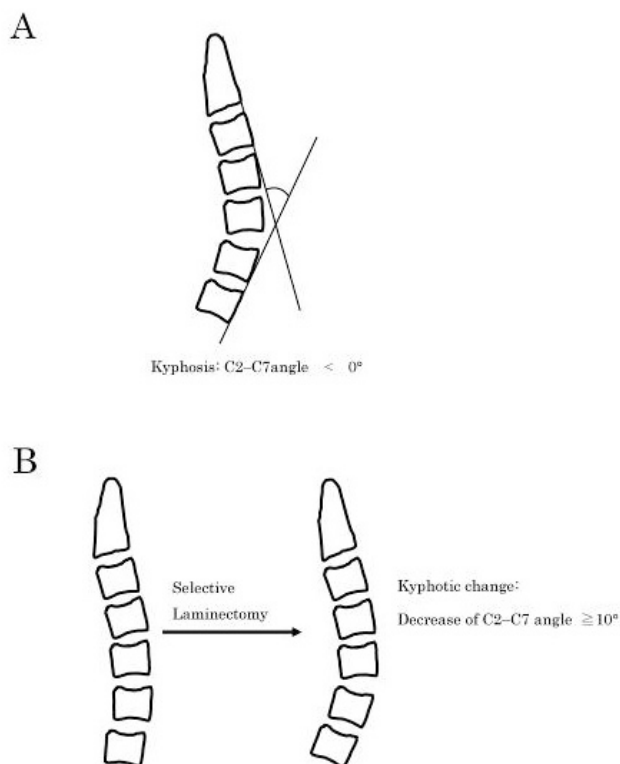


Figure 1. Kyphosis and kyphotic change after selective laminectomy. (A) The preoperative C2–C7 angle $< 0^\circ$ was defined as kyphosis. (B) A decrease in the C2–C7 angle $\geq 10^\circ$ after selective laminectomy was defined as a kyphotic change.

Figure 2

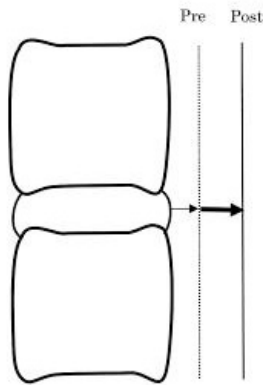


Figure 2. Measurement of the posterior spinal cord shifting (PSCS). PSCS was calculated as the magnitude of postoperative backward shifting of the spinal cord at the most stenotic level on the sagittal MRI.

Figure 3

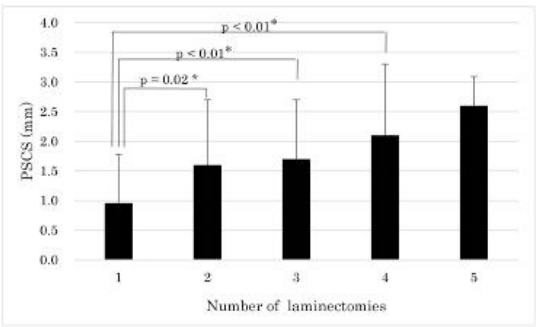


Figure 3. Correlation between posterior spinal cord shifting (PSCS) and the number of laminectomies using one-way analysis of variance.

Figure 4

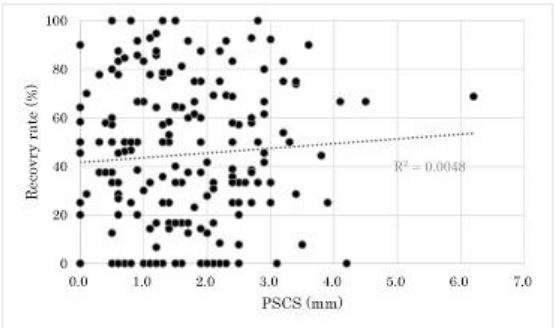


Figure 4. Correlation analysis between Japanese Orthopaedic Association (JOA) recovery rate and postoperative spinal cord shifting (PSCS). PSCS did not significantly correlate with JOA recovery rate.

Figure 5

Table 1. Comparison analysis based on the presence of kyphosis

Variables	Group K	Group non-K	p value
	n (%) or mean \pm SD	n (%) or mean \pm SD	
Number of patients	30 (12.7)	207 (87.3)	
Age (years)	61.6 \pm 14.8	61.6 \pm 9.9	1.0
Gender			0.41
Males	18 (7.6)	141 (59.5)	
Females	12 (5.1)	66 (27.8)	
Follow-up period (months)	44.2 \pm 8.4	47.5 \pm 8.4	0.24
Number of laminectomies	2.6 \pm 1.0	2.7 \pm 0.9	0.91
Preoperative JOA score	11.5 \pm 2.6	11.6 \pm 2.3	0.78
Postoperative JOA score	13.8 \pm 1.9	14.0 \pm 2.1	0.57
JOA recovery rate (%)	42.6 \pm 25.8	43.9 \pm 30.4	0.82
C2–C7 angle (°)			
Neutral	−8.7 \pm 5.5	15.2 \pm 10.7	<0.01*
Flexion	−21.9 \pm 13.6	−7.8 \pm 11.8	<0.01*
Extension	15.0 \pm 14.5	28.9 \pm 11.3	<0.01*
ROM (°)	36.9 \pm 15.9	36.7 \pm 13.9	0.95
C2–C7 SVA (mm)	20.7 \pm 13.4	20.5 \pm 12.0	0.94
C7 tilt (°)	15.6 \pm 8.5	25.4 \pm 8.5	<0.01*
PSCS (mm)	1.7 \pm 0.9	1.7 \pm 1.1	0.91

Group K, those who had preoperative kyphosis; group non-K, those who did not have preoperative kyphosis. ROM, range of motion; C2–C7 SVA, C2–C7 sagittal vertical axis; PSCS, posterior spinal cord shifting; JOA, Japanese Orthopaedic Association. *Statistically significant

Figure 6

Table 2. Comparison analysis based on kyphotic changes

Variables	Group KC	Group non-KC	p value
	n (%) or mean \pm SD	n (%) or mean \pm SD	
Number of patients	21 (8.9)	216 (91.1)	
Age (years)	59.9 \pm 10.7	61.7 \pm 10.7	0.45
Gender			0.47
Males	16 (6.8)	143 (60.3)	
Females	5 (2.1)	73 (30.8)	
Follow-up period (months)	48.3 \pm 21.5	46.3 \pm 21.0	0.60
Number of laminectomies	2.8 \pm 0.8	2.6 \pm 0.9	0.54
Presence of preoperative kyphosis	2 (9.5)	28 (13.0)	0.93
Preoperative JOA score	10.3 \pm 2.6	11.7 \pm 2.3	0.01*
Postoperative JOA score	13.6 \pm 2.3	14.1 \pm 2.0	0.29
JOA recovery rate (%)	46.9 \pm 27.7	43.5 \pm 30.0	0.61
C2–C7 angle (°)			
Neutral	17.9 \pm 15.0	11.5 \pm 12.6	0.03*
Flexion	−9.9 \pm 16.3	−9.5 \pm 12.6	0.90
Extension	27.5 \pm 13.2	27.1 \pm 12.6	0.91
ROM (°)	37.4 \pm 16.6	36.7 \pm 13.9	0.83
C2–C7 SVA (mm)	23.4 \pm 11.0	20.3 \pm 12.3	0.25
C7 tilt (°)	28.0 \pm 8.8	23.8 \pm 9.0	0.04*
PSCS (mm)	1.4 \pm 1.0	1.7 \pm 1.1	0.30

Group KC, those who had postoperative kyphotic change; group non-KC, those who did not show postoperative kyphotic change. ROM, range of motion; C2–C7 SVA, C2–C7 sagittal vertical axis; PSCS, posterior spinal cord shifting; JOA, Japanese Orthopaedic Association. *Statistically significant

P10

Dropped Head syndrome requiring reconstruction surgery after cervical laminoplasty: Report of three cases and review of the literature

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Question: Introduction: Dropped Head Syndrome (DHS) is characterized by severe weakness of the neck extensor muscles with or without involvement of the neck flexors. Most of the DHS is caused by a specific generalized neuromuscular diagnosis.

This causes the chin to rest on the chest in standing or sitting, where persistent chin to chest deformity may gradually cause or aggravate preexisting degenerative changes of the cervical spine and ultimately result in myelopathy.

DHS after cervical laminoplasty (LAMP) is a rare complication. We present three patients who developed severe DHS after LAMP despite having no preoperative cervical sagittal malalignment.

Methods: Case presentation: These three cases underwent LAMP for cervical spondylotic myelopathy. They achieved satisfactory improvement of neurological symptoms immediately after surgery. However, they exhibited a dropped head and complained of difficulty maintaining horizontal gaze. Postoperative images showed cervical kyphotic deformity causing anterior shift of the head.

Results: After LAMP, in accordance with decreases in their cervical lordosis, their head shifted anteriorly. The abnormal lever arm acting on the neck put further stress on the neck extensors, and the overstretched neck extensors possibly no longer generated enough power to raise the head. Uncompensated very high T1 slope because of marked thoracic kyphosis plus invasion of the posterior extensor mechanism by LAMP may have contributed to their catastrophic DHS development. One patient had a C2-T2 anterior and posterior fusion, C4-7 anterior and posterior fusion and C2-T4 anterior and posterior fusion surgery and successfully managed with extension of the constructs.

Conclusions: Conclusions: In the treatment of cervical myelopathy, posterior decompression alone should be applied carefully with cervical sagittal imbalance even if they have apparent cervical lordosis.

P11

The relations with cervical kyphosis change and sagittal global alignment to occur after cervical laminoplasty

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Question: Postoperative cervical kyphosis after laminoplasty has been reported as complication of laminoplasty, however there are few reports about the influence of preoperative global alignment to postoperative cervical alignment after laminoplasty. The purpose of this study is to evaluate the risk factors related to postoperative cervical kyphosis after laminoplasty.

Methods: The subjects were 64 patients who underwent cervical laminoplasty for cervical spondylotic myelopathy and ossification of the posterior longitudinal ligament. We evaluated the risk factors by comparing the progressive to kyphotic deformity group with non-progressive group. We defined kyphotic deformity progressive group as postoperative C2-7 angle of 0° or less from preoperative angle of more than 0°. Measurement parameters were sagittal alignment in preoperative cervical spine (flexion and extension position), global sagittal spinal sagittal alignment.

Results: The progressive to kyphotic deformity group included 20 patients (31%) and non-progressive group included 44 cases (69%). C2-7 angle in extension position, cervical lordosis(CL) and thoracic kyphosis(TK) significantly low in the progressive to kyphotic deformity group (P<0.01, P<0.01, P=0.04, respectively). The area under the curve (AUC) for these risk factors were 0.62, 0.71, 0.66, respectively. Using Youden index, the cut off value were 23.2°, 9.7°, 30.2° respectively, and the sensitivity were 0.89, 0.90, 0.90, respectively and the specificity were 0.68, 0.52, 0.39, respectively. The other global sagittal alignment parameter significantly had no difference.

Conclusions: The results indicated that preoperative cervical hypolordosis and thoracic hypokyphosis were risk factors of postoperative cervical kyphosis deformity after laminoplasty. This study suggested that the postoperative cervical kyphosis after laminoplasty was related with cervical and thoracic alignment without relating with the lumbar and pelvic alignment.

P12

Morphologic change of the spinal cord according to correction of cervical kyphosis by surgical intervention

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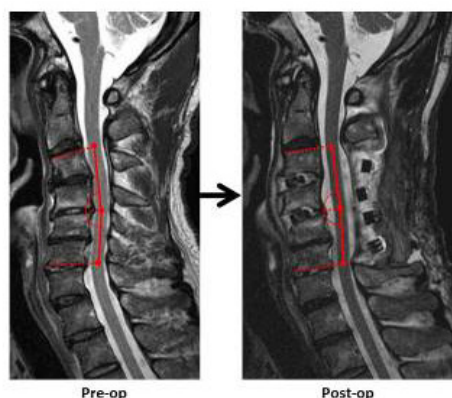
Question: Correction surgery of cervical kyphosis can be done for the patients in whom the kyphosis causes myelopathy and/or severe cervical deformity. In those cases, morphologic change of the spinal cord according to the correction of cervical kyphosis is unknown.

Methods: Thirty-seven patients who underwent correction surgery using cervical pedicle screw (21 male, 16 female, a mean of 71 years old) were enrolled. When coincided with canal stenosis, posterior decompression was performed before kyphosis correction. Local kyphosis angle which was measured between two lines parallel to the upper and lower end plates constituting the kyphosis were measured at pre- and post-operation on MRI (Figure). To measure the angle of the spinal cord, the mid points of the cord at the extension of the upper and lower endplates and the beak of the local kyphosis were indicated (Figure), and the angle between the lines constituting these dots were measured at pre- and post-operation (Figure). Width of the cord at the beak of kyphosis and the distance of the posterior shift of the cord between at pre- and post-operation were also measured.

Results: There found correlation between the change of local kyphosis and the change of the spinal cord angle between at pre- and post- operation. There also found correlation between the change of local kyphosis and the changes of the spinal cord width and the posterior spinal cord shift between at pre- and post-operation.

Conclusions: This study, for the first time, has indicated the morphologic change of the spinal cord according to the correction of cervical kyphosis by surgical intervention. That is, the morphology of the cord may be got back in shape after correction surgery for cervical kyphosis. It is important to perform posterior decompression before the kyphosis correction for avoiding iatrogenic cord injury due to buckling of the cord. Correction surgery for cervical kyphosis, free of canal stenosis, provides good direct and indirect decompression of the spinal cord.

Figure 1



P13

Outcomes of correction surgery using cervical pedicle screw for dropped head syndrome

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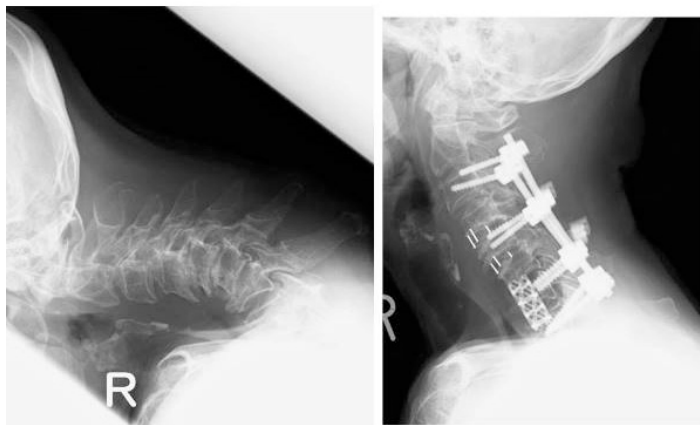
Question: Dropped head syndrome (DHS) is a rare clinical entity which is defined as a chin-on-chest deformity in the standing or sitting position, resulting from sagittal imbalance of the cervical region. DHS disturbs the patient's quality of life because they hardly gaze horizontally. Surgical intervention is a therapeutic option, and posterior fixation using cervical pedicle screw (CPS) is a gold standard to correct such severe kyphotic deformity. However, outcomes of correction surgery for DHS using CPS is unknown.

Methods: Sixteen DHS patients [2 male and 15 female, with an average age of 76 years] who underwent correction surgery using CPS were enrolled. Seven cases underwent posterior surgery, and nine with rigid kyphosis required anterior release, cage insertion, and posterior fixation. Extent of the fixation involved any drivers in the cervical and thoracic spine. Spino-pelvic lateral radiographs in the standing position were taken. Parameters such as C2-7 angle, C2-7 SVA, and T1 slope were measured, and the parameter changes between pre- and post-operation were also examined. Complications such as spinal cord injury, C5 palsy, proximal/distal junctional kyphosis (PJK, DJK) non-union were investigated.

Results: All patients who underwent correction surgery were able to gaze horizontally after surgery. No spinal cord injury was observed. Three transient C5 palsy, one DJK were found. No non-union was observed. Pre-/post-operative C2-7 angle (degree) and C2-7 SVA (mm) were; $-35.9 \pm 21.1/8.6 \pm 7.6$ and $56.7 \pm 20.4/27.6 \pm 17.0$ respectively, and these changes showed statistical significance. On the other hand, Pre-/post-operative T1 slope (degree) was $23.4 \pm 19.3/27.1 \pm 9.8$, and the change did not reach to statistical significance.

Conclusions: In this study, we have indicated the outcomes of correction surgery using CPS for DHS. Because of the older age of the patients, several patients did not agree with surgical intervention, however, surgery brought good clinical and radiological outcomes with fewer complications.

Figure 1



P14

Changes in the quality of life of patients operated on for kyphotic deformity of the cervical spine, depending on the parameters of the local sagittal balance of the cervical spine

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Question: to study the effect of the parameters of the sagittal balance and the quality of life patients operated with kyphotic deformity of the cervical spine.

Methods: 25 patients was operated with kyphotic deformities of the cervical spine (42% - women, 58% - men) in ours clinic in 2014-2018. The average age 35.3 ± 14 years. The mean follow-up period was 25.4 ± 11.3 months. The evaluation of the neurological status was performed the scale of the JOA, EMS. The pain was assessed by a VAS, the quality of life, the NDI questionnaire was used. Clinical outcomes were assessed by the modified Macnab criteria. Neuroimaging methods: MRI, CT and X-ray. According to the radiography the evaluation was performed: Sagittal vertical axis (SVA) C2-C7, SVA center gravity of head (CGH) -C7, C1-C2 lordosis, Cobb angle C2-C7, Spino-cranial angle (SCA), Thoracic inlet angle TIA), Neck tilt (NT), T1 slope, C7 slope, Cranial incidence (CI), Cranial slope (CS), Cranial tilt (CT). Statistical analysis was conducted using Welch's t-test, Mann-Whitney and Fisher's exact test (R software).

Results: all patients had a positive clinical outcome, VAS scores ($p = 0.00012$), NDI ($p = 9.53E-05$), JOA ($p = 0.00057$), EMS ($p = 0.00063$) significantly changed in comparison with preoperative results. The relationship between center SVA gravity of head (CGH) -C7 with clinical indices of VAS ($p = 0.002$), NDI ($p = 0.04$) and clinical outcomes on the Macnab scale ($p = 0.009$) was revealed. Cobb angle C2-C7 ($p = 0.00782$), Spino-cranial angle (SCA) ($p = 0.00715$), C7 slope ($p = 0.05287$) in the postoperative period were compared with preoperative values.

Conclusions: the SVA gravity of head (CGH) -C7 parameters of the regional cervical sagittal balance have a correlation with the clinical indices of VAS, NDI, and the clinical outcomes on the Macnab scale.

Radiographic and clinical outcomes can correlate in cervical deformity correction: a discriminant analysis of HRQL outcomes and correlation with an established morphological classification

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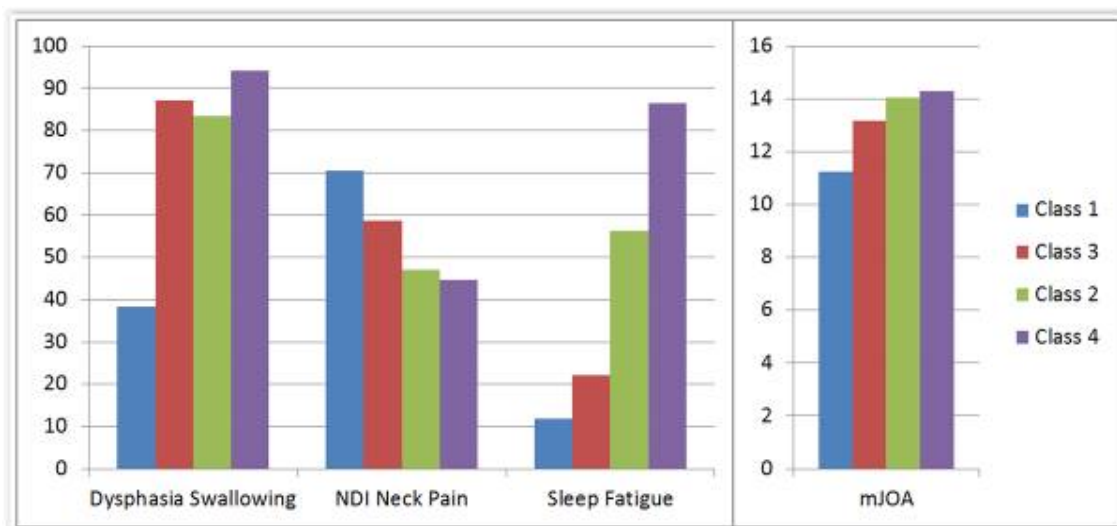
Question: There is an increasing appreciation of the complexity and heterogeneity of CD patients. Notably, broad variability in presentation with regards to the effect of functional status and quality of life exists. Our objective was to characterize clusters of CD from a health related quality of life perspective

Methods: Adult CD patients with preoperative HRQL scores were included. Factor analysis categorized individual clinical characteristics from SWAL-QOL, NDI, and mJOA into four independent factors, followed by a latent class analysis (LCA) to assign patients into homogeneous classes of clinical outcomes. One-way analysis of variance (ANOVA) assessed differences in demographics, HRQL scores, and radiographic alignment across classes

Results: 137 patients (61±10 years, 61% female) were included. Polychoric correlations identified four independent factors: 1=difficulty with dysphasia/swallowing, 2=Neck Pain, 3=fatigue and sleep, and 4=physical function and myelopathy. The LCA identified 4 classes of distinct patients. Class 1 (n=13, 9.5%) and 3 (n=55, 40.1%) had the greatest disability in NDI (68±17), sleeping, and myelopathy, with Class 1 presenting additional impairment in dysphasia and swallowing (SWAL scores<54.9). Class 2 (n=38, 27.7%) showed small dysphasia/swallowing impairment, and moderate levels of disability in other domains. Class 4 patients (n=31, 22.5%) had the lowest neck disability (NDI 43±16), and presented no issue in other domains. The distribution of deformity morphotypes was different across classes (p=0.009): 66.7% of CT deformity in Class 1, 50% of focal deformity in Class 3, and resp. 42% and 50% of flatneck (TS-CL and a lack of compensation) in Classes 2 and 4.

Conclusions: Distinct patterns of specific clinical deficits were observed across a heterogeneous population of CD patients. These findings form a potential basis for a future CD classification system rooted in clinical outcomes.

Figure 1



Intraoperative alignment goals for severe cervical deformity to achieve optimal improvements in health-related quality of life measures

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Question: Patients with severe cervical deformity (sCD) have deficits in activities of daily living. Association between health status and radiographic goals of surgery is difficult to quantify. We aimed to quantify radiographic goals that correlated with enhanced post-surgical outcomes

Methods: Patients with sCD were isolated based upon a previously presented combination of radiographic parameters and grouped into 3 patterns of CD: focal deformity (FD), flatneck (FN), or cervicothoracic (CT). Post-operative outcomes were defined as "good" if a patient had ≥ 2 of the 3 following criteria (1) NDI < 20 or meeting MCID, (2) mild myelopathy (mJOA ≥ 13), and (3) NRS-Neck ≤ 5 or improved by ≥ 2 points from baseline. We compared patients with good versus poor outcomes via Chi-squared or student's t-tests

Results: 40/105 patients met the criteria of sCD and had 1-year FU. Patient breakdown by deformity pattern was: CT (N=13), FN (N=17), and FD (N=17), with 7 patients meeting criteria for both FD and FN. For FD patients, focal kyphosis was corrected in patients with a "good" outcome ($p = 0.03$). In the FN cohort, patients with "good" outcomes had worse preop horizontal gaze ($p=0.061$) and cSVA ($p=0.030$) and had greater postop correction of horizontal gaze ($p = 0.031$). CT patients with "good" outcomes had larger global alignment (SVA) both pre- ($p < 0.001$) and postop ($p=0.001$), better postop cervical alignment (cSVA, $p=0.030$), and less postop kyphotic segments in extension ($p=0.011$). In the FD cohort, "good" outcome patients showed improved postoperative focal kyphosis ($p=0.030$). In 3 deformity patterns categories, there were no differences between "good" and "poor" outcome patients in demographic or surgical parameters (all $p > 0.050$)

Conclusions: These results show intra-operative goals for 3 sagittal morphotypes of sCD. Intra-operative goals include obtaining proper sagittal global/cervical alignment for CT patients, correcting max focal kyphosis in FD patients, and correcting horizontal gaze for FN patients

P17

Upper thoracic versus mid-thoracic lower instrumented endpoints have similar radiographic and clinical outcomes in cervical deformity patients

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Question: Often patients with CD require extensive fusions that extend into the thoracic spine. However, factors that influence the treatment approach and level selection are poorly understood

Methods: A prospective CD database was analyzed for the following inclusion criteria: LIV between C7-T5 and a UIV of C2, and 1 yr min follow up (f/u). Patient demographics, operative details, radiographic parameters and clinical outcomes were compared between those with a LIV from C7-T2 (UT) versus T3-T5 (MT). X2 and independent samples T-Tests were performed for Statistical Analysis

Results: 64 patients met inclusion criteria for the study and 46 were included in the analysis (avg. age 62, 58% Female, avg 1yr f/u) with 22 in UT versus 24 in the MT groups. No differences were seen in age or revision case prevalence, EBL, Operative Time or surgical approach (anterior, posterior, combined) types between groups. MT patients had a higher pre-op cSVA, TS-CL, Max Kyphosis and T9PA and were treated with a larger number of PSOs ($p<0.01$). There was a larger correction in Cervical Lordosis (CL) seen in the MT group (29 vs. 17, $p=0.04$) and larger changes in T4-T12 (9.6 vs. 0.0, $p<0.01$). No differences were seen in DJK ($p=0.22$) or rates of revision surgery (5% vs. 21%, $p=0.19$, UT – 1 for Neuro deficit, MT – 2 DJK, 2 Neuro deficit, 1 prominent instrumentation). There were no differences in major or minor complications or in the rate of reoperations. No differences were noted in NDI, mJOA or SWAL-QOL between groups at pre-op baseline values or at final follow up

Conclusions: Similar radiographic and clinical outcomes were noted in patients undergoing fusion to the UT or MT spine. MT patients had larger pre-operative deformities evidenced by a larger cSVA, TS-CL and Max Kyphosis and were more likely to undergo PSOs for treatment.

P18

Importance of the sagittal Occipitoaxial alignment in rheumatoid arthritis, clinical outcome and adjacent levels degeneration analysis: A retrospective study on 35 patients treated by Occipitocervical stabilization

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Question: To evaluate the relevance of the alteration of the physiologic Occipitoaxial alignment in developing adjacent levels degeneration in the subaxial spine, in patients stabilized due to an evolving symptomatic rheumatoid arthritis.

Methods: We present a retrospective study on a series composed of 35 patients, treated between 1992 and 2018, affected by rheumatoid arthritis with localization to the atlantoaxial joint. Patients were classified, according to Steinbrocker classification for rheumatoid arthritis, in 4 groups. Occipitoaxial alignment was assessed radiographically using the McGregor line. Patients were followed up afterwards and evaluated by the Visual Analogue Scale for the assessment of pain, and by the Nurick scale for the cases associated with myelopathy. SF36 was used to evaluate clinical outcome.

Results: We observed an improvement in the subjective evaluation of pain in all treated patients, with a 46% improvement from the initial values. Moreover patient stabilized with an Occipitoaxial angle included in the physiologic range, showed better results either for the survival of the instrumentation or the onset of junctional pathology. Occurrence of subaxial dislocation and adjacent level instability occurred mostly in severe rheumatoid arthritis. This group of patients, mostly in class III and IV, according to Steinbrocker classification, showed the highest rate of complications and up to 75% of subaxial subluxation.

Conclusions: The study of the occipitoaxial angles has shown that the better results and the long lasting stability of the implant are correlated to a fusion angle included in the physiological range. In our experience Occipitocervical fixation showed a reliable and reproducible outcome with a solid improvement in pain management of all patients

P19

Occipital cervical fixation in pediatric patients under 10 years of age

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Question: In the past literature indication for pediatric occipital cervical fixation with rigid instrumentation (adult instrumentation) is to use in children at least 10 ys of age, later with time also in children younger until 3 ys of age. Our experience shows that these rigid instrumentations can be used under this age, while in patients under 18ms of age we prefer treat this small children with simple arthrodesis with or without wiring, but may be on the base of our experience, supported by recent literature, shows that these age limits can be lowered

Methods: Limit in instrumentation use is determined by the accuracy of the surgical technique and by the anatomic size of the patient, and only partly by patient age. We used rigid adult instrumentation in 10 patients under 10 years of age, treated by rod, occipital screws and screws/hooks instrumentation until two years of age. In Most cases they where isolated malformation or malformations in syndromic patients. . We operated 3 patients under 2 years of age, using wirings and autograft.

Results: Mean follow up is 9 years (range 5 – 16 years). No Major complication; 1 case of bursitis at occipital fixation level, resolved with medical therapy; 1 case of occipital screw mobilization without bone/instrumentation defaults; 1 case of superficial wound infection treated by antibiotic therapy.

Conclusions: In our opinion the occipital-cervical fixation is yet to use in young people when the malformation involving especially foramen and dens. We have two most important matters in pediatrics occipital-cervical fixation/arthrodesis: A) Anatomy is the most important factor in determining the use of instrument arthrodesis to treat pediatric cervical spine malformations/instability. Any way The risks of a more invasive implant are balanced out by potential results. B) The loss of range of motion related to occipital- cervical arthrodesis fixation, but in our experience this loss of motion resulted well balanced and compensated by the adjacent segments.

P20

Comparison of perioperative complications following posterior column osteotomies versus posterior based three column osteotomy for correction of moderate to severe cervical sagittal deformity in 95 patients at single center

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Question: Are posterior based 3CO (Cervical Osteotomy Ames Grades 5-OWO or 6-CWO) are associated with higher perioperative complication rates and more severe complications compared to PCO (Cervical Osteotomy Ames Grade 2-PCO)?

Methods: A retrospective comparison of complication profile between posterior based 3CO and PCO was performed in a single surgeon experience from 2011 to 2018 of all patients with cSVA of >4 cm who underwent correction for cervical deformity. Multivariate analysis was utilized.

Results: 95 patients were included: 49 3CO and 46 PCO. 12 of PCO had anterior releases. Mean age was 63.2 years and 60.0% were female. Preoperative and postoperative parameters: cSVA (6.2 cm and 3.5 cm, $p<0.001$), cervical lordosis (-6.8 degrees (kyphosis) and 7.5 degrees, $p<0.001$), and T1-slope (40.9 degrees and 35.2 degrees, $p=0.026$). Complication rate was 37.9% and neurologic deficit was 16.8%. Surgical and medical complication rates were 17.9% and 23.2%. Overall, surgical, and neurologic complication rate was higher with 3CO compared to PCO but this was not significant (42.9% vs. 32.6%, $p=0.304$, 18.4% vs. 10.9%, $p=0.303$, and 20.4% vs. 13.0%, $p=0.338$). Medical complication rates were similar (23.9% vs. 22.4%, $p=0.866$). Independent risk factors for surgical complication were male gender (OR 10.88, $p=0.014$) and cSVA >8 cm (OR 10.36, $p=0.037$). Anterior-posterior surgery was independently associated with medical complications (OR 10.30, $p=0.011$). Kyphosis >20 degrees was an independent risk factor for neurologic deficit (OR 2.08, $p=0.011$).

Conclusions: There was no significant difference in complication rates between 3CO and PCO. Preoperative cSVA > 8 cm and kyphosis >20 degrees are risk factors for surgical and neurologic complications, respectively. Larger prospective studies are needed.

P21

Neurologic complication rates and utility of intraoperative neuromonitoring in lower cervical and upper thoracic posterior based three column osteotomies for correction of cervical deformity

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Question: Are neurological deficit rates higher following posterior based three column osteotomies (3CO) for cervical deformity and is current neuromonitoring modality sufficient in detecting postoperative weakness?

Methods: This study performed a retrospective review of a single surgeon experience from 2011 to 2018 of all patients who underwent posterior based 3CO in the lower cervical or upper thoracic spine. Medical and neuromonitoring records were reviewed.

Results: 49 patients were included: 31 PSO and 18 VCR. Mean age was 61.1 years and 44.9% were male. 65.3% were myelopathic and 30.6% had preop weakness. Mean blood loss was 1674.5 ml and surgery length was 314.6 minutes. Preoperative and postoperative measures were cSVA (6.8 and 3.7 cm, $p<0.001$), lordosis (0.0 and 9.1 degrees, $p=0.030$), and T1-slope (49.8 and 36.7 degrees, $p<0.001$). Complication rate was 44.9% and neurological deficit rate was 20.4%. When stratified by osteotomy level, there was significantly higher rates of neurological deficits at C7 and T1: C7 (37.5%), T1 (37.5%), T2 (20.0%), T3 (15.4%), T4 (0.0%) ($p=0.023$). C7 and T1 level deficits were most consistent with single nerve root weakness; C8-hand intrinsic most common followed by C7 triceps rather than spinal cord injury. There was 8 NM signal changes with 3 true positives and 7 false negatives (false negative rate of 70.0%) Performance measures were: accuracy 75.5%, PPV 37.5%, NPV 82.9%, sensitivity 30.0%, and specificity 87.2%.

