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Trauma and Infection

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THE IMPACT OF LATERAL PEDICLE SCREW MISPLACEMENT AND SUBSEQUENT CORRECTION OF SCREW TRAJECTORY ON SCREW ANCHORAGE. A BIOMECHANICAL ANALYSIS

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Introduction: Pedicle screws are widely used in the treatment of thoracolumbar spinal pathology. Although intraoperative guidance improved over the last decade, pedicle screw misplacement remains a common complication. However, the effect of screw misplacement and associated pedicle wall perforation on screw anchorage has not been well studied. This biomechanical study therefore sought to answer the following two questions: (1) Is pedicle screw anchorage of laterally misplaced screws (LM) inferior to that of well-placed control screws (CON)? (2) Does redirection of laterally misplaced screws improve or rather compromise pedicle screw anchorage?

Twenty fresh frozen human thoracolumbar vertebrae were randomly assigned to one of two test groups (group 1 (CON vs. LP) or group 2 (LP vs. CORR)). Mean age and BMD were comparable among the two groups (group 1: 64.2±8.4 years, 92.8±18.45 mg/cm³; group 2: 62.6±9.3 years, 96.8±21.77 mg/cm³). In the first part of the study, laterally misplaced screws with lateral cortical perforation (LM) were compared to well-placed control screws (CON) contained within the cortices of the pedicle. In the second part (group 2), laterally misplaced screws with subsequent correction of screw trajectory (CORR) were compared to laterally misplaced screws without redirection. The experimental design allowed for pairwise left-right comparisons under comparable conditions, such as bone quality and pedicle morphology. Each screw was subjected to cyclic loading in cranio-caudal direction (initial +50N to -50N) with an increasing load magnitude (-5N every 100 cycles) until screw loosening. For statistical analysis, a paired t-test was used.

Laterally misplaced pedicle screws resisted a significantly lower mean number of load cycles and maximal force until loosening than the well-placed control screws (5230±2481 vs. 8205±3027 load cycles; and 304.5±123.7 vs. 453.5±151.3N, respectively) (both p = 0.003). Redirected laterally misplaced screws showed a significantly lower number of load cycles until loosening than laterally misplaced screws (3686±2105 vs. 5489±2731 (p = 0.018); and 227.5 N±104.12 N vs 316.5 N±136.46 N (p=0.020)

Our results indicate that lateral pedicle screw misplacement negatively affects screw anchorage. However, redirection of laterally misplaced pedicle screws does not improve but rather compromise screw anchorage and may not be desirable if the misplaced screw does not harm relevant anatomical structures.

Disclosures:

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RISK FACTORS FOR FAILURE OF NONOPERATIVE TREATMENT OF UNILATERAL LATERAL MASS FRACTURE

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Study Type: Case-control

Objectives

Unilateral lateral mass fractures include a wide spectrum of injuries, ranging from isolated nondisplaced to complex dislocated fractures. This variability and the low frequency, have made it difficult to understand their biomechanical behavior and the features that determine segmental stability. On the other hand, the imaging parameters associated with instability have been widely described in tomography, however, the value that magnetic resonance imaging for predicting instability and failure of conservative treatment is unknown.

Materials and Method

A retrospective case-control study was carried out in 32 patients, with a diagnosis of unilateral lateral mass fracture, treated at a Level I Trauma Center in Chile, between 2009 and 2020. The clinical and imaging history was recovered: X-Ray, CT, and MRI records, of patients with a diagnosis of F1 to F3 Fracture of AOSpine subaxial classification system. The variables in MRI of acute intervertebral disc disruption, pre-vertebral soft-tissue edema, facet synovitis, and posterior ligament complex injury (PLC) were analyzed, as well as cervical sagittal balance parameters of T1 Slope and Thoracic Inlet Angle (TIA). Two groups were categorized: failure of conservative treatment and successful conservative management, with failure defined as the appearance of neurological symptoms in the follow-up, spondylolisthesis $> 3.5\text{mm}$ or progression, angulation $> 11^\circ$, and nonunion.

Results

6 patients failed conservative treatment and 26 patients were successfully non-operatively managed. In the group of patients with failure of conservative treatment, it was reported: 83% of traumatic disc disruption, 83% pre-vertebral soft-tissue edema, and 100% facet synovitis at the injured level. In the nonoperative treatment group, the same findings were: 21%, 46%, and 73%, respectively. From the cervical sagittal balance, no significant differences were found in T1 slope and TIA, between the groups.

