EFFECT OF COMPRESSION PRELOAD ON THE RESPONSE OF THE ANTERIOR LUMBAR INTERBODY FUSION CAGE CONSTRUCT AND ADJACENT SEGMENTS

INTRODUCTION: Anterior lumbar interbody fusion (ALIF) using threaded cylindrical interbody fusion cages has gained widespread use to address segmental instability in patients with symptomatic lumbar disc degeneration. The cage construct is expected to provide rigidity to the unstable segment so that an early solid biologic fusion can be attained in proper alignment. A goal of spinal fusion is to restore the spine’s ability to support loads during activities of daily living (ADL). The compressive load on the lumbar spine ranges from 200 N to 1200 N during ADL. While previous cadaveric studies have applied physiologic levels of bending moments, the effect of in vivo compressive loads on the performance of fusion constructs has not been investigated. In the absence of a realistic compressive preload, the loads experienced by the implant in the ex vivo experiment differ significantly (both in magnitude and direction) from those in patients (2).

The purpose of this study was to quantify the effects of the anterior lumbar interbody fusion (ALIF) cage construct on the biomechanical response of instrumented and adjacent segments under realistic in vivo loads. A unique experimental model was used that can subject human cadaveric specimens to loads of in vivo magnitudes (1).

METHODS: Thirteen lumbar spine specimens (L1-sacrum) (age: 52±15 years) were tested in flexion, extension, and lateral bending with and without an L5-S1 ALIF construct under increasing compressive preload of up to 1200 N. To simulate physiologic compressive loads, a follower preload was applied bilaterally using cables (Fig. 1) (1). The follower load cables maintain a compressive preload on each lumbar segment throughout the range of motion. The specimens were tested under a continuous bending moment applied to L1 (0-8 Nm Flexion, 0-6 Nm Extension, 0-3 Nm lateral bending). Three-dimensional motions were measured at all lumbar segments using an optoelectronic motion monitoring system for at least two complete cycles of moment application.

After testing the intact specimen, two threaded, cylindrical interbody cages were inserted anteriorly at L5-S1 and the specimen was retested. Radiographic templating was used to select the cage size. Fusion cages of 13, 15, and 17 mm diameter were used in 2, 10, and 1 specimens, respectively.

The load-displacement curves were analyzed to obtain the range of motion (ROM) and stiffness at the instrumented and adjacent segments in flexion, extension, and lateral bending as a function of compressive preload. The ROM and stiffness values after cage insertion were compared to the values for the intact segment for the corresponding compressive preload.

RESULTS: The ALIF cages decreased the L5-S1 ROM in both the sagittal and frontal planes (p<0.05). Their effectiveness improved with increasing compressive preload in flexion and extension (Fig. 2, Table 1). The cages decreased L5-S1 flexion ROM by 27-41% of intact for low preloads (0-400 N), while the decrease in flexion ROM at L5-S1 was 68-78% of intact under preloads of 800-1200 N (p<0.05).

In extension, the ALIF cages permitted more motion than the intact segment in the absence of a compressive preload (p<0.05). In contrast, the cages decreased 48% of the motion in extension relative to intact at preloads of 800-1200 N (p<0.05). In lateral bending, the cages decreased 40% of the motion relative to intact at 400 N compressive preload as compared to a 15% decrease in the absence of preload. At the adjacent L4-L5 and L3-L4 segments, there were few significant changes in ROM after insertion of the interbody cages at L5-S1.

DISCUSSION: This experimental model allows for interbody cage testing under conditions that closely mimic in vivo conditions. The response of the ALIF construct in flexion-extension under low compressive preloads is consistent with previous studies that tested the construct under zero or low compressive preloads. In contrast, the segmental stability of the ALIF construct in flexion and extension was significantly greater under high compressive preloads that correspond to standing and walking. This emphasizes the importance of preload for cage stability that may be partially achieved by annular pre-tensioning. This study also supports a role for supplemental stabilization or postoperative immobilization to protect the ALIF construct during activities of daily living that induce minimal or low levels of compressive preloads on the lumbar spine.


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