Conclusions: Complication rates are high following posterior 3CO for cervical deformity. 3CO at C7 and T1 have the highest rates of neurological deficit. Current transcranial NM and EMG have modest utility in predicting postoperative deficits. A large multicenter prospective study is warranted to study neurological risk in cervical deformity surgery.

P22

Hybrid fixations for atlantoaxial dislocation or instability

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Question: Most of atlantoaxial dislocation and instability need operative treatment. Many different fixation methods can be choose, like C1C2 pedicle screws fixation, C2 laminar screws fixation, subaxial lateral mass screws, transarticular screw, Halo-vest external fixation, which used to fixed symmetry. When atlantoaxial dislocation or instability combined with pedicle dysplasia or vertebral artery high riding, we must treat it by Hybrid fixation to get firm fixation.

Methods: From Feb 2010 to May 2015, 16 cases with atlantoaxial dislocation and instability were reviewed retrospective, with 10 cases of male and 6 cases of female(mean,42.3 years). 10 cases were atlantoaxial dislocation and 6 cases with instability. 11 cases with high cervical myelopathy, with JOA score 9-14, average 12.5.

Results: 15 cases were operated by 2 different fixations and 1 case by 4 different fixations. Hybrid fixations were used because of C2 vertebral artery high riding, C2 pedicle maldevelopment, osteoporosis. 10 cases with atlantoaxial fixation and 6 cases with occipital- cervical fixations. no intraoperative vertebral artery injury and spinal cord injury were noted. All patients were followed up for average30.5 months(from14 to 60months) cases. JOA scores ranged from 13 to17 (mean,15.0). No postoperative internal fixation loose and breakage were observed and atlantoaxial fusion was seen in all the cases.

Conclusions: Atlantoaxial dislocation or instability combined with pedicle dysplasia or vertebral artery high riding, we can have good outcome by Hybrid fixation.

Figure 1



Question: Dropped head syndrome (DHS) is caused by various disease. We present three cases of DHS with severe sagittal imbalance treated by surgical procedure. They had postural disorder, inability of horizontal gaze, gait disturbance, and no neurological or muscular disorders.

Methods: Case report

Results: Case 1. A 76-year-old woman with low back pain. On the lateral X-ray, C2-C7 angle (C2-7A) showed 40° kyphosis, Cervical anteversion angle (CAA; the angle between vertical line and the line connecting C1 anterior arch and C7 vertebral body) showed 63°, C2-7SVA showed +91mm, with 40° thoracic kyphosis (TK), 0° lumbar lordosis (LL) and +28mm SVA. We performed posterior correction and fusion (PCF) from L2 to pelvis. TK, LL and SVA changed to 41°, -46° and -16mm. C2-7A, CAA and C2-7SVA also improved to 4°, 9° and +20mm.

Case 2. A 78-year-old woman. C2-7A, CAA and C2-7SVA showed 69° kyphosis, 91° and +87mm, with 46° TK, 6° LL and +232mm SVA. We performed PCF from T10 to pelvis with L2 VCR. TK, LL and SVA changed to 53°, -48° and +31mm. C2-7A, CAA and C2-7SVA also improved to 2°, 20° and +32mm.

Case 3. A 74-year-old woman. She also had cervical myelopathy such as numbness and difficulty at her fingers. C2-7A, CAA and C2-7SVA showed 24° kyphosis, 47° and +73mm, with 27° TK, -6° LL and +114mm SVA. We performed PCF from C2 to T5 at first with the aim to improve her myelopathy. C2-7A improved to -11° post-operatively, but CAA, C2-7SVA, TK, LL and SVA showed 40°, +65mm, 50°, -15° and +138mm. She still had postural disorder, inability of horizontal gaze and gait disturbance, so we performed PCF from T5 to pelvis after 3 weeks. CAA, C2-7SVA, TK, LL and SVA improved to 1°, +6mm, 35°, -66° and +6mm.

Conclusions: Discussion In the case of DHS with severe sagittal imbalance, it might be better to correct the thoracolumbar alignment and balance at first. In the case with cervical myelopathy, it might be better to do just decompression at first and to evaluate the whole sagittal balance afterwards.

Figure 1

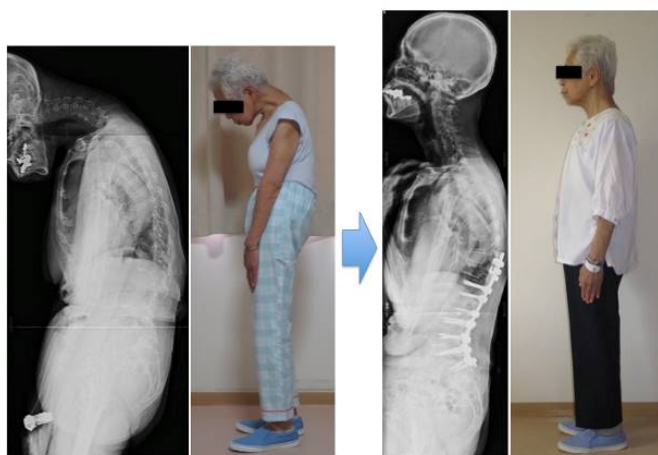
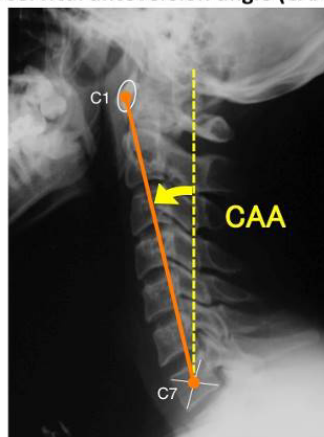


Figure 2

Cervical anteversion angle (CAA)



P24

The Impact of the lower instrumented level on outcomes in cervical deformity surgery

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Question: Compare outcomes in CD patients undergoing instrumented correction according to the relation of LIV with primary driver of deformity

Methods: CD database inclusion: cervical kyphosis $>10^\circ$, scoliosis(coronal Cobb $>10^\circ$), positive cervical sagittal imbalance (cSVA $>4\text{cm}$ or TS-CL $>10^\circ$), or CBVA $>25^\circ$. Patients were stratified by primary driver of deformity: *cervical*(C) via Ames classification(TS-CL >20 or cSVA >40) & *thoracic*(T) via hyper/hypo-kyphosis(TK) from T4-T12 ($60<\text{TK}<40$). Pts were further stratified by LIV in relation to curve apex (above/below). Univariate and multivariate analyses identified group differences in post-op HRQLs and DJK(>10 degrees LIV and LIV+2) rate up to 1-year

Results: 62 CD patients (54.9yrs, 62.8%F) were analyzed. Mean parameters at BL: TSCL 28.1, cSVA 26.9, T4-T12 angle 38.1. 21 pts had a C primary driver and 41 had a T primary driver by definition. 100% of C primary drivers had LIVs below CL apex, while 9.2% of T primary drivers had LIVs below (caudal) to TK apex and 90.8% had LIVs above TK apex. No differences in HRQLs were found between C and T groups at BL and 3mo post-op. By 1Y, C patients trended lower NDI(21.9vs29.0,p=0.245), lower NRS Neck pain (4.2vs5.1,p=0.358), and significantly higher EQ5D VAS (69.2vs52.4,p=0.040). When T pts with LIVs below TK apex were excluded, remaining T pts with LIV above apex had significantly higher 1Y NDI than C pts(37.5vs21.9,p=.05). T patients also trended higher rates of post-op DJK than C (19.5%vs4.8%, p=0.119). No significant differences in mJOA were found (p>0.05)

Conclusions: Stopping prior to apex was more common in patients with a primary thoracic driver (T) and associated with deleterious effects. Those with a primary cervical driver (C) tended to have LIVs inclusive of CL apex with lower rates of post-op DJK. Additionally, T patients with LIVs above TK apex had significantly higher NDI and lower EQ5D VAS scores by 1-year.

Complications: epidemiology, diagnosis and imaging

P25

C5 palsy develops relatively often after multilevel anterior or anteroposterior combined surgery in cervical spine

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Question: C5 palsy was sometimes seen after cervical spine surgeries. The results after laminoplasty and/or instrumentation were often reported. However those after anterior surgeries in the cervical spine were not well known. We investigated the incidence rate and cause of C5 palsy after anterior reconstructive surgery in the cervical spine.

Methods: Fifty-seven patients who underwent anterior reconstructive surgeries with corpectomy and bone graft in the cervical spine, W/WO posterior fixation, were included. The lesion was multilevel and including C4/5 level. In those, 33 underwent anterior pedicle screw (APS) W/WO plate fixation (A group) and 24 APS and posterior fixation (A&P group).

Results: Nine patients developed C5 palsy postoperatively (9/57; 15.7%). Five of 33 patients (15.2%) were in A group and 4 of 24 (16.7%) in A&P group. The surgical time and bleeding (C5 group / non-C5 group) were 300.6 / 234.9 minutes and 339.4 / 264.8 ml. The surgical lesion was 3.1 / 2.6 levels. JOA score was 10.0 / 11.1 preoperatively and 12.3 / 14.6 postoperatively, and its recovery rate was 37.3 / 58.9 % respectively. The local kyphotic angle was 14.3 / 8.2 degrees preoperatively and 0.9 / -3.2 degrees postoperatively. The correction angle by surgery was 13.4 / 11.6 degrees. C2-7 angle was 13.3 / 4.6 degrees kyphotic before surgery and 2.1 / -4.6 degrees kyphotic in final follow-up. Six of 22 cases (27%) with 15 degrees or more kyphosis preoperatively developed C5 palsy postoperatively.

Conclusions: Higher incidence rate (15.7%) was seen after multilevel anterior or anteroposterior combined surgery in cervical spine. There was no significant difference of incident rate between anterior alone surgery and anteroposterior combined surgery. When the patients have more severe kyphotic deformity and /or severe myelopathy symptom preoperatively, they are likely to develop C5 palsy after anterior or anteroposterior reconstructive surgery.

P26

Corticospinal tract function and clinical presentations among various morphologies of ossification of the posterior longitudinal ligament in the cervical spine

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Question: To investigate the correlation between the corticospinal tract function, clinical symptoms, and morphology of the cervical ossification of the posterior longitudinal ligament (OPLL).

Methods: Motor evoked potentials following transcranial magnetic stimulation, as well as M- and F-waves following electrical stimulation of the ulnar and tibial nerves, were measured from the abductor digiti minimi muscle (ADM) and abductor hallucis muscle (AH) in 60 patients with OPLL, and the central motor conduction time (CMCT-ADM/AH) was calculated. The JOA score for cervical myelopathy was obtained before and at one year after surgery. As radiological assessments, an extended form of the OPLL to the adjacent vertebral body was evaluated and expressed as a "disconnected" (D), "beyond the intervertebral level" (IV), "bridge formation to the adjacent vertebral body" (VB), or "at the vertebral level but non-bridge" (VnB), in each level on sagittal CT images in the level of the severest cord compression. Dynamic lateral radiographs were evaluated for the segmental range of motion (ROM) and occupying ratio (OR) of the OPLL at the level that the largest OPLL was detected.

Results: The OR in the IV and VnB groups were significantly higher than that in the D group. The ROM in the IV group was higher than that in the VnB group (Wilcoxon rank-sum nonparametric test, $0 < 0.001$). The ROM in the VB group was absolutely lower than those in the other groups ($0 < 0.001$). The CMCT-ADM and CMCT-AH were significantly higher in the IV group than in the VB group ($p = 0.002-0.012$). The CMCT-AH was higher in the IV group than in the VnB group ($p = 0.002$). The JOA score before and one year after surgery in the IV group was significantly lower than that in the other groups ($p = 0.000-0.002$).

Conclusions: Our results suggest that the patients with OPLL which extends beyond the intervertebral level presented high segmental ROM and RR, and prolonged CMCT values, which may contribute to low JOA score before and after surgery.

P27

Analysis of complications of pedicle screw fixation in surgery of the cervical spine

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Question: Objective: to evaluate the results of transpedicular fixation of the cervical spine.

Methods: The study included 42 patients operated on the cervical spine. Of these, 9 with degenerative diseases, 21 with injuries, 7 patients with tumors, anomalies and systemic diseases of 5 patients, in the period from March 2013 to September 2018, 23 were men (54.7%) and 19 women (45.3%). The age was 42.3 / 37 (25;44) and ranged from 3 to 70 years. Localization: craniocervical transition 26 (61.9%), subaxial level 16 (38.1%). ASIA, VAS, ODI. Radiography, CT, MRI of the cervical spine, performed before and after surgery and 12 months. When damage to the vertebral artery was performed CT angiography, Doppler ultrasound, BCA. To determine the position of the screws used classification Abumi (2014). The follow-up from 12 to 48 months.

Results: 282 screws were implanted in 42 patients. Posterior approach surgery was performed, patients were divided into two groups. In group I in 15 patients 110 (39%) screws were implanted using C-arm, in group II in 27 patients, 172 (61%) screws were implanted using O-arm. According to the classification of Abumi G0-210 screws were implanted, G1-40, G2 -35 screws. In the first group, screw malposition with spinal artery stenosis with clinical manifestation of vertebrobasilar insufficiency was noted in 2 cases (4.7%). In the second group, intraoperative vertebral artery injury was observed in 5 patients without clinical manifestation (11.9%). Malposition screw with clinical manifestation were observed. Blood loss – 360/100 (200;500), was varied from 100 to 2000 ml. When damage to the vertebral artery blood loss amounted to an average of 2100±500 ml.

Conclusions: Screw malposition in transpedicular fixation of the cervical vertebrae is frequent and occurs from 12% to 14.5%. Of these, clinically significant malposition requiring audit intervention amount to 4.7%. The use of O-arm navigation reduces the number of positions.

P28

Surgical outcomes for upper cervical lesions in athetoid cerebral palsy patients

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Question: Cervical disorders in athetoid cerebral palsy (CP) patients are well known as difficult situation for surgical treatments. Among them, cranio-cervical lesions sometimes gave us various troubles after surgery. This study aimed to elucidate failures and complications of upper cervical surgeries for athetoid CP patients and to discuss on possible solutions.

Methods: Subjects were 35 athetoid CP patients (18 males and 17 females) who underwent surgical treatments on the cranio-cervical junction in past 35 years (1983-2017). The mean age at surgery was 60.9 years old and the mean follow-up period was 7.1 years. Adopted surgical methods were occipito-cervical (O-C) fusion in 29 patients, C1-C2 fusion in one and C1 posterior decompression in five. Surgical outcomes were reviewed on instrument failures, post-operative complications and functional improvement.

Results: All surgical procedures were safely completed without complications except for one patient who showed dyspnea immediate after extubation and required re-intubation. Instrument failures occurred in 6 out of 29 (20.1%) patients who underwent O-C fusion. These failures were found after 6 months following the surgery. Fortunately none of them ever showed neurological deterioration, and then, required any revision surgeries (but one patient underwent occipital plate removal because of skin irritation). Neurological improvement was limited in most patients and the mean recovery rate was just 9.5% by JOA score evaluation.

Conclusions: We believed that immobilization on the pathological lesions was crucial for athetoid CP patients, and therefore, selected O-C fusion for majority of patients with cranio-cervical instability. However, we experienced high incidence of instrument failures in chronic stage. Fortunately, none of them required revision procedures because of neurological deteriorations. These facts might indicate we should consider decompression surgery without instrumentation in proper cases.

P29

Serious complications related to surgical site infection after cervical laminoplasty : A report of two cases

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Question: Background: Infection-related complication after spinal surgery could be sometimes life-threatening and can cause a significant consequence. We report two cases of infection-related serious complications after cervical laminoplasty.

Methods: Case1. A 39-year-old male who complained of gait disturbance underwent laminoplasty (LP). During surgery, dural tear occurred at lateral gutter. He was afebrile and surgical wound was clear although he felt occasional headache. He lost consciousness suddenly and presented with general convulsion on 13th day from surgery. Lumbar puncture suggested bacteriogenic meningitis. We carried out spinal drainage and started intravenous antibiotics administration. Spinal drainage was placed for 10 days, then removed. Gradually, his laboratory data improved. He was discharged six weeks after surgery.

Results: Case2. A 66-year-old male presented with clumsiness and walking difficulty. He had long standing Parkinson disease (PD). After LP, partial dehiscence and discharge developed. The patient underwent surgical debridement. Two days after debridement, quadriplegia occurred. MRI revealed discitis change at C4-5. The patient underwent second urgent surgery of anterior debridement and bone graft. Administration of antibiotics was carried out and infection subsided completely in four weeks. His neurological function improved gradually, however clumsiness and sensory loss remained strongly.

Conclusions: Meticulous evaluation of patient is always crucial in the treatment of postoperative infection which is prone to worsen patient's condition rapidly. In case1, spinal drainage should have been performed earlier postoperatively to eliminate abnormal flow at dural tear site. Case2 presented rare and rapid expansion of infection from posterior side to anterior disc space despite urgent intervention. Quadriplegia caused by discitis first seemed to be akinesia resulted from suspension of anti-PD medication, which added to confusion in observing patient.

P30

Notfall reposition of atlantioaxial dislocation in trauma

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Question: Possibility of reposition of traumatic atlantioaxial dislocation in the emergency Departement in pateints with cervical trauma before surgery

Methods: C arm and short ananthesia

Results: Out of 3 patients 2 patints profited hugly from the reposition

Conclusions: Neu methods should be implemented in the reposition

P31

Percutaneous ultrasonographic observation of the spinal cord in cases of epidural hematoma after cervical laminoplasty

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Question: In cervical laminoplasty using suture anchors, the postoperative condition of the spinal cord can be observed using percutaneous ultrasonography. In some cases with epidural hematoma after cervical laminoplasty, we obtained interesting ultrasonographic findings of the spinal cord.

Methods: Four patients who underwent cervical laminoplasty with suture anchors and had troubles related to postoperative epidural hematoma were investigated. The state of the spinal cord was observed using a percutaneous ultrasonography at the time of occurrence of the trouble and over time. Ultrasonographic findings (presence of epidural hematoma and spinal pulsation) and clinical course were examined.

Results: Case 1: Epidural hematoma was observed, but spinal pulsation was kept. The clinical course was normal. Case 2: Quadriplegia occurred from 3 hours after surgery. Epidural hematoma was observed and the spinal pulsation disappeared. After emergency hematoma removal surgery, paralysis improved and the spinal pulsation also recovered. Case 3: Temporary paralysis occurred at 2 days postoperatively. Paralysis improved in about 10 minutes. Epidural hematoma was observed, and the spinal pulsation was weak. The clinical course was normal. Epidural hematoma was absorbed and the pulsation improved over time. Case 4: Temporary quadriplegia occurred from 1 hour postoperatively. Epidural hematoma was observed, spinal pulsation was weak. Because the paralysis improved in about 30 minutes, surgery was not enforced. After that, no paralytic symptoms occurred, but even 14 days postoperatively, epidural hematoma was recognized and the spinal pulsation was weak. Because the wound reopened at 20 days postoperatively, we performed hematoma removal. After that, improvement of spinal pulsation was observed.

Conclusions: Disappearance and weakness of the pulsation of the spinal cord indicate that the spinal cord was under pressure and can be an indicator of revision surgery.

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Defining an algorithm for treatment of severe cervical deformity using surgeon survey and treatment patterns

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Question: Patients with severe cervical deformity (sCD) present a unique challenge to surgeons. The literature provides only limited guidance on operative strategies for these patients. We aimed to create treatment guidelines based on patient radiographic parameters for sCD patients

Methods: We sent 10 sCD cases to 7 surgeons to find consensus on 1) approach 2) UIV 3) LIV 4) osteotomy. We performed a descriptive analysis and created a treatment algorithm that was then applied to a sCD database to find frequency of following our algorithm

Results: There was consensus on 5/10 cases for posterior approach because of CT deformity or a high cSVA. Of 15 pts with cSVA>5cm and T1S>50° we found 13/15 had a posterior approach and 2/15 had an antero-posterior (AP) approach. Two cases had consensus of AP, because of local kyphosis. Of 25 pts with a local kyphosis >18°, 14 had an AP, 7 had posterior and 4 had anterior. There was a higher rate of osteotomies for posterior versus AP approach (6/7 vs 3/14). UIV was consensus for C2 for 5/10 cases, because of fusion length and fixation strength. Of 35 pts that had a posterior fusion >6 levels, 20/35 had a UIV of C2. 3/10 cases had consensus LIV below a UIV of previous fusion. If a previous UIV was at T6 or higher then 34/36 pts had a LIV below previous UIV. In 6/10 cases a VCR/PSO was not needed due to flexibility of the cervical spine. Of 12 pts within the database that had a VCR/PSO there were 9/12 that were inflexible

Conclusions: We recommend for sCD that 1) if T1S> 50 deg, cSVA > 5cm use a posterior approach 2) if local kyphosis is >18 deg then use of an anterior-posterior approach be considered 3) if instrumentation is higher than T6 then LIV bypass old UIV and 4) if there is >10 deg in C2-C7 Cobb angle motion on flex/ex radiographs a VCR/PSO may be avoided

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The X-ray of upper cervical spine is generally unclear. The computed tomography (CT) doesn't reflect the weight of head. Therefore, the accurate diagnosis of vertical subluxation (VS) is difficult. Tomosynthesis (TOMOS) can be taken in standing position. We investigated the effectiveness of TOMOS for VS.

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Question: The X-ray of upper cervical spine is generally unclear, especially in bone destructive lesions such as rheumatoid arthritis. The computed tomography (CT) of upper cervical spine doesn't reflect the weight of head, because it is taken in supine position. Therefore, the accurate diagnosis of vertical subluxation (VS) is sometimes difficult. Tomosynthesis (TOMOS) is new high performance tomography which can be taken in standing or sitting position. In this study, we consider which the method effect for the diagnosis of VS in rheumatoid arthritis patients.

Methods: Twenty three atlantoaxial lesions of rheumatoid arthritis patients were included in this study. All patients underwent X-ray, CT and TOMOS at the same time. The distance between McGregor line and the top of the dens (defined as VS value) was measured with above three radiographies. The VS value among three radiographies was investigated.

Results: A total of 20 cases were diagnosed as VS by TOMOS, 17 cases by CT, 12 cases by X-ray. In 8 cases, the dens was not clearly identified in X-ray. In 11 cases, the VS value of TOMOS increased compared to CT. In 9 cases, the VS value of X-ray increased compared to CT. In this study, we investigated the effectiveness of TOMOS for the diagnosis of VS in rheumatoid arthritis patients. With TOMOS, 20 cases were diagnosed as having VS, though 17 cases in CT and 12 cases in X-ray. Furthermore, the clear dens was not identified with X-ray in 8 cases. Above results indicated that TOMOS is useful for the diagnosis of VS in rheumatoid arthritis patients, because it clearly shows the landmark of the upper cervical spine, and it can take the weight of head into consideration.

Conclusions: TOMOS is effective for the diagnosis of VS in rheumatoid arthritis patients. Because TOMOS clearly shows upper cervical spine.

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New id: O26 | Mario Boni Grant nominated ePoster

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Two case reports of bilateral C5 palsy after laminoplasty for cervical spondylotic myelopathy

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Background: Cervical laminoplasty (CLP) is a common procedure for cervical spondylotic myelopathy (CSM) with favorable outcomes and high in safety. However, some surgical complications including C5 palsy have been reported. The C5 palsy usually occurred unilaterally, therefore, few studies have focused on bilateral C5 palsy. In addition, although there are various hypotheses, the etiology of postoperative C5 palsy has not been clarified

Objectives: We try to reveal the etiology of C5 palsy through the two cases of bilateral C5 palsy after CLP.

Results: Case Description: The first case is 60year-old man of CSM, who underwent a C3-6 CLP. C5 palsy was not observed just after CLP. At 10 hours after CLP, he suffered from right followed by left C5 palsy. The bilateral C5 palsy progressed in severity (MMT: 1+) at 24 hours after CLP. The second case is a 68year-old man who underwent a C4-6 CLP concomitant with C3 laminectomy for CSM. Neurologic deterioration was not observed just after CLP. At 4 days after CLP, he suffered from right C5 palsy. Six days later, left C5 palsy occurred. The bilateral C5 palsy progressed (MMT: 1+) at 2 weeks after CLP. In both cases, MRI obtained within 48 hours after CLP showed an excessive posterior shift of the spinal cord. However, the posterior shift of the spinal cord nearly regressed about 1 month later. The first case showed complete recovery at 1 year after surgery. The second case also showed a recovering tendency 3 months after surgery.

Conclusions: In our cases, C5 palsy occurred first unilaterally with some delay after CLP and progressed to bilateral C5 palsy soon. Besides, we found that an excessive posterior shift of the spinal cord immediately after CLP, followed by restoration of the excessive shift, might cause bilateral C5 palsy. The specific MRI findings had not been showed in patients without C5 palsy. These features suggest that postoperative C5 palsy may be a result of tethering phenomenon.

Degenerative cervical spine

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Radiographic and clinical results of C1 laminoplasty for the treatment of compressive myelopathy

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Question: C1 laminectomy has been the standard procedure for decompression at the C1 level. However, there have been some reports of trouble cases such as spontaneous anterior arch fracture and dynamic paraspinal muscle impingement causing acute hemiplegia after C1 laminectomy. C1 laminoplasty might be superior to C1 laminectomy in some respects. The purpose of this study was to evaluate the radiographic and clinical results of C1 laminoplasty without fusion.

Design: A retrospective review of the patients treated with C1 laminoplasty for compressive myelopathy at C1 level.

Methods: Seven patients with spinal cord compression without obvious segmental instability at the C1 level treated by C1 laminoplasty were included. The indication of C1 laminoplasty was same as C1 laminectomy. C1 laminoplasty was performed in the same way as subaxial double door laminoplasty. Imaging findings such as segmental instability of C1/2 and the size of the retroodontoid pseudotumor were evaluated using X-ray films and MRI. Clinical results were evaluated using the Japan Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ) and JOA score. Perioperative and postoperative complications were also investigated.

Results: No patients showed increase of C1/2 segmental instability after surgery. The mean pre- and postoperative sizes of retroodontoid pseudotumor were 8.7 and 9.3 mm, respectively. The mean pre- and postoperative JOA scores were 8.6 and 11.7, respectively. The mean recovery rate was 40.2%. Each domain in the JOACMEQ except upper extremity function improved. No major complications including spontaneous anterior arch fracture was observed over a period of about four years follow-up.

Conclusions: There were no complications that seemed to be unique to C1 laminoplasty. C1 laminoplasty for patients without obvious segmental instability might be a viable alternative procedure to C1 laminectomy.

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Jugular outlet syndrome (JOS), a common sequela of chronic upper cervical dysfunction

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Upper cervical dysfunction is a common complaint amongst patients with whiplash-associated disorders (WAD) and chronic neck pain (CNP), however, conventional diagnostic criteria often fail to reveal focal segmental abnormalities in these patient groups. This presentation aims to demonstrate the existence of and diagnostic criteria for “jugular outlet syndrome” (JOS), a common condition where the neurovascular bundle emerging from the jugular foramen gets compressed between the transverse process of the C1 and styloid process of the skull due to forward subluxation of the atlanto-occipital facet joints, often resulting in many diffuse problems such as craniocervical instability, CNP, migraines, endolymphatic hydrops, cranial nerve dysfunction, visual impairment, and intracranial hypertension. The paradoxical notion that a normal mediosagittal cervical alignment and subluxed atlantoaxial facet joints may coexist, was first mentioned by Indian Neurosurgeon Atul Goel (2015). Similarly, anterior atlanto-occipital subluxations are rarely evident by reviewing only the mediosagittal alignment, which is where most conventional craniocervical measurements are made, but may rather be detected by evaluating the alignment of the paramedian facet joints as well as the transverse processes’ alignment in relation to the jugular foramen. This can usually be done with conventional capital MRI. As the C1 subluxes forward, usually due to longstanding poor craniocervical postures and consequent myoligamentous compromise, the occipital and atlantal condyles lose their vertical alignment, allowing the occipital condyles to sink posteroinferiorly due to forced posterior angulation of the odontoid peg. This may cause JOS along with a reduced clivoaxial angle. Interventions such as jugular stenting, styloidectomy, transversectomy, or specific conservative therapy may ameliorate the condition.

Figure 1

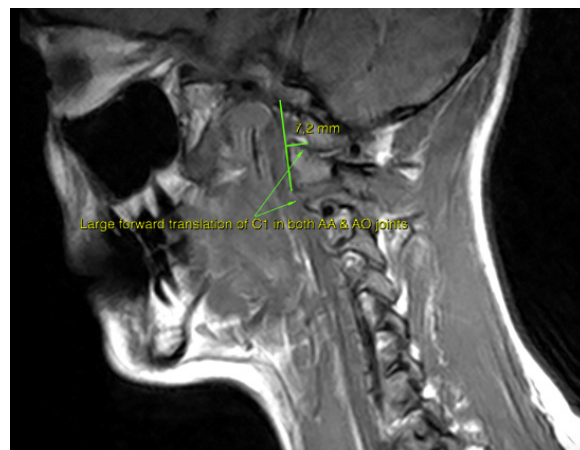
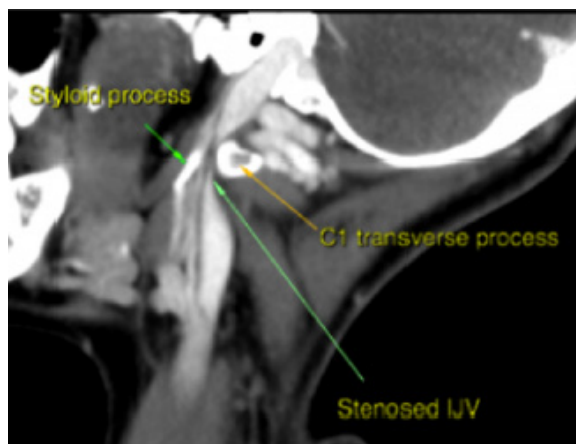


Figure 2

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Anterior vs posterior foraminotomy in solution of isolated cervical radiculopathy

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Question: Is there any difference in results between anterior and posterior surgery

Methods: 234 patients with a degenerative cervical spondylopathy were treated surgically at the Neurosurgery department of Ceske Budejovice over the period of 2012 to 2016. Since 2012 less invasive approaches have been used at our department in patients with cervical radiculopathy caused by isolated foraminal stenosis without spinal canal stenosis. Two approaches have been employed: anterior cervical microforaminotomy and posterior cervical foraminotomy as described by Frykholm. The inclusion criteria for both approaches were: cervical radiculopathy with a corresponding foraminal compression without instability, myelopathy or medial cord compression.

Results: 15 anterior cervical microforaminotomies (ACF) and 27 posterior cervical foraminotomies (PCF) were performed in the period between January 2012 and December 2016. The C6/7 was the most frequently treated segment. A complete relief from irritation was observed in 66% and 55% of patients when comparing ACF with PCF respectively. The ACF group was noticed to have a full recovery of sensorimotor deficit in 33% of cases while it was 25% in the PCF group. Partial relief from radicular irritation was noticed in 20% of ACF patients and in 37% of PCF patients. Partial improvement in sensorimotor deficit was seen in 58% of cases in both groups alike. 13% of ACF and 7% of PCF patients had no relief from irritation. No improvement in sensorimotor deficit was noticed in 6% and 16% of cases respectively. None of the patients suffered from worsening of either radicular pain or a deficit. One patient from either group developed a wound infection. Indication of ACDF was necessary in 1 ACF patient. No cases of a new radicular lesion, cervical sympathetic trunk trauma or vertebral artery damage were observed.

Conclusions: A retrospective analysis of treatment outcome was performed in a small group of patients. Neither of the two approaches was associated with serious complications.

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Extremely high preoperative C7 slope limits compensatory cervical lordosis after muscle-preserving selective laminectomy

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Question: A high C7 slope induces C2–C7 lordosis to compensate for cervical sagittal balance adjustments. A muscle-preserving selective laminectomy (SL) can maintain this compensation postoperatively. Our research question is whether the extremely high C7 slope (\geq average + 1 SD, 30°) whose cervical sagittal alignments highly compensated by preoperative C2–C7 hyper-lordosis limit compensatory mechanism of cervical lordosis after SL.

Methods: This retrospective study enrolled 151 cervical compressive myelopathy patients who underwent SL. Lateral cervical spine radiographs were taken before surgery and during final follow-up. Patients were divided into extremely high C7 slope ($\geq 30^\circ$) (EH) and non-high C7 slope ($< 30^\circ$) (NH) groups and the influence of a high C7 slope on radiological and surgical outcomes was examined. Unpaired t-test, chi-square test, Mann-Whitney U test and multiple linear regression analysis were used for statistical analyses.

