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THE ANATOMICAL AND BIOMECHNICAL CONSEQUENCES OF ANTERIOR VERTEBRAL STAPLING FOR THE FUSIONLESS CORRECTION OF SCOLIOSIS

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INTRODUCTION:

Fusionless scoliosis surgery is an emerging treatment for idiopathic scoliosis as it offers theoretical advantages over current forms of treatment. Anterior vertebral stapling using a nitinol staple is one such treatment. Despite increasing interest in this technique, little is known about the effects on the spine following insertion, or the mechanism of action of the staple. The aims of this study were threefold; (1) to measure changes in the bending stiffness of a single motion segment following staple insertion, (2) to describe the forces that occur within the staple during spinal movement, and (3) to describe the anatomical changes that occur following staple insertion.

METHODS:

Immature bovine spines were obtained from the local abatoir and stored frozen at the testing facility. On the the evening prior to testing spines were defrosted then cut into individual motion segements of T3-4, T5-6, and T7-8. Initially, fourteen segments underwent displacement controlled testing to compare the change in bending stiffness of an unstapled condtion with that following insertion of a four-prong SMA staple. Strain guages were attached to staples in three specimens and used to measure staple forces during movement. Micro CT scanning was used to describe the anatomical consequences of staple insertion. Descriptive analysis of these results are reported with paired t-tests used to to compare the stiffness measures.

RESULTS:

Stiffness measurements in the control condition were representative of previously published measures[1]. A significant decrease in motion segment bending stiffness ($p>0.05$) occured following staple insertion in flexion, extension, lateral bending away from the staple, and axial rotation away from the staple. The greatest staple forces occurred in flexion and the least in extension. Each staple showed a baseline compressive loading on the tips following insertion which was seen to gradually, but consistently, decrease across the five cycles of testing. Micro-CT scanning demonstrated significant unilateral damage to the vertebral body and endplate.

DISCUSSION:

These results suggest that staple insertion consistently decreased stiffness in all directions of motion. An explanation for the finding may be found in the outcomes of the strain gauge testing and micro-CT scan. The strain gauge testing showed that once inserted, the staple tips applied a baseline compressive force to the surrounding trabecular bone and vertebral end-plate. This finding would be consistent with the current belief that the clinical effect of the staples is via unilateral compression of the physis. Interestingly however, as each specimen progressed through the five cycles of each test, the baseline load on the staple tips gradually decreased, implying that the force at the staple tip-bone interface was decreasing. We believe that this was likely occurring as a result of structural damage to the trabecular bone and vertebral end-plate by the staple effectively causing 'loosening' of the staple. This hypothesis is further supported by the findings of the micro-CT scan. The pictures depict significant trabecular bone and physeal injury around the staple blades. These results suggest that the current hypothesis that stapling modulates growth through physeal compression may be incorrect, but rather the effect occurs through mechanical disruption of the vertebral growth plate.

REFERENCES:

1. Wilke, H.J., et al., Load-displacement properties of the thoracolumbar calf spine: experimental results and comparison to known human data. European Spine Journal. 6:129-137, 1997.