Conclusions

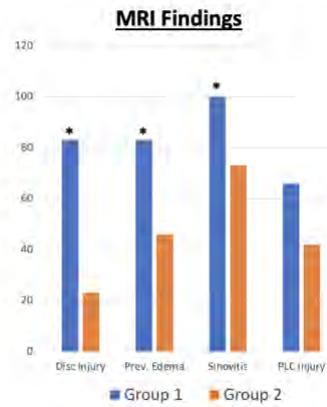
The results obtained show no association between the cervical sagittal balance parameters as a risk factor for failure of nonoperative treatment. Meanwhile, acute disc disruption appears to be a determining factor of segmental instability and predictor of failure in conservative treatment, like other MRI findings. This imaging study should be considered in the initial analysis of these injuries. Further investigations are needed to determine a stronger statistical association between these findings and the prediction of failure of nonoperative treatment in unilateral lateral mass fractures.

Results

- **Group 1:** (6) Failure of Non-operative treatment
- **Group 2:** (26) Non-operative treatment

- **Acute disc disruption ***
83% (5/6) vs 23% (6/26)
- **Prevertebral edema***
83% (5/6) 46% (12/26)
- **Facet joint synovitis***
100% vs 73% (19/26)
- **PLC injury**
66% (4/6) vs 42% (11/26)

*= $p < 0,05$



Disclosures:

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OF PELVIS: A RELIABLE CLASSIFICATION FOR OSTEOPOROTIC SACRAL AND PELVIC RING FRACTURES

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Introduction:

Osteoporotic fractures are an increasing issue in orthopedics. Motivated by the successful development of the classification for osteoporotic thoracolumbar spine fractures the working group „Osteoporotic Fractures“ of the spine section of the German orthopaedics and trauma society (DGOU) decided to develop a classification for osteoporotic sacral and pelvic ring fractures.

Methods:

A structured dialogue over a period of three years was performed to reach a consensus of experts for categorization of osteoporotic sacral and pelvic ring fractures. Repeated evaluations of the consensus draft has now been completed resulting in the OF Pelvis classification. The classification consists of five categories with increasing instability in relation to CT and MRI findings (OF1 only edema, OF2 only anterior fracture, OF3 sacral fracture one side, OF4 sacral fracture both sides, OF5 iliac or sacroiliac fracture, Pic.1). Additionally three modifiers have been defined which can be assigned alone or in combination with each other (M1 Fracture of L5 transversal process in CT, M2 displacement at any localization, M3 edema at any localization additional to the fracture localization). Those modifiers identify higher levels of instability.

25 anonymized cases were analyzed two separated times using X-Ray, CT- and MRI-scans within a delay of four weeks in altered order by 28 independent raters. Fleiss' Kappa (kF) was calculated to describe the inter rater reliability (interRR). Using the Landis und Koch categories the quality of agreement was assessed. The intra rater reliability (intraRR) was calculated using Kendalls Tau (t) for classification and Cohens Kappa (kC) for the presence of at least one modifier. All 28 raters were experienced orthopedic surgeons. Fifteen raters have been involved in the development process (developing rater, DR) and 13 worked with the score the first time (user rater (UR)).

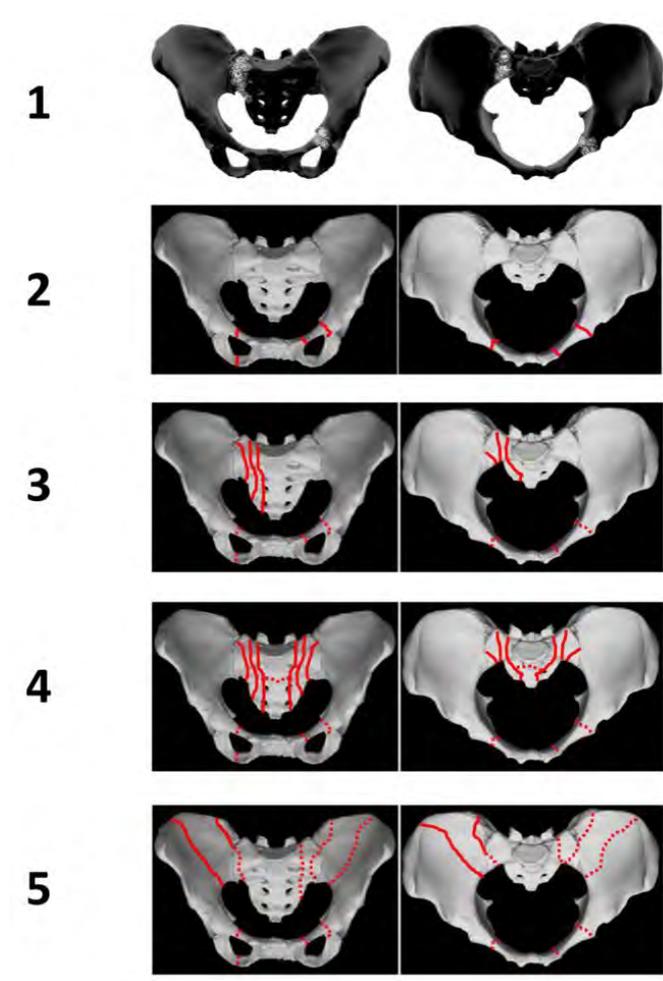
Results:

