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Biomechanical Evaluation of Lumbar Interbody Fixation Techniques: A Comparative Study of Standalone Cages vs. 360-Fixation Constructs

Ali Kiapour[1], Mohammadjavad Einafshar[2*],Elie Massaad[1], John Shin[1]

1. Department of Neurosurgery, Massachusetts General Hospital, Harvard, Medical School, Boston, MA, USA.
2. Department of Material and Production, Aalborg University, Aalborg, Denmark.

INTRODUCTION

Low fusion rates and cage subsidence have been reported as the main drawbacks of lumbar fixation with static interbody cages [1]. Although several clinical and biomechanical studies have evaluated the efficacy of 360 interbody fixation constructs (Anterior cage plus posterior fixation) [2,3], no study has reported the biomechanical comparison between such constructs and more novel techniques which use standalone fixation implants [4]. A cadaver validated computational model of lumbar spine was used to compare the biomechanics of spine instrumented with 360 fixations versus standalone cage with screw and cage with lateral plate systems.

To compare the mechanical stability of different interbody fixation techniques in lumbar spinal segments with standalone interbody versus static cage with posterior fixation or lateral plate system.

METHODS

An experimentally validated Finite element (FE) model of L1-Pelvic segment (Figure 1) was used to simulate ALIF and LIF lumbar fixation techniques including: ALIF cage at L5-S1 plus posterior screw-rod fixation (360 construct) versus ALIF standalone (screw through the cage). LIF cage at L4-L5 versus LIF cage with integrated two-hole lateral plate system. 4WEB Medical's Truss ALIF (40mm x 28mm), Lateral Truss (26mm X 50mm) cages and 2-hole integrated plate systems were used for simulation of the surgical procedure. For 360 constructs, a generic posterior rod and screw system was used. All models were subjected to a 400N compressive pre-load followed by an 8 Nm moment to simulation Flexion-Extension, Left and Right Bending and Axial Rotation motions. The segmental kinematics and the load sharing at the inferior endplate were compared among the cases.

RESULTS

The segmental motion in standalone ALIF construct was 1.3°(Flex-Ext), 1.4° (LB) and 1° (AR) versus 1°, 1° and 0.7° in 360 ALIF in the same planes of motion. When comparing lateral constructs, the motions were 1.5° (Flex-Ext), 1.1° (LB) and 0.9° (AR) in Lateral cage with plate versus 1.1°, 1.0° and 0.8° in the 360-lateral construct for the same loads. The peak stresses in extension for the LIF stand-alone cage were slightly higher than the posterior instrumented cases. When comparing the mechanical stress on the inferior endplate of the index segment, the Stand-alone ALIF had almost 20% higher peak stress compared to the 360 ALIF construct. In the lateral construct, the cage-plate segment experienced 15% lower stresses on the endplate compared to the 360-lateral construct.

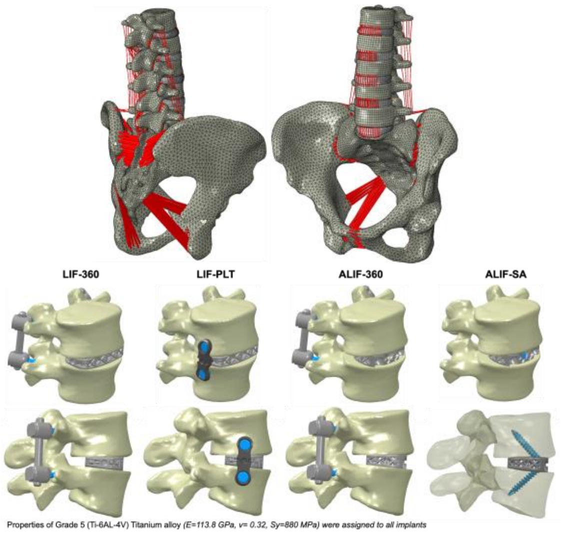

Figure 1: *a) Finite element model of lumbo-pelvic spine used in this study b) Lumbar spine motion segment instrumented with various interbody fixation constructs.*

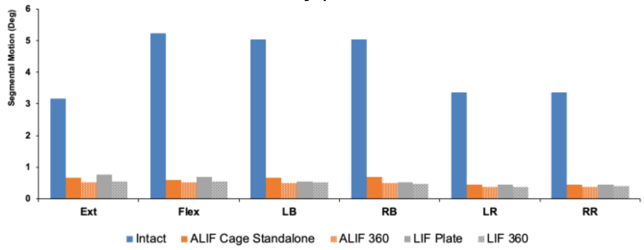

Figure 2: *Comparison of segmental range of motion among instrumented constructs versus intact.*

DISCUSSION

Our data suggest that the 360 construct were able to provide greater stability in the sagittal plane. The lateral cage with integrated plate had stability closed to the 360-lateral construct in axial rotation [1,2]. The standalone cage resulted in higher stresses at the endplate compared the 360 constructs. Standalone ALIF and LIF with lateral plate are biomechanically efficient alternatives to 360-fixation constructs at least under the controlled conditions analyzed in the present study. Clinical data are required to support the findings and defining the further role and application of stand-alone cages.

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