Results: Mean age was higher in group EH ($p < 0.001$) (Fig 1). Preoperatively, patients in group EH had a larger C2–C7 sagittal vertical axis (SVA) ($p = 0.001$) and greater cervical lordosis ($p < 0.001$) (Fig 2). Although C2–C7 SVA increased after surgery, mean C2–C7 angle of group EH decreased (Fig 2 and 3). Mismatches between C7 slope and C2–C7 angle increased for group EH postoperatively ($p = 0.015$) (Fig 2). Postoperative Japanese Orthopedic Association (JOA) score and recovery rate (RR) were slightly lower in group EH ($p = 0.001$ and $p = 0.006$, respectively) (Fig 1). Multiple linear regression analyses revealed that extremely high C7 slope, not age, affected the RR of JOA score ($\beta = -0.223$, $p = 0.006$) (Fig 4).

Conclusions: Patients in group EH were older and had highly compensated cervical sagittal alignment preoperatively. They demonstrated postoperative cervical sagittal balance mismatch increases and slightly worse functional recovery. An extremely high C7 slope limited compensatory cervical lordosis following SL.

Figure 1

Figure 1. Patients' characteristics as affected by preoperative C7 slope

	Preop. extremely high C7 slope ($\geq 30^\circ$, EH group)	Preop. non-high C7 slope ($< 30^\circ$, NH group)	p-value
Number of cases	31	120	
Age at surgery	67.5 \pm 9.5	58.2 \pm 11.8	<0.001
Sex (male, %)	74.1	60.8	0.168
OPLL (%)	22.6	27.5	0.580
JOA score			
Preop.	11.4 \pm 2.2	12.2 \pm 2.2	0.096
Postop.	13.3 \pm 2.0	14.6 \pm 1.7	0.001
RR (%)	35.1 \pm 20.4	49.1 \pm 25.9	0.006
Surgical factors			
The number of CLs surgically treated	2.9 \pm 1.0	2.7 \pm 0.8	0.315
Op. time (min)	141.3 \pm 36.9	128.9 \pm 28.3	0.091
Blood loss (g)	9.4 \pm 18.4	10.7 \pm 29.3	0.813
Operative level (n: cases)			0.095
C6 SL	4	8	
C5-C6 SL	4	34	
C4-C6 SL	14	60	
C3-C6 SL	9	18	

SL, selective laminectomy; OPLL, ossification of posterior longitudinal ligament; JOA, Japanese Orthopedic Association; RR, recovery rate; CLs, consecutive laminae

Figure 2

Figure 2. Patients' radiological parameters as affected by preoperative C7 slope

	Preop. extremely high C7 slope ($\geq 30^\circ$, EH group)	Preop. non-high C7 slope ($< 30^\circ$, NH group)	p-value
C2-C7 angle ($^\circ$)			
Preop.	23.9 \pm 9.6	7.6 \pm 10.8	<0.001
Postop.	22.2 \pm 11.0	9.7 \pm 11.7	<0.001
Postop. - Preop.	-1.8 \pm 5.8	2.2 \pm 6.5	0.003
C2-C5 angle ($^\circ$)			
Preop.	14.1 \pm 10.1	3.8 \pm 10.9	<0.001
Postop.	15.1 \pm 9.6	9.4 \pm 11.4	0.011
Postop. - Preop.	1.0 \pm 6.4	5.5 \pm 6.1	<0.001
C5-C7 angle ($^\circ$)			
Preop.	10.0 \pm 9.9	3.4 \pm 7.7	0.001
Postop.	7.7 \pm 10.2	0.0 \pm 9.4	<0.001
Postop. - Preop.	-2.3 \pm 6.0	-3.4 \pm 5.4	0.354
C7 slope ($^\circ$)			
Preop.	33.1 \pm 2.6	18.4 \pm 6.2	<0.001
Postop.	32.3 \pm 6.9	18.3 \pm 7.1	<0.001
Postop. - Preop.	-0.8 \pm 6.7	0.0 \pm 5.4	0.496
C7 slope - C2-C7 angle ($^\circ$)			
Preop.	9.2 \pm 10.2	10.8 \pm 9.0	0.391
Postop.	10.2 \pm 10.6	8.6 \pm 9.2	0.420
Postop. - Preop.	1.0 \pm 6.5	-2.2 \pm 6.3	0.015
C2-C7 SVA (mm)			
Preop.	25.8 \pm 17.5	16.0 \pm 14.0	0.001
Postop.	29.2 \pm 20.1	17.1 \pm 13.6	0.003
Postop. - Preop.	3.4 \pm 12.5	1.0 \pm 9.4	0.243
Cervical ROM ($^\circ$)			
Preop.	30.3 \pm 10.4	36.2 \pm 12.4	0.016
Postop.	23.6 \pm 9.7	30.9 \pm 12.7	0.003
Postop. - Preop.	-6.7 \pm 12.5	-5.3 \pm 14.4	0.624

SVA, sagittal vertical axis; ROM, range of motion

Figure 3

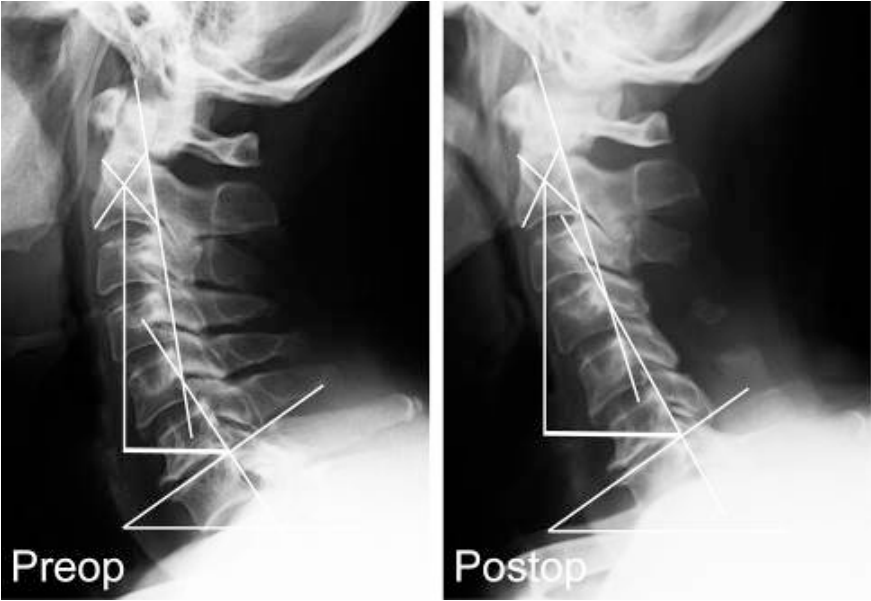


Figure 4

Figure 4. Multiple linear regression analysis of RR of JOA score

Characteristic	β	p-value
Preop. extremely high C7 slope ($\geq 30^\circ$)	-0.223	0.006
Age at surgery		0.185
C2-C7 angle ($^\circ$)		
Preop.		0.245
Postop.		0.382
Postop. - Preop.		0.735
C2-C5 angle ($^\circ$)		
Preop.		0.245
Postop.		0.298
Postop. - Preop.		0.871
C5-C7 angle ($^\circ$)		
Preop.		0.947
Postop.		0.528
C7 slope - C2-C7 angle ($^\circ$)		
Postop. - Preop.		0.282
C2-C7 SVA (mm)		
Preop.		0.419
Postop.		0.778
Cervical ROM ($^\circ$)		
Preop.		0.643
Postop.		0.942

RR, recovery rate; JOA, Japanese Orthopedic Association; SVA, sagittal vertical axis; ROM, range of motion

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Intradural cervical disc herniation: a case report

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Question: Introduction) Intradural disc herniation (IDH) were rare, especially in the cervical spine. This was a report of an intradural cervical disc herniation (ICDH) treated with spinal drainage following anterior cervical discectomy and fusion (ACDF) resulted in cerebrospinal fluid (CSF) fistula.

Methods: Case description) A 33-year-old male presented with a rapidly progressive neck pain radiating to the left limbs and left sided hemiparesis over a 3-month period. This was attributed to a cervical disc herniation at C6/7 on the MRI. The ACDF resulted in a dural defect and there was CSF fistula as the arachnoid membrane remained defective. This CSF fistula indicated a diagnosis of ICDH during the surgery. This CSF fistula was repaired by using fat and Neoveil patch with fibrin glue. Spinal drainage was inserted after the surgery under the same general anesthesia. This patient's postoperative course was uneventful and he almost completely recovered motor function.

Results: Discussion) ICDH is extremely rare. The diagnosis, treatment and pathology of condition are still unclear. It was difficult to diagnose ICDH before surgery depending on MRI findings only. We confirmed diagnosis of ICDH during the surgery and treated with fat graft and fibrin glue using with a lumbar drainage. In general, CSF leak after a ventral cervical spine surgery can be troublesome, resulting in a pseudomeningocele, respiratory obstruction, continuous CSF fistula and meningitis. Then it is important to repair the unexpected CSF leakage with meticulous management of dural and arachnoid tears. We chose spinal drainage rather than lumbar punctures because it was easy to control of CSF volume with patients' bed rest.

Conclusions: Conclusion) Here, a patient with ICDH sustained a durotomy with a CSF fistula during an ACDF. It was effective to repair for dural defect using patch closure and spinal drainage under the same anesthetic.

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Surgical outcome and characteristics of C7 spondylolisthesis with myelopathy

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Question: Incidence of C7 spondylolisthesis is low and reports of C7 spondylolisthesis with myelopathy are rare. The purpose of this study to evaluate the surgical outcome and characteristics of C7 spondylolisthesis with myelopathy.

Methods: Six patients (5 males and 1 females) with C7 spondylolisthesis and myelopathy who received surgery from June 2010 to April 2017 and could be followed for at least 1 year were included in this study. C7 spondylolisthesis was defined as an anterior slip of 2mm or more. Medical records were evaluated retrospectively. Evaluated factors were as follows: surgical procedure, JOA score and recovery rate, Frankel grade, occurrence of ossification of posterior longitudinal ligament (OPLL), ossification of yellow ligament (OYL) and calcification of yellow ligament (CYL).

Results: Mean age at the time of surgery was 60 (52-68) years old, and mean follow up periods were 38 (12-97) months. Posterior spinal fusion using pedicle screw and partial laminectomy was performed in 5 cases. Cystectomy with partial laminectomy was performed in one case with juxta facet cyst. The mean JOA score was 6 before surgery and improved to 9 at the final follow up. The mean recovery rate of JOA score was 61% (18-89%). Pre-operative Frankel grade was C in 3 cases and D in 3 cases. Post-operative Frankel grade was D in 2 cases and E in 4 cases. All cases improved more than one grade. OPLL was found in 3 cases. OYL or CYL were found in 4 cases. Computed tomography (CT) revealed that osteoarthritis of the facet joint at the C7/T1 spinal segment in all cases. Juxta facet cyst at the C7/T1 spinal segment was found in 3 cases.

Conclusions: In this study, paralysis in the patients with C7 spondylolisthesis was relatively severe. However, it was improved after surgery. We thought that the mechanical stress between the rigid thoracic vertebrae and the movable cervical spine might cause C7 spondylolisthesis. Posterior spinal fusion and partial laminectomy for C7 spondylolisthesis resulted satisfied outcome.

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Calcification of cervical ligamentum flavum: Cause of rapid progressive cervical myelopathy

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Question: Acute onset and rapid progression of cervical myelopathy is very rare, except massive disc herniation. Calcification of the ligamentum flavum (CLF) is one of the causes in some cases. CLF was reported first in 1976 and there are many case reports in Japan. However, there has been no report on clinical features for cervical spondylotic myelopathy (CSM) with CLF compared with those without CLF. The aim of this study was to investigate clinical features and surgical outcomes after laminoplasty (LP) for CSM with CLF.

Methods: 21 consecutive patients with CLF (CLF (+) group) since January 2012 were included in this study. All patients underwent LP and were followed for at least 2 years after surgery. A control group consisted of 59 consecutive patients without CLF who underwent LP (CLF (-) group). We investigated duration of the symptom (time from onset to surgery) and JOA score.

Results: The mean duration of the symptom was 10.4 month in the CLF (+) group and 28.6 month in the CLF (-) group with significantly shorter duration of the symptom in the CLF (+) group. The duration of the symptom was less than three months in 47.6% of the CLF (+) group. The mean JOA score improved significantly from 10.1 points before surgery to 13.0 points at 2-year after surgery in the CLF (+) group (mean recovery rate 43.6%), and from 11.3 points to 13.5 points in the CLF (-) group (mean recovery rate 35.5%). The mean preoperative JOA score was significantly lower in the CLF (+) group.

Conclusions: Duration between onset of myelopathy and operation was significantly shorter, and JOA score was significantly lower in the CLF (+) group, suggesting sudden onset and rapid progression in this group. Because several studies demonstrated hydroxyapatite and/or calcium pyrophosphate dehydrate in the ligamentum flavum in patients with CLF, crystal deposition might induce rapid progress of myelopathy. Early decompression resulted in better neurologic outcome.

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Comparison of clinical outcome between posterior foraminotomy and anterior cervical discectomy and fusion for drop finger caused by 8th cervical nerve root impairment

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Question: Drop finger is well known symptom of posterior interosseous nerve palsy. Recently, it has been reported that impairment by an 8th cervical nerve root lesion can cause drop finger, namely C8 drop finger. Appropriate surgical procedure for C8 drop finger still remains to be elucidated. Here, we compared clinical outcome between posterior and anterior surgeries for C8 drop finger to allow for a better choice of surgical procedure.

Methods: The present study included 15 consecutive patients (13 male and 2 female) who were diagnosed as having C8 drop finger, in which muscle strength of the extensor digitorum communis (EDC) showed a manual muscle testing (MMT) grade of 3 or less, underwent surgery and were followed-up at least 1 year after surgery.

For initial nine patients, we performed foraminotomy via posterior approach. We applied anterior cervical discectomy and fusion (ACDF) for remaining six patients (Figure 1).

We retrospectively investigated the recovery of MMT of the EDC muscle by subtraction of preoperative from the final follow-up values. We compared the EDC muscle power recovery between surgical procedures.

Results: Patients underwent foraminotomy showed recovery of EDC muscle power (average MMT: 1.4 preoperatively and 3.2 postoperatively) and patients underwent ACDF also showed recovery of EDC muscle power (average MMT: 2.0 preoperatively and 4.0 postoperatively). There was no statistical difference in EDC muscle power recovery between both groups ($p=0.38$) (Figure 2).

Conclusions: C8 drop finger is better treated by surgery than conservative therapy. To date, there is no statistical difference in clinical outcome between foraminotomy and ACDF for C8 drop finger.

Figure 1

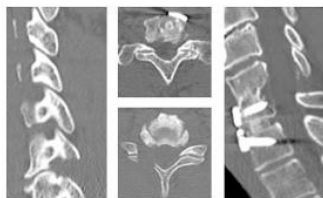
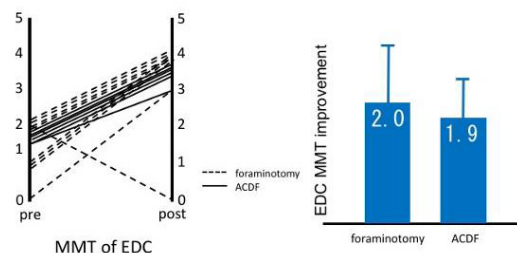


Figure 2



P44

CT morphometric analysis of the cervical spinal canal with special reference to the correlation between the levels of the vertebra

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Question: Sagittal diameter of the cervical spinal canal has been examined because the narrowness of the spinal canal associates with the development of cervical myelopathy. However, few studies have evaluated the correlation of the size with regard to the levels of the vertebra. In the present study, we measured the sagittal diameter of the cervical spinal canal and evaluated their correlation between them.

Methods: We included 84 patients with cranial or spinal disorders in this retrospective study. The spinal canal diameter (SCD) at C1 to C7 and the inner anteroposterior diameter (APD) of the atlas were measured on CT images and their correlations between the levels were evaluated.

Results: SCD at C1 was the largest and at C4 was the smallest in the cervical spinal canal. While there was a strong correlation between APD and SCD at C1 level ($r = 0.8$), the correlation between the size of the atlas and SCD at C4 to C7 was weak ($r = 0.2$). We classified the obtained data into two groups according to their SCD; normal group (SCD ≥ 12 mm at any level) and developmental stenosis group (DS group) (SCD < 12 mm at any level). The mean SCD at C2 to C7 was significantly larger in normal group than in DS group, however, there was no significant difference between two groups with regard to the APD and SCD at C1 level.

Conclusions: Present study indicates that the subaxial spine does not always affect the size of the atlas. The pathophysiology of the developmental spinal canal stenosis should be considered the subaxial level and the C1 level separately.

P45

Short-term effects of hyperbaric oxygen therapy for the patients with cervical myelopathy after cervical laminoplasty

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Question: Hyperbaric oxygen therapy (HBO) is one of the treatment options for spinal cord injury, myelopathy, and so on. Past literatures have discussed the effects of HBO such as recovery of motor functions, early wound healing, and prevention of infection. However, the effects of HBO are still controversial. In our institution, patients routinely underwent HBO after cervical laminoplasty. The purpose of this study was to evaluate the short-term effects of HBO for the patients with cervical myelopathy after cervical laminoplasty. A retrospective review of the patients treated with HBO after cervical laminoplasty.

Methods: Patients who underwent cervical laminoplasty from 2008 to 2018 in our institution were recruited and were divided into two groups. One was treated with HBO another was treated without HBO. The reasons for not receiving HBO were due to patient factors. Clinical results were evaluated using the Japan Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ) and JOA score. Treatment-related complications were also investigated.

Results: We ultimately included 45 patients with complete data after cervical laminoplasty. Thirty-five of 45 patients underwent HBO and remaining 10 patients did not undergo HBO. The average number of HBO treatments was 4.4 (3-6 single sessions). No significant differences in the clinical data were confirmed between two groups. No treatment-related complications were also confirmed in HBO groups.

Conclusions: HBO has no short-term effectiveness after cervical laminoplasty in this study. Less frequent HBO compared to past reports might affect these results. Furthermore the number of patients was small in present study. Therefore, these results might not be generalized immediately. Large scale and better quality study should be needed in the future.

P46

Radiographic evaluation of retro-odontoid pseudotumor associated with degenerative change and posterior fixation

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Question: Non-rheumatoid or non-dialysis retro-odontoid pseudotumor is caused by the chronic atlantoaxial (A-A) or occipito-cervical (O-C) instability. We have performed posterior fixation for this. The aim of this retrospective study is to evaluate the radiographic characteristics and outcomes in patients with retro-odontoid pseudotumor who underwent the posterior fixation.

Methods: We retrospectively reviewed 13 patients of non-rheumatoid or non-dialysis retro-odontoid pseudotumor who underwent posterior fixation; A-A fixation (A-A-F) or O-C fixation (O-C-F). Preoperative CT was evaluated for the existence of ossification of the anterior longitudinal ligament (OALL), ossification of the posterior longitudinal ligament (OPLL), and degenerative changes of A-A and O-C joints. We divided them into 4 groups based on the extent of degenerative change of A-A and O-C joints (none, mild, moderate and severe). Pre- and post-operative CT and MRI were evaluated for the change of tumor size. We also evaluated clinical outcome using Japan orthopedic association (JOA) score.

Results: 7 patients of them underwent O-C-F and others underwent A-A-F. 4 cases of them had OALL and 2 cases with OALL underwent O-C-F. The number of patients with degenerative change of A-A joint are 0, 1, 12 and 0, respectively and of O-C joint are 0, 4, 8 and 1, respectively. O-C mild group (4 cases) underwent A-A-F. 7 cases of O-C moderate group (8 cases) underwent O-C-F. O-C severe group (1 case) underwent A-A-F. The tumor size became reduced except on only two cases (1 O-C moderate and severe group with A-A-F). JOA score was improved on all cases.

Conclusions: This results suggested that using O-C-F on O-C mild and severe group might make reducing the tumor size compared with using A-A-F. We should make decision of the surgical method for retro-odontoid pseudotumor, considering the extent of degenerative change of O-C.

P47

A comparison of stand-alone locking zero-profile spacer and cage+plate for two-level cervical spondylopathy: a randomised control single-center trial

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Question: Anterior cervical decompression and fusion using cages+plates is a standard procedure for patients with multilevel cervical disc disease (cDD). However, plates might increase rates of postoperative dysphagia and adjacent segment degeneration. We investigated, if zero-profile devices prove superior versus a cage+plate-construct.

Methods: Consecutive patients with two-level cDD were assigned either to the interventional group (stand-alone zero-profile device) or control group (cage+plate). Primary endpoint was prevalence of dysphagia at 24 months. Disability according to the Neck Pain Disability Index (NPDI) at 24-months and progress of adjacent segment degeneration (Kellgreen score) were secondary outcome measures. Operation time, patient related outcome, complications, loss of correction measured by changes of Cobb angle (C2-C7) and changes of fused segment angle were recorded. Primary outcome parameter was statistically analysed by Chi-square test.

Results: 41 patients were randomly assigned to the interventional group (n=21) and to the control group (n=20). Dysphagia occurred frequently in either group at 3-months follow-up (FU), favouring interventional group (7 vs. 12 patients p=0.078). At final FU less patients of the interventional group complained about dysphagia (3 vs. 6 patients p=0.21) but the difference was not significant. No relevant differences were recorded for operation time (141min vs. 143 min), NPDI pre operative and at 24 months (56.8%±25.8% vs. 44.1%±22.2%), ODOM's criteria (3.2 vs. 3.5), loss of segmental (4.8° vs. 4.3°) and global (3.3° vs. 3°) correction and adjacent level degeneration. Fusion rate was slightly lower in the interventional group (92.5% vs. 97.5%).

Conclusions: Using a zero-profile cage dysphagia was infrequent at 24-months but the value did not reach statistical significance. Hence, this randomized trial was not able to proof the proposed clinical superiority for zero-profile anchored spacer in two-level cDD.

Question: The main objective of this observational cohort study was to assess the responsiveness and reliability of mid-sagittal and axial plane metrics in the quantitative assessment of degenerative cervical stenosis on T2-weighted magnetic resonance (T2-MR) images.

Methods: We retrospectively reviewed T2-MR images of patients with single-level degenerative cervical stenosis. Canal compromise and cord compression were evaluated using three mid-sagittal plane metrics: M1 (ratio of cord to canal diameters), M2 (ratio of cord diameter to the average of mid-vertebral caudal and cephalad cord diameters), M3 (ratio of canal diameter to the average of mid-vertebral caudal and cephalad canal diameters). Cord compression was further evaluated using two axial plane metrics: M4 (ratio of cord anteroposterior diameter to transverse diameter), M5 (absolute area of the cord). Metrics were evaluated at the level of stenosis and non-stenotic cephalad and caudal levels (controls). Responsiveness was evaluated as percentage deviation of the given metric from the estimated normal based on cephalad and caudal controls. Reliability for each metric was evaluated using intraclass correlation coefficients (ICC).

Results: MR data from 85 consecutive patients (48 M and 37F, median age 58 years) were considered in this study. Cervical stenosis showed a bimodal distribution peaking at C5-6 (n=32) and C3-4 (n=29) levels. No consistent variation was observed in the canal and cord morphology along the rostrocaudal axis. For the same severity of stenosis, M3 (-32.87±10.60%) was more responsive compared with M1 (16.64±16.48%) and M2 (-23.95±11.12%). Similarly, M4 was more responsive (-24.62±12.17%) compared with M5 (-6.71±11.08%).

Conclusions: In the assessment of single-level cervical stenosis on T2-MR images, M3 is more responsive compared with M1 and M2, and M4 is more responsive compared with M5.

Figure 1

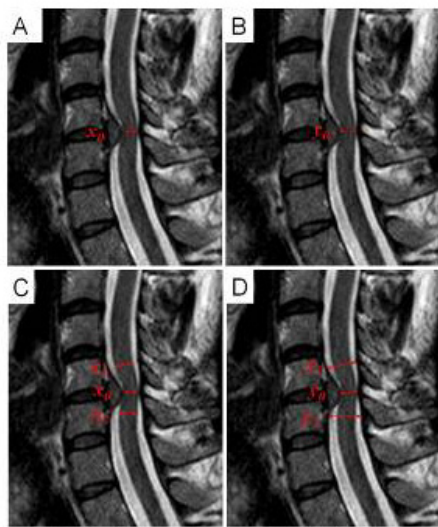


Figure 1. Mid-sagittal T2-weighted MR images of a patient with single-level cervical stenosis. A and B) $M1 = x_c/y_c$, where x_c is the cord diameter and y_c is the canal diameter at the level of stenosis. C) $M2 = x_c/(0.5*(x_c+x_d))$, where x_c is cord diameter at the level of stenosis, x_c and x_d are the cord diameters at the mid-vertebral cephalad and caudal levels respectively. D) $M3 = y_c/(0.5*(y_c+y_d))$, where y_c is canal diameter at the level of stenosis, y_c and y_d are the canal diameters at the mid-vertebral cephalad and caudal levels respectively.

Figure 2

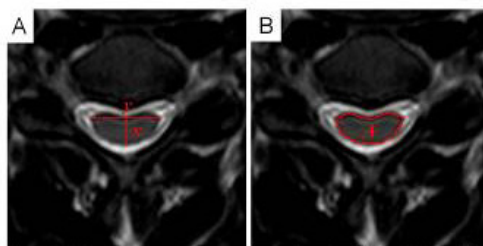


Figure 2. Axial T2-weighted magnetic resonance images of a patient with single-level cervical stenosis. A) $M4 = x/y$, where x is the anteroposterior diameter and y is the transverse diameter of the cord. B) $M5 = A$, where A represents the absolute cross-sectional area of the cord as enclosed by the free-hand contour.

Figure 3

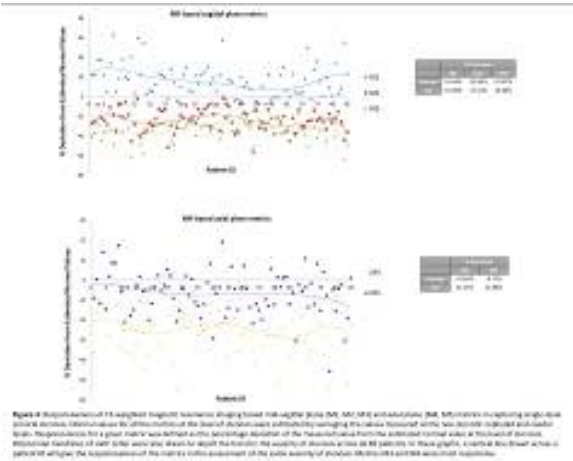


Figure 4

Table 1. Patient inclusion and exclusion criteria for the present observational cohort study.

Criteria for inclusion	Criteria for exclusion
1) Age \geq 18 years	1) Patients with a history of surgical intervention to the cervical canal or the cord
2) Evidence of non-traumatic, degenerative changes in the cervical spine, including disc desiccation, disc herniation, posterior osteophytes, flaval hypertrophy, ossification of the posterior longitudinal ligament at one or more cervical levels	2) Non-degenerative cord compression (e.g. tumorous or traumatic)
3) Cervical stenosis at no more than one level, defined as a change in spinal cord contour at the level of an intervertebral disc on mid-sagittal MR scan	3) Patients with multi-level compression, where adjacent cephalad and caudal levels show canal compromise and/or cord indentation
4) Nil compression, defined as nil canal compromise or cord indentation, at adjacent cephalad and caudal levels (to serve as controls)	

Figure 5

Table 2. Inter-rater and intra-rater reliabilities: Intraclass correlation coefficient (ICC) and their 95% confidence interval (CI at $\alpha=5\%$) for various geometrical measurements on mid-sagittal and axial T2-weighted MR scans of single-level cervical stenosis patients. ICC values less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.90 indicates poor, moderate, good, and excellent reliability, respectively. * denotes statistical significance for the given ICC.

		Intra-rater reliability (ICC values (95% CI))	Inter-rater reliability (ICC values (95% CI))
Mid-sagittal plane	Cord diameter	0.968 (0.883-0.992)*	0.928 (0.732-0.982)*
	Canal diameter	0.984 (0.931-0.998)*	0.973 (0.901-0.993)*
Axial plane	Transverse area of cord	0.953 (0.347-0.991)*	0.820 (0.100-0.960)*
	Anteroposterior cord diameter	0.750 (0.306-0.930)*	0.753 (0.144-0.937)*
	Lateral cord diameter	0.982 (0.932-0.995)*	0.992 (0.969-0.998)*

Figure 6

Table 3. Average (standard deviation) values for the T2-weighted magnetic resonance imaging based mid-sagittal plane (M1, M2, M3) and axial plane (M4, M5) metrics used for capturing morphological characteristics of the cervical spine at the stenotic and non-stenotic (cephalad and caudal) levels in 85 patients with single-level cervical stenosis. *, †, ‡ denotes statistical significance between stenotic- cephalad, stenotic-caudal, and caudal- cephalad, respectively.

Stenotic level		Non-stenotic levels	
Metrics		Cephalad	Caudal
M1	0.73 \pm 0.09 ^{†,‡}	0.64 \pm 0.06 ^{*,†}	0.61 \pm 0.06 ^{*,‡}
M2	0.74 \pm 0.11 ^{†,‡}	0.39 \pm 0.06 [†]	0.97 \pm 0.06 [†]
M3	0.65 \pm 0.10 ^{†,‡}	0.98 \pm 0.06 ^{*,†}	0.96 \pm 0.06 ^{*,‡}
M4	0.33 \pm 0.06 ^{†,‡}	0.46 \pm 0.07 ^{*,†}	0.43 \pm 0.06 ^{*,‡}
M5	56.71 \pm 11.40 ^{†,‡}	62.60 \pm 10.42 ^{*,†}	58.91 \pm 11.25 ^{*,‡}

Question: To describe our experience with syrinx formation in eleven cases with cervical spondylosis and to propose the natural history of this association. This report becomes more interesting if we consider that the literature is composed of only 6 isolated cases.

Methods: 11 cases with combination of cervical syrinx and cervical spondylosis are presented. The cause for detection of this combination was neck pain in 7 and minor neck trauma in 3 cases. Evaluation of one patient who had done already ACDF result in detection of Syrinx in one case. Neurological exam was normal in all 11 cases. T2-weighted magnetic resonance imaging (MRI) in all cases showed an hyperintense signal within spinal cord, in the vicinity from C3 to T4. All these neurologically asymptomatic cases were followed from 2 to 5 years

Results: In this combination despite progression of cervical spondylosis, the size of the syrinx and neurological exam remained unchanged in 9 cases. Interestingly, the syrinx disappeared in two cases.

Conclusions: Despite high frequency of cervical spondylosis development of small syrinx in cervical region is very rare. Local arachnoiditis should be the cause of its formation. With respect of the natural history, despite progression of cervical spondylosis, in this association, the neurological status of all patients remained normal. For this reason, prophylactic surgery is not recommended. The mechanism of spontaneous regression of syrinx which occurred in two of our cases has remained questionable.

Figure 1



Figure 2



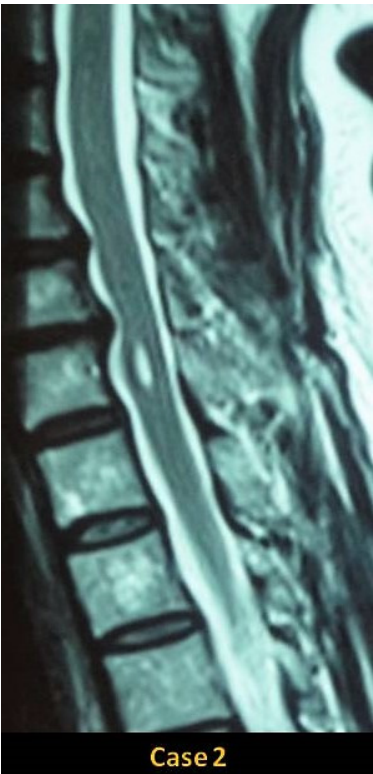
Figure 3



Figure 4



Figure 5



Question: Asymptomatic small and medium size cervical cyst are rare entity and are usually detected incidentally. The information about this pathology is scarce in the literature. Our aim is to describe our experience about medium term and long term follow-up of the patients with this pathology.

Methods: 14 cases including 6 males and 8 females with small to medium size cervical syrinx are presented. The age ranged from 23 to 48 years the syrinx was discovered incidentally in evaluation of simple neck pain in 10 and in three after mild neck trauma and in one volunteer employee of a radiology department for testing a MRI system.

Neurological exam was normal in all cases. No history of a congenital anomaly could be found in any of these patients. The patients were followed from 6 months to 7 years with periodic MRI.

Results: None of the patients developed neurological deficit. The size of the syrinx remained constant in all cases.

Conclusions: A small or a medium- sized cervical intramedullary syrinx might be discovered incidentally in a MRI done for other purposes. With respect to the natural history and their benign course, these asymptomatic pathologies don't require surgical intervention. Although periodic MRI is recommended.