In both surveys the interRR for categories were substantial kF=0,764 (1. Survey) and kF=0,790 (2. Survey). The interRR of DR and UR were nearly on a par (kF 1. Survey/2. Survey: DR 0,776/0,813; UR 0,748/0,766). The agreement for each category was also substantial (kF min./max. 1. Survey/2. Survey: 0,708 - 0,827/0,747 - 0,852). The existence of at least one modifier was rated with substantial agreement (kF 1. Survey/2. Survey: 0,646/0,629).

The IntraRR showed almost perfect agreement mit t=0,894 (DR: t=0,901, UR: t=0,889). The modifier had an intraRR of kC=0,684 (Senior-Rater: kC=0,758, Junior-Rater: kC =0,621) which is also considered to be substantial.

Conclusions:

The OF Pelvis resulting from a consensus process is showing a substantial interRR and an almost perfect intraRR following Landis und Koch. The similar promising reliabilities between the DR and UR rater group proof that this classification can be used independently of the training status of the user. It may be a valid fundament for an indication for treatment score.



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THE INFLUENCE OF SURGEON EXPERIENCE AND SUBSPECIALITY ON THE RELIABILITY OF THE AO SPINE SACRAL CLASSIFICATION SYSTEM

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Study Design: Cross-sectional survey

Objective: To determine the influence of surgeons' level of experience and subspecialty training on the reliability, reproducibility, and accuracy of sacral fracture classification using the AO Spine Sacral Injury Classification System.

Summary of Background Data: An ideal classification system is easily comprehensible and reliable amongst the diverse group of surgeons. A surgeons' level of experience may have a significant effect on the reliability and accuracy of a classification system. Moreover, surgeons of different subspecialties may have various levels of comfort with imaging assessment of sacral injuries required for accurate diagnosis and classification.

Methods: High-resolution computerized tomography (CT) images from 26 cases were assessed by 172 investigators from a diverse array of surgical subspecialties (general orthopaedics, neurosurgery, orthopaedic spine, orthopaedic trauma) and experience (<5, 5-10, 11-20, >20 years). Validation assessments were performed via web conference using high-resolution images, as well as axial/sagittal/coronal CT scan sequences. Two assessments were performed by each investigator independently three weeks apart in randomized order. Reliability and reproducibility were calculated with Cohen's kappa coefficient (k) and gold standard classification agreement was determined for each fracture morphology and subtype and stratified by experience and subspecialty.

Results: Respondents achieved an overall $k = 0.87$ for morphology and $k = 0.77$ for subtype classification, representing excellent and substantial intraobserver reproducibility, respectively. Respondents from all four practice experience groups demonstrated excellent interobserver reliability when classifying overall morphology ($k=0.842/0.850$, Assessment 1/Assessment 2) and substantial interobserver reliability in overall subtype ($k=0.719/0.751$) in both assessments. General orthopaedists, neurosurgeons, and orthopaedic spine surgeons exhibited excellent interobserver reliability in overall morphology classification and substantial interobserver reliability in overall subtype classification. Surgeons in each experience category and subspecialty correctly classified fracture morphology in over 90% of cases and fracture subtype in over 80% of cases according to the gold standard. Correct overall classification of fracture morphology (Assessment 1: $p = 0.024$, Assessment 2: $p=0.006$) and subtype ($p < 0.001$) differed significantly with surgeons with >20 years of experience demonstrating increased difficulty correctly classifying all fracture subtypes overall in comparison to the other experience groups. Correct overall classification did not significantly differ by subspecialty.

