Analysis of Endplate Strength through Cage Compression With and Without Cement Augmentation

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INTRODUCTION:

Mechanical failure of anterior spinal reconstructions begins at the cage-endplate interface through interbody subsidence.1, 2 The purpose of this study is to determine whether there is a difference in superior (SEP) and inferior endplate (IEP) strength in lumbar vertebral bodies and to see if pedicle screw position and/or polymethylmethacrylate (PMMA) augmentation through the pedicle screws can improve the strength at the cage-endplate interface.

METHODS:

Fresh-frozen human thoraco-lumbar spines (T9-L5) were thawed overnight. Several vertebral bodies from each spine were separated and stripped of all soft tissue. X-rays were taken to determine if the bone density was uniform between the vertebral bodies in each spine. The height of the vertebral body was measured before and after testing. Two prototype pedicle screws were inserted in the pedicles of each vertebra.Figure 1 - Location of cages

Two comparisons were made in matched paired tests: 1) screw vs. no screw, 2) uncemented screw vs. cemented screw. In group 1, a screw was placed in one pedicle, and one screw was placed in the contralateral pedicle of each of eight vertebral bodies. The side for screw deployment was randomly selected. In group 2, special cannulated pedicle screws with holes in the base of the threaded portion that communicated with the cannulation were placed in both pedicles in each of nine vertebral bodies. One side was randomly selected for testing. After testing the first side, the screw on the contralateral side was injected with PMMA and then tested. Nine grams of PMMA powder (Kyphoplasty grade) for each 5 cc of monomer were injected at 1.5 cc per screw. A third group was formed from all vertebral bodies tested for superior and inferior endplate interface loading either with a pedicle screw in place or with no pedicle screw. The superior and inferior values for each vertebral body were paired per side.

The vertebral body, with superior surface facing up, was placed on a self-centering vise with custom grips that allowed adjustment of the endplate to ensure vertical loading. A 13.9mm Harms titanium mesh cage is then placed over one screw where there is only cancellous bone underneath the endplate. When the endplate and cage were vertical, a flat platen attached to the upper actuator was lowered to come in contact with the cage. All tests were performed on the MTS 858 MiniBionix II testing machine (MTS, Minneapolis, MN). A pure compression load on the cage was applied at a rate of 3 mm/min.