Figure 1

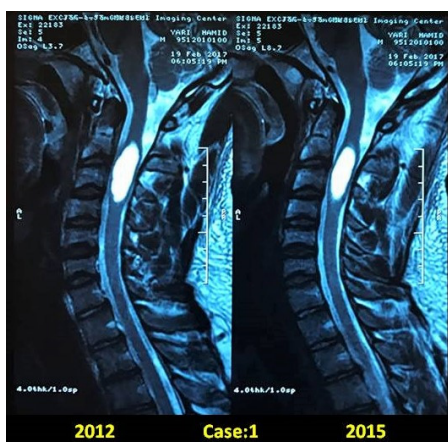


Figure 2



Figure 3



Figure 4

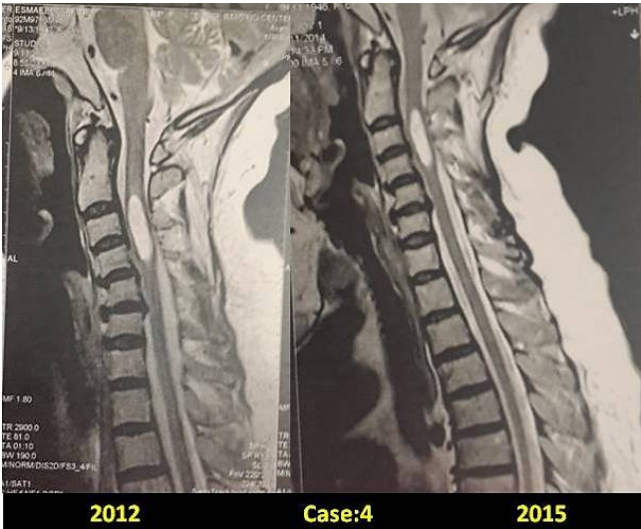
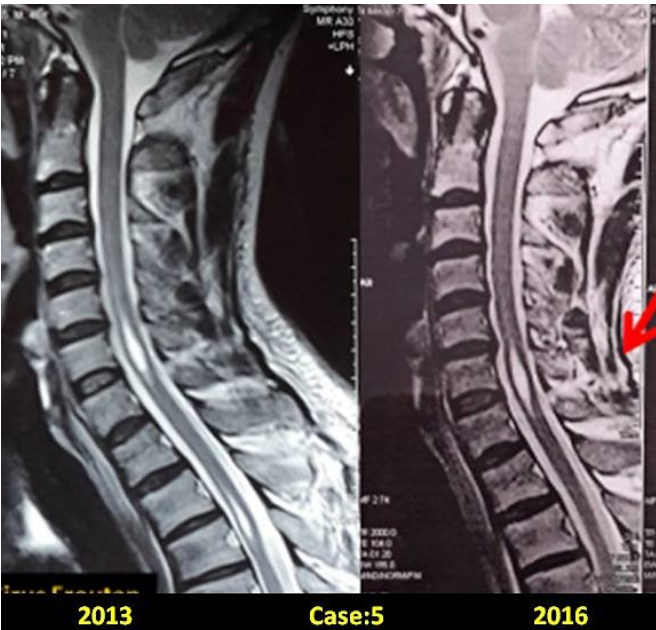


Figure 5



Clinical and radiological results of hybrid surgery combined fusion and non-fusion for four-level cervical degenerative disc disease: a case series study with maximum 6-year follow-up

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Question: Hybrid technique which combines fusion and non-fusion can perform fusion or replacement selectively according to different degenerative degrees for each segment. However, the studies about four-level hybrid surgery is limited and there are still concerns about the ideal range of motion and the fusion rate. This is the first study reported the clinical results of four-level cervical hybrid surgery. We summarized the follow-up and outcomes of nine patients to explore the effect of hybrid technique for four-level DDD, and discuss the hybrid operation idea of four-level DDD.

Methods: We collected patients who suffered myelopathy and/or radiculopathy with four-level hybrid in our hospital. The inclusion criteria consisted of (1) continuous 4 levels of cervical DDD between C3 and C7, (2) intact X-ray, CT and MRI information. (3) the follow-up > 12 months. And exclusion criteria involved: (1) previous cervical spine surgery. (2) cervical trauma, infection, tumor or severe osteoporosis. And finally, from September 2012 to October 2017, a total of 9 patients suffered four-level symptomatic DDD and underwent hybrid were investigated retrospectively.

Results: The NDI decreased from 41.22 ± 3.38 to 14.56 ± 2.88 , the JOA increased from 10.56 ± 1.33 to 15.11 ± 2.03 , and the VAS decreased from 7.11 ± 1.05 to 2.44 ± 0.53 . The cervical lordosis values were $8.64 \pm 7.27^\circ$ preoperatively to $10.37 \pm 5.10^\circ$ at final follow-up. The ROM of C2-C7 was $42.85 \pm 5.47^\circ$ to $26.13 \pm 4.48^\circ$. The ROM of replacement segment was $9.74 \pm 2.30^\circ$ to $8.69 \pm 2.67^\circ$. And the ROM of fusion segment was $8.84 \pm 2.53^\circ$ to $1.21 \pm 1.20^\circ$. The disc angle was $2.83 \pm 2.77^\circ$ to $2.91 \pm 2.30^\circ$. HO of grade 0-II was observed in 8 patients, while severe HO of grade III-IV in 1. Significant device subsidence was observed in 3 patients in ACCF level.

Conclusions: Hybrid technique is a safe and effective procedure for the treatment of four-level cervical DDD.

Figure 1

case no.	Age	Sex	Clinical diagnosis	procedure used per disc level		Hemorrhage	Hospital stay	Follow-up time
				arthroplasty	arthrodesis			
1	47	F	Myelopathy	C4/5 C5/6	C3/4 C6/7	400	13	72
2	56	M	Myelopathy	C4/5 C5/6	C3/4 C6/7	50	16	54
3	59	F	Myelopathy	C5/6 C6/7	[C3/4 C4/5]	200	13	48
4	63	F	Both	C3/4	[C4/5 C5/6] C6/7	50	9	37
5	48	M	Both	C3/4 C4/5	C5/6 C6/7	250	3	37
6	39	F	Both	C4/5 C6/7	C3/4 C5/6	60	5	24
7	54	M	Both	C3/4	[C4/5 C5/6] C6/7	70	6	24
8	53	F	Both	C4/5	C3/4 C5/6 C6/7	100	8	12
9	50	F	Both	C3/4 C4/5	C5/6 C6/7	80	2	12
mean	52.1					140	8.33	35.56

Table 1. Basic characteristics of patients and [] means fusion with ACCF, otherwise with ACDF.

Figure 2

Assessment	Preoperation(mean±standard deviation)	Final follow-up(mean±standard deviation)
NDI	41.22±3.38	14.56±2.88
JOA	10.56±1.33	15.11±2.03
VAS	7.11±1.05	2.44±0.53
ROM of C2/C7	42.85±5.47	26.13±4.48
ROM of arthroplasty segment	9.74±2.30	8.69±2.67
ROM of arthrodesis segment	8.84±2.53	1.21±1.20
ROM of superior adjacent segment	8.35±3.02	8.45±2.70
lordosis of C2/C7	8.64±7.27	10.37±5.10
angle of prosthesis	2.83±2.77	2.91±2.30

Table 2. The clinical and radiological data of patients preoperatively and postoperatively.

Figure 3

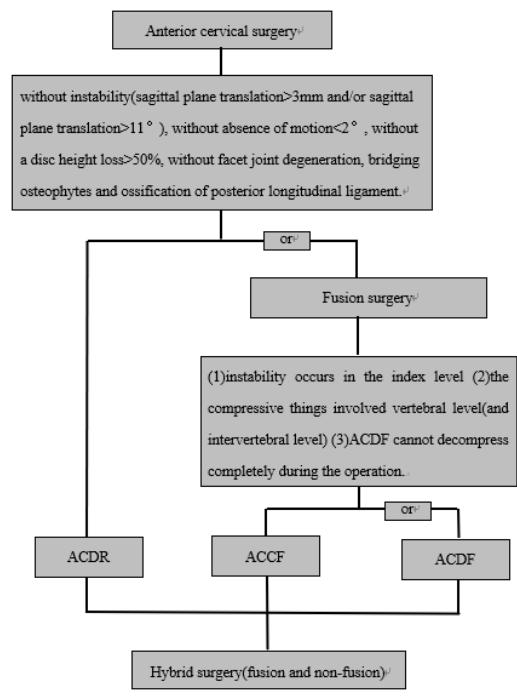


Figure 4

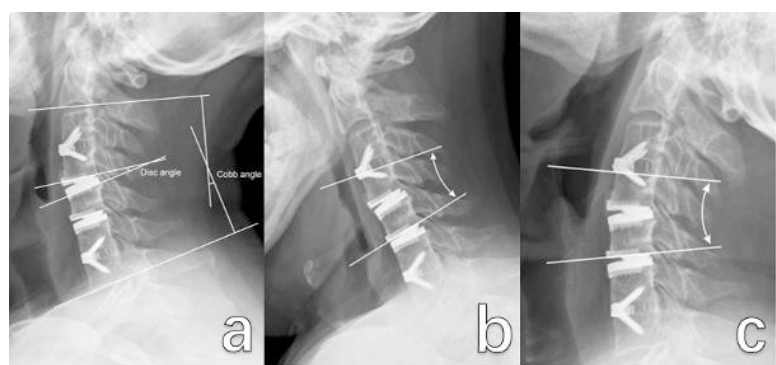
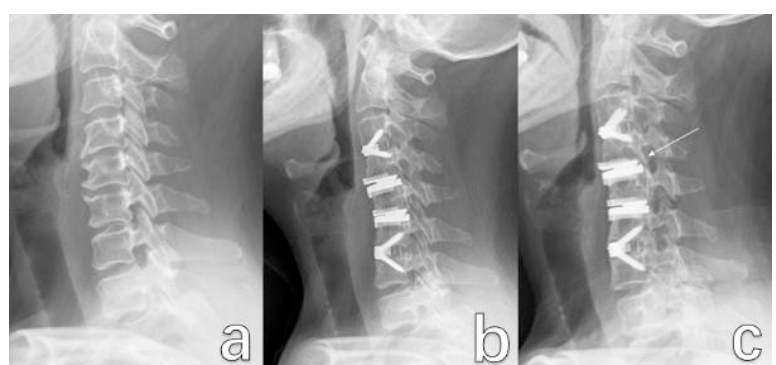


Figure 5



Question: Spontaneous intracranial hypotension is considered to be caused by spontaneous spinal cerebrospinal fluid leaks. Because of the relatively rare disease, it is easily initial misdiagnosed. We experienced a relatively rare case of CSF leaks diagnosed by ¹¹¹In-DTPA scintigraphy and MRI-myelography and with featured findings of Xanthochromia in lumbar spinal tap.

Methods: A 26-year old man presented with a 10 days history of neck pain, nausea and bussing. Neckpain and headache occuerd at a sudden during driving a car. Then, symptoms are induced in upright position and are relieved by lying down. No specific finding was detected by an ENT examination. Magnetic resonance imaging showed widening of extral dural space in cervical and thoracic spine. Magnetic resonance imaging myelography showed T2 high intensity in cerebro-cervical junction, that is compatible with cerebrospinal fluid leak. Lumbar spinal tap showed Xanthochromia. By ¹¹¹In-DTPA scintigraphy, early phase leakage of CSF in cranial-cervical junction was confirmed.

Results: After conservative treatment of bed rest and urging oral water intake for 4 weeks, headache and neck pain were gradually reduced. In 8 weeks, any symptoms were gone and returned to work as a gardener.

Conclusions: We report a relatively rare case of CSF leaks. MRI and ¹¹¹In-DTPA scintigraphy was useful for its diagnosis. Lumbar spinal tap showed specific findings of Xanthochromia. Symptoms were relieved after conservative treatment of bed rest and water intake.

Figure 1



Figure 2



Figure 3

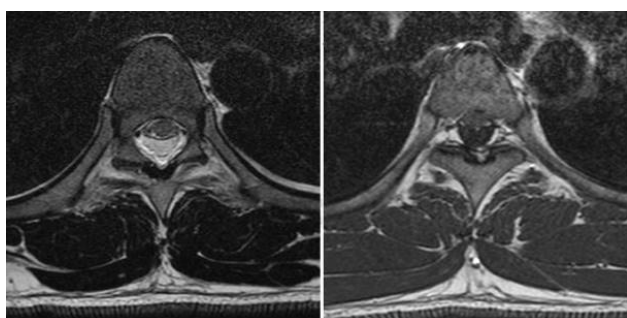


Figure 4



Figure 5



Is the behavior of disc replacement adjacent to fusion affected by the location of the fused level in hybrid surgery?

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Question: Hybrid surgery (HS) could be a promising treatment for patients with multilevel cervical degenerative disc disease (DDD). An advantage of this technique is that it utilizes an optimal procedure according to the status of each level. However, information is lacking regarding the influence of the relative location of the replacement and the fusion segment in vivo.

Methods: This is an observational study. Between January 2010 and July 2016, 75 patients with cervical DDD at 2 contiguous levels undergoing 2-level HS were retrospectively reviewed. The patients were divided into (arthroplasty-fusion) AF and (fusion-arthroplasty) FA groups according to the locations of the disc replacement. Clinical outcomes were evaluated according to the Japanese Orthopedic Association (JOA), Neck Disability Index (NDI) and Visual Analogue Scale (VAS). Radiological parameters, including cervical lordosis, the range of motion (ROM) of C2- C7, the operated and adjacent segments, and complications, were also evaluated.

Results: JOA, NDI and VAS scores were improved in both the AF and FA groups. Both groups maintained cervical lordosis, but no difference was found between the groups. Segmental lordosis at the fusion segment was significantly improved postoperatively, while it was maintained at the arthroplasty segment. The FA group exhibited a non-significant improvement in ROM at the arthroplasty segment. The ROM adjacent to the arthroplasty segment was increased, although not significantly, while the ROM adjacent to the fusion segment was significantly improved after surgery in both groups. Fusion was achieved in all the patients. No significant difference was found between the groups regarding complications.

Conclusions: In HS, cephalic or caudal fusion segments to the arthroplasty segment did not affect the clinical outcomes and the behavior of arthroplasty. However, the ROM of adjacent segments was affected by the location of the fusion segment.

Figure 1

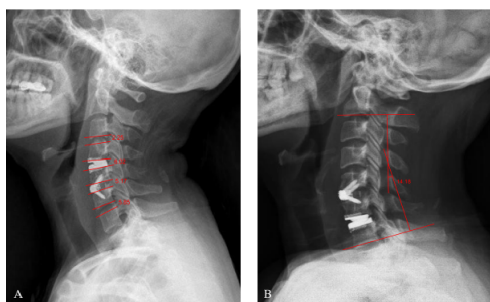


Figure 2

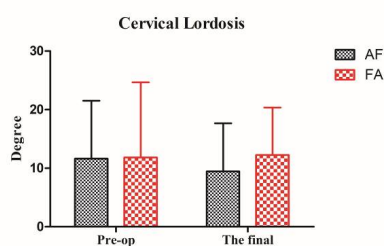


Figure 3

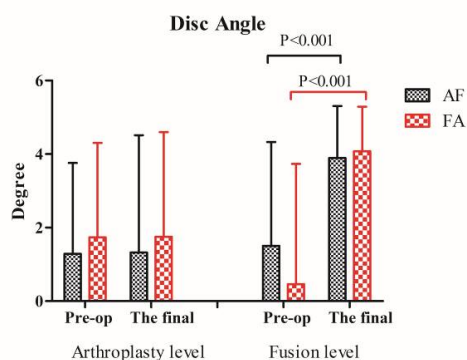


Figure 4

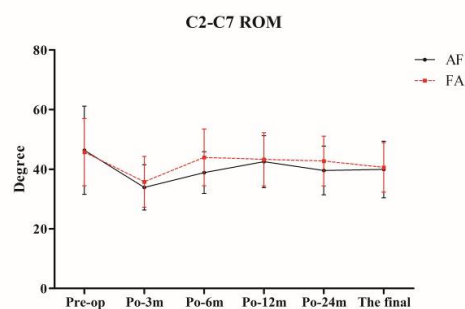


Figure 5

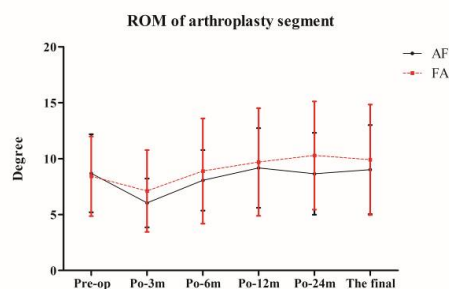
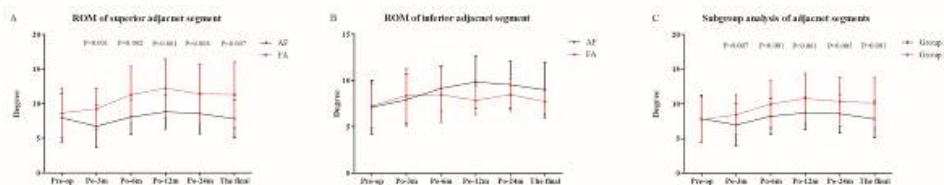


Figure 6



P54

The relationship between American Society of Anesthesiologists Classification (ASA classification) and postoperative outcomes for the patients treated by cervical laminoplasty

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Question: The majority of treatment for cervical myelopathy is surgical procedure. However, the relationship between preoperative ASA classification and postoperative outcomes is unknown. The purpose of this study is to evaluate the influence of ASA score to postoperative outcomes of cervical laminoplasty.

Methods: 121 patients who underwent surgery of cervical laminoplasty (male / female, 89/32: mean age at surgery, 67.8 years old) were enrolled. All cases were performed open-door laminoplasty and consisted of 59 cervical spondylotic myelopathy patients and 62 cervical ossification of posterior longitudinal ligament patients. The minimum follow up periods was 1 years after surgery. Preoperative and postoperative Japanese Orthopaedic Association score (JOA score) and ASA score (Maximum 6 points) were obtained. The correlation coefficients between the ASA score and final follow-up JOA score were measured.

Results: The mean operative time was 81 minutes and the mean intraoperative blood loss was 77 ml. The mean follow-up period was 31.5 months. The average of JOA score was 10.7 before surgery, and 14 at final follow-up. The JOA improvement rate was 54.1%. The total average ASA score was 1.8. The correlation coefficient between ASA score and JOA improvement rate was -0.3, it was weak relationship. The correlation coefficient between ASA score and operation time, or intraoperative blood loss had almost no relationship ($r = -0.04$ respectively). There were no major postoperative complications in all patients.

Conclusions: The ASA score is very useful item to evaluate preoperative status of the patients and would be good predictor of postoperative outcomes and complications. This study showed the tendency that high ASA score related low JOA improvement. However, in this study, we could not find the coefficient between the ASA score and postoperative outcomes. The limitation of this study was small sample cases. We continue this study to evaluate in more bigger cases and determine the influence of ASA score.

P55

Cervical disc prosthesis compared to anterior cervical interbody fusion: Experience and results

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Question: The purpose is to compare the patients outcomes after intervertebral cervical disc prosthesis and after anterior fusion according to the provide relief from objective neurological symptoms and signs, improve patient function, decrease pain, and provide motion.

Methods: 10 patients with disc prosthesis, 10 with cage and 10 with pallacos were assessed pre/post-op, 6 weeks, 3/6 months, 1 year. Patient inclusion criteria: disc herniation/spondylosis, with radiculopathy or myelopathy. Exclusion criteria included previous cervical spine surgery, significant cervical anatomical deformity or clinical instability. Results were scored according to a modified Odom's Criteria, based on relief of preoperative symptoms and relief of objective neurological signs associated with the treated level. Radiographs were analysed to determine range of motion and assess device migration or subsidence.

Results: Of the 10 with disc prosthesis at 1 year follow-up, 8 (80%) were classified as excellent, 1 (10%) as fair and 1 (10%) as poor. Of the 10 with cage at 1 year follow-up, 8 (80%) were classified as excellent, 1 (10%) as fair and 1 (10%) as poor. Of the 10 with pallacos at 1 year follow-up, 7 (70%) were classified as excellent, 2 (10%) as fair and 1 (10%) as poor. The range of motion for patient with disk prosthesis at 6 months was unvaried compared to pre-op range of motion. The patients with anterior fusion lose the pre-op range of motion. There have been no device migrations or device subsidences in all patients.

Conclusions: The reconstruction of a failed intervertebral disc with a disc prosthesis should offer the same benefits as decompression and fusion while simultaneously providing motion thereby protecting the adjacent level disc from the abnormal stresses associated with fusion by maintaining physiological motion and kinematics.

P56

The utility of electrophysiological examination measuring F-waves and compound action potentials of upper extremities for prognosis of the symptom of cervical radiculopathy

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Question: Most patients with cervical radiculopathy are effectively treated by conventional and non-invasive methods. However, some patients do not respond to these treatments. The aim of this study was to determine the usefulness of measuring F-waves and compound action potentials (CMAPs) of the upper extremities to predict response to non-invasive treatment in patients with cervical radiculopathy.

Methods: We included 17 patients diagnosed with C6, 7, 8 cervical radiculopathy. We measured F-waves and Erb-point-stimulated CMAPs and analyzed the relationship between these findings and changes in symptoms over three months. We assessed F-waves in bilateral median and ulnar nerves. Each nerve was stimulated with a supramaximal current intensity using 52 consecutive stimulations. The F-wave parameters included the incidence and chronodispersion of F-waves. We also analyzed the amplitude of Erb-point-stimulated CMAPs in the affected side of upper extremities comparing with unaffected side.

Results: 10 patients did not respond to conventional treatment. In these 10 patients, 5 patients needed specific nerve root block, and 4 patients required surgical treatment. In these non-respond patients, 8 patients showed a decreased incidence of F-waves (<70%) or an increased chronodispersion of F-waves (>150%) on the affected side compared with unaffected side. Furthermore, in 2 of 4 patients who had surgical treatment, the amplitude of CMAPs on affected side was decreased to <30% compared with unaffected side.

Conclusions: It is possible that patients with fewer anterior horn cells and severer conduction disturbance, resulting in a decreased incidence or increase of chronodispersion of F-waves, may be resistant to conventional treatment and decreased amplitude of CMAPs may indicate persistence of muscle weakness. The analysis of F-waves and CMAPs in upper extremities of patients with C6,7,8 cervical radiculopathy could be prognostic of changes in symptoms and need for surgery within three months.

P57

Multilevel cervical spondylo-arthritis with or without myelopathy Evaluation of long term-follow-up between anterior and posterior approach

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Question: In case of cervical spondylo-arthritis, between anterior and posterior surgery, do one approach is superior to the other, in terms of clinical and radiological outcomes?

Methods: From 2008 to 2018 we have collected data from archive and we performed this retrospective study which included 350 consecutive patients (200 males and 150 females) that undergoing surgery for multilevel spondylotic disease. Then the patients have been divided into two groups according to surgical approach: anterior (n = 303) and posterior (n = 47). Among them, we selected only the patients of whom surgery has been involved ≥ 3 intervertebral segments. The average follow-up was 4 years and 6 months long. We evaluated either clinical parameters and radiological issues before and after surgery.

Results: Among the anterior group the patients selected had a better pre-op clinical status either under neurological and general point-of view. Apart that, the selection of the approach has been made on the surgeon preference and thus there's a slight predilection for the posterior one. The rate of clinical complications, such as temporary dysphagia and or dysphonia was obviously much higher on the anterior group than the posterior. On the posterior group, we had two cases of reoperation due to a screws pull-out, both of them over 1-year of follow-up. The neural recovery rate appeared to be the same between the two groups.

Conclusions: Our study clearly shows that there are not significant differences, in terms of clinical and radiological outcome, on the follow-up, even on a long-term one between anterior and posterior approach for multiple level spondylotic cervical disease. We noticed that patients underwent anterior approach tend to have a better post-operative neural function than posterior ones; in the meantime, there is no substantial difference in the clinical recovery rate.

P58
withdrawn

P59
[Does cervical cage shape. Influence intersomatic fusion? Perspect studio and clinical experience](#)

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Question: There are many different types of cages on the market, regardless of the material of which they are composed, different sizes and shapes so that they adapt perfectly to the disc space and allow a solid interbody fusion. The purpose of our study is to understand if and how cage shape (in particular anatomical or lordotic) affects the quality of interbody fusion.

Methods: From 2014 to 2017, 86 patients underwent ACDF in a single level for degenerative disc disease (DDD). The clinical and radiological outcome was evaluated in 57 eligible patients after an average of 12 months. In 31 patients an anatomic cage was used, while in 26 patients a lordotic cage was used. The materials used were trabeculated titanium and PEEK (polyetheretherketone) filled with synthetic bone in a different shape. Numeric rating scale (NRS) and Neck Disability Index (NDI) was used for clinical evaluation

Results: Solid arthrodesis was obtained in 90.3% in the group treated with anatomically designed cages and in 88.5% in the group treated with lordotic cages. The subsidence of the cage (> 2mm) was observed in 15.5% of the group treated with anatomical cages and in 12.4% in the group treated with lordotic cages. A significant correction of segmental lordosis was obtained with both types of cages. Both groups showed significant clinical improvement, assessed with numeric rating scale (NRS) and Neck Disability Index (NDI).

Conclusions: The clinical and radiological outcomes of ACDF with anatomic or lordotic cages do not appear to be influenced by the chosen graft. The material, the size, the bone density, the preparation of the vertebral end-plates and the distraction applied during the surgery must be considered as further important factors.

P129
[Clinical study of anterior cervical discectomy and fusion for elderly patients with cervical anterior slip – postoperative correction loss of slip was a risk factor for early deterioration](#)

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Question: The aim of this study is to investigate postoperative correction loss of slip after anterior cervical discectomy and fusion and clarify its influence on early deterioration of myelopathy.

Methods: Sixty-four patients over 70y.o. who underwent anterior cervical discectomy and fusion with a dynamic plate in our hospital from 2006 to 2017 and followed more than 3mo were included in this study. Their mean age was 78.1yo. We defined anterolisthesis as anterior vertebra displacement more than 3mm in a flexion radiograph. We investigated incidence of anterolisthesis, anterior-posterior instability, the correction of the slip by surgery and the loss of the correction in follow-up. We also researched the early deterioration of myelopathy within 1mo after surgery and assessed the influence of the correction loss of the slip on the early deterioration.

Results: There were 13 cervical anterior slip cases and 7 out of them had anterior-posterior instability. We found 6 out of 7 cases with A-P instability had loss of the correction postoperatively. There were 6 cases who developed early deterioration of myelopathy, 3 out of them had the loss of the correction.

Conclusions: We thought postoperative correction loss of slip after anterior cervical discectomy and fusion was a risk factor for early deterioration of myelopathy. Therefore, anterior cervical corpectomy of lower vertebra of the slip and fusion should be considered in such cases.

Motion preservation

P60

A direct *In Vivo* comparison of five cervical disc prostheses: A caprine study

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Question: Despite the widely heterogeneous designs of the approved cervical prostheses for cervical arthroplasty, there is a paucity of direct comparison studies. The authors decided to conduct a direct comparison study of five popular, but biomechanically heterogeneous, cervical disc prostheses.

Methods: A total of 21 goats underwent C3-4 cervical arthroplasty under general anesthesia and were monitored for three months in a monitored veterinary unit. Group A (n=5) received Bryan (Medtronic) (unconstrained one-piece enclosed design). Group B (n=5) received ProDisc-C (Centinel Spine) (semi-constrained two-piece open metal-on-polymer design). Group C (n=4) received Mobi-C (Biomet Zimmer) (unconstrained three-piece open metal-polymer-metal design). Group D (n=3) received Prestige LP (Medtronic) (semi-constrained two-piece open metal-on-metal design). Group E (n=4) received Secure C (Globus Medical) (semi-constrained three-piece open metal-polymer-metal design). Intra- and post-op radiographs were obtained up to three months.

Results: No goat in Group A had adverse effects. One out of five goats in Group B had anterior extrusion at 3 months. All four goats in Group C experienced anterior extrusion (3 in one week and 1 in one month). Three out of three goats in Group D demonstrated anterior migration (1 extruded at two months; 1 extruded at three months; 1 migrated anteriorly but did not extrude by the end of three months). One out of four in Group E anteriorly migrated at one week but did not extrude.

Conclusions: This caprine model simulates a highly active and flexible human cervical spine. Open multi-piece semi-constrained or unconstrained designs with permissible translation of axis of rotation may be susceptible to anterior migration and possibly complete extrusion out of the disc space followed by disintegration. This should be considered when evaluating a patient for possible cervical arthroplasty and choosing a specific cervical disc prosthesis.

Figure 1



Figure 2



Figure 3

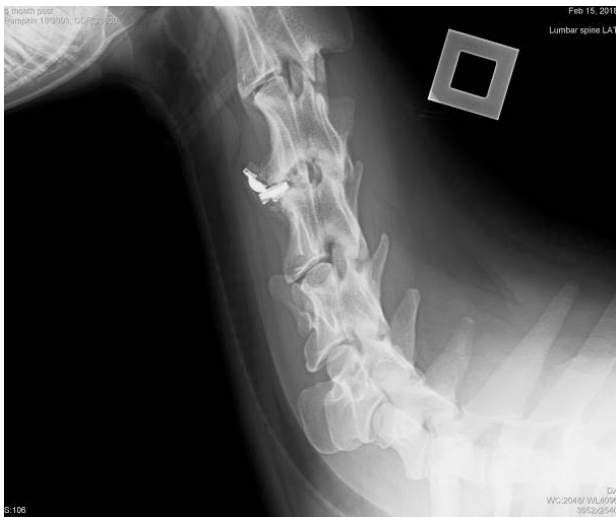


Figure 4



Figure 5



Question: Cervical radiculopathy due to foraminal stenosis is most commonly treated with ACDF. However, this fusion procedure carries future risk of adjacent segment disease. To overcome this unsolved problem, anterior foraminal decompression without fusion is another treatment of choice. In anterior foraminal decompression surgery, only proximal foramen is usually decompressed and this partial decompression carries risks of inadequate decompression and future recurrence. In the present study, we conducted anterior foraminal decompression with removal of all the uncovertebral joint, achieving complete foraminal decompression, and investigated postoperative clinical and radiological outcomes.

Methods: Twenty two patients with cervical radiculopathy due to foraminal stenosis underwent anterior foraminal decompression with complete resection of uncovertebral joints. Neck and arm VAS, Neck disability index (NDI) were measured and cervical XP, CT and MRI were done pre-and post-operatively.

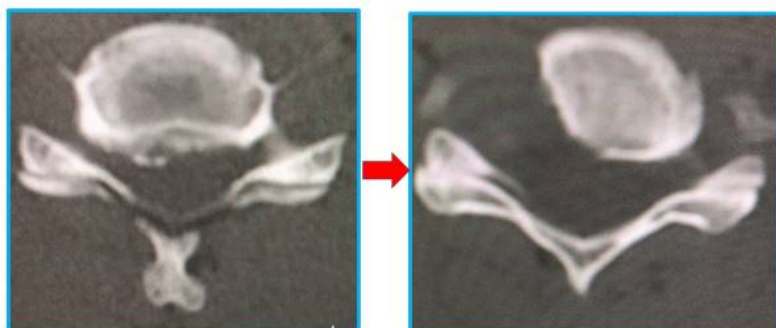
Results: Most patients preoperatively had marked painful symptoms which almost disappeared immediately after operations in all cases. Preoperative Arm-VAS, Neck-VAS, NDI was average 8.0, 7.8, and 22.3 changed 1.1, 0.8, and 3.1, respectively. Average follow-up period was 3.8 years (6-2) and there was no newly-developed cord compression at adjacent disc levels although natural intervertebral fusion was observed in some patients. No patient had experienced the recurrent radiculopathy at the same decompression site or any other level. No alignment problems occurred.

Conclusions: All patients experienced immediate, clear-cut pain relief, which might be achieved by complete and direct decompression of nerve root. There was no case with adjacent disc disease, which could be due to motion-preserving procedure. Although the present study had significant outcomes in the treatment of cervical radiculopathy, more cases and longer follow-up will require to draw any conclusions.

Figure 1



Figure 2



P62

Comparison of clinical and radiological outcome of 2 cervical disc prostheses with particular focus on the development of heterotopic ossifications

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Question: Aim of this non randomised prospective comparative case series study was to determine whether the prosthesis design, and especially changes in the primary anchoring mechanism between a the keel-based and the spike-based cervical total disc replacement (cTDR) affects the frequency of heterotopic ossifications (HO) formation over time. Secondary the aim of this study was to evaluate the influence of the prosthesis design regarding the clinical and the radiological outcome.

Methods: 40 consecutive patients treated with a keel-based and 42 consecutive patients treated with a spike-based cTDR were compared with respect to radiological and clinical outcome with 2 years of follow up. Clinical outcome scores included the Neck Disability Index (NDI), Visual Analogue Scale (VAS), arm and neck pain self-assessment questionnaires. The radiological outcome included the segmental lordosis and range of motion (ROM) of the index-segment as well as the occurrence of HO.

