BIOMECHANICS OF A LUMBAR SPINE SEGMENT STABILIZED WITH MORSELIZED BONE INTERBODY GRAFT

INTRODUCTION: Anterior bone graft in combination with posterior instrumentation has been shown to