Conclusions: Overall, the AO Spine Sacral Injury Classification System appears to be universally applicable among surgeons of various subspecialties and levels of experience with acceptable reliability, reproducibility, and accuracy.

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BLOOD PRESSURE MANAGEMENT IN TRAUMATIC SPINAL CORD INJURY: DOES MAP TARGETING IMPROVE NEUROLOGICAL OUTCOME?

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Background

Patients with acute traumatic spinal cord injury are at risk of developing secondary injury due to spinal cord ischaemia. Current guidelines recommend a mean arterial blood pressure (MAP) of 85-90mm Hg for 7 days after injury (1). These are level III recommendations based on limited evidence.

Purpose of the study

Determine the relationship of MAP augmentation and neurological outcome in traumatic spinal cord injury.

Materials and methods

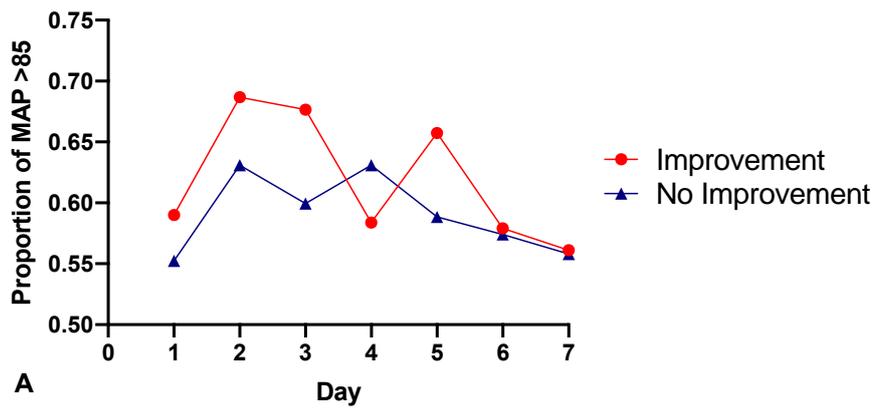
Retrospective cohort study of adult patients admitted to a level 1 major trauma centre with traumatic spinal cord injury over a 4-year period between 2016-2019. All recorded MAP values within the emergency department, ward and intensive care unit for 7 days after date of injury were collected. Average MAP values and the proportion of MAP values >85 mm Hg were calculated. American spinal cord injury association impairment scale (ASIA) scores and ASIA motor scores on admission and at longest follow up point were recorded. Primary outcome was ASIA score improvement at follow up. Secondary outcome was improvement in motor score at follow up. These outcomes were compared with both average MAP values and the proportion of values >85mm Hg. Days after initial injury were categorised into early (days 1-3), and late (days 4-7).

Results

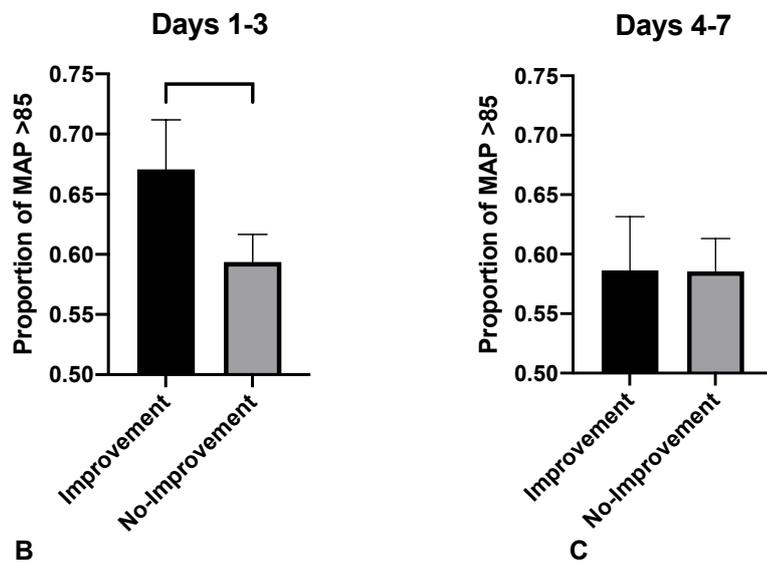
122 patients were included in the study, with a median follow up time of 27 days (IQR 12.6-87.8). The median age was 64 (IQR 49.8-76.0), with 72% male. 84% of injuries were of the cervical spinal cord, 15% thoracic and 1% lumbar. Initial ASIA scores of patients were 29% A, 9% B, 20% C and 42% D. 35 (29%) of patients had improvement in ASIA score at follow up. These patients had a significantly higher proportion of MAP values >85mm Hg within the first 3 days after injury than patients without improvement in ASIA score (0.67 vs 0.59, $p=0.049$), (Figure 1b). There was no difference in the proportion of MAP values >85mm Hg at days 4-7 between patients with and without improvement in ASIA score (0.59 vs 0.59, $p=0.99$), (Figure 1c). Patients with improvement in motor scores tended to have a higher, although not significant, proportion of MAP values > 85mm Hg within the first 3 days after injury (0.63 vs 0.58, $p=0.12$). This difference was not maintained at 4-7 days post injury. Average MAP values tended to be higher in those with improvement in ASIA scores and motor scores at follow up, however there was no significant difference between the two groups.

