A Synthetic, Absorbable, Anterior Tension Band Improves Cervical Spine Fusion Outcome in an In Vivo Caprine Animal Model

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(a-DePuy Spine)

INTRODUCTION: Current trends in cervical spine fusion are moving steadily towards so-called minimally invasive techniques, which include smaller incisions, lower profile devices and temporary (bioabsorbable) materials. Given that the rate of cervical spine fusion is very high with modern surgical techniques using metallic plates and interbody grafting, researchers are pushing the envelope towards less permanent and lower profile solutions to minimize clinical problems such as swallowing difficulties, imaging artifacts and revision complications. This study evaluates the in vivo use of a low profile, bioabsorbable, anterior tension band device for augmenting anterior cervical interbody fusion in a caprine animal model.

METHODS: Seven skeletally mature female crossbred goats were utilized in this study and followed for a period of four months post-operatively. Using the Smith-Robinson approach, each animal had surgical implantation procedures in two cervical (C3-C4 and C5-C6) motion segments. Two treatments were studied: 1) tricortical iliac crest autograft with an absorbable tension band and 2) control autograft without implant. The synthetic, absorbable tension band consisted of a braided fabric strap (~1 mm thick) with radial expansion anchors attached at each end. Upon implantation of the device, the anchors were buried completely within the vertebral bodies and the strap conformed to the anterior surface of the spine.

After four months, the animals were humanely sacrificed and the spines were harvested for evaluation. Fusion was assessed using radiographic, biomechanical and histological techniques. Flexion-extension plain films were obtained following animal sacrifice and removal of residual soft tissues to evaluate segmental motion and endplate radiolucencies. To determine the multidirectional flexibility properties, six pure, unconstrained moments: flexion and extension (±4Nm X-axis), left and right lateral bending (±4Nm Z-axis), and left and right torsion (±4Nm Y-axis) were applied at a ramp rate of 3 deg/second using a six degree of freedom spine simulator. Following biomechanical testing, each treatment level was processed using undecalcified techniques and stained using the Villanueva Osteochrome Bone Stain. Histological sections were evaluated for bridging bone and trabecular bone density was quantified using
image analysis. Statistical comparisons of quantitative data were made using Student’s t-test at a p-value of 0.05.

RESULTS: All animals recovered uneventfully. Combining the results of radiographic, biomechanical and histological evaluation, it was found that 3 out of 7 treatments had fused using the absorbable tension band versus 0 out of 7 control treatments. Radiographic assessment alone showed 5/7 fused with augmentation versus 0/7 in the control group. Range-of-motion results were not statistically different between the treatments, however, there was a strong trend towards reduced motion in the tension-band augmented cervical spine levels for all motions tested (Figure 1). Histological analysis alone showed 3/7 fused with augmentation versus 0/7 in the control group. Trabecular bone formation as a percentage of the area of the fusion site ranged from 5% to 23% for the augmented treatments versus a range of 0.93% to 23% for the control treatments. Mean trabecular bone area percentage was not statistically different comparing augmented (15.2%) versus control levels (10.7%), but there was a trend of higher bone formation in the augmented group.

CONCLUSIONS: Previous studies have shown that augmentation of cervical interbody fusion in the very similar caprine and ovine models using plates\(^1\), interference screws\(^2\), and a non-absorbable tension band\(^3\) were able to provide a modest improvement to the fusion outcome. With a lower rigidity, lower profile augmentation, we were able to show a superior improvement in fusion outcome compared to the previous studies.

In a highly challenging animal model of interbody fusion, a low-profile, bioabsorbable, anterior tension band was able to improve the autograft fusion outcome from 0% to 43% using the Smith-Robinson technique in the cervical spine.

REFERENCES:
Figure 1  Results of multi-axis spine flexibility testing expressed as total angular excursion range of motion during a loading cycle of +/- 4 Nm in each direction.

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