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THE BIOMECHANICAL EFFECTS OF THORACIC SPINE STAPLING

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Introduction

The use of anterior vertebral staples in the fusionless correction of scoliosis has received increased attention in recent literature. Several animal studies have shown stapling to be effective in modulating vertebral growth. In 2005 Betz (1) published the only clinical series to date.

Despite the increasing volume of literature suggesting the efficacy of this treatment, little is known about it's biomechanical consequences. In 2007 Puttlitz (2) measured the change in spinal range of motion after staple insertion in a bovine model. They found a small but statistically significant decrease in range of motion in axial rotation and lateral bending. The clinical significance of this is questionable as the differences were only a few degrees over three vertebral levels. A well designed biomechanical evaluation of the effects of staple insertion on spinal stability is needed. The aim of this study was to evaluate the effect of insertion of a laterally placed anterior vertebral staple on the stiffness characteristics of a single motion segment.

Methods

Four-pronged shape memory alloy staples were inserted into fourteen individual bovine thoracic motion segments. A displacement controlled six degree-of-freedom robotic facility was used to test control and staple constructs through a pre-determined range of motion in flexion, extension, lateral bending, and axial rotation. All data were synchronised with robot position data and filtered using moving average methods. The stiffness in each condition was calculated in units of Nm/degree of rotation. Paired t-tests were used to compare results.

Results

Stiffness measurements in the control condition correlated with previously published measures (3). A significant decrease in stiffness ($p<0.05$) following staple insertion was found in flexion, extension, lateral bending away from the staple, and axial rotation away from the staple. Stiffness for axial rotation towards the stapled side was significantly greater than for away. A near significant increase in lateral bend stiffness away from the staple compared with towards was also seen.

Discussion

These results suggest that staple insertion consistently decreased stiffness in all directions of motion. This is contrary to the results of Puttlitz (2), which reported a reduced range of motion (i.e. increased stiffness) for some motions using moment-controlled testing. This decrease in stiffness could not be explained by changes in anatomy or tissue properties between specimens, as each stapled motion segment was compared with its own intact state. Addition of the staple would intuitively be expected to increase motion segment stiffness, however we suggest that the staple prongs may cause sufficient disruption to the vertebral bodies and endplates to slightly reduce overall stiffness. Hence, growth modulation may be achieved through physical disruption of the endplate, rather than static mechanical stress. Further research is planned to investigate the proportion of load carried by the staple during spinal movement and the anatomical effect of the staple on the physis. In conclusion, anterior vertebral stapling causes a slight but significant decrease in the stiffness of treated motion segments.

References

1. Betz R.R., et al. Vertebral body stapling procedure for the treatment of scoliosis in the growing child. Clinical Orthopaedics And Related Research, 34:55-60, 2005.
2. Puttlitz C.M., et al. A biomechanical assessment of thoracic spine stapling. Spine, 32:766-771, 2007.
3. Wilke H.J., et al. Biomechanical comparison of calf and human spines. Journal of Orthopaedic Research, 14:500-503, 1996.