Conclusion

This study supports current guidelines that augmenting MAP above 85mm Hg improves neurological outcome in traumatic spinal cord injury. Our results show the importance of achieving this MAP target as soon as possible as we did not find any benefits for delayed (>3 days) augmentation of MAP.



A



B

C

Figure 1. Relationship of improvement in ASIA impairment scale score at follow up and proportion of MAP values >85 mmHg. Groups categorised into Improvement and No-Improvement. (A) Comparison of days 1-7 (individual days shown). (B) Comparison of days 1-3 combined. (C) Comparison of days 4-7 combined. * statistically significant at $p < 0.05$.

References

1. Walters BC, Hadley MN, Hurlbert RJ, et al. Guidelines for the management of acute cervical spine and spinal cord injuries: 2013 update. *Neurosurgery* 2013; 60: 82-91.

Disclosures:

author 1: no indication; author 2: none; author 3: none; author 4: consultant=Imperial College Healthcare NHS Trust

INFECTIOUS AND AUTOINFLAMMATORY MODIC TYPE 1 CHANGES HAVE DIFFERENT PATHOMECHANISMS

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Background: Modic type 1 changes (MC1) are vertebral bone marrow (BM) edema that associate with non-specific low back pain (LBP). Two etiologies have been described. In the infectious etiology *Cutibacterium acnes* (*C. acnes*) invades damaged intervertebral discs (IVD) resulting in disc infection and endplate damage, which leads to an immune response in the BM. In the autoinflammatory etiology disc and endplate damage lead to the exposure of immune privileged disc cells and matrix to leukocytes, thereby evoking an immune response. Different etiologies require different treatment strategies. However, it is unknown if etiology-specific pathological mechanisms exist.

Aim: To identify etiology-specific dysregulated pathways of MC1 and to perform in-depth analysis of immune cell populations of the autoinflammatory etiology.

Methods: BM aspirates/biopsies were obtained from LBP patients with MC1 undergoing spinal fusion. From each patient, a MC1 and an intra-patient control aspiration/biopsy from the adjacent vertebral level was taken. If *C. acnes* in IVD adjacent to MC1 were detected, patients were assigned to the infectious, otherwise to the autoinflammatory etiology. Total RNA was isolated from aspirates and sequenced (inf. n=3+3, auto. n=5+5). Differentially expressed genes (DEG) were determined (p-value<0.01, log₂fc>±0.5) and gene ontology (GO)/gene set enrichment analysis (GSEA) were performed. Cell population changes in the autoinflammatory etiology were analyzed with single cell RNA sequencing (scRNAseq) of CD45+CD66b- cells isolated from biopsies (n=1+1). Transcriptomic changes (n=5+5) of CD45+CD66b+ neutrophils isolated from aspirates were analyzed as with total bulk RNAseq. Neutrophil activation (n=3+3) was measured as CD66b+ expression with flow cytometry.