Results: The clinical outcome parameter improved in both groups significantly. (keel-based TDR: VAS arm and neck pain from 6.3 and 6.2 in mean preoperatively to 0.7 and 1.3. NDI from 23.0 points to 3.7 points; spike-based TDR: VAS arm and neck pain from 6.3 and 4.9 to 1.4 and 1.6, NDI from 34.1 points to 8.7 at the 2 years FU). The spike-based cohort has statistically significant lower incidence of HO compared to the keel-based group in both FU ($p=0.00052$ at 1 year FU and $p=0.0053$). At the 2 years follow up in the spike-based group high grade ossifications were detected in only 9%. This is a significant reduction in comparison with the keel anchoring prosthesis group (31%).

Conclusions: The primary anchoring of the prosthesis without violating the cortical surface might help to reduce the incidence of severe ossifications and seems to influence positively the functionality and mobility of the artificial disc device in the progression of time.

P63

Unintended fusion in cervical artificial disc replacement: A prospective study on heterotopic ossification and clinical outcome, with 5 years follow-up

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Background: ACDF is the gold standard surgical treatment in patients with cervical degenerative disc disease with radiculopathy. Implants for artificial disc replacement (ADR) were developed as an alternative to ACDF. ADR was expected to preserve motion, decrease the incidence of adjacent segment pathology and consequently lead to better clinical outcomes. Heterotopic ossification (HO) is an unintended event that may lead to spontaneous fusion of the ADR, thus failing to preserve motion.

Research question: What are the prevalence and predisposing factors for HO in cervical ADR? Does severe HO affect clinical outcomes?

Design: Analysis of a multicentre prospective RCT. 153 patients blindly randomized to ADR or ACDF, maximum two disc levels. All ADR patients received NSAID to prevent HO.

Methods:

Of 83 ADR patients, we included the 64 (86 prosthesis) that had good-quality radiological follow-up studies at 5 years.

HO was graded on X-ray 5 years postoperatively (2 viewers, modified McAfee classification). Baseline characteristics and several parameters on image studies (CT, MRI and X-ray) were analysed. The clinical outcome measure was NDI.

Results: HO in 92% of the prosthesis after 5 years.

Severe HO (grade 3 or 4) in 71% and complete fusion (grade 4) in 27% after 5 years.

Significantly less HO (and of lower grades) in women.

Age and BMI seem to be predisposing factors for HO.

No difference in NDI found between patients with severe HO and those with none or mild HO.

Discussion: Disc prosthesis are meant to move, in order to be an alternative to fusion regarding the potential prevention of adjacent segment pathology.

Despite NSAID treatment, almost all patients have HO after 5 years, more than 2/3 of prosthesis have severe HO and over 1/4 actually spontaneously fuse. However, clinical outcomes were not affected by severe HO.

Male sex, older age and obesity are known risk factors for DISH. Perhaps HO in artificial discs has a similar pathomechanism.

P64

Anterior bone loss of vertebral bodies after cervical total disc replacement: an opposite of anterior heterotopic ossification?

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Question: Heterotopic ossification of the anterior part of vertebral bodies (AHO) after cervical total disc replacement (c-TDR) has been widely observed. However, few studies have reported the prevalence and clinical significance of anterior bone loss (ABL) after c-TDR. Besides, the relationship between ABL and AHO remains unknown. The first objective of this study was to describe the impact of ABL on c-TDR. The second objective was to compare the clinical and radiological differences between ABL and AHO.

Methods: This was a single-center, retrospective study. We reviewed 53 patients underwent single-level c-TDR with a minimum 24-month follow-up. Patients were divided into ABL group or AHO group based on postoperative radiographs. Demographic information, cervical alignment, disc angle, range of motion (ROM), VAS, NDI, and JOA scores at each follow-up time were analyzed.

Results: The mean follow-up time was 55.3 months. At the last follow-up, the incidence of ABL was 58.5% (31/53), and the incidence of AHO was 26.4% (14/53). Except for 4 patients presented ABL during the first year after surgery and had grade 3-4 AHO gradually, there were 27 patients in ABL group, 11 patients in AHO group and 11 patients in normal group (without ABL or AHO). It could not conclude that there was a significant difference in age, sex, sagittal alignment, disc angle, VAS or JOA scores among the three groups. Compared to the AHO group, the ABL group had a smaller sagittal alignment (5.9° vs 11.2°) and ROM (7.9° vs 11.9°) before surgery. Besides, the ABL group had a smaller variation of ROM immediately after surgery (1.7° vs -4.3°). The subsidence rate in ABL group was 7.4% (2/27), while there was no subsidence in AHO group. No patients required revision surgery.

Conclusions: ABL is common and does not affect long-time outcomes. ABL is not an opposite of AHO, they occur in a different period. Patient with ABL may get AHO during follow-up. Compared to AHO, ABL may be responsible for a good motion preservation effect after c-TDR.

Trauma of the subaxial cervical spine

P65

A case report of "locking spondyloptosis" ; the most severe traumatic cervical spondyloptosis with locking of spinous process and vertebral arch into spinal canal

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Question: Compressive-extension injury stage 5, namely traumatic cervical spondyloptosis is not uncommon, however, case with locking of spinous process and lamina into spinal canal is extremely rare

Research question There is no report of traumatic cervical spondyloptosis with locking of spinous process and vertebral arch into spinal canal.

Design : Case report.

Methods: A 69-year-old man was injured by a motor vehicle collision and diagnosed as C7 spondyloptosis of compressive extension (CE) stage 5 of Allen's classification in our department about 6 hours after injury. He had paraparesis with American Spinal Injury Association (ASIA) Impairment Scale (AIS) Grade B . CT scan showed C7 spondyloptosis with locking of C6 spinous process and vertebral arch into spinal canal.

Results: Closed reduction was absolutely invalid because of rigid locking of spinous process and vertebral arch into spinal canal. He was transferred to operation room 30 minutes after arrival of our institute and underwent open reduction and fusion via only posterior approach. Three months after surgery, he had made significant neurologic recovery up to ambulatory (AIS Grade D).

Conclusions: Although high-grade CE injuries are usually instrumented an anterior-posterior combined approach, instrumentation with posterior approach alone is available by making sure of reliable anchors such as pedicle screws or multiple lateral mass screws. To our knowledge, this is the first report of traumatic "locking spondyloptosis", of the spinous process and vertebral arch into spinal canal. Because closed reduction is invalid for "these rigid locking" , urgent open reduction would be beneficial for that "locking spondyloptosis".

Figure 1

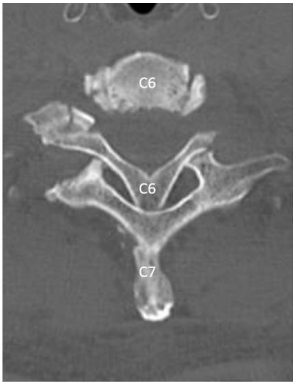


Figure 1. Locking spondyloptosis

P66

What is the best indication for CT angiography screening of vertebral artery injury associated with cervical trauma?

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Question: Vertebral artery injury (VAI) is a common complication of cervical spine injury. Either CT angiography (CTA) or MR angiography (MRA) would be first choice, however, there is no clear strategy of screening using CTA which is invasive compared to MRA.

Research question: We queried whether all patients with cervical spine injuries required CTA to rule out VAI.

Design: A retrospective study using CTA on consecutive patients with cervical spine injuries.

Methods: During a 4-year period, 112 patients (16 female, 96 male; mean age 67.5 years) with cervical spine fractures-dislocations were retrospectively evaluated for patency of the vertebral artery using CTA.

Results: The injury type were distractive flexion (DF) in 34 patients (30.4%), distractive extension (DE) in 34 patients (30.4%), compressive extension (CE) in 17 patients (15.2%), compressive flexion (CF) in 8 patients (7.1%), lateral flexion (LF) in 1 patient (0.9%), and upper cervical spine in 10 patient (8.9%). The remaining injuries (7.1%) were unclassified. The incidence of vertebral artery occlusion detected by CTA (n = 6) was 5.4% in all types of cervical spine injuries. Each injury types of patient with vertebral artery occlusion was 2 patients in DF stage 2 and DF stage 3, 1 patient in CF stage 4 and LF stage 1 respectively. Separated by injury type, the incidence of vertebral artery occlusion was 11.8% in DF (4/34), 5.9% in CE (1/34), 100% in LF (1/1).

Conclusions: This study shows that any grade of DF and high grade CE have high risk of VAI. For these injuries CTA is more advantageous in terms of saving time, because they need urgent reduction and fusion in order to save the spinal cord.

P67

Clinical management for spinal cord injury in patients with cervical ankylosing disorders (ASD)

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Question: Ankylosing spinal disorders (ASD) includes AS, ASH and DISH. ASD is a great risk factor for fracture due to the loss of flexibility and bone quality.

In this study we reviewed our management for cervical fracture and discussed about the pathology in ASD patient.

Methods: We report 48 cervical ASD cases with spinal cord injury (SCI). The clinical records were reviewed regarding to pain and neurological status. CT revealed bone condition and MRI identified 3-columns injury. We investigated ASD type and bone quality.

Results: Neurological deficits were revealed in 40 / 48 patients. 40 patients (83%) had minor trauma and 21 / 40 patients had late neurological deterioration.

Surgical treatment has been performed in 45 patients. The rest three patients were followed conservatively due to their comorbidity. In this series, all patients except one ABF case were treated with using posterior screw fixation. Surgical outcomes were reliable. Pain control was good. 13 / 37 patients showed neurological recovery. However there was no improvement in 24 cases including 10 Frankel A. One Frankel A patient was died due to postoperative pneumonia. One anterior fusion case needed revision surgery according to non-union.

We divided into three groups to assess ASD type (1:continuous, 2:segmental, 3:combined type). 45 surgical cases were divided in 20 continuous, one segmental and 24 combined cases.

Pathology of the fracture was different between ASD types. Continuous group showed bone injury like long bone, however 24 combined cases showed 13 bone fractures and 11 marginal lesions. Though bone quality was poor, CT revealed rim sclerosis including bone bridge and ossification in 23 cases. These rim sclerotic changes assisted short fusion in 9/23 cases.

Conclusions: Cervical fracture in ASD requires aggressive surgical intervention. Multiple screw fixation is the first line to allow sound bone healing. However short fusion is also available in combined ASD type with rim sclerosis.

P68

Clinical analysis of lower cervical spine injury according to injury mechanism: Data of 477 surgical patients

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Question: To analyze the incidence and treatment outcomes of lower cervical spine injury since there is no long term, large Korean data available.

Methods: We analyzed 477 patients with lower cervical spine injury who underwent surgical treatments between January 2000 and December 2017. The injury types are based on Allen's classification, and neurologic injury was classified as complete, incomplete cord injury, root injury and no neurologic status. We analyzed postoperative complications, neurologic recovery and the relief of pain.

Results: Distractive-extension injury occurred most commonly in 245 patients (51.6%). Neurologic injury was detected in 432 cases (90.5%); 62 (14.3%) complete cord injury; 270 (62.5%) incomplete cord injury; and 96 (22.2%) root injury. Incomplete cord injury of distractive extension injury was poorly recovered. Clinical outcomes demonstrated improvement compared with the preoperative values in mean visual analogue scale. Complications were respiratory failure, neurogenic bladder, urinary tract infection and gastritis.

Conclusions: This study showed the highest incidence of distractive extension injury and neurologic injury contrary to previous studies. This result was caused by the use of plain radiograph to establish Allen's classification in the past. Therefore, we suggest the use of magnetic resonance imaging for evaluating soft tissue injury with Allen's classification to achieve accurate assessment.

P69

Surgical strategy in cervical fracture-dislocation: anterior, posterior, or new approaches? A novel technique of cervical pedicle screw fixation with reverse insertion in the supine position

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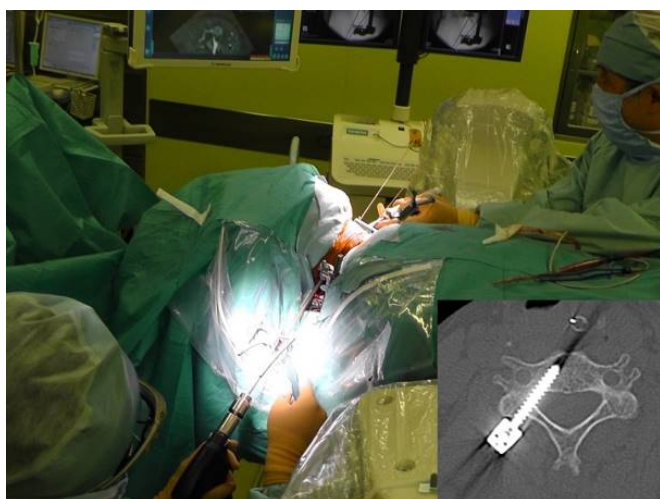
Question: To resolve reduction-induced disc herniation (DH) and vertebral artery injuries (VAI) in patients with cervical fracture-dislocation, we evaluated conventional procedures and developed a novel technique.

Methods: The first phase included 35 patients during a 12-year period starting in April 2005. Anterior fusion was performed in 10 patients, posterior fusion in 7, and minimally invasive cervical pedicle screw fixation (MICEPS) via a posterolateral approach in 18. In the second phase starting in 2017, a novel technique of minimally invasive cervical pedicle screw fixation with reverse insertion following anterior cervical discectomy and fusion (reverse MICEPS) was performed in the supine position. A probe was passed from the anterior aspect of the vertebra to the pedicle using a navigation system and a guide pin was passed through the posterolateral skin. A small incision was made, and cannulated pedicle screws were placed using reverse insertion and fixed with a rod. This procedure was used in 7 patients who were then evaluated. The mean age was 64.0 years.

Results: 1) An extruded DH was identified on preoperative MRI in 11 (31.4%) of 35 patients and VAI was diagnosed in 22.8%. 2) Discectomy was added in 2 (8.0%) of 25 patients who underwent posterior or posterolateral procedures due to DH-induced neurological deterioration after reduction. 3) In the reverse MICEPS group, mean operative time was 187 minutes and blood loss was 164 ml. 4) The approach side was selected to avoid dominant VA injury, and the procedure was performed in 3 patients via the right anterior neck, and in 4 patients via the left. 5) DHs were removed in all cases and a cage was inserted. 6) There was no neurological deterioration.

Conclusions: The posterior or posterolateral approach is limited in the ability to remove the DH, and has a potential risk of causing a neurological deficit. We developed the reverse MICEPS in the supine position to enable removal of the DH and provide strong fixation with restoration of lordosis.

Figure 1



P70

Deformity correction in cases of lower cervical spine trauma of patients with ankylosing spondylitis

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Question: The optimal management of patients with lower cervical spine trauma with AS is not clearly established. The strategy of simultaneously treating the traumatic lesion as well as correcting spinal deformity is not universally accepted.

Methods: Retrospective analysis was performed in 22 cases of patients with AS, operated during the last decade for acute subaxial trauma. There were 20 male and 2 female patients, average age was 67 years, the most commonly involved segment was C6/7 (50%). A secondary level spinal injury was present in 4 cases. Ten patients presented without a neurological deficit, 9 patients had an incomplete lesion and 3 patients had a complete spinal cord lesion. The preferred therapeutic strategy was a 360 degree stabilization and fusion, which was performed in 16 cases, an isolated anterior approach was used in 6 cases. The analyzed parameters included clinical and neurological state at admission and follow-up, radiological parameters, segmental kyphosis correction and CBVA measurements.

Results: All 3 patients presenting with complete spinal cord lesions died. Of the 9 patients with an incomplete spine lesion, 7 improved by one or two ASIA grades, 2 had stationary lesions. Of the patients operated using an anterior approach, one patient had instrument failure, which required a 360 degree correction. There were no cases of instrument failure in the group of 360 degree corrected patients. The average segmental correction was 6 degrees (0-11) in the group of patients treated using solely the anterior approach and 21 degrees (4-45) in the group treated by a 360 degree approach. These results are in correlation with the CBVA.

Conclusions: These preliminary results suggest that a 360 degree correction is superior to an isolated anterior approach in achieving deformity correction as well as the construct stability and long-term outcome. The main limitation of the broader 360 degree approach is clinical state of the patient.

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Recurrent dislocation after anterior surgery in subaxial traumatic fractures

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Question: Recurrent dislocation after surgery in cervical spine requires careful planning and revision. The purpose of this study is to assess the clinical and radiological outcome of patients undergoing revision surgery for hardware failure in subaxial cervical fractures.

Methods: In a series of 128 consecutive patients with cervical subaxial fractures operated on in our Department, 3 needed a second surgery because of recurrent dislocation. Clinical and radiological features are presented. Surgical solutions are assessed.

Results: The 3 patients initially underwent an anterior approach and, in the short to medium term, had a mechanical failure of the system with graft and vertebral dislocation and onset of spinal cord compression. In the second surgery, we carried out an anterior revision, obtaining decompression of the spinal cord and reconstruction of the anterior column; we finished with a posterior fixation. Radiographic control shows the stability of the system and the maintenance of correction.

Conclusions: The sub-axial cervical spine fractures sometimes are complex and the choice of surgical approach to treat them is difficult. The diagnosis is achieved with the CT scan. The MRI is essential to show a discoligamentous complex injury, though even with MRI the injury is not always evident. In our view, the failure of the first surgery results from misinterpretation of the morphology of the original lesion. Failure is likely whenever the anterior approach alone is not adequate to restore the posterior "tension band." Mechanical complications in the treatment of sub-axial cervical lesions, especially for the more complex and unstable fractures, can be reduced by careful surgical planning.

Figure 1



Figure 2



Figure 3



Figure 4



Figure 5



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Surgical treatment of subaxial cervical spine fractures following AO spine sub axial classification criteria: What, when, why? A 4 years experience in a single center

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Question: Management of subaxial cervical spine fractures (SCSF) is always challenging because these often occur in patients with multiple injuries after major trauma. In the last decade, adoption of the Advanced Trauma Life Support protocols highlighted the importance of assuming a cervical spine injury in all patients with a history of trauma until proven otherwise. Is the AO spine cervical subaxial fractures classification and all its recommendations the best tool to choose the best surgical treatment for SCSF and avoid postoperative complications?

Methods: Retrospective analysis of the last 5 years SCSF surgically treated in our center. Every fracture was retrospectively classified with AO spine subaxial classification (A,B,C,F), including neurological status (N) and modifiers (M). Mechanism of trauma was also investigated.

Results: 54 patients suffered from SCSF surgically treated (39 M, 15F, mean age 56.1), 23 motor vehicle accident, 15 fall from height, 8 domestic fall, 4 fall after syncope, 4 sport injuries. 29 were type A fractures (23 A3 in which 2 N1 and 1 N3, 6 A4 in which 1 N3 and 1 N4), 15 type B (5 B1 in which 2 M2 and 1 N3, 7 B2 in which 1 N3 and 3 B3 in which 1 N3) 10 type C (3 N3 and 2 N4) 36 patients were treated with anterior approach (27 ACDF, 9 ACCF) 12 with posterior approach (10 lateral mass screws in which 8 with decompression and 2 without, 2 sublaminar hooks), 6 circumferential (4 ACCF with lateral mass screws, 2 ACDF with decompression and lateral mass screws).

Conclusions: AO SCSF classification and its management strategy suggestions are absolutely a valid tool to reach the best outcome. Highlighting our best and worst cases in terms of radiological and clinical outcome showed that a correct identification of the type of fracture and a consequent optimal surgical strategy is mandatory, because in all our worst cases the lack in global management of the injury led to poor outcome, while instead a correct radiological diagnosis and surgical treatment led to the best outcomes

Trauma of the upper cervical spine

P73

The outcomes of surgical treatment for axis fractures

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Question: The treatments for the axis fractures are controversial. In order to provide early rehabilitation, we perform surgery as soon as possible for Anderson type2 and type3 odontoid fractures, and Hangman fractures which have the instability between C2-3. The purpose of this study was to clarify the early clinical outcomes of surgical treatment for axis fractures in single hospital.

Methods: A total of 66 patients who underwent surgery for axis fractures from April 2005 to December 2017 were included. The mean age was 61.8 years (17-88), 44 male and 22 female. We used the Anderson classification for odontoid fractures and Levine-Edwards classification for Hangman fractures.

Results: Of 66 patients with axis fractures, 35 patients had odontoid fractures, 22 had Hangman fractures and 9 had fractures of the axis body. This series of odontoid fractures included 0 type1, 22 type2, and 13 type3. Nineteen type2 cases and 11 type3 cases were performed posterior C1-2 fixation. For the remaining five cases, anterior odontoid screw fixation was administered. The union rate of type2 fractures was 86% and that of type3 fractures was 100%. Hangman group was classified as follows, 7 type1, 6 type2, 5 type2a, and 4 type3. Seven cases were performed direct screw osteosynthesis and 15 cases were performed posterior cervical fixation. Bone union was achieved in all cases. In all cases, the mean waiting days until the surgery were 4.8 days (1-14). The complications such as aspiration pneumonia, urinary tract infection were detected in 16 cases.

Conclusions: There are no accurate indications for the duration of waiting days because of the systemic complications. It is important, however, to provide early rehabilitation in order to prevent complications. In this series, we performed surgery in the early period and there were no crucial early complications after surgery. Therefore, operative treatment for the cervical fracture was seemed to be minimally invasive and performing surgery in the early period is desirable.

P74

Recommendations for diagnostics and treatment of axis ring fractures

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Question: To develop diagnostics and treatment recommendations for axis ring fractures.

Methods: Taking the current literature into account, the "upper cervical spine" group of the spine section of the German Society of Orthopaedics and Trauma (DGOU), formed in 2017, developed recommendations in a formal consensus process including 4 onsite sessions.

Results: Axis fractures are detected at a frequency of 19-41% as part of cervical spine injury and are potentially combined with a discoligamentous instability C 2/3. For classification, the Josten as well as the Effendi classification modified by Levine are recommended. The Canadian-C-Spine Rule has proven itself for primary clinical screening. CT scanning is the imaging tool of choice to detect axisring injury. MRI serves to assess the integrity of the discoligamentous complex C 2/3. Stable axisring fractures (Josten I & II) can be treated conservatively in a cervical orthosis, with close monitoring of potential progressive dislocation. In case of secondary dislocation, surgical stabilization is indicated. Primary surgery is indicated for dislocation and / or discoligamentous instability C 2/3, which is most prevalent in Josten type III & IV fractures. The standard surgical treatment is anterior fusion C 2/3 (ACDF). A primary posterior approach for fracture reduction and stabilization may be necessary in case of type IV fractures. The recommendations were finalized with strong consensus (approval of > 95% of the 21 participants).

Conclusions: Conservative therapy may be preferential in Josten type I & II fractures. Unstable Josten Type III & IV fractures should be treated surgically, with anterior fusion C 2/3 as standard procedure, especially in case of Josten type III fractures. In type IV fractures, a primary posterior approach is usually required to reduce facet joint dislocation.

P75

Atlantoaxial dislocation due to os odontoideum in patients with Down's syndrome: literature review and case reports

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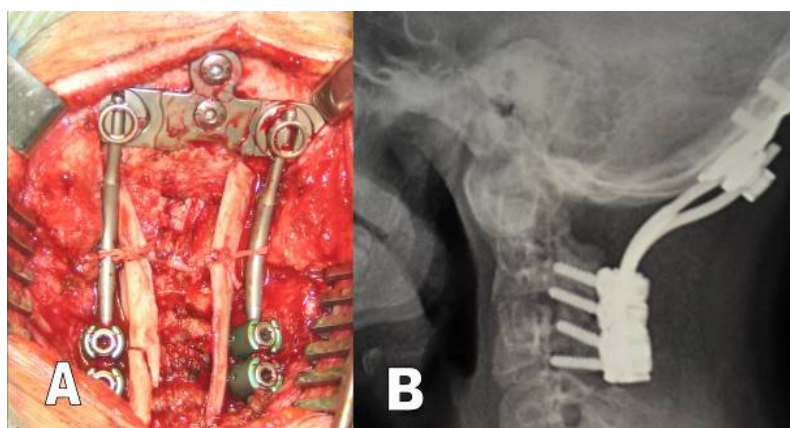
Question: What is the cause of frequent occurrence of os odontoideum (OsO) in patients with Down syndrome (DS)? How often odontoid ossicles occur in patients with DS? What is the best treatment option for patients with DS and OsO?

Methods: We described and analyzed three clinical cases of AAD due to OsO in DS patients and reviewing descriptions of similar cases in the scientific sources.

Results: According to literature review more than 80% of DS patients with odontoid ossicles had atlantoaxial instability (AAI). AAI in DS patients with OsO is more often manifested in childhood and adolescence, rarely in adults when ligament relaxation is reduce. Some patients had acute clinical manifestation after a minor trauma without any precursors, in some of cases neurological deterioration increased during several years. We found that the earlier surgical treatment of AAD due to OsO in DS patients carries the higher recovery potential.

Conclusions: Since most patients with DS have a mobile OsO and AAI, the method of appropriate treatment is a posterior screw fixation (fig.1). Halo-traction and posterior fusion have proved to be a very useful tool in the treatment of reducible unstable AAD due to OsO in DS patients.

Figure 1



P76

Anomaly-related traumatic atlantoaxial rotatory fixation: A case report

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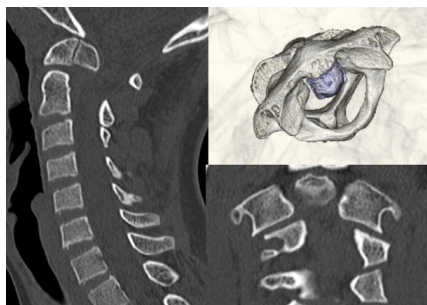
Question: Fielding and Hawkins first described Atlantoaxial Rotatory Fixation (AARF) as a fixed clinical torticollis. They separated AARF into four different types based on the axial images of the C1 and C2 vertebrae. However, treatment strategy for AARF is remained controversial. Especially AARF "Type IV" is so rare condition that there are few report of treatment for Type IV. We present a case report of Anomaly-Related Traumatic AARF that classified Type IV.

Methods: Case Presentation: A 12-years-old male presented remained torticollis since he got a blow in the back of the head 5 days before. He suffered severe neck pain and neck movement restriction. CT showed Atlantoaxial Rotatory dislocation (The atlas is displaced posteriorly) and Os odontoideum. MRI T2 fat-saturated imaging shows hyperintensity involving C1–C2 articular capsules. At first we supposed the condition was Atlantoaxial dislocation (AAD) However, according to the traumatic onset and restriction of cervical rotation, we diagnosed his condition as AARF "Type IV". For primary treatment, indirect traction therapy (Glisson's traction) was being performed at 2 kg. The neck position of the traction was conducted to be flexion and rotation to the right to achieve reposition.

Results: One week after the start of the therapy, the symptoms (torticollis, neck pain, neck movement restriction) improved. CT showed that the reposition of Atlantoaxial Rotatory was almost achieved. To date there is no the recurrence. However, dynamic study detected atlantoaxial instability. We are planning surgical treatment

Conclusions: It was a diagnostic question to treat the patients as AARF or AAD. According to the traumatic onset and restriction of cervical rotation, we diagnosed his condition as AARF "Type IV". Traction therapy was effective for primary treatment of AARF type IV in our case.

Figure 1



P77

Remote traumatic Spondylolisthesis of C2 on C3, report of five cases

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Question: Remote isolated Spondylolisthesis of C2 on C3 are infrequent and also unique in being inherently unstable and prone to progress or malunion or non-union. The present study discusses their management via high cervical retropharyngeal route.

Methods: 5 patients with remote hangman's fracture causing pain in all five and their treatment is described. All of them were irreducible despite of applying traction with gradual increase of the tongs. In all five patients Corpectomy of C3 was done followed by insertion of a strut graft from autogenous iliac bone adding a plate in three or expandable cage and plate in two cases. In one case posterior screw rod hook was used as well.

Results: All five patients improved with no pain and quadriparesis disappeared. Postoperative follow up of from 8 months to 3 years after surgery showed achievement of good solid fusion. No complication was observed with regard to vital structures located in the vicinity of our surgical route.

Conclusions: Remote isolated Hangman's fractures with marked listhesis of C2 on C3 are potentially unstable and might progress with time. In dealing these irreducible fractures, C3 corpectomy and graft or cage and plating seems reasonable. For exposure of C2 and its instrumentation, the spine surgeons familiar with neurovascular structures of high cervical region. Also, we advocate using surgical microscope for more safety.

Figure 1



Figure 2

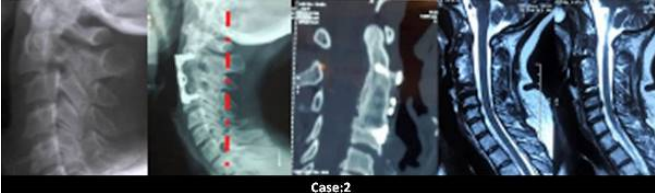


Figure 3

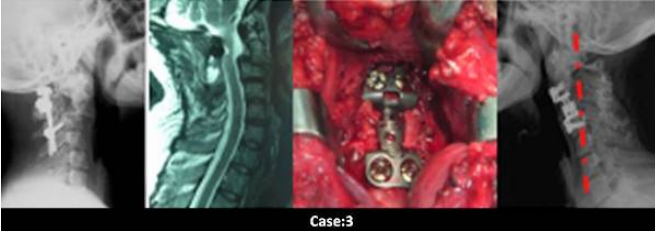


Figure 4



Figure 5



Question: Avulsion fracture of the foramen magnum (including both occipital condyles and the anterior aspect of the clivus) is a rare variant of occipitocervical dislocation where the injury does not involve the tectorial membrane and the other ligaments connecting the upper cervical spine to the base of the skull which remains strongly connected to the first two cervical vertebrae. Therefore, although these injuries produce a severe and potentially fatal instability, adequate immobilization may lead to bone healing with complete stability recovery. Once the bony lesion is healed, hardware removal let the patient recover a norma ROM of the cervical spine without any risk.

Methods: Two consecutive patient reported an avulsion fracture of the occipital condyles and clivus without neurologic involvement following car accidents. Preoperative CT scan revealed a continuous bone ring including the three mentioned structures in one single block, wich remained normally connected with C1 and C2. They were both treated by occipitocervical stabilization without fusion (one from occiput to C5 and the second from occiput to C2). Bone healing was assessed through CT scan and hardware was removed 4 months after the surgical procedures in both patients. Cervical spine range of motion was evaluated before the second surgery and two months after it following 4 weeks of rehabilitation.

Results: Head rotation before hardware removal was 60° in the 65 years old patient submitted to C0-C5 fixation and reached 120° at follow up. In the 18 years old patients with C0-C2 fixation rotation reached 180° at follow up starting from a preoperative value of 120°. Also flexion extension ROM improved in both patients wich regained an almost normal quality of life year after the second surgery.

Conclusions: Avulsion fracture of the clivus and occipital condyles require immediate stabilization as potentially fatal. Hardware removal, once bone healing is achieved, will not affect spine stability allowing a better functional recovery.

Figure 1

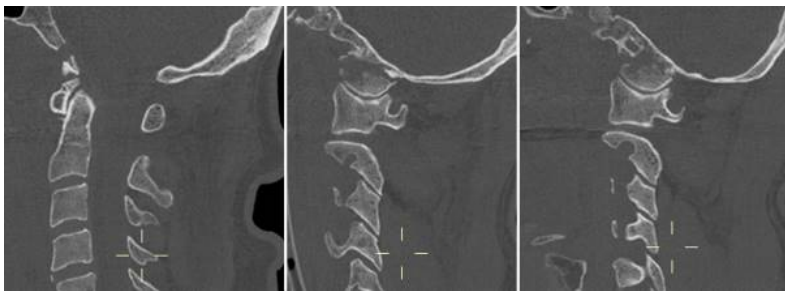
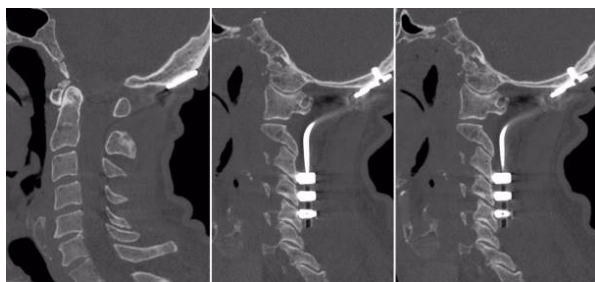


Figure 2



Figure 3



P80

Type II dens fractures: demographics and treatment experience of a single center over 10 years

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Question: Type II dens fracture is typical of the elderly. Our national demographic data shows a 14.2% increase in people >65 y.o. and a striking 28.9% increase in people >80 y.o. over the last decade. These fractures have been historically treated by means of a conservative approach or by an anterior or posterior surgical approach. To date, no definitive advantage has emerged between these treatment paradigms. Our research question is, therefore, to analyze our single-center experience with Type II dens fractures and to correlate incidence and outcomes with demographic data.

