Predicting anterior Column Load Transfer at Multiple Levels in the Thoracic Spine Using Surface Strains and Neural Networks Analysis

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Introduction: A previous technique of using surface strain data and neural networks analysis to assess load transfer across the posterior spinal column during in vitro loading has been incorporated into recent experiments. A new method was conceived in which strain gauges were used to assess anterior column load transfer in vitro. This new technique was used to assess load transfer simultaneously across two anterior thoracic bodies separated by a burst fracture. Such information is useful in understanding the effect on load transfer of different injuries and implants.

Methods: Seven T9-L1 human spine segments were potted and subjected to impact loading in a weight drop apparatus, creating burst fractures at T11 (verified by x-ray). A total of twenty uni-axial strain gauges were then attached just under the superior endplate of T12 (n=10) and above the inferior endplate on T10 (n=10). Changes in surface strain were recorded during flexibility testing (7.5 Nm flexion [FL], right lateral bending [RLB] and left lateral bending [LLB]), upright posture with 70 N, 110 N and 150 N preloads, and during flexion with 70 N follower load. After testing, the T10 and T12 vertebral bodies were disarticulated and post-hoc calibration loads (25 to 400 N in axial compression) were applied at defined points on a plate positioned across the inferior end plate of T10 and superior end plate of T12, respectively. Silicone rubber (Dow Corning 3110 RTV) was molded to fit between each endplate and the metal plate used for load application, to ensure even load distributions during calibration. Computational models were created using experimental surface strain data recorded during calibration and neural networks analysis software (Predict by Neuralware), and used to assess load transfer (magnitude and load location points) across the inferior T10 and superior T12 endplates that had occurred during experimental testing. Data were analyzed using one-way RM ANOVA/Holm-Sidak with P< 0.05 considered significant.

Results: Mean compressive loads were greater across the T12 superior endplate vs. the T10 inferior endplate during all loading configurations (Fig. 1). Load location points did not vary between levels during flexion (with or without preload) in anteroposterior or mediolateral directions, or during lateral bending in the anteroposterior direction. However, location shifted mediolaterally during lateral bending, following the direction of bending, with a greater magnitude at T10 (P=0.009) vs. at T12 (P=0.2).

Conclusions: The difference in load transfer across T10 and T12 may be related to the induced burst fracture injury at T11 and/or differences in orientation of T10 and T12 relative to the loading vector due to kyphosis. The method of using anterior strain and neural networks analysis to assess load transfer across multiple spinal levels, requiring no cutting into tissue to insert sensors (which could alter important load transfer patterns), shows great promise and has possible applications for a wide range of adjacent level load transfer studies.
[Fig. 1. Mean body loads. Error bars show stdev.]