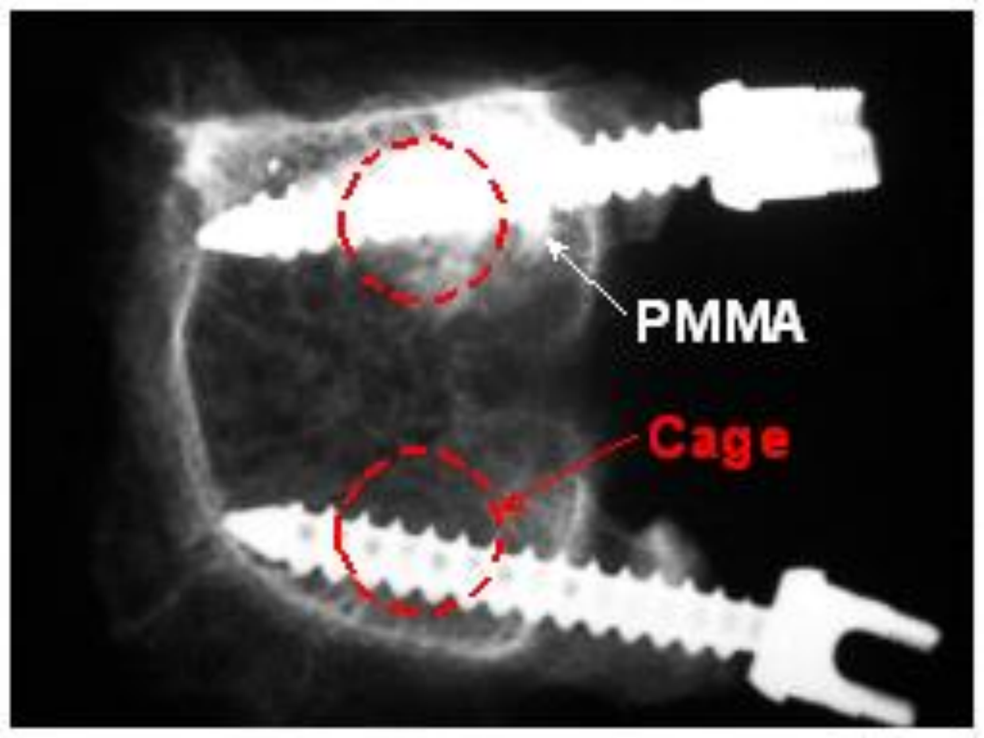

Figure 1- Location of Cages

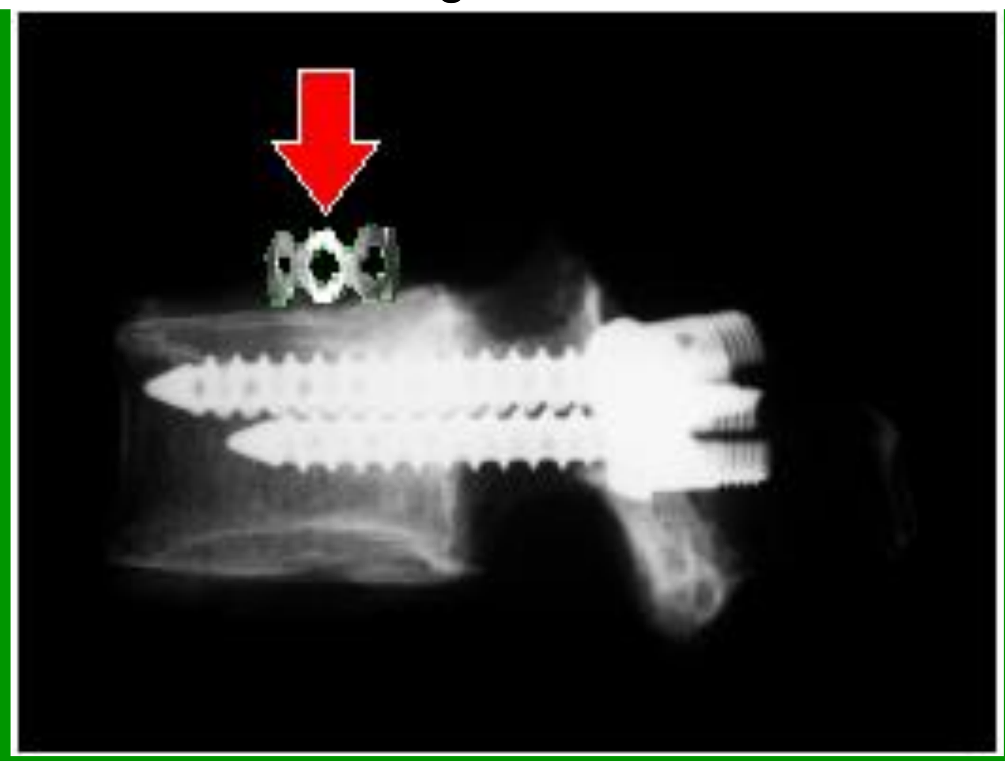

Figure 2 - Cage was compressed into endplate

Table 1- Testing Results for Screw Variations

Constant	Variable	Surface	Peak Force (N)	
Cannulated Screw (N=8)	Screw	Superior	394.1 ± 55.46	
		Inferior	511.6 ± 184.33	
	No Screw	Superior	393.9 ± 151.39	
		Inferior	543.4 ± 238.61	
Cannulated Screw (N=9)	Cement	Superior	520.4 ± 209.80	*
		Inferior	497.0 ± 301.26	
	No Cement	Superior	302.2 ± 146.8	*
		Inferior	509.6 ± 301.12	

* indicates significance

METHODS (Cont'd):

The amount of compression/interbody subsidence was determined by the changes in the force/displacement curve recorded by the testing machine. After 5mm of interbody subsidence, clinical failure was determined and the test stopped. The cage and vertebral body were then adjusted to test the contralateral screw and the loading procedure was repeated. This vertebral body was then inverted so the inferior endplate was facing up and the same tests were performed in the locations seen in Figure 1. After the testing was completed, the vertebral bodies were cut along the axis of each screw to evaluate the condition of the screw track in the bone and the bone-implant interface. The procedure was repeated six times for each prototype screw.

Statistical comparisons between groups and parameters were made with paired Student's t-test with Bonferroni correction for multiple comparisons.

Table 2- Effect of Screw Positioning

Constant	Variable	Peak Force (N)
No Screws (N=12)	Superior	382.7 ± 131.37
	Inferior	511.25 ± 223.17
Straight Screw (N=14)	Superior	361.2 ± 132.79
	Inferior	508.7 ± 239.12
Angled Screw (N=13)	Superior	395.9 ± 82.62
	Inferior	471.0 ± 145.38

RESULTS:

The insertion of a pedicle screw straight into a vertebral body did not significantly effect the endplate strength when compared to no screw, but the inferior endplate was significantly stronger (p=0.0058) than the superior endplate.

There was a significant difference in superior endplate strength when cement was injected through the cannulated screw (p=0.006) compared to no cement, but inferior endplate strength was not significantly affected (p=0.752). The superior portion of the endplate with the cannulated screw that had been injected with cement was significantly stronger in compression (p=0.006) than the portion of the endplate with the cannulated screw that had not been injected with cement. The cement reinforced endplate was now stronger in compression than the inferior plate, though not statistically significantly so.Figure 2 - Cage was compressed into endplate

The injection of cement into a pedicle screw angled toward the inferior endplate increased the compressive strength of both the inferior and superior endplates but it was not statistically significant.

DISCUSSION:

Inserting a pedicle screw either straight into a vertebral body or angled toward the inferior endplate does not significantly alter the cage-endplate compression strength of either the superior or inferior endplates.

The inferior endplate of a vertebral body is significantly stronger in compression than the superior endplate (p = 0.0058). The injection of bone cement into screws inserted straight into the vertebral body significantly increased the strength of the superior endplate by 72.2%. The superior endplate was actually stronger in compression with cement than the inferior endplate, but not significantly so.

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