Results: Comparing MC1 to control in total bulk RNAseq, 204 DEG in the autoinflammatory and 444 DEG in the infectious etiology were identified with only 67 shared genes (Fig.1a). GO enrichment revealed „T-cell activation“ (p=2.50E-03) in the autoinflammatory and „complement activation, classical pathway“ (p=1.1E-25) in the infectious etiology as top enriched upregulated biological processes (BP) (Fig.1b). ScRNAseq of autoinflammatory MC1 showed an overrepresentation of T-cells (p=1.0E-34, OR=1.54) and myelocytes (neutrophil progenitor cells) (p=4.0E-05, OR=2.27) indicating an increased demand of these cells. Bulk RNAseq analysis of neutrophils from the autoinflammatory etiology revealed an activated, pro-inflammatory phenotype, which was confirmed with more CD66b^{high} neutrophils in MC1 (+11.13 ± 2.71%, p=0.02) (Fig 1c).

Conclusion: Autoinflammatory and infectious etiologies of MC1 have different pathological mechanisms. T-cell and neutrophil activation seem to be important in the autoinflammatory etiology. This has clinical implication as it could be explored for diagnostic approaches to distinguish the two MC1 etiologies and supports developing targeted treatments for both etiologies.

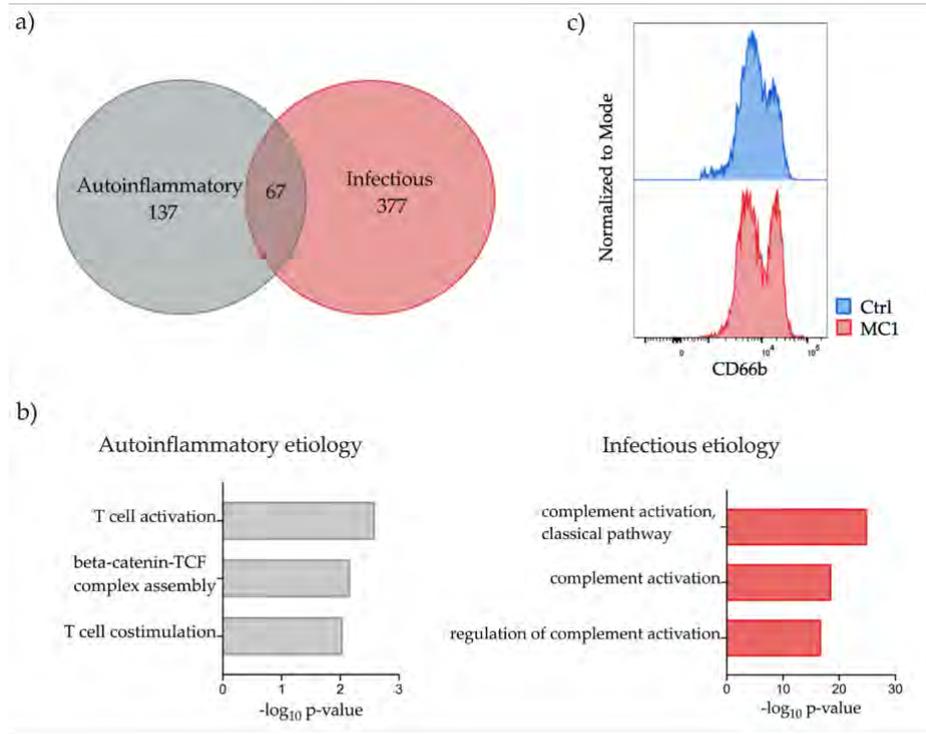


Figure 1: (a) Overlapping DEG total bulk RNAseq (b) Top enriched upregulated BP (c) Representative histogram of CD66b⁺ expression in MC1 and control neutrophils

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THE ADIPOKINE PROFILE AND ELEVATION OF THE RANKL/OPG RATIO IN VERTEBRAL BODIES AND INTERVERTEBRAL DISCS OF PATIENTS WITH VERTEBRAL OSTEOMYELITIS: IMPLICATIONS FOR THE DISEASE PATHOGENESIS.

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Background

Vertebral Osteomyelitis (VO) as the most frequent manifestation of hematogenous osteomyelitis in the adult patient can lead to the destruction of the intervertebral disc (IVD) and vertebral bodies (VB). The underlying pathogenesis and the associated immunolo-inflammatory mechanisms, favoring tissue degradation have not been illuminated in detail.