Methods: We designed a retrospective, observational study about type II dens fractures consecutively treated at our institution in a 10 year span since 2009. Pre-clinical, operative and follow-up clinico-radiological parameters will be analyzed and correlated to demographic variations.

Results: A total of 15 patients with a Type II dens fracture were treated at our institution (10 M, 5 F). During the first 5 years we evaluated 4 patients, whereas 11 of them (+175%) were assessed in the following years. Mean age at presentation was 76 ± 14 but an age increase by 16.8% was recorded over the last 5 years. 14 patients were treated by means of anterior odontoid screw fixation, whereas 1 patient refused any surgical treatment. All treated patients achieved a stable reduction of the fracture with no major intraoperative complication. Mean surgical time was 66 ± 29 min, 64% of the patients were discharged less than a week post-intervention.

Conclusions: Type II dens fracture is going to have an increased incidence in the next few years because of a demographic shift toward an older population. In our experience an anterior odontoid screw fixation represents a safe, rapid solution, with few anesthesiological and surgical burdens, even in the elderly population.

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Long term patient reported clinical outcomes in patients with type 11 odontoid fractures

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Question: What are the long term patient reported outcomes in operatively and non-operatively treated type 11 Odontoid fractures.

Methods: Patients treated for Type 11 Odontoid fractures treated at our institution from 2006-2015 were identified in the electronic medical record using standard diagnosis and procedure codes. Patients were grouped into non-operative and operatively treated groups: demographics, all cause mortality rate, and time from injury to completion of the surveys was determined. Patient reported outcomes were the Neck Pain Disability Index Questionnaire, Visual Analogue Scale survey, and SF-12 Health Survey; Physical and Mental Health Composite Scale Scores from the SF-12 were determined.

Results: 116 patients were identified with Type 11 Odontoid fractures were identified; 70 were treated non-operatively and 46 operatively. The all cause mortality rate was 26% in the operative group and 61% in the non-operative group (55 patients). 16 patients were lost to follow up. 38 patients completed the surveys, with 7 patients declining to participate. The NDI and VAS scores were lower in the non-operative group, although not statistically significant. The all cause mortality rate was significantly different between the operative and non-operative groups.

Conclusions: At an average of 35 months after injury, the patient reported clinical outcomes between operatively and non-operatively treated Type 11 Odontoid fractures were similar and not statistically different. The all cause mortality was higher in the non-operatively treated group; possibly age, comorbidities, and described everyday activity levels may bias the selection of treatment by a mixed group of orthopaedic surgeons and neurosurgeons. The mortality level may reflect a correlation between odontoid fractures and physiologic fragility.

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C1-C2 Traumatic fractures treatment and clinico-radiological outcome in a consecutive series of 94 patients

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Question: Our study is designed to analyze the clinical outcome following a conservative or surgical treatment in patients suffered by a C1-C2 traumatic fracture.

Methods: We retrospectively evaluated 94 patients treated to our institution in two years (2015-2016), encompassing 28 cases treated by surgery and 66 by an orthosis. We focused our analysis in a specific cohort of patients, the elderly ones, meaning only patients over 70 years. We administrated the NDI questionnaire for the clinical outcome evaluation and investigated the rate of fusion as well as the impact of this feature on the outcome. The acquired data have been tested with SPSS IBM v.25 statistical tool and refined by the Student's t-test, Pearson's chi-squared test and the Fisher's exact test.

Results: Even our results are similar than those showed on literature, we focus on three pivotal points: 1) the best clinical outcome in patients suffered by a type-2, type-3 dens fracture treated by surgery, according to the NDI. 2) the worst outcome in patient with a C1-C2 non fused fracture treated by an orthosis, compared to patients with the same but fused fracture. 3) the statistical independence to the rate of fusion of the surgically treated patients, in the 6-months and 1-year outcome.

Conclusions: Our observations led us to the superiority of surgical treatment in elderly patients affected by a type-2 fracture of the dens, when those patients are eligible for surgery, and to the evidenced that the non-fusion in patients treated conservatively represent an extremely negative prognostic factor. In conclusion, we may assume that an elderly patient eligible for surgery, suffering from a C1-C2 fracture, should be treated as the rest of the population, not allowing the advanced age to be an inhibiting factor in the choice of proper treatment.

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Unstable odontoid fractures: A case series

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Background: An unstable odontoid fracture can lead to a spinal cord damage. In this case, it is essential to choose the adequate treatment even though is still argue what the correct treatment is, which different surgical option is the best and the correct timing of treatment.

Research question: Evaluate the results of the anterior odontoid screw fixation with special attention to the timing of surgery, the age of the patients, the fusion rate and the different direction of the fracture line.

Design: A retrospective series of 31 unstable fractures of the odontoid process of C2 treated with anterior odontoid screw fixation.

Methods: 31 consecutive patients (18 male and 13 female; aged from 19 to 86) with unstable odontoid fracture were treated by anterior odontoid screw fixation. Fractures were diagnosed by CT-scan of the cervical spine and classified according to the Anderson - D'Alonzo classification. Patients were followed-up with radiological and clinical controls using assessment tests (Nurick scale, ODI).

Results: There was no mortality related to the surgical procedure. There are no cases of infection and no neurological deficit in the post-operative. The direction of the fracture line (down and forward or horizontal, down and back, or comminuted fracture line) did no change the decision of the anterior screwing.

Follow-up radiological studies showed bone union in 22 patients, with no difference of age. The rate of non-union was higher in patients treated after 48 hours.

Conclusions: The anterior odontoid screw fixation is a safe and effective procedure. The fusion rate is influenced only by the time of surgery and not for the age of the patients treated.

Discrepancies in the surgical management of central cord syndrome: assessment of non-operative, surgical, and crossover to surgery patients

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Question: In a population of CCS patients, assess disparities in presentation and treatment between those undergoing immediate surgery and those who delay operative treatment

Methods: Patient-specific linkage codes allowed longitudinal tracking of inpatient stays. Demographics, comorbidities, complications, and surgical factors were compared between CCS patients that initially underwent surgery (Initial) and patients that delayed operative treatment (Delayed) using Chi-squared tests and independent samples t-tests. Similar tests assessed differences in demographics and comorbidity burden between non-operative patients and surgical crossover patients

Results: Included: 1,301 CCS patients (62±16yrs, 27% female). Follow-up rate was 67.3%; mean follow-up time was 515±707 days. By level of CCS injury, 61.0% of patients were injured between C1 and C4, 59.2% between C5-C7, 1.0% between T1-T6, and 0.6% between T7-T12. Overall, 800 (61%) patients underwent surgical treatment. Of the surgical patients, 78% had surgery at first recorded hospital visit, while 22% experienced a delay before surgical treatment. For patients that delayed treatment, mean time to surgery was 203±358 days. Initial and Delayed patients differed in age (60±15 yrs vs 63±13, p=0.016), rates of diabetes, valvular disease (both p<0.05). Initial patients underwent more invasive procedures than Delayed (5.1±2.6 vs 4.3±3.2, p=0.003), including higher rates of fusion (84% vs 71%, p<0.05), but not decompression: overall (59% vs 60%, p=0.816), discectomy (39% vs 35%, p=0.306), other canal decompression (22% vs 27%, p=0.175). LOS was longer for Initial patients (16±20 days vs 7±10, p<0.001), but complication rates did not differ (all p>0.05)

Conclusions: Though CSS patients managed with initial surgical treatment had longer hospital stays and were treated with more invasive procedures, periop complications did not differ. 22% of CCS patients crossed over from nonop to operative treatment, with a mean time to crossover of 203 days

Figure 1

	Patient Group		<i>p-value</i>
	Initial Surgery (N=621)	Delay (N=179)	
Demographic and Clinical Factors			
Age (years)	60±15	63±13	*0.016
<u>Charlson</u> Comorbidity Index score	1.06±1.47	1.04±1.49	0.894
Sex (% female)	24%	30%	0.109
Length of inpatient stay (days)	16±20	7±10	*<0.001
Surgical Factors			
Mirza Surgical Invasiveness Score	5.1±2.6	4.3±3.2	*0.003
Fusion procedure (%)	84%	71%	*<0.001
Decompression (%)	59%	60%	0.816
Discectomy (%)	39%	35%	0.306
Other exoloration/decompression of canal (%)	22%	27%	0.175

P86

Anterior atlantoaxial transarticular screw fixation: Impasse or standard option?

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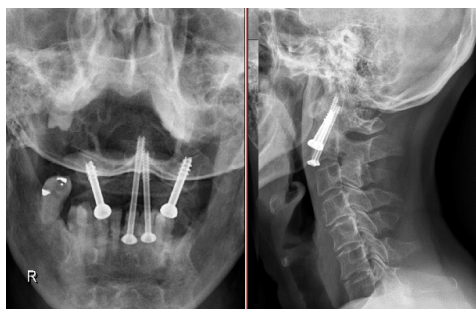
Question: Traumatic atlantoaxial instability is usually treated via posterior C1-2 instrumentation techniques, which are accepted as standard methods of treatment. Although retropharyngeal approach for anterior transarticular C1/2 fixation was described more than 12 years ago, this way of stabilisation is not widely adopted and used. From the biomechanical point of view, the fusion rate is referred to be similar to the posterior instrumentation. Is it only a salvage procedure to failed C2 dens direct instrumentation? Is there any evidence that anterior atlantoaxial instrumentation is a standard method and should be used more often? We present our cases and add a review of literature.

Methods: We retrospectively enrolled patients with dens axis fracture and atlantoaxial subluxation. Anterior transarticular screw fixation was performed with anteroposterior open-mouth and lateral intraoperative radiographs. The dens fracture was classified according to d'Alonzo, C1/2 luxation was described with Fieldings classification. Patients were evaluated by X-rays and CT scan at follow-up to identify bone fusion. We obtained classification forms for neurological status, pain and postop satisfaction.

Results: Our criteria met eight patients - 6 women and 2 men. Their median age was 83,5 years. The clinical outcome was excellent in all patients except one, where a failure of the fixation was observed. A half of our patients died soon for their high age, the rest is satisfied, although perfect bone fusion was proved by CT scan in only two cases.

Conclusions: Anterior atlantoaxial transarticular fixation is an effective and safe technique, although it is not widely known. This procedure offers some advantages over posterior approaches. It should be the standard treatment option for carefully selected patients, not only a rare or "salvage" technique.

Figure 1



Tumors and infections

P87

Managing the cervical spine in multiple myeloma patients

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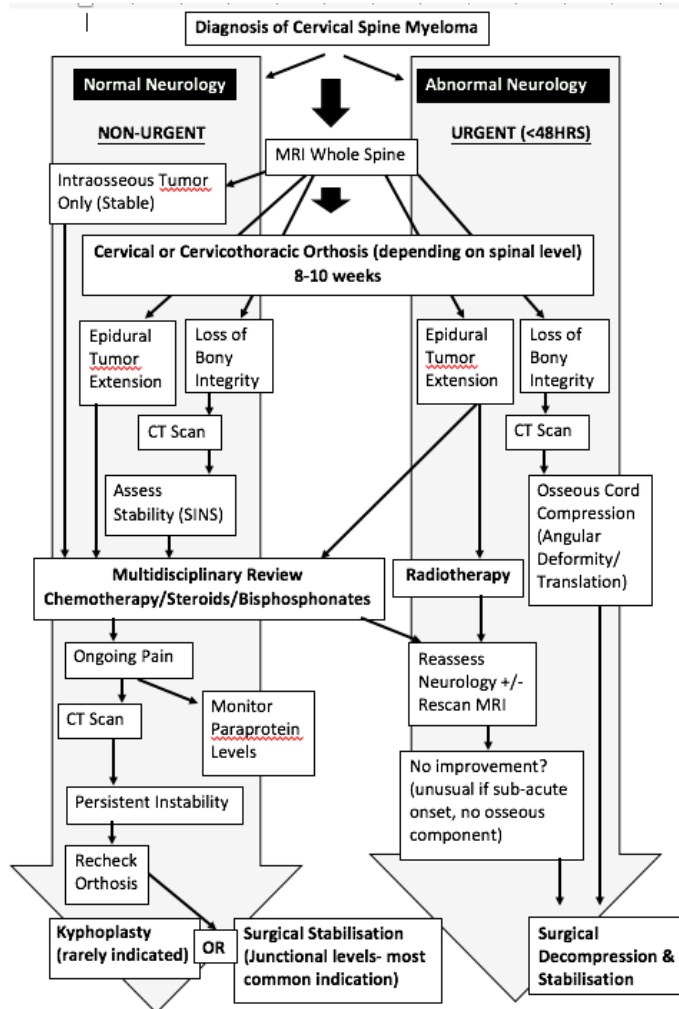
Question: Existing surgical algorithms designed for neoplasia of the spine may not suit the management of spinal myeloma. With the advances of chemotherapy, early orthosis management, radiotherapy and high definition imaging including CT, SPECT and MRI, surgical indications in MM have changed. What are the outcomes of multidisciplinary management of cervical spine myeloma in a tertiary

Methods: Method: We included all MM patients with cervical spinal disease treated between 2007 and 2016 with minimum follow-up of 6 months. This service was established for the MM patients with spinal disease to enable urgent management and avoid long term neurological and deformity deficits. 66 MM patients with cervical spinal disease were identified from 692 patients prospectively registered in the myeloma spinal database at the tertiary referral myeloma spinal unit. Radiotherapy regimens, medical therapies, bracing, SIN (Spine Instability Neoplastic) score, spinal cord compression, types of surgery, relapse status, neurological outcomes (Frankel score), pain outcomes and survival status were recorded. The management and outcomes were outlined at six-month follow up.

Results: Results: 48 patients were conservatively treated with resolution of pain and instability in all cases. 9 patients died during the course of the treatment. 9 patients were treated surgically for acute trauma, osseous translation with neurological injury, persistent biomechanical instability and epidural tumor cord compression. Serial CT evaluation adequately prognosticated osseous integrity and spinal stability. There was a chronological trend towards more conservative measures throughout the time period under evaluation.

Conclusions: Conclusion: Medical decompression/ or oncolysis, including in the presence of orthotic stabilization are proving viable non-surgical options to manage MM. Key to decision making is the assessment and radiographic monitoring of biomechanical spinal stability as part of a multidisciplinary approach.

Figure 1



P88

Acute quadriparesis due to calcium pyrophosphate dihydrate deposition disease of the cervical ligamentum flavum mimicking an epidural abscess: a case report

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Question: Calcium pyrophosphate dihydrate deposition (CPPD) disease of the cervical ligamentum flavum is a rare disorder. To our knowledge, acute quadriparesis caused by CPPD has not been previously reported in the literature.

Methods: We describe an extremely unusual case of acute quadriparesis due to CPDD of the cervical ligamentum flavum at the C4/C5 level that was mimicking an epidural abscess and briefly review the pertinent literature. A 79-year-old woman complained of high fever and serious neck pain, and presented with quadriparesis in a few hours after the onset of the symptoms. Magnetic resonance imaging revealed cervical spinal cord compression by epidural fluid at the C4/C5 level. We regarded the fluid lesion as an epidural abscess. The patient emergently underwent C4-C6 laminoplasty. The fluid was totally evacuated, and the calcified ligamentum flavum was resected.

Results: Operative intervention resulted in a marked neurological improvement and relief from neck pain. The culture test result was negative for septic organisms. Histopathological examination of the calcified ligamentum flavum showed that the deposits consisted of CPPD.

Conclusions: We report a rare case of acute quadriparesis due to CPPD disease of the cervical ligamentum flavum. CPPD deposition in the cervical ligamentum flavum is usually associated with severe neck pain and insidious progression of compression myelopathy. This unusual case of acute quadriparesis mimicking a cervical epidural abscess has not been previously described. Emergent decompression with laminoplasty and resection of the flavum can improve neurological function. Owing to the rarity of the disease, it is important to keep in mind and perform a pathological examination during surgery.

P89

Atlantoaxial dislocation secondary to the tumors of the upper cervical region: Report of 6 cases

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Question: Atlantoaxial dislocation (AAD) is mostly due to traumatic events, although, rheumatoid arthritis and tuberculosis are other unusual causes of this pathology. However, occurrence of ADD secondary to a tumor either at C1 or C2 is extremely rare and has been reported only in one rare occasion.

Methods: Six cases with atlantoaxial dislocation secondary to the tumors of upper cervical vertebrae are presented. One was a 19 year old girl with AA dislocation affection of the axis due to Hodgkin"s disease The second case was a 3-year old girl with painful torticollis secondary to rotatory atlantoaxial fixation (RAAF) due to osteoblastoma of atlas The third and fourth were a 47-year old woman and 59 –year old man in whom atlantoaxial dislocation were due to destructive lesions of the axis due to solitary plasmacytoma. The fifth and sixth cases were two children with ABC of axis. Combined anterior and posterior surgery was done in second and forth patients. Posterior only approach with p VCR of C2 was done in the first case and posterior only approach with tumor resection and C1-C3 fixation was done. In the third, fifth and sixth cases posterior only approach with **C1to C3** fixation was done.

Results: All patients showed good result post operatively. The cases were followed from 2 to 12 years. In case three and four, the solitary plasmacytoma changed to multiple myeloma within 3 to 5 years. In both cases appropriate chemotherapy and bone marrow transplant was performed with good results. The remaining four cases are also symptom free.

Conclusions: Atlantoaxial dislocation secondary to tumors of atlas or axis are rare with only one case being reported previously. Management of atlantoaxial dislocation requires a thorough knowledge about the anatomy of the atlas and its counterpart axis. Moreover, the surgeon should be quite familiar with the anatomy of V3 segment of the vertebral artery and the tips and tricks which are necessary for its isolation.

Figure 1

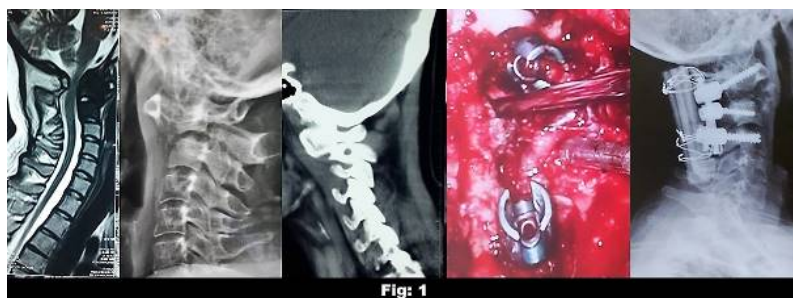


Figure 2



Figure 3

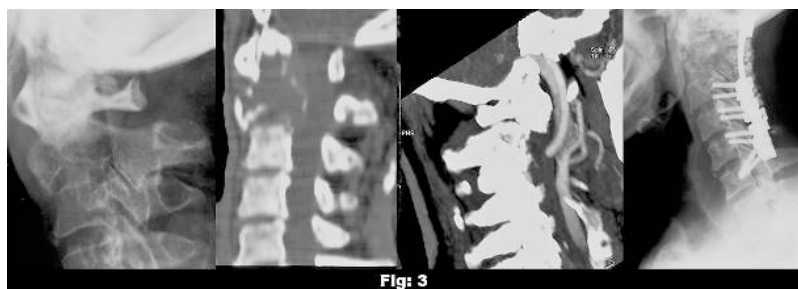


Figure 4



P90

Palliative surgery for metastasis in the cervical spine

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Question: Malignant neoplasms metastasize to the cervical spine occasionally. Patients with cervical metastasis may have severe neck pain with severe instability and paralysis with spinal cord compression. For these conditions, palliative spinal surgery is indicated to improve patient's pain and paralysis. Research question of this study was if palliative surgery improves patient's pain and paralysis.

Methods: Retrospective case series. Seven consecutive patients with cervical metastasis who received palliative surgeries in our department were included in this study. Evaluated factors were follows: primary neoplasms, spine instability neoplastic score (SINS), operation, Frankel grade, pain relief, and prognosis.

Results: The average of age of patients was 63.6 years old. There were three males and four females. The average of follow-up periods was 5.0 (1-15) months. Primary neoplasms were prostate cancer in two patients, and others in five patients. The average of SINS was 14.4 ± 2.3 (11-18). All patients received posterior cervical fusion with or without laminectomy. Preoperative Frankel grade was C in one patient, D in one patient and E in four patients. Frankel grade was deteriorated in two patients at the final follow-up. Six of seven patients had severe neck pain or radicular pain. However, pain was resolved immediately after operation in all patients. One patient died one month after operation due to respiratory disturbance, and three patients were transferred to hospices.

Conclusions: The prognosis of patients with cervical metastasis was relatively severe. However severe pain with high spinal instability was resolved after palliative posterior cervical fixation. Therefore, palliative surgery may improve patient's pain even with short prognosis.

Question: Non-traumatic atlantoaxial subluxation(AAS) is known as Grisel's syndrome, and mainly affecting children. It occurs in a context of pharyngeal infection, head and neck surgery. It is relatively rare condition, even standard treatment has not been established, medical treatment is first line. However if severe myelopathy has occurred, how is it treated? We experienced the case of this AAS due to sinusitis, presenting severe myelopathy in elderly. The treatment for this rare condition is presented here.

Methods: The case was 66yrs male. He was alcohol abuser, and in poor nutritional condition. He had left abducens palsy and visited other hospital. Sphenoid sinusitis and osteomyelitis in skull base and clivus was diagnosed. Antibiotic therapy was started, but the lesion spread to retropharyngeal space. His symptoms deteriorated into respiratory disorder, consciousness disturbance and tetraparesis, and he became respirator dependent. MRI revealed severe compression for cervical cord due to AAS. He was transferred to our hospital 1 month after the admission in prior hospital.

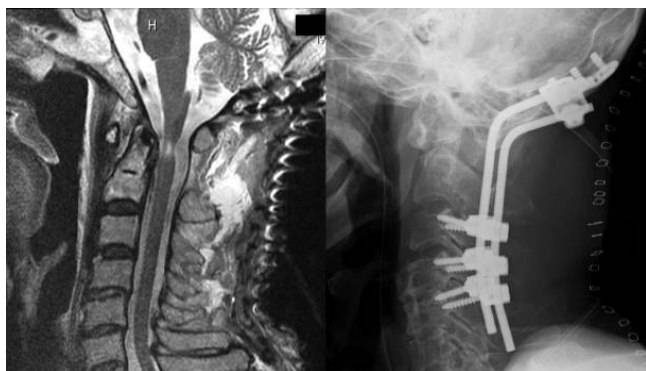
Results: Since admission in intensive care unit of our hospital, nutritious therapy and antibiotics therapy has done to improve his general condition. AAS could be reduced in neck extension position, and was fixed with neck collar. His respiratory disorder and paresis of left side had gradually improved. In the 18th day, occipito-cervical fixation was performed. C1 and C2 were skipped, and pedicular screws were put in C3, 4 and 5. After the surgery, antibiotics had been continued. His symptoms had improved more, withdrawn from respirator. Then he was transferred to rehabilitation hospital.

Conclusions: AAS due to sinusitis in elderly, extremely rare condition, was presented. He had severe myelopathy but was successfully treated with occipito-cervical fixation. There is hesitation for putting artificial materials in active infection part, but this case encourage to treat such condition.

Figure 1



Figure 2



P92

Multiple surgeries for multiple recurrences of spinal meningioma: A case report

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Question: Research question of this study was to evaluate multiple operations for multiple recurrences of spinal meningioma in a case report.

Methods: A case report.

Results: Seventy years old man developed back pain twenty years after the first total resection for thoracic meningioma at the T2/3 spinal level. He received second total resection for recurrence tumor and coagulation of dura matter, and third total resection for second recurrence tumor and reconstruction for dura matter, five years and eleven years after first operation, respectively. MRI revealed that recurrence of three tumors at the T2/3, T1/2 and C6 spinal levels. One month later, His back pain was deteriorated and he developed muscle weakness at the left fingers and gait disturbance as well. The second MRI revealed that a tumor has grown at the C6 spinal level. Laminectomy with posterior cervical fixation and total resection of a tumor at the C6 spinal level was undertaken. The C6 tumor was adhered to the spinal cord, and removed using CUSA. His motor weakness was dissolved after operation. However, paralysis was deteriorated to Frankel C two months after operation. Total resection of a tumor at the T1/2 spinal level and extension of posterior fixation to the T3 spinal level was carried out. The T1/2 tumor was adhered to dura matter, and coagulation of dura matter was added. His paralysis was dissolved and he was able to walk freely 6 months after the last operation (Frankel E). Pathological diagnosis of tumors was always atypical meningioma (WHO class II). Radiotherapy (45Gy/25fr) was performed to the C6-T3 spinal level including a remaining tumor at the T2/3 spinal level.

Conclusions: In this case report, multiple operations were needed for multiple recurrences of spinal atypical meningioma even after total resection. Multiple operations were effective for neurological impairments. Adjuvant radiotherapy may be considered for recurrence of atypical meningioma to prevent multiple recurrences.

P93

Hypoplasia of the atlas may be a risk factor for the retro odontoid pseudotumor

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Question: We investigated that the association of hypoplasia of the atlas and instability between atlas and axis. This study retrospectively investigated radiographic finding in patient with retoroodontoid pseudotumor due to hypoplasia of atlas.

Methods: From November 2012 to May 2018, 7 patients with diagnosis of retro odontoid pseudotumor received surgical treatment, there were 5 male and 2 female. And we made a comparison 7 patients with 48 patients (29 males and 19 females) who received lumbar operation between 2016 and 2018. Cervical computed tomography (CT) findings with three-dimension (3D) reconstruction were used in this study. We selected the largest spinal canal on sagittal CT images and measured the inner anteroposterior diameter (IPA) of atlas. We also used axial CT images passing the mid-portion of the atlas and recorded the cross-sectional area of the atlas (CSA). The IAP was measured from the posterior-most portion of the anterior arch of the atlas to the anterior-most portion of the posterior arch of the atlas. The CSA was traced along the inner cortical surface of the atlas with manual cursor.

Results: The mean IPA was 27.7 ± 1.1 mm (range 26.7 to 29.6 mm) in males with pseudotumor, and 30.8 ± 1.7 mm (28.2 to 32.7 mm) in males without pseudotumor, and 27.9 ± 0.3 mm (27.7 to 28.1 mm) in females with pseudotumor, and 28.2 ± 1.4 mm (24.6 to 31.9 mm) in females without pseudotumor. The mean CSA was 528.2 ± 34.5 mm² (range 498.3 to 587.2 mm²) in males with pseudotumor, and 663.1 ± 75.6 mm² (571.5 to 863.8 mm²) in males without pseudotumor, and 452.9 ± 5.0 mm² (449.3 to 456.4 mm²) in females with pseudotumor, and 571.7 ± 73.3 mm² (452.1 to 688.0 mm²) in females without pseudotumor.

Conclusions: Atlas of the patients with retro odontoid pseudotumor were smaller than the patients treated lumbar surgery. Instability due to hypoplasia of atlas was suggested as one of factors causing odontoid pseudotumor.

P94

Analysis of the results of surgical treatment of patients with cervical spine metastases

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Question: to evaluate the results of surgical treatment of patients with cervical spine metastases.

Methods: the study included 32 patients with tumors of the cervical spine operated in the spinal Department of the Federal neurosurgery center of Novosibirsk in the period from March 2013 to November 2018. of these, 20 men (62.5%) and 12 women (37.5%) aged 40 to 79 years ($M=47.2\pm 11.3$). The functional status of the patient was assessed on the Karnovsky scale, the life expectancy forecast on the Tokuhashi scale (2005), Tomita classification (2001). VAS, ODI Radiography, CT, MRI. The mean follow-up time was 3.5 years. Static methods: Kaplan-Mayer, Schonfeld and Cox proportional hazards model. In all cases, the diagnosis was morphologically verified.

Results: Patients were divided into 3 groups with different life expectancy according to their total score on the Tokuhashi scale. Volume of interventions: tumor resection-11 patients, palliative surgery - 21. 5 patients was performed embolization of tumor vessels. The severity of pain before surgery was 5.4 ± 2.0 points for VAS in the back. After VAS operation: 2.7 ± 1.3 points. Evaluation of the degree of functional adaptation after surgery on the ODI questionnaire showed improvement in all patients compared to the preoperative value. The average score decreased from 40.0 ± 4 to 18.2 ± 1.5 . The median lifespan was 12 months (7 to 36). Significant influence on the survival term was provided by the group on a scale of Tokuhashi ($p=0.0056$); chemotherapy after surgery ($p=0.0148$); scores on the Karnovsky scale ($p=0.0464$). There is no reliable statistical relationship between the type of surgery and the life expectancy of patients. Intraoperative blood loss amounted to 1202.8 ± 327.4 ml, elapsed time: $270.0\text{ min}\pm 50.1$ min. Average length of stay in hospital - 17,6 bed-days.

Conclusions: Differentiated surgical treatment tactics provides improvement of quality of life of patients with cervical spine tumors.

P95

Epidemiology and surgical management of tumors of the cervical spine: review of 241 cases

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Question: Spinal tumors are classified in intradural and extradural tumors. Most extradural spinal tumors are metastatic. The treatment of these tumors mostly requires surgery due to compression of the spinal cord and/or instability of the cervical spine. In this study we review our experience with 241 cases of cervical spinal neoplastic lesions.

Methods: Retrospective analysis of prospectively collected data in a single operative centre of patients who underwent surgery for tumors of the cervical spine in the time between January 1994 and December 2017. Exclusion criteria were intradural tumors and a probable bad prognosis (under 4 months). The analysis revealed 241 cases. We analysed epidemiological data, clinical presentation, radiological and laboratory findings and treatment methods.

Results: From a total of 241 patients 143 (59%) were male and 98 (41%) female. The mean age was 61 years (range: 5 to 88 years). According to the pathohistological findings 28 tumors (11.3%) were classified to be primary tumors of the spine whereas 176 (73 %) were metastatic lesions. In 37 cases myeloma was verified. The most common entity was lung cancer in 47 cases (19.5%). In 12 patients (5%) the staging detected no primary (CUP). Predominantly a combined approach (anterior-posterior in 81, posterior-anterior in 13 cases) was regarded necessary. From anterior alone 75 patients were treated, while in 72 cases a posterior-only approach was chosen. Out of these in 20 cases a transoral access was required. The mean follow-up was 14.2 month (range: 0 to 180 month).

Conclusions: Most extradural spinal lesions can be treated with long-term control or cure of the lesion and preservation of neurological function. Anterior approaches provide adequate exposure to safely remove the vast majority of these lesions. In cases where reconstruction of the anterior column cannot sufficiently re-establish mechanical stability a combined surgery is required.

P96

Preoperative planning using virtual reality technology and intraoperative navigation using mixed reality technology to cervical tumor surgery

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Question: Recently virtual reality (VR) and augmented reality (AR) technology are increasingly used in medical field. We report this technology because we use this technique for cervical dumb-bell schwannoma for preoperative planning and intraoperative navigation.

Methods: We created a 3D CT angiogram and made VR using the VR / MR(Mixed reality) application. We check the position of vertebral artery and plan area of the laminectomy and resection method of tumor before surgery. During surgery, we checked the position of vertebral artery and the area of laminectomy with Microsoft HoloLens, and performed laminectomy and tumoresection.

Results: [Case]73-year-old man. Diagnosis of cervical spine dumb-bell tumor. MRI showed a tumor in C2-3 level inside and outside the spinal canal. On CT angiogram we could see the vertebral artery just in front of the tumor and C2-3 facet joint fusion. So, we performed a preoperative plan to preserve vertebral artery and facet joint with VR. During surgery, we resected the lamina and tumor as planned using Microsoft HoloLens. There was no damage of the vertebral artery. And facet joint can be preserved, so spinal fusion surgery was unnecessary.

Conclusions: By using VR it was possible to accurately ascertain the position of bone, tumor and vertebral artery, and surgery could be performed safely by using MR during surgery. We think that VR and AR techniques are useful for preoperative planning and intraoperative navigation of spinal tumor surgery.

P97

Intra-medullary spinal cavernomas in the cervical spine: technical considerations about 4 original surgical cases

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Question: Intra-medullary spinal cavernomas represent 5% of all the cavernomas of the CNS and surgically cervical locations may be challenging.

Methods: We presently report 4 original cases of cervical cavernomas treated surgically and discuss the technical aspects.

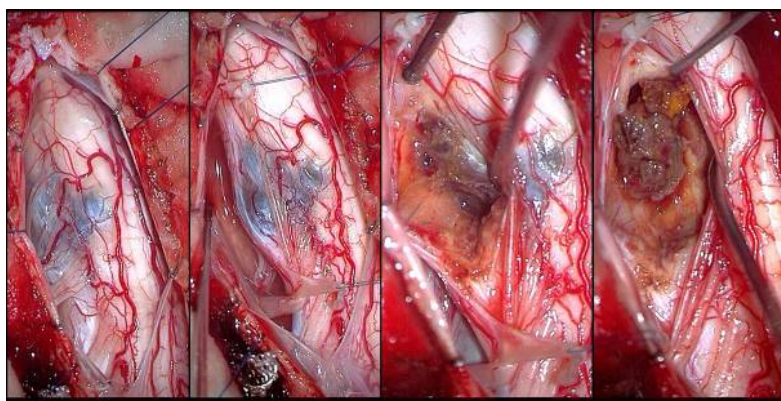
There were 2 males and 2 females. 1 case in the upper cervical spine, 2 giants (size > 10 mm) and 1 antero-lateral location. The size varied from 4 to 18 mm.

