INSTABILITY ANALYSIS AFTER THORACIC SPINAL COMPRESSION AND FLEXION-COMPRESSION TRAUMA: AN IN VITRO STUDY

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Introduction

Spinal instability resulting from traumatic injury represents a constant matter of debate due to missing clear definitions. Detailed understanding of spinal instability might support surgical treatment as well as the optimization of fixating spinal implants.

Numerous experimental studies have investigated the effects of spinal injuries on resulting instability patterns, primarily focusing on the cervical and lumbar spine and rarely using mechanical injury generation and detailed instability analysis [1]. The purpose of this in vitro study therefore was to determine the most relevant instability parameters after compression and flexion-compression trauma of the lower thoracic spine.

Methods

Twelve fresh frozen human thoracic spinal specimens (T9-T11; 4 f / 8 m; 40-60 years) including costovertebral and costotransverse joints were dynamically loaded with pure compression (n=6) or flexion-compression (i.e. compression + 10 Nm flexural preload, n=6). The impact was applied displacement-controlled with a velocity of 300 mm/s up to 20% of the T10 vertebral body height after applying a 400 N axial preload in a material testing machine. Traumatic injury was defined as load drop during controlled displacement of at least 10% and detectable injury in the lateral radiograph.

Instability was measured in a universal spine tester before and after trauma by applying pure moments of 5 Nm in flexion/extension, lateral bending, and axial rotation to determine range of motion, neutral zone, coupled rotations, and coupled translations. Besides, translations under 100 N shear loads and height loss under 400 N axial compression were evaluated.

Statistical analysis was performed using the Friedman test in SPSS with a significance level of 0.05.

Results

Traumatic injuries occurred at a median of 5 kN (2.4-9.2 kN) independent of the trauma type, resulting in AOSpine type A1 injuries [2] in all tested specimens. Pure compression mainly provoked isolated medial endplate fractures (n=5), whereas flexion-compression primarily led to combined anterior endplate fractures and upper vertebral body compression fractures (n=3, Fig. 1). Significant instability increases after trauma ($p<0.05$) were found for all parameters except coupled rotations (for both trauma types) and posterior shear translation (for pure compression trauma). Highest instability increases were detected for height loss (compr. +136% / flexion-compr. +200%) as well as for neutral zone values in flexion/extension (+177%/ +188%) and lateral bending (+174%/+126%, Fig. 2). Range of motion and coupled translation increases were overall higher compared to shear translation increases.

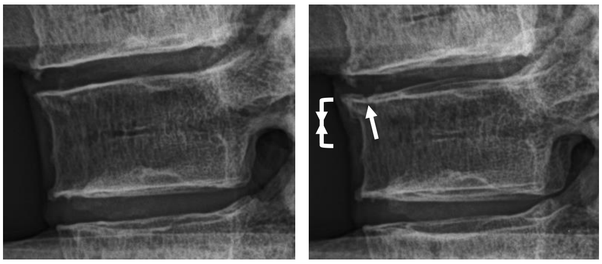

Figure 1: Exemplary lateral x-rays under 400 N axial preload before (left) and after (right) flexion-compression trauma resulting in an endplate fracture (white arrow) and compression fracture (white bracket).

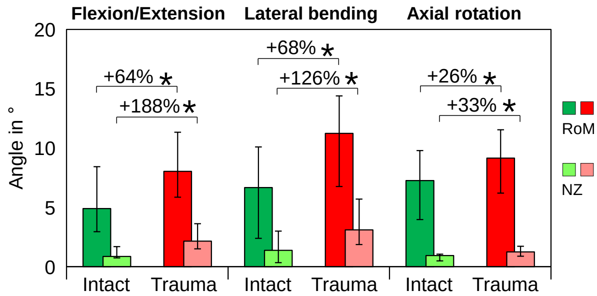

Figure 2: Range of motion (RoM) and neutral zone (NZ) increases after flexion-compression trauma (p<0.05).*

Discussion

The present study focused on the effect of minor trauma on spinal instability in order to reveal the sensitivity of an instability analysis. With regard to clinical instability, the effects of major trauma, such as pincer-type or burst fractures, and other trauma types, such as flexion-distraction injuries, have to be investigated in future studies, as well as the protecting effect of the rib cage.

In conclusion, height loss and neutral zone represent the most relevant instability parameters after (flexion-) compression trauma of the lower thoracic spine.

References

1. Liebsch et al, Spine J, 22(1):136-156, 2022.
2. Schnake et al, J Orthop Trauma, 31(4):S14-S23, 2017.

Acknowledgements

This study was funded by the Baustein program of the Ulm University Medical Faculty (Grant no. L.SBN.0186).