Methods

Patients with clinical, radiological, and microbiological proven diagnosis of VO (group I) and with unstable fractures of the spine (group II) treated in our level-1 trauma center have been prospectively included. The causative pathogens were identified and the therapy with anti-inflammatory drugs and antibiotics was monitored. Tissue biopsies from affected intervertebral disc and adjacent vertebral bodies have been collected and were analyzed for mRNA expression levels of 14 candidate genes, comparing both groups. RNA was isolated from preserved tissue samples and absolute quantification of transcripts was done by RT-qPCR. Significant correlations between expression levels were evaluated, and the RANKL/OPG and Leptin/Omentin (LEP/ITLN2) ratios were calculated. Next to patient-related data and treatment details, laboratory infection markers (CRP, Leukocyte count and PCT) were measured during the hospitalization period and the follow-up. Further, treatment success was assessed by the evaluation of patient-reported outcome (PROM) preoperatively (t0) and at least 12 months postoperatively (t1) in terms of the Oswestry Disability Index (ODI) and Core Outcome Measurement Index (COMI).

Results

28 patients were included in the study (n=14 group I, mean age 67.1 ± 11.7 years and n=14 group II, mean age 42.7 ± 13.5 years). Staphylococcus aureus was identified as the most frequent causative pathogen (n=8). Treatment success was proven by the decrease of CRP, Leukocyte counts and PCT during the hospitalization and at the follow-up and by a significant improvement of ODI and COMI scores between t0 and t1 (both $p < 0.05$). The mRNA expressions of the neutrophil- and lymphocyte-attracting chemokines IL8 and CCL20 were significantly higher VB samples of group I ($p < 0.05$). The pro-inflammatory adipokine leptin showed a significant higher mRNA expression in IVD tissue in group I ($p < 0.05$), whereas Omentin mRNA expression was lower in VBs in group I vs. group II ($p < 0.05$). The calculated Leptin/Omentin ratio was accordingly elevated in VB of the VO group. OPG mRNA expression was significantly lower in VB and in IVD tissue compared to group II (both $p < 0.05$). In line with this, RANKL/OPG ratio was elevated in VB and IVD of group I compared to group II ($p < 0.05$ and $p = 0.23$).

Conclusion

In a comprehensive clinical study, we identified changes in the Adipokine profile as well as the RANKL/OPG expression ratios as potential markers in VO regulating the balance between pro- and anti-inflammatory pathways and the changes in tissue metabolism, eventually favoring degradation of VB and IVD alike.

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Jungingen; author 7: none; author 8: none; author 9: consultant=MSD, Correvio, other financial report=Basilea, Portola

A VALIDATED SCORE FOR EVALUATING SPINAL INSTABILITY TO ASSESS SURGICAL CANDIDACY IN ACTIVE SPINAL TUBERCULOSIS - AN EVIDENCE-BASED APPROACH AND MULTINATIONAL EXPERT CONSENSUS STUDY

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Background context: Multidrug chemotherapy has made spinal tuberculosis (STB) mainly a medical disease. However, instability in STB leads to disabling spinal deformity and neurological deficit. The ability to identify and estimate instability remains largely subjective based on experience resulting in overdo or delayed surgical treatment with serious consequences to the patient.

Purpose: To develop an objective scoring system to determine instability in STB.