Results: All patients were evaluated preoperatively, and post-operatively at 3 months and 1 year using Mc Cormick score and by performing MRI. All patients were operated from posteriorly even the antero-lateral location. The resection was total in all cases and was conducted under neuro-monitoring and operative microscope. The cavernoma was approached via its exophytic part. The antero-lateral cavernoma was removed by a gentle rotation of the spinal cord via traction of the dentate ligament. The surgery was guided by the neuromonitoring including MEPs, SSEPs and D-wave.

There was no neurological deterioration post-operatively and MRI at 1-year confirmed the total resection for all the 4 patients.

Conclusions: In conclusion, the surgery is safe and effective in the cervical spine to eradicate cavernomas even in case of giant, trans-medullary and/or antero-lateral lesions.

Figure 1



Question: Myelopathy is often caused by degenerative cervical spinal cord compression. The clinical picture can be heterogenous and has a wide range.

Are there definitive signs for cervical compression and is there a practical possibility to exclude a thoracic pathology?

case report

Methods: A 54 year old patient presented with neck and shoulder pain on the right side, a diffuse numbness of the lower extremities and paresthesia in the right hand. Further on the patient suffered from a ataxia. The symptomatic started 4 weeks ago. The cervical MRI illustrates a big disc herniation at the level C5/6 which migrated caudally and is right sided. We performed an ACDF with complete removal of the sequester at the corresponding level without any complications.

Results: After the operation the patient was pain free but presented a week later with a worsened ataxia and hypesthesia of the lower extremities

In further MRI investigations a free spinal canal cervical was illustrated but we saw a tumor of Th4 with massive compression of the spinal cord.

Conclusions: The illustrated case is rare. Neurologic examination before the first operation showed no pathologic reflexes and the clinical symptomatic correlated with the presented disc herniation. Electrophysiological examination was not performed.

After presenting again the clinical examination showed a progression of the myelopathy.

Electrophysiologic Examination now showed normal Medianus SEPs and Tibialis SEPs couldn't be rated because of artefacts.

The only way in our view to detect the Tumor before the first operation would have been an MRI of the whole spine which is not routinely performed when the symptomatic correlates with the present MRI of the cervical spine.

Figure 1

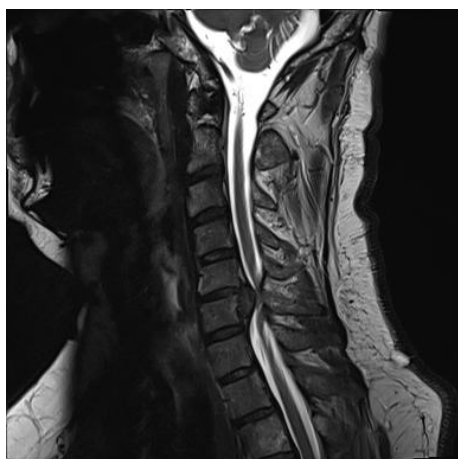


Figure 2



Figure 3



Figure 4

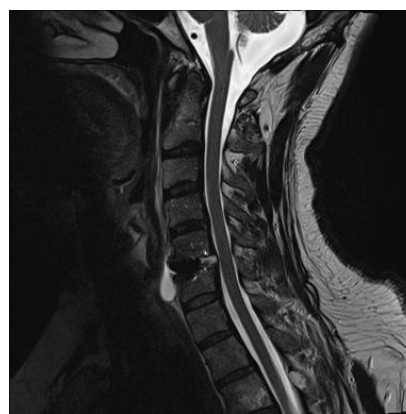
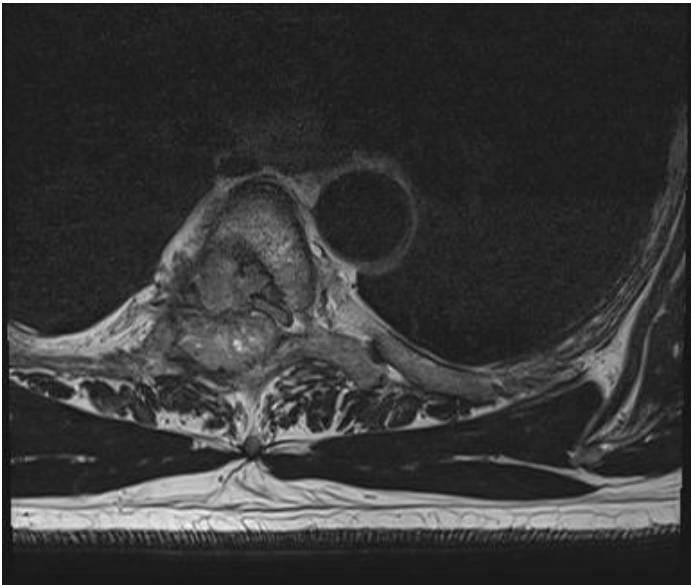


Figure 5



Figure 6



P100

Retrospective review of 32 cases with os odontoideum

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Question: To review different C1-C2 fixation techniques in 32 cases with os odontoideum and a new technique for reduction of irreducible ones as well as the clinical outcome of surgery in the patients with atlantoaxial dislocation (AAD due to os odontoideum.

Methods: From January 2004 to Nov 2018, 32 patients with os odontoideum including 20 men and 12 women were operated in our institute. The age of the patients ranged from 15 to 72 years with mean of 40.3 years. 28 patients had cervicomedullary myelopathy and quadriplegia. But, 4 cases despite unstable OO had only neck and suboccipital pain. All patients underwent a posterior atlantoaxial fixation with C1-C2 fixation. In 19 cases classic Harms technique was used. In 6 cases translaminar screws at one or two sides were used. Atlas hook was used unilaterally or bilaterally with C2 screws in 6 cases. In one case C2-C1 laminar hooks were used. In 2 patients with irreducible atlantoaxial dislocation after facet release reduction was achieved with transverse rod technique. Clinical and radiographic analyses were performed at 3 and 12 months postoperatively and annually thereafter.

Results: The follow-up period was from 4 months to 14 years. No neurologic or vascular complications occurred in these cases, and the device was placed well with no loosening or breakage. Postoperatively, myelopathic patients got better except Two bed ridden patients.

Conclusions: All C1-C2 screw –rod- or hook procedures can result in stability and good outcome. Preoperative CT scan of C2 vertebra and visualization of overriding vertebral artery one can avoid VA injury with translaminar screw effectively with a relatively simple procedure resulting in excellent biomechanical strength and high bone fusion rate.

Figure 1



Figure 2



Figure 3

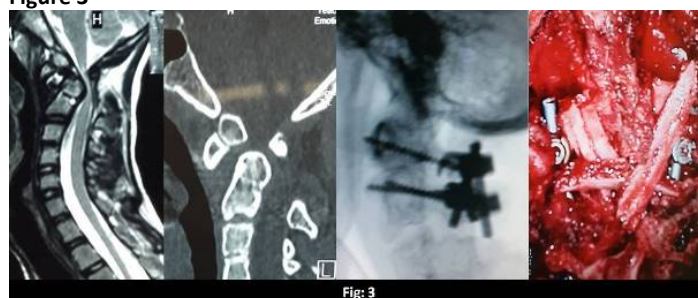


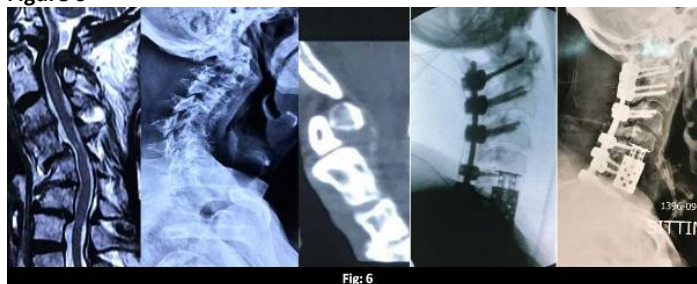
Figure 4



Figure 5



Figure 6



P101

Intraoperative spinal navigation in dorsal cervical instrumentation using iCT: A report on one year of workflow, feasibility and accuracy

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Question: In recent history the importance of navigated approaches to spinal screw placement is constantly increasing. While the use of intraoperative fluoroscopic, isocentric 3D C-arm imaging is still the most common clinical practice, a growing number of medical centers have introduced intraoperative CT (iCT) navigation as a new clinical standard. In this study we report on work flow, feasibility and accuracy of dorsal cervical spine instrumentation with iCT AIRO®.

Methods: Between September 2017 and September 2018 we analysed a consecutive series of cervical dorsal instrumentation using iCT AIRO®. Patients with screw placement in C1/2, subaxial and combinations were included. Each screw was individually assessed by an independent observer making use of the Gertzbein & Robbins classification.

Results: In this period 26 Patients were treated with a total amount of 152 implanted screws. We achieved an overall initial accuracy of 92.77% (n=121 screws) and after intra-operative revision of detected misplacements (5) 96.05%. In the atlanto-axial region n=30 screws were implanted, resulting in an accuracy of 96.67% (n=29) and 100% after revision of one misplaced screw. There was no significant fluctuation in accuracy over the course of the year.

Conclusions: In summary iCT-navigated screw placement yields a good accuracy in the cervical spine region, where accuracy is of special importance due to critical structures in close proximity. Further more, it is easy to use and reoperation rates can be reduced due to intra-operative detection of screw misplacements.

P102

Surgical strategy for severe OPLL (S-OPLL; ossification of the posterior longitudinal ligament with K-line (-) and/or a maximal spinal canal occupation ratio of 50% or more)

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Question: Surgical procedures for OPLL include the posterior, anterior or anterior-posterior combined approach, with advantages and disadvantages. Performing only posterior decompression for S-OPLL does not have good surgical outcomes. In this report, we retrospectively investigated the surgical results of S-OPLL, and elucidated the predictors of poor surgical outcomes.

Methods: This study included 40 patients (29 men, 11 women; 64.2 years) with S-OPLL, who were undergone the first surgery after 2011 and followed up for more than 1-year. We defined the JOA improvement rate less than 40% at 1-year post-surgery as poor surgical outcome. Predictive factors included sex, age, the preoperative JOA score, the surgical procedure (posterior decompression; PD, posterior decompression fusion; PSF, and anterior decompression fusion [\pm posterior fusion]; ASF). We performed multiple regression analysis to identify predictors of poor surgical outcomes (significance level: $p < 0.05$).

Results: The PD included 20 patients (17 men, 3 women; 64.1 years), PSF; 10 (5 men, 5 women; 69.9 years), and ASF; 10 (7 men, 3 women; 58.5 years). In the PD, PSF, and ASF, the OPLL occupancy ratio was 51.0, 53.2, and 63.1%, respectively. The JOA improvement rate was 27.6, 47.3, and 55.7%. Sex ($p = 0.037$) and surgical procedure ($p = 0.009$) significantly associated with poor surgical outcomes. Women had a higher risk than men (odds ratio, 12.6). The PD had a higher risk than the PSF and ASF (odds ratios, 25.1 and 16.2).

Conclusions: Although ASF has much surgical stress, direct decompression is possible, and hence it obtained the best postoperative outcomes in S-OPLL. PSF (PD with posterior fusion) obtained good surgical outcomes, next to the ASF. Selecting operative procedures may be limited by the cervical level of OPLL, physical status, and whether the facility can manage intensive care after surgery. Thus, in unadaptable cases for performing ASF, it is possible to increase improvement rate by additional posterior fusion to PD.

P103

Segmental instrumented fusion with laminoplasty for cervical OPLL with K-line (+)/large segmental motion - retrospective analysis compared with laminoplasty without segmental fusion

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Question: Cervical laminoplasty (LMP) is a widely performed surgical procedure for cervical OPLL. The K-line is a useful indicator to determine surgical method. Although LMP is usually preferred in K-line (+) patients, previous study revealed that large segmental motion at the peak of OPLL might have negative impact on clinical outcome after LMP. Therefore, we apply segmental posterior instrumented fusion (sPDF) in addition to LMP. The aim of the present study was to determine the efficacy of sPDF for cervical OPLL with K-line (+) with large segmental motion at the peak of OPLL.

Methods: Twenty-one patients of cervical OPLL with K-line (+) with large segmental motion at the peak of OPLL were retrospectively analyzed. Six patients underwent sPDF in addition to LMP (sPDF group: 5 male, 1 female; age, 54-78 years, mean 70.7 years) and 15 patients underwent LMP (LMP group: 9 male, 6 female; age 56-86 years, mean 67.5 years). OPLL occupation ratio, segmental range of motion (sROM) were assessed from preoperative X-ray and CT scans, cervical JOA score were obtained preoperatively and at the final follow-up, and JOA score recovery rate was calculated.

Results: There was no significant difference between sPDF and LMP groups in regards OPLL occupation ratio, sROM, and pre-op JOA score. Follow up period was significantly longer in the LMP group compared with that in the sPDF group ($p = 0.03$). Post-op JOA score and recovery rate were significantly higher in sPDF group compared to LMP group (Post-op JOA score: sPDF 13.2 ± 3.0 points, LMP 11.0 ± 2.7 points, $p = 0.03$, recovery rate: sPDF $57.5 \pm 28.9\%$, LMP $21.4 \pm 21.7\%$, $p = 0.01$). No adverse event was observed in both groups.

Conclusions: Our results suggest that addition of the segmental posterior instrumented fusion to LMP has potential beneficial effect for cervical OPLL with K-line (+) with large segmental motion.

Submandibular approach to the craniovertebral junction: single-stage ventral decompression and stabilization with an innovative hybrid construct: A cadaveric study of feasibility and technical illustration

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Question: The craniovertebral junction (CVJ) may be affected by several diseases. It is anatomically complex, involving osteo-ligamentous, vascular and nervous structures, which makes surgeries challenging. When there is evidence of ventral compression, an anterior approach is preferable, but a subsequent atlanto-axial fixation is often required. Trans-mucosal approaches are associated with high rates of infections, which could result increased when instrumentation devices are placed through these ways. The aim of the present investigation is to investigate the feasibility of a single stage, anterior extramucosal approach to the CVJ for simultaneous decompression and stabilization.

Methods: The present is a preliminary cadaveric feasibility study on two injected heads. Submandibular (SM) approach variation with a short "boomerang" incision, microsurgical decompression of the ventral CVJ and a new hybrid construct for atlanto-axial stabilization have been investigated. The surgical approach, the decompression steps, and the hybrid instrumentation technique have been described. In addition, intra-procedural images and x-rays, and post-procedural CT scan results were collected. Surgical exposure, working angles and corridors, and decompression grade were measured.

Results: SM approach provides the possibility for an extramucosal instrumentation of the CVJ. The hybrid construct, using a contralateral trans-articular screw and an ipsilateral intra-articular cage, results in a comfortable bilateral instrumentation. Mechanical investigations of this new hybrid system and in-vivo studies are needed to confirm our results. The ventral decompression was complete as confirmed on post-procedural CT scans.

Conclusions: A single stage, anterior extramucosal approach for decompression and stabilization of CVJ may result in shorter surgical duration and less related comorbidities.

Figure 1

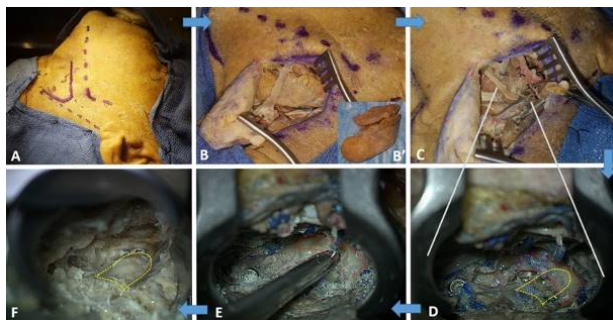


Figure 2

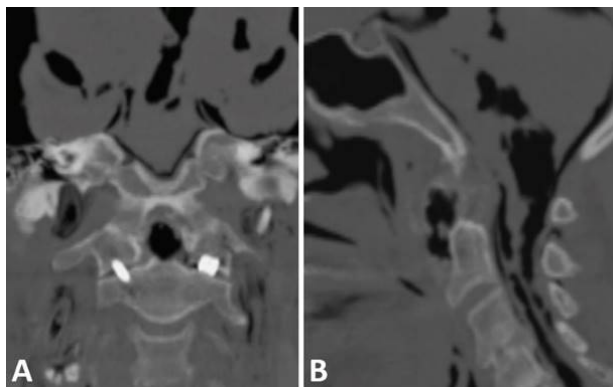
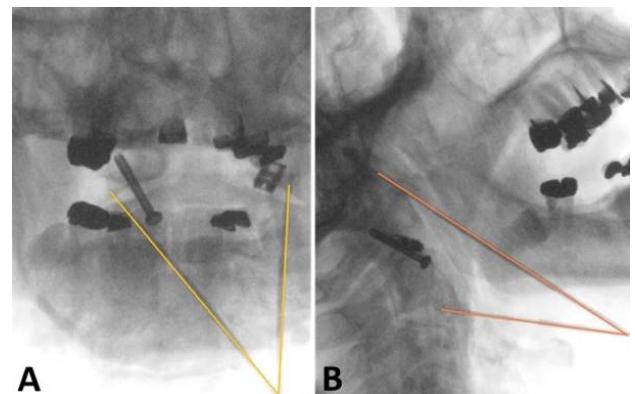


Figure 3



Efficacy of posterior articular segment decompression for cervical spondylotic myelopathy: a 5-year follow-up study of microendoscopic laminotomy versus conventional laminoplasty

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Question: The cervical spondylotic myelopathy (CSM) consists of a pincer mechanism due to a bulging disc and a hypertrophied ligamentum flavum. The concept of cervical microendoscopic laminotomy (CMEL) is the relief of pincer mechanism due to remove the dorsal compressive elements of articular segment. CMEL is a minimally invasive spine surgery using endoscope, and may provide some benefit with regard to maintaining lordosis and decreasing axial symptoms. The goal of this study was to characterize the long-term clinical and radiological results of CMEL for CSM and to compare outcomes to conventional expansive laminoplasty (ELAP).

Methods: Consecutive patients with CSM who required surgical treatment were enrolled. All enrolled patients (n =78) underwent CMEL or ELAP. All patients were followed postoperatively for more than 5 years. The preoperative and 5-year follow-up evaluations included neurological assessment (Japanese Orthopaedic Association [JOA] score), JOA recovery rates, VAS for axial neck pain, the SF-36, and cervical sagittal alignment (C2–7 subaxial cervical angle).

Results: Sixty-one patients were included for analysis, 31 in the CMEL group and 30 in the ELAP group. The JOA recovery rates were similar, 57.6% in the CMEL group and 55.4% in the ELAP group ($p > 0.05$). The axial neck pain in the CMEL group was significantly lower than that in the ELAP group ($p < 0.01$). At the 5-year follow-up, cervical alignment was more favorable in the CMEL group, with an average 2.6° gain in lordosis (versus 1.2° loss of lordosis in the ELAP group [$p < 0.05$]) and lower incidence of postoperative kyphosis.

Conclusions: CMEL is a novel, less invasive technique that allows for multilevel posterior cervical decompression for the CSM treatment. This 5-year follow-up data demonstrates that after undergoing CMEL, patients have similar neurological outcomes to conventional laminoplasty, with significantly less postoperative axial pain and improved subaxial cervical lordosis when compared with their traditional ELAP.

Figure 1



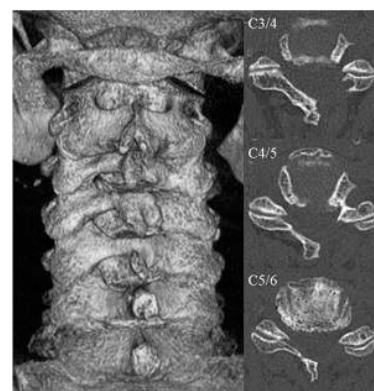
Figure 2



Figure 3



Figure 4



P106

The radiographical outcomes of C1-2 fusion for atlantoaxial subluxation in rheumatoid arthritis patients

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Question: Atlantoaxial subluxation (AAS) is one of the important comorbidities in severe rheumatoid arthritis (RA) patients. Many techniques like trans-articular screw (TAS), pedicle screw (PS), and laminar screw (LS) could be chosen for anchors of axis depending on patient's individual anatomies. We compared radiographical outcomes based on anchors of axis.

Methods: 20 patients (18 female and 2 male, mean age at surgery 67.8 years) underwent C1-2 fusion for atlantoaxial subluxation secondary to RA were enrolled. Mean follow-up was 3.3 years. Radiographic assessment consisted of lateral cervical radiographs in neutral and dynamic views and atlanto-dental interval (ADI) was measured in flexed view. Fusion was assessed using flexion-extension x-rays and CT image. As C2 anchors, bilateral PS in 8 cases, bilateral LS in 5 cases, bilateral TAS in 3 cases, unilateral LS and TAS in 2 case, unilateral LS and PS in 1case, and unilateral PS and TAS in 1case were used. Radiographical courses were evaluated.

Results: Nonunion was occurred in 2 cases out of 20 cases (1 unilateral LS and TAS and 1 unilateral LS and PS cases), and union rate was 90%. Revision surgery was performed in 1 case due to malposition of C2 laminar screw. The mean preoperative, postoperative, and final ADIs in total cases were 8.9mm, 4.3 mm, and 5.4mm, respectively. Those in the cases of bilateral laminar screws were 7.4mm, 3.5mm, and 6.1mm, respectively. Those in the other cases were 9.5mm, 4.5mm, and 5.1mm, respectively. The correction loss of ADI in bilateral LS cases and the other cases were 2.6mm and 0.6mm, respectively, and there were significant different in two groups ($P=0.0239$).

Conclusions: In this series, the cases of bilateral LS had larger correction loss. The plane of instability of AAS was sagittal. LS axis is nearly vertical toward this plane though PS and TAS were nearly parallel. Screws couldn't tolerate twisting force well, so in the cases of bilateral LS the correction loss was larger than the other constructs.

P107

Surgical outcomes of postural instability in patients with cervical myelopathy

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Question: Surgical outcomes of postural instability and its predictors in CM patients.

Methods: Postural stability in CM patients was assessed using a stabilometer preoperatively, at the early phase (3 to 6 months postoperatively), and at 1-year postoperatively, employing 2 stabilometric parameters: sway area (SA [cm²]: greater value indicating greater body sway) and sway density (SD [/cm]: greater value indicating better proprioceptive reflex), and compared to 27 age-, gender-, and BMI-matched healthy volunteers. Multivariate analyses for postoperative stabilometric parameters were performed to elucidate the predictors of surgical outcome.

Results: A total of 54 CM patients included in the present study. SA was 7.89 ± 0.84 , 4.78 ± 0.68 , and 4.85 ± 0.49 , and SD was 14.63 ± 0.85 , 20.41 ± 1.23 , and 19.36 ± 1.40 preoperatively, at early phase, and 1-year postoperatively, respectively. Two stabilometric parameters improved postoperatively; however, in all time points, they were significantly worse compared to the healthy subjects (SA: 2.68 ± 0.24 , SD: 24.91 ± 1.83). Multivariate analyses showed that worse preoperative stabilometric parameters were significantly related to worse ones.

Conclusions: Surgery significantly improves the postural stability in CM patients; however, it does not reach the level of healthy population even postoperatively. A predictor of worse postoperative postural stability is worse preoperative one. To achieve better surgical outcome of postural instability, the surgical intervention is recommended before symptoms of bodily imbalance worsen.

P108

Effectiveness of laminoplasty for cervical myelopathy due to disc herniation: Is there limitation in cases with a herniated disc exceeding the K-line?

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Question: The K-line is the index for making decisions regarding the surgical approach for cervical ossification of the posterior longitudinal ligament (OPLL). However, the usefulness for cervical disc herniation is unclear. This study aimed to evaluate the clinical results of laminoplasty for cervical myelopathy due to disc herniation, including cases with a herniated disc exceeding the K-line.

Methods: 11 consecutive patients (female, n=4; males, n=7; mean age, 53.9 years) with cervical myelopathy due to disc herniation were included in the present study. All patients underwent laminoplasty without discectomy at our hospital and were followed up for more than 1 year (mean, 28.9 months). In 3 patients, the herniated disc exceeded the K-line (defined as the line connecting the midpoints of the spinal canal at C2 and C7) on preoperative sagittal MRI. Using the JOA Cervical Myelopathy Evaluation Questionnaire, a visual analog scale (VAS; 0-10) and lateral radiographs, the cervical spinal function, axial neck pain, sagittal alignment and range of motion (ROM) of C2-7 were evaluated in the preoperative period, and at the 6-month, 1-year, and final follow-up examinations. Using post-operative MRI, the size of the herniated disc was evaluated.

Results: The cervical spine, upper extremity and lower extremity function and QOL scores were significantly increased in comparison to the preoperative scores (the mean preoperative and final follow-up scores were 75 and 92.3, 79 and 97.6, 62.1 and 83.7, 47.7 and 61.4, respectively; $P<0.05$). Axial neck pain decreased after the operation (4.6 and 3.4). The cervical alignment and ROM were maintained (cervical alignment: 8.2 and 8.6 degrees; ROM: 39.5° and 30.5°). Postoperative MRI was performed in 8 cases. The herniated disc was absorbed in 6 of the 8 patients, including 3 with a herniated disc exceeding the K-line before surgery.

Conclusions: Laminoplasty might be effective for cervical myelopathy due to disc herniation in cases where the herniated disc exceeds the K-line.

P109

Return to rugby after cervical arthroplasty

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Question: Are rugby players able to return to contact sports after cervical arthroplasty?

Methods: A 28-year-old male amateur rugby player with symptomatic degenerative disc disease of the cervical spine underwent a two-level arthroplasty. Clinical data were obtained retrospectively from the medical record. The patient was treated with a two-level arthroplasty (C5-C6-C7) at our department. Clinical status and radiographic parameters were evaluated preoperatively and during follow-up. In addition, information was gathered regarding VAS pain and point of return to sport.

Results: The preoperative radicular pain and numbness resolved completely following total disc replacement. Radicular pain significantly improved from VAS 8 to VAS 0 at the latest follow-up. No new neurological deficits were found.

The patient had a post-operative rest of 3 weeks, without cervical collar. He then started rehabilitation and cardio at the 4th week and sports activities without contact at 3 months. A return to competitive events and collisions was possible after 4 months. Currently, the patient is performing gymnasium training sessions 4 times a week (60 minutes each), rugby training 3 times per week (90 minutes each) and competition 1 time per week (80 minutes).

Long term follow-up 16 months after surgery demonstrated a correct alignment of the implants and the patient reported as very satisfied.

Conclusions: The return to physical activity and sports is of outstanding importance in young athletes with degenerative spinal disease who need to undergo surgical treatment. In our opinion, cervical arthroplasty is a logical option in young rugby athletes as they can successfully return to play at their previous level of function and competition.

P110

CT morphological analysis of the inferior limit by endonasal access to the craniovertebral junction

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Question: Endoscopic endonasal approach (EEA) has been accepted as an alternative option for diseases of the craniovertebral junction (CVJ). Compared with the transoral approach, the lowest point through endonasal corridor is concern, therefore, preoperative estimation to reach is mandatory for the appropriate indication selection. In the present study, we examined the inferior limit through endonasal corridor, and evaluated the relationships between surrounding anatomical factors and the lowest point.

Methods: 20 patients (9 men and 11 women), the mean age was 59.5 (range, 37-71), who underwent trans sphenoidal surgery for an intrasellar lesion in our hospital were included in this study. We measured 4 parameters including nasal length (NL, length of rhinion to anterior nasal spine), hard palate length (HPL), the anterior-posterior diameter of the nasopharynx (APDN), and naso palatine angle (NPA) on preoperative CT images. At the start of surgery, the lowest point was marked with a straight probe and 0 degree endoscope under guidance of the navigation system. The cases where the target is on or above hard palatine line were classified as Group A, and below the hard palatine line as Group B.

Results: The target points were more than the hard palate line in 13 patients (Group A) and under the hard palate line in 7 patients (Group B). None of the target points were below the nasoaxial line. The mean NL was 31 mm (range, 29 - 36 mm), HPL was 52 mm (range, 43 - 60mm), APDN was 25 mm (range, 20 - 29 mm), and NPA was 28 ° (range, 23 - 31 °). Comparing with two groups, a significant difference was found at NL and NPA (both $p = 0.01$). There was no significant difference in APDN and HPL.

Conclusions: The present study indicated that the size of the nasal entrance affect the accessibility of the surgical instruments. Preoperative evaluation of the parameters listed in this study gives useful information for the treatment of CVJ diseases.

P111

Accuracy of subaxial cervical pedicle screw placement with computer navigation system

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Question: Accurate placement of cervical pedicle screws remains a surgical challenge. In this study, the accuracy of subaxial cervical pedicle screw placement was compared with preoperative 3D CT-based navigation system and intraoperative 3D CT-based navigation system.

Methods: Posterior cervical instrumented fixation of cervical spine using subaxial CPS was performed in 59 pts at our institute between 2008 and 2018. The clinical diagnosis was CSM with instability or destructive spondyloarthropathy in 16 pts, CSM associated with cerebral palsy in 8 pts, rheumatoid arthritis (RA) in 8 pts, cervical deformity 3 pts, trauma in 11 pts, neoplastic destruction in 13 pts. Degeneration group (35 pts) is CSM, RA and deformity patients. Non-degeneration group (24 pts) is trauma and neoplastic patients. CPSs were placed using a preoperative 3D CT-based navigation system (preoperative group) during the first study period (2008–2012) and using an intraoperative 3D CT-based navigation system (O-arm group) during the second study period (2013–2018).

Results: The radiological accuracy of CPS placement was evaluated using postoperative CT scans and was defined retrospectively by a grading scale originally proposed by Neo et al. A total of 164 CPSs were placed in preoperative group, and a total of 132 CPSs in O-arm group, so that 296 CPSs were placed in the spine level of C3 to C7. In preoperative group, accuracy of CPS placement was 91.5 % (150 of the 164 screws) in grade 0, 5.4 % (9 of the 164 screws) in grade 1, 1.2 % (2 of the 164 screws) in grade 2, and 1.8 % (3 of the 164 screws) in grade 3. In O-arm group, accuracy of CPS placement was 97.0 % (128 of the 132 screws) in grade 0, 2.2 % (3 of the 132 screws) in grade 1 and 0.8 % (1 of the 132 screws) in grade 3. Malposition of CPS in degeneration group was identified in 16 pts of the 35 pts. Malposition of CPS in non-degeneration group was identified in 0 pts of the 24 pts.

Conclusions: There is no difference in accuracy in navigation. Accuracy was different in disease.

P113

Analysis of the Indications, surgical profile, and complications of Occipitocervical Fusion; retrospective review of 230 patients long-term follow up

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Question: *Occipitocervical fusion is a surgical technique in continuous evolution due to the innovation of devices, operative and instrumentation techniques. In this work the indications, surgical technique, and complications of the Occipitocervical fusions were analysed.*

Methods: A retrospective analysis of the collected data in a single high-volume spine centre over 25 years starting from 1994 to 2016 revealed a series of 230 consecutive surgical procedures involving the Occipitocervical junction. the preoperative, operative, and postoperative surgical outcome were analysed.

Results: There were 128 females and 102 males with a mean age of 61±17 years. The indications of fusion were; rheumatoid arthritis with instability in 50. post traumatic instability in 50, odontoid fracture pseudarthrosis in 23, tumour metastasis in 28, Occipitocervical malformations in 17, infections in 12, and non-rheumatic instability in 50 patients. In 75 patients there were neurological deficits which improved in 40 patients. Blood loss was 800±600 ml with significantly more bleeding in tumour patients, operation time 240±125 minutes. Posterior approach was performed in 130 and combined anterior transoral and posterior fixation was indicated in 100 patients. Plates and screws were used in the first 110 patients and screw-rod and occipital plate were used in 120 patients. post-operative mean follow up was 56±36 months.

Reoperations were performed in 55 (24%) of patients mostly due to wound healing problems in 25, screws loosening in 11, restenosis in 12, and adjacent segment stenosis in 6 patients. Early postoperative mortalities within one month were in 5 patients representing Only 2.1 %

Conclusions: Occipitocervical fusion is a safe procedure. In many cases an additional transoral decompression of the brain stem is necessary. Improvement of the implants leads to a significant reduction of the surgical risks and the implant related revisions specially wound healing and screw loosening

Changes of OPLL foci at residual vertebral body in surgical site after a hybrid decompression and arthrodesis for multilevel myelopathy due to cervical OPLL

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Question: A hybrid decompression and fusion in combination with ACF and ACDF with a dynamic plate, fixed by 6 screws can reduce perioperative complications and eliminate not only halo-vest immobilization but also a posterior instrumentation although in this OPLL situation, a growth or newly developed OPLL foci at residual vertebral body within decompression site may have a risk of neurological deterioration in longer term(fig. arrow).

