THE EFFECT OF CAGE POSITIONING ON LUMBOSACRAL VERTEBRAL ENDPATE FAILURE IN COMPRESSION

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INTRODUCTION

This biomechanical study addressed the question of where is the best position to place an interbody fusion cage or graft for greatest anterior column structural support in the lumbosacral spine. Careful attention was made to simulate a posterior interbody fusion construct, with pedicle screw instrumentation, followed by positioning of titanium mesh cages in one of three positions between the vertebral endplates.

Specifically, the hypothesis was that two smaller, posteriorly positioned interbody cages would provide superior construct stiffness and strength in compression. The basis of this hypothesis was from previous work that demonstrated that the posterolateral lumbosacral endplates are stronger than the anterior and central regions. The same work also showed that the sacral and inferior lumbar endplates were both stronger than the superior lumbar endplates, but themselves were not significantly different.

METHODS

Nine human cadaver spine specimens from L3-S1 were dissected and instrumented posteriorly with 6mm polyaxial pedicle screws at each level, with a pair of 5mm stainless steel rods (Moss® Miami, Depuy Acromed, Raynhem, MA) into the screw heads on each side. This continuous instrumented construct, was potted in dental cement and plaster of Paris in such a way as to enable individual axial compression testing of each functional spinal unit (FSU) from L3/4, L4/5, L5/S1. Sequential potting after testing the superior FSU to failure, and removal, enabled three FSU's tested per specimen, for a total of 27 FSU's.

All specimens were x-rayed, and scanned with DEXA for bone mineral density pre-testing. The compression stiffness of each FSU was determined by applying a force to the upper vertebral mount until 2mm of axial displacement. The position of force application was through the center of the upper vertebral body. The stiffness measurement was repeated after disc removal and after cage insertion. Three patterns of titanium mesh cages (Surgical Titanium Mesh®, DePuy Acromed, Raynhem, MA) was used: one large central, two small central, or two small posterolaterally positioned cages. All cages were packed with human bone graft in a standardized fashion. Cage/graft surface area to endplate surface area ratios were standardized. After stiffness testing, the construct was tested in compression at 0.5mm/s until gross failure.

Infrared light emitting markers were attached to the cages, and the upper and lower vertebras. After digitizing points on the cage and vertebral body pre-test, an optoelectric camera system (Optotak 3020, Northern Digital Inc., Waterloo, Canada) was used to track motion of the cage and vertebral body for future analysis in a separate paper.

Construct stiffness with intact disc, no disc, and one of the three cage patterns were compared using repeated measures ANOVA. Failure loads in axial compression for the cage patterns were correlated with bone mineral density values of the adjacent vertebral bodies. One factor analyses of covariance were conducted for the failure load with BMD as a covariate to assess the effects of cage position and vertebral level.

RESULTS

The compressive stiffness of the construct at all spinal levels was significantly higher with the intact disc (897N/mm²±539) compared to without the disc (175N/mm²±83), and with any of the three cage patterns (334N/mm²±109), and these differences were highly significant (p=0.0001).

Mean failure loads for the three cage positions ranged between 2000N and 2500N and were not significantly different, though tended to be higher for the 2 posterolateral cage position (p=0.20). (Figure 1) There was no significant difference for mean failure loads versus spinal level tested.

Mean bone mineral density values for both superior and inferior vertebras of the FSU tested, were significantly correlated with failure load values (p=0.0068, r=0.519). (Figure 2)

DISCUSSION

Unlike the indentation study results that showed a difference in the lumbosacral endplate strength posterolaterally, these results did not statistically show such a difference. However, there was a trend that showed higher failure loads for two posterolaterally positioned cages, and lack of sufficient statistical power may be the explanation.

Bone mineral density values did relate significantly to the peak failure loads for all cage patterns, however the correlation coefficient was lower than expected. It is likely that the more clinically styled model that included posterior instrumentation with anterior interbody support may have introduced more variability between FSU’s tested, and may be enough to explain some of the scatter on failure load versus BMD plot. (Figure 2)

Failure loads in compression in excess of 2000N were achieved with all three of the cage positions described in the posteriorly instrumented cadaver spine model tested. The cage/graft to endplate surface ratio was approximately 20% for all FSU’s. These values lend support to the biomechanical validity of PLIF and especially TLIF type surgeries, with the often preferred placement of two smaller posterolaterally positioned titanium mesh cages.

Figure 1: Mean failure load (±SEM) with respect to cage position

![Figure 1](image1.png)

Figure 2: Failure load against average BMD for that FSU

![Figure 2](image2.png)

References:

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