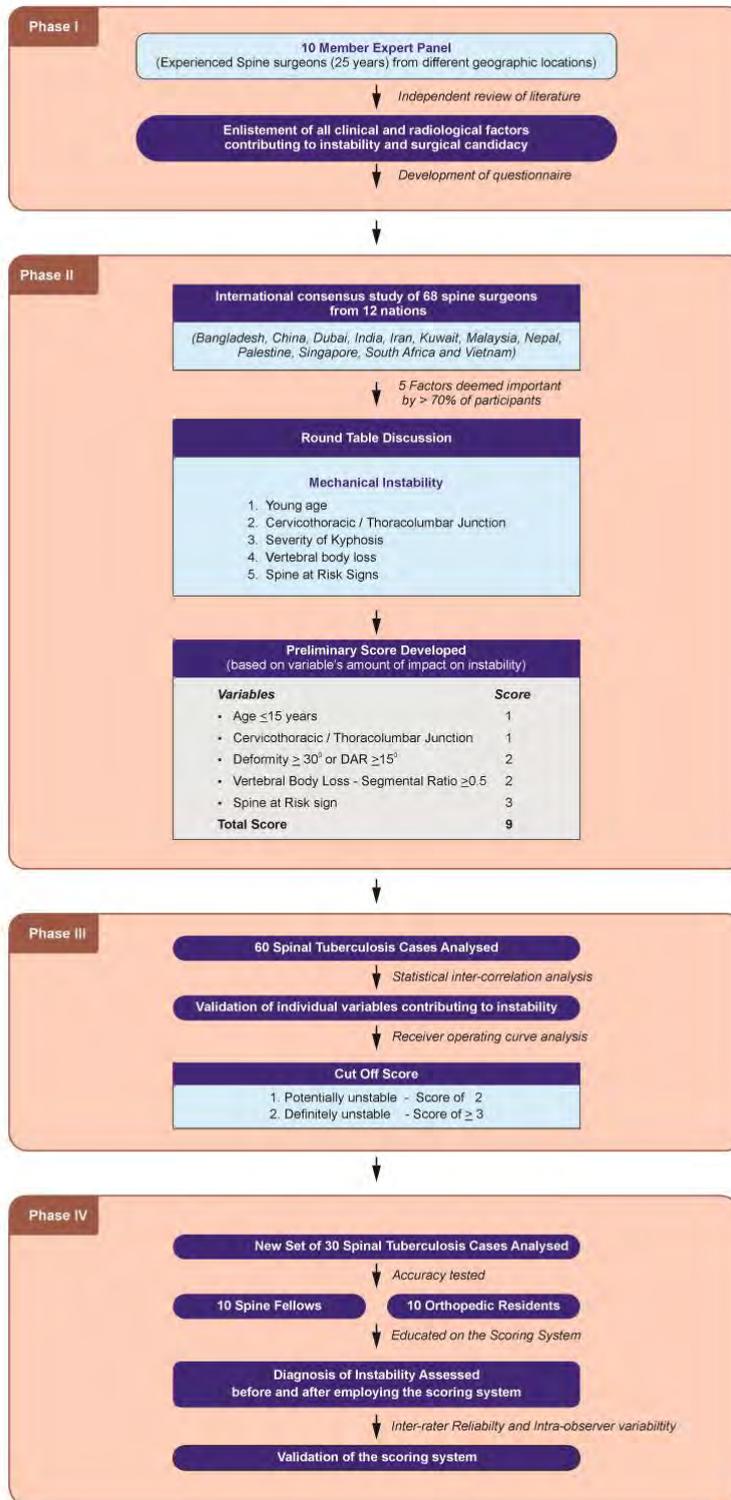
Study design: Modified Delphi Consensus and Observational Study.

Materials and Methods: The study was conducted in four phases. 1) A 10-member expert panel of spine surgeons with 25 years' experience performed an extensive review of literature to enlist all factors influencing management in STB and a questionnaire was developed. 2) 68 experienced spine surgeons from 12 different nations opined on the importance of each factor in an online survey. 5 factors deemed important by >70% of participants were included for further analysis 3) 60 representative cases of STB were analysed for several factors and their association with instability. A preliminary scoring system was developed and threshold score for determining instability was derived. 4) Results were validated in a new set of 30 cases. 10 spine fellows and orthopaedic residents naïve to the scoring system evaluated these cases before and after employing the scoring system and the overall agreement, reliability and reproducibility were analysed. This project was self-funded.

Results: 68/76 of the invited spine surgeons participated and factors considered important by >70% of the participants were - 'Spine at risk' signs deemed important by all (100%), followed by severity of vertebral body loss (89.56%), Cervico-thoracic/Thoraco-lumbar junction involvement (86.57%), age below 15 at presentation (85.07%), and kyphotic deformity ≥ 30 degrees (80.60%). All these five factors considered in the scoring system were found to be associated with instability: age ≤ 15 years (p-value, 0.05), cervicothoracic/thoracolumbar junction involvement (p-value, 0.028), sagittal deformity angle ratio (DAR) ≥ 15 degrees (p-value < 0.001), vertebral body loss-segmental ratio ≥ 0.5 (p-value < 0.001) and presence of spine at risk signs (p-value < 0.001). A total score of $\geq 3/10$ was indicative of definite instability with a good sensitivity (77%) and excellent specificity (100%). The scoring system was validated in a new set of 30 cases with excellent accuracy. The overall diagnostic agreement assessed by Inter-rater Intraclass co-efficient improved following usage of scoring system to predict instability in both spine fellows [.794 to .971] and orthopedic residents [.683 to .957].

Conclusion: A simple objective method of scoring system for predicting instability in STB has been developed using five main factors; young age, junctional involvement, severity of deformity, vertebral body loss and presence of spine at risk signs.

Spinal Instability In Tuberculosis Scoring System Development



Disclosures:

author 1: none; author 2: none; author 3: none; author 4: none