Objective of this study is to assess the change of OPLL foci at the residual vertebral body within decompression site and to discuss the validity of this method from this point.

Methods: Sixty-two cases out of seventy cases, treated with a hybrid method between 2007 and 2015 were analyzed in this study. Mean age at surgery was 61 y/o with 67 months F/U periods on an average and mean surgical extension was 3.5 segments.

(Method) SAC (space available for the spinal cord), changed by OPLL foci at residual vertebral body at latest F/U was assessed on CT and JOA score was used for neurological assessment. These results were compared between union group and non-union group.

OPLL growth or suppression was defined when the change of SAC extend its value over 1mm at the peak of OPLL foci of the residual vertebral body.

Results: No newly development nor growth of OPLL foci at residual vertebral body was found in all case and SAC expanded in 3 cases (1.1mm suppression of OPLL foci on an average).

In union group (57 cases), JOA score has improved from 10.4 points on an average before surgery to 14.7 points at final F/U with no neurological deterioration case. In non-union group (5 cases), no growth of OPLL foci was also founded with good neurological recovery (11.7/16.4, RR 87%).

Conclusions: Smaller number of cases showed the suppression of OPLL foci however no growth nor newly developed OPLL foci was detected in this series. Hybrid method for cervical OPLL with multilevel lesion is thought to be an effective procedure from the standpoint of relatively long term F/U outcomes.

Figure 1



P115

Long-term outcome of anterior cervical decompression with fusion for cervical ossification of posterior longitudinal ligament

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Question: There is little information on the long-term surgical outcome of anterior cervical decompression and fusion (ACDF) in patients with cervical ossification of longitudinal ligament (OPLL). The aim of this retrospective study was to assess the outcome, perioperative complications, and prognostic factors including postsurgical remnant ossified spinal lesion of ACDF.

Methods: Eighty patients with cervical myelopathy due to OPLL underwent ACDF. Among these, 42 patients were followed-up for at least 5 years and their data were analyzed.

Results: The mean follow-up period was 7.9±2.8 years, and the overall improvement rate was 59.2±15.0%. Although 12 (15.0%) perioperative complications were observed, none of the patients had chronic complications. Multivariate logistic regression analysis that included the preoperative Japanese Orthopaedic Association (JOA) score, type of OPLL, occupying ratio of OPLL, and number of fused segments and increase in the transverse area of the cord identified the latter parameter as the only independent and significant determinant of radiological and clinical improvement of >50%. Among the patients with remaining ossified spinal lesions out of the decompressed range (16 patients), postoperative progression was observed in 6 cases (14.3%) who were all of the mixed type; floated lesions within the decompressed range did not show progression. Adjacent segment degeneration was seen in 9 (21.4%) patients, and neurological signs and symptoms were seen in only 3 and only 1 patient required revision surgery.

Conclusions: The long-term clinical outcome of patients with cervical OPLL after ACDF is considered satisfactory. Surgery-related complications and adjacent segment diseases should not be reasons to avoid ACDF. Care should be taken in selecting ACDF with postsurgical remnant ossified spinal lesion since it could progress postoperatively especially in the mixed type OPLL.

P116

Supralaminar C1 lateral masses screw insertion

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Question: What types of C1 lateral masses screws insertion used most often? Which ones are the safest? In what cases supralaminar C1 lateral masses screws insertion is acceptable?

Methods: The literature review was carried out in English, Russian and Spanish in PubMed, GoogleScholar and eLibrary databases. The search queries were: C1-C2 screw fixation, technical note. 434 articles were found. Also we analysed five own patients with atlantoaxial instability operated by the Goel-Harms technique. The subjects of analysis were: technical aspects of the C1 lateral masses screw insertion, variants of anatomy in V3 segment of vertebral arteries (diameter, the distance from the upper surface of the posterior arch C1 to the occipital bone squama).

Results: Three main types of C1 lateral masses screw implantation mainly used by spinal surgeons, according literature review: completely translaminar, partially sublaminar and completely sublaminar. Only the completely translaminar screw insertion do not accompanied by risk of the venous plexus and C1 root damage. The completely translaminar C1 lateral masses screw insertion possible only when its thickness is more than 4 mm. When analyzing the data of CT angiography of five patients with C1-C2 instability, we found that completely or partial supralaminar C1 lateral masses screw insertion were possible in all cases (the distance between the posterior C1 arch and occipital bone squama varies from 6 mm to 1 cm) without the risk of vertebral artery damage or compression. This technique was applied in five patients: no complications were noted.

Conclusions: Supralaminar C1 lateral masses screw insertion provide an almost "bloodless", feasible and safe method (fig.1 and 2). This alternative option can be useful in pediatric patients, when the C1 arch width is less than 4 mm.

Figure 1

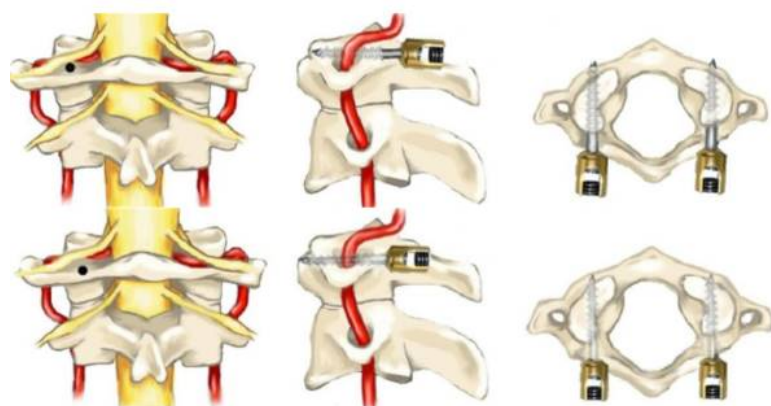
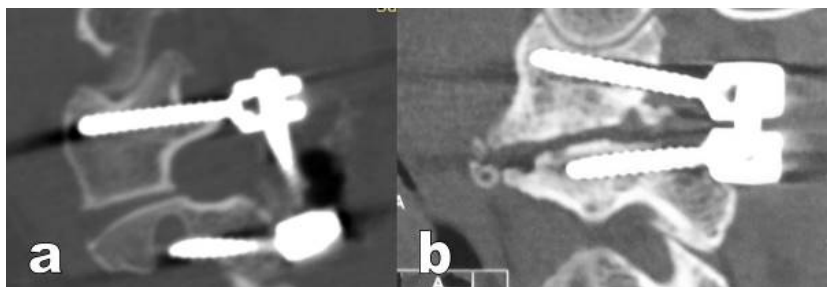


Figure 2



P117

Three-rod constructs for posterior craniocervical and cervico-thoracic stabilization

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Question: In what cases using of three-rod constructs for posterior craniocervical and cervico-thoracic stabilization use justified? Do its increase the reliability of screw fixation? Is its safe and effective?

Methods: Three-rod constructs for posterior craniocervical and cervico-thoracic stabilization was applied in four patients with developmental anomalies and systemic diseases: cervico-thoracic in two cases, craniocervical in one case, and its combination in one case.

Results: Three-rod constructs in the craniocervical junction was carried out in next way: occipital plate - three screws in C2 (intralaminar, pedicle screw or/and interarticular) - C1 lateral mass screw (fig.1). Three-rod constructs in the cervico-thoracic junction was carried out by using the subaxial vertebra (usually C7) and the upper-thoracic (usually Th1) vertebra for like anchor (3-point screws: transpedicular, intralaminar or/and lateral mass) (fig.2). During the assembly of the constructions in four patients there were no difficulties. No complications were found in the early and late postoperative periods. The follow-up period is from 6 months to 1.5 years, fusion was achieved in all cases.

Conclusions: Three-rod constructs for posterior craniocervical and cervico-thoracic stabilization justified in cases of congenital abnormalities and systemic diseases. It is safe and effective method, increased the reliability of screw fixation.

Figure 1

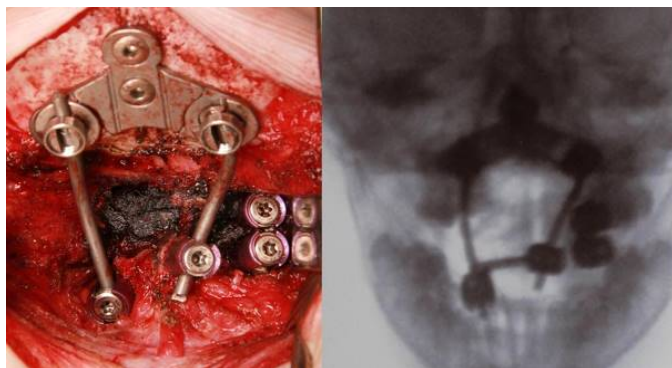
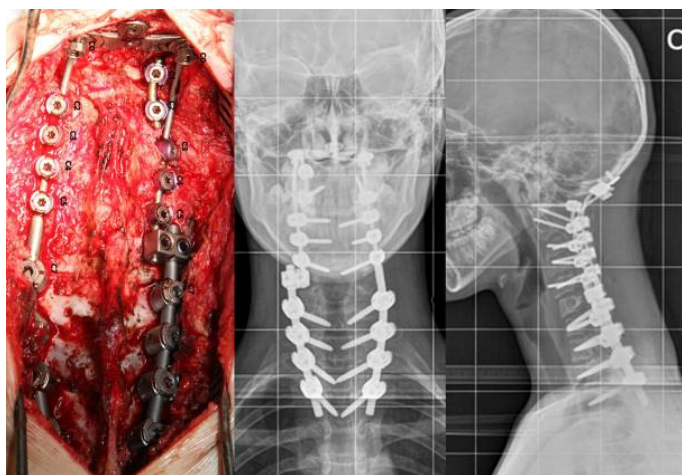


Figure 2



P118

Surgical treatment of anomaly-related atlantoaxial dislocations in pediatric patients

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Question: Which indicators of atlantoaxial dislocation (AAD) suitable for use in pediatric patients with craniovertebral junction (CVJ) anomalies? How to choose the optimal type of treatment in patients with congenital AAD? Is screw fixation safe and effective in pediatric patients with congenital AAD?

Methods: We analyzed 25 pediatric cases of CVJ anomaly-related atlantoaxial dislocations, treated in our hospital for the last 9 years (2009-2018).

Results: There are 6 patients with local CVJ abnormalities, 6 patients with Klippel-Feil syndrome and 13 patients with different systemic diseases. The most common in our group were odontoid abnormalities (20 patients) and hypoplasia of the C1 structures (15 patients). In Klippel-Feil group dislocations were predisposed by the combination of congenital C2-3 block and C1 occipitalization. Most common symptoms were: cervical myelopathy (19 patients), cervical spine deformity, restriction of neck movements and neck pain (14 patients). Local symptoms were more typical to the patients with KFS. Myelopathy occurred more often in patients with "syndromic" AAD. Full or partial reduction of dislocation and decompression of spinal cord were achieved in all cases. All cases of screw malpositions were asymptomatic and did not require reoperation. In almost all of the cases, there was neurological and functional status improvement. Two patients had a rod fracture, requiring reoperation.

Conclusions: CVJ anomaly-related AAD more often occurs in the result of odontoid abnormalities and hypoplasia of the C1 vertebra. Local symptoms are more typical to patients with non-syndromic AAD and KFS-related AAD, than to "syndromic" AAD. Myelopathy occurs more often in patients with syndromic AAD, than in patients with non-syndromic AAD and KFS-related AAD. Screw fixation for treatment of anomaly-related AAD in pediatric patients is a safe and reliable method. The total number of complications in our group was 6 (24%), 2 of them required reoperation (8%).

P119

High-angle Screw Setting at Anterior Cervical Plating Prevents graft subsidence and Correction Loss Following Anterior Cervical Discectomy and Fusion

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Question: For preventing dysphasia or heterotopic ossification relating to anterior cervical plating, a shorter plate which allows high-angle screw setting at the top or the bottom is recommended. We noticed that when the top screws inserted from the antero-inferior corner of the vertebra with high-angle, graft subsidence became minimal in many cases taking anterior cervical discectomy and fusion (ACDF). This study retrospectively investigated whether such screw setting would prevent graft subsidence and correction loss following ACDF.

Methods: From January 2014 to September 2016, 38 patients underwent ACDF using anterior plate systems which had a swing angle over 30 degrees for variable screw setting. These subjects were divided into two groups according to the screw setting angle beyond 20 degrees (H group) or not (L group) and then plate setting level, number of fusion levels, pre- and post-operative neurological status (JOA score), graft (cage) subsidence and correction loss of the lordosis were compared between two groups.

Results: The mean screw setting angle at the top was 21.8 degrees. The H group showing the insertion angle beyond 20 degrees included 24 cases and remaining 14 cases with the angle less than 20 degrees were classified in L group. There were no significant differences in plate setting level, number of fusion levels, or pre- and post-operative JOA scores. The mean subsidence of a cage in a year was 0.9mm in group H and 1.3mm in group L, but the difference was not statistically significant. However, 0.7 degrees of the correction loss in group H was significantly smaller than 2.3 degrees in group L.

Conclusions: High-angle Screw Setting in anterior cervical plating successfully reduced graft subsidence and subsequently prevented correction loss of the cervical lordosis following ACDF.

Which NDI domains best predict change in physical function in patients undergoing cervical spine surgery?

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Question: NDI is a widely validated outcome measure, yet to what extent its individual domains predict changes in physical function remains unknown. The purpose of this study is to examine the impact of NDI domains on changes in physical function in patients undergoing cervical spine surgery.

Methods: Patients undergoing cervical spine surgery between 2016-2018 were prospectively enrolled. Patients completed questionnaires (NDI, SF-36 PCS, and PROMIS PF) preoperatively and at 6 months postoperatively. A stepwise linear regression analysis was performed to identify NDI items that are independently predictive of PROMIS PF and SF-36 PCS

Results: A total of 137 patients were included in the study, with mean age 56.9 yrs (range, 24.4-84.9). All NDI domains as well as PROMIS PF and SF-36 PCS demonstrated significant improvement following cervical spine surgery ($p < 0.001$). Changes in NDI domains demonstrated significant negative correlation with changes in PROMIS PF ($p < 0.001$), with recreation ($R = -0.537$), work ($R = -0.514$), and pain intensity ($R = -0.488$) having the greatest negative correlation. Changes in NDI domains demonstrated significant negative correlation with changes in SF-36 PCS ($p < 0.001$), with recreation ($R = -0.451$), work ($R = -0.443$), lifting ($R = -0.373$) and driving ($R = -0.373$) having the greatest negative correlation. For PROMIS PF, the NDI domains that were independently associated with changes were work, pain intensity, and recreation. For SF-36 PCS, the NDI items that were independently associated with changes were work and recreation

Conclusions: All NDI domains improve significantly after cervical spine surgery and demonstrate significant correlation with changes in PROMIS PF and SF-36 PCS. The work, recreation, and pain intensity domains were the only independent predictors of physical function changes postoperatively. Our findings highlight the importance of considering changes in individual NDI domains in addition to the total score

Figure 1

Table 1: Linear Regression Modeling				
	PROMIS PF		SF-36 PCS	
Item	Coefficient (95% CI)	p-value	Coefficient (95% CI)	p-value
Pain Intensity	-0.089 (-0.147, -0.032)	0.003		
Personal Care	-		-	
Lifting	-		-	
Reading	-		-	
Headaches	-		-	
Concentration	-		-	
Work	-0.092 (-0.148, -0.036)	0.001	-0.269 (-0.444, -0.093)	0.003
Driving	-		-	
Sleeping	-		-	
Recreation	-0.067 (-0.112, -0.022)	0.004	-0.215 (-0.351, -0.079)	0.002

NDI: Neck Disability Index; PROMIS: Patient Reported Outcomes Measurement Information System; PF: physical function; SF-36: Short Form 36; PCS: Physical Component Score; CI: confidence interval

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The use of Patient Reported Outcomes Measurement Information System (PROMIS) in spine surgery: A systematic review

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Question: PROMIS has emerged as a promising outcome tool, yet whether it correlates with legacy outcomes across the spine literature remains unknown

Methods: A systematic search of the Pubmed, EMBASE, and Cochrane databases using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines was performed yielding 254 unique studies reporting on "PROMIS" in spine. Ultimately 16 studies were selected for inclusion

Results: There were a total of 4344 patients included. In the cervical population, PROMIS physical function (PF), pain intensity (Pin), pain interference (Pif), and pain behavior (PB) all strongly correlated with NDI (average $|r|=0.64-0.76$), and PF correlated with mJOA (average $|r|=0.66$). In lumbar pathology and spinal deformity, the PF, Pin, Pif, PB, and social roles satisfaction (SR) all strongly correlated with ODI ($|r|=0.66-0.76$). PF, PI, and anxiety (AX) also strongly correlated with the SRS-22/SRS-30. In general health, PROMIS PF was strongly correlated with the SF-12 ($|r|=0.67$), while PROMIS AX and depression (D) correlated with the GAD and PHQ-8 measures. On average, all individual PROMIS domains required less time to complete (49.6-56 s) compared to ODI (176 s), NDI (190.3 s), SF-12 (214 s), and SF-36 PCS (99 s). The responsiveness of the PROMIS PF (ES=0.85, SRM=0.88), Pif (ES=1.14, SRM=0.92), and PB (ES=0.895) was comparable to that of legacy measures ODI (ES=1.02, SRM=1.06), NDI (ES=0.75, SRM=0.96) and SF-12 (ES=0.675)

Conclusions: PROMIS PF, Pin, Pif and PB demonstrated strong correlations with NDI, mJOA, ODI, SRS, and SF-12 measures in spine patient populations. Decreased time to completion and comparable responsiveness of PROMIS suggests that these questionnaires may be used to assess patient-reported outcomes in spine surgery. Various PROMIS domains have demonstrated strong correlations with disease-specific and global health measures in cervical, lumbar and adult deformity patients. These results support more widespread use of PROMIS in spine.

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A Prospective, psychometric validation of NIH PROMIS physical function, pain interference and upper extremity CAT in cervical spine patients: successes and key limitations

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Question: Patient-reported outcomes in cervical pathology have substantial limitations. PROMIS offers the potential for improved psychometric properties with reduced questionnaire burden. The purpose of this study is to validate PROMIS against existing patient-reported outcomes in patients undergoing cervical spine surgery

Methods: Adult patients undergoing cervical spine surgery at a single institution between 2016-2018 were prospectively enrolled. Patients completed questionnaires (SF-36, NDI, VAS arm/neck, and PROMIS Pain Interference [PI], Physical Function [PF], and Upper extremity [UE]) preoperatively and at 6 months postoperatively. Demographic data, diagnosis, and procedural data were recorded. Validation of the instruments was completed with a Rasch Model as well as measurement of coverage, efficiency, test-retest reliability, responsiveness, and convergent validity

Results: Of 198 eligible patients, 164 had 6-month follow-up data. Most common diagnoses were radiculopathy (37.6%), myeloradiculopathy (30.5%), and myelopathy (28.4%). Time to completion was less for PROMIS PI (39s), PF (47s), and UE (54s), compared to NDI (117s) and SF-36 PCS (175s). Responsiveness for PROMIS CATs was similar to NDI and SF-36. Test-retest reliability was lower for PI (ICC:0.68), PF (0.70), and UE (0.59), compared to NDI (0.86) and PCS (0.85). For convergent validity, PI was strongly correlated to NDI and PF to SF-36 PCS. There were no significant floor or ceiling effects for the PROMIS domains, although UE had postoperative clustering a high score (56.4) and PI had postoperative clustering at a low score (38.7)

Conclusions: PROMIS CATs demonstrate several advantages, including improved efficiency and comparable responsiveness and convergent validity with legacy instruments. Nevertheless, CATs had lower test-retest reliability and had significant clustering at higher levels of function for the PI and UE CATs. These limitations must be considered before broad adoption of CATs in cervical spine patients

P123

Correlation between clinical outcomes and quantitatively analyzed spinal cord pulsation in anterior cervical decompression surgery

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Question: The purposes of this study were to quantitatively evaluate the spinal cord pulsatile motion in ACDF and to compare them with clinical results.

Methods: Subjects included 29 patients (mean age:72.8 years, 13 female and 16 male) who underwent intraoperative sonographic evaluation during ACDF for CSM. The mean number of decompressed levels was 2.3 (1-4) and the spinal cord pulsation was analyzed at the responsible level for myelopathy. As to sonographic assessments, the spinal cord pulsatile motion in antero-posterior direction (AP pulsation) and in cranio-caudal direction (sliding pulsation) were quantitatively analyzed using two-dimensional motion measurement software (Move-tr / 2D, Library Co.). In addition, the clinical outcomes were evaluated with the JOA score, GRT (Grip and Release Test) and TST (Triangle Step Test) scores.

Results: The maximum velocity was 3.46mm/s (AP pulsation) and 6.84mm/s (Sliding pulsation). The maximum amplitude was 0.50mm (AP pulsation) and 1.34mm (Sliding pulsation). The preoperative JOA score was 8.6, the postoperative JOA score was 12.9 and the recovery rate of JOA score was 51.8%. The preoperative GRT was 13.9, the postoperative GRT was 21.6 and the recovery rate of GRT was 51.3%. The preoperative TST was 17.2, the postoperative TST was 23.1 and the recovery rate of TST was 52.1%. Regarding correlation between the respective clinical results and the cord pulsation, the sliding pulsation showed a positive correlation with both the postoperative JOA score (with Max Amplitude; $r=0.33$, $P=0.049$. with Max velocity; $r=0.42$, $P=0.028$.) and the recovery rate of JOA score (with Max Amplitude; $r=0.39$, $P=0.043$. with Max velocity; $r=0.47$, $P=0.016$.). On the other hand, the AP pulsation and the other items did not affect the clinical results.

Conclusions: According to the results of this study, we hypothesize that the physiological motion of the cord might be larger in cranio-caudal direction rather than that in antero-posterior direction after decompression.

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The association between the accuracy of the bony gutter with three-dimensional printed model-assisted surgical planning and posterior shift of the spinal cord in treating cervical laminoplasty

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Question: The aim of this study was to evaluate the accuracy of the bony gutter with three-dimensional printed model-assisted surgical planning and the association between the accuracy of the laminoplasty and the posterior shift of the spinal cord or clinical results.

Methods: Thirty-five patients treated with cervical laminoplasty for cervical myelopathy. Group A included 20 patients who received the conventional free-hand technique. Group B included 15 patients who were treated with 3D printer assistance to decide the position of the bony gutter. The target position of the bony gutter (PBG) was defined on the edge of the medial aspect of the zygapophyseal joint of the cervical spine to maximize the angle of the opened lamina (AOL). The PBG and the AOL were measured by CT. The posterior shift of spinal cord (PSSC) was measured by midsagittal MRI images before and 7 days after surgery. Clinical outcomes were evaluated by the Japanese Orthopaedic Association (JOA) Score, JOA recovery rate and the incidence of radiculopathy after surgery. We compared the PBG, AOL, PSSC and clinical outcomes between Groups A and B.

Results: The average degree of the PBG was significantly lower in Group B than in Group A at both sides of C4 and at left of C6 level. The AOL was significantly higher in Group B than in Group A at right side of C4, both sides of C5, left side of C6, and right side of C7 level. Percent of Target PBG was significantly higher in Group B than in Group A at the right side of C4, right side of C5, and left side of C7. The PSSC was significantly higher in Group B than in Group A at the C4 and C5 level. There were no significant difference between Groups A and B in the JOA score and JOA recovery rate. The incidence of radiculopathy was significantly higher in Group B than in Group A.

Conclusions: 3D printer assistance made the position of the bony gutter more accurate. However, maximizing the spinal canal increased the posterior shift of the spinal cord and caused radiculopathy.

Figure 1

Fig. 1 3D printed model-assisted surgical planning



P125

Long term success with cervical disc replacement (cTDR) – review of patient reported outcomes

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Question: To study patient reported comes at long term follow up in those who underwent cTDR for degenerative disease.

Design : Prospective case series of all consecutive patients who underwent cTDR for cervical degenerative disc disease at a single institution between 2007-2009.

Methods : Independent assessment of all patients both preoperatively and at 6, 12, 24 and 105 months after procedure. Outcome measures were visual analogue score (VAS) for neck and arm pain severity and frequency, Neck Disability Index questionnaire (NDI) and Centre for Epidemiologic Studies Depression questionnaire (CES-D).

We calculated the survival rate of implants (Kaplan- Meir curve) [end point of reoperation at same or adjacent level] and compared patient outcomes (paired t test; MedCalc@) .

Results: Of 61 patients (25 men, 47 women, average age 52 years) with cTDR, 47 (73% follow up) were assessed at long term follow up [average 105 months (8.7 years)]

VAS (mean) for neck pain improved from 6 to 2 at 12 and 24 months and comparable at 105 months (VAS =3) [p<0.006]. Arm pain (mean VAS) showed periodic improvement 7 to 5 (12 months); VAS 4 (24 months) and significantly better at final review. (VAS = 3) [p<0.006]

NDIQ (average) improved from 51 to 30 at 12 months, 35 at 24 months and 26 at 105 months (p<0.0001). CES-D scores improved from 20 to 13 at 12 months, 18 at 24 months and 14 at 105 months (p<0.0001).

There were no adverse events recorded at the time of procedure. There were no revisions performed at the same level, 3 patients had further adjacent level cTDR (2 at 2 years, 1 at 9 years) and median survival time was 9.6 years (9.2 to 9.9 95% CI).

Conclusions: Cervical TDR improves pain and function in patients with degenerative disc disease both in the early and long term.

We are able to report a survival time of 9.6 years with the prosthesis used with no revision surgery performed at the same level.

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Inserting paravertebral foramen screws (PVFS) as an anchor screw to C6 vertebra is effective in reducing the risk of implant failure

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Question: We reported that the incidence of implant failure of the screws in long-segment posterior cervical fusion surgery (PCF) is higher especially in the lowest instrumented vertebra (LIV). Paravertebral foramen screw (PVFS) is a novel technique for inserting screw. It uses a short wide screw with its thread purchasing relatively hard cancellous bone around the lateral border of the vertebral foramen. We have used it for C6 vertebra which had been often floating vertebra in PCF. The purpose of this study was to investigate the difference in the incidence of implant failure by inserting PVFS in C6.

Methods: The present study was a retrospective observational study. Of the 47 patients who were performed PCF (fixed range: C2-7 or C2-T1) and were observed for more than 1 year, 19 patients whom screws were inserted on both sides of C3 to C5 were included. PVFS was inserted in C6 in eight cases (group P), and in other 11 cases C6 was a floating vertebra (group F). Screw loosening was defined as 1mm or more radiolucent area around the screw in the radiograph or CT, the incidence of loosening and breakage of the screw was examined.

Results: Loosening was four out of 90 screws (4.4%) and 22 out of 122 screws (18%) and breakage was one out of 90 screws (1.1%) and one out of 122 screws (0.8%), in the group P and group F respectively (P = 0.00675). Especially, when T1 was LIV, the incidence of loosening of the screw was 0% and 15%, and breakage was 0% and 1.4%, in the group P and group F respectively (P = 0.00048).

Conclusions: The incidence of implant failure was reduced by inserting screws on both sides in C6. Increasing the screw density is presumed to decrease the stress to LIV and reduces the occurrence of implant failure. Inserting PVFS as an anchor screw to C6 vertebra can be effective in reducing the risk of implant failure.

Question: What are the differences in cost among inpatient and outpatient anterior cervical discectomy and fusion (ACDF) at an academic medical center?

Methods: Retrospective review of ACDF patients at an academic medical center. Outpatient surgery was defined as discharge within 23 hours.

Results: A total of 210 patients were included (154 inpatient and 56 outpatient). There were no significant differences in age (55 vs. 56 years, $p=0.61$), female gender (53% vs. 57%, $p=0.62$), and body mass index (BMI, 29.3 vs. 28.3, $p=0.32$). There was a higher proportion of ASA class 2 patients in the outpatient group (79% vs. 64%, $p=0.041$), but no difference in Charlson comorbidity scores (2.0 vs. 2.4, $p=0.195$). There were no significant differences in the number of levels fused with slightly higher rates of three-level fusion in the outpatient group (27% vs. 16%, $p=0.07$). Outpatient ACDF was associated with a lower procedure duration (122 vs. 160 minutes, $p<0.001$) and estimated blood loss (EBL, 38 vs. 78 ml, $p<0.001$). Within the outpatient cohort, 55% were discharged the same day and 45% were observed overnight but discharged within 23 hours. The average length of admission for inpatient ACDF was 2.7 days. Transition to a complete outpatient ACDF protocol was estimated to save 13 hospital admissions per 25 operations. Both total hospital charges (\$151,952 vs. \$94,269, $p<0.001$) and total cost (direct + indirect cost, \$32,935 vs. \$22,041, $p<0.001$) were significantly higher for the inpatient group. Rates of readmission (2% vs. 2%, $p=0.94$) and fusion at 1 year (95% vs. 90%, $p=0.371$) were not significantly different.

Conclusions: ACDF can be safely performed in the outpatient setting on patients with similar demographic and preoperative risk stratification metrics. There were no differences in levels fused although outpatient surgery was associated with shorter procedure time and EBL. Hospital charges and total cost were significantly higher with inpatient surgery. Rates of readmission and fusion at 1 year were no different.

Figure 1

Comparison of inpatient and outpatient ACDF

Variable	Inpatient (N=154)	Outpatient (N=56)	Significance (p value)
Age (years)	55	56	0.611
Female gender	82 (53%)	32 (57%)	0.616
BMI	29.3	28.3	0.324
ASA classification			
1	5 (3%)	0	0.172
2	98 (64%)	44 (79%)	0.041
3	49 (32%)	12 (21%)	0.142
4	2 (1%)	0	0.392
Charlson comorbidity index	2.0	2.4	0.195
Levels fused			
One	57 (37%)	19 (34%)	0.681
Two	69 (45%)	22 (39%)	0.475
Three	24 (16%)	15 (27%)	0.065
Four	4 (2%)	0	0.223
Procedure duration (min)	160	122	<0.001
EBL (ml)	78 ml	38 ml	<0.001
Hospital charges	\$151,952	\$94,269	<0.001
Direct cost	\$20,743	\$13,171	<0.001
Indirect cost	\$12,193	\$8,871	<0.001
Total cost	\$32,935	\$22,041	<0.001
Readmission	3 (2%)	1 (2%)	0.939
Fusion at 12 months	62/65 (95%)	18/20 (90%)	0.371
Follow-up (months)	12	10	0.059

Predictors of superior recovery kinetics in adult cervical deformity correction: an analysis using a novel area under the curve methodology

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Question: Identify demographic, surgical, and radiographic factors that predict superior recovery kinetics

Methods: CD patients (C2-C7 Cobb>10°, CL>10°, cSVA>4cm, or CBVA>25°) with BL, 3M, 1Y, 2Y follow-up. Following univariate analyses, the AUC method for NDI was used by dividing all BL and postop by BL. Normalized scores(y) were plotted against follow-up interval(x). Area was calculated for all follow-up, divided by cumulative follow-up, determining overall, time-adjusted HRQL recovery[IHS]. IHS NDI scores were stratified by quartile, the uppermost 25% were categorized as having SRK vs. "Normal" Recovery Kinetics(NRK). BL factors were used to predict SRK using generalized linear modeling

Results: 51 patients included (61.5yrs, 27.9kg/m², 66%F). Surgical approach: combined(39%), posterior(35%), anterior(26%). Mean CCI:0.89, EL: 916ccs, op time:523min. Relative to BL NDI scores(Mean:48.5), normalized postop NDI disability decreased at 3M(0.93, p=0.295) and further at 1Y(0.77, p<0.001) and 2Y(0.69, p<0.001). Normalized NDI scores showed patient improvement from BL to 2Y(p<0.001). NDI IHS scores correlated with BL PT(p=0.004), PI-LL(p=0.031), and T1-FH-S1(p=0.024). After grouping by quartile, patients with greater BMI(SRK: 31, NRK: 26.9kg/m²;p=0.042), BL PT(SRK:24.1°, NRK: 15.9°,p=0.036), PI-LL(SRK:10°, NRK:-3.4°, p=0.050), anterior approach(SRK: 58.3%, NRK 15.4%; , p=0.002), and less levels fused(SRK: 5.1, NRK: 8; p=0.010) correlated with SRK. 51% of patients met MCID for NDI(<Δ-15) and 58.8% met SCB(<Δ-10); 100% of SRK met MCID and SCB. The final predictive model for SRK included(AUC=88.1%): BL VAS EQ5D score, BL swallow sleep score, BL PT, BL mJOA score, BL T4-T12, BL T10-T12, BL T12-S1 and BL L1-S1

Conclusions: Superior recovery kinetics following cervical deformity surgery was predicted with high accuracy. Patients and healthcare providers should be aware of predictive factors, including BL HRQLS (VAS EQ5D, swallow sleep, and mJOA scores), and BL parameters(TK, T10-T12, T12-S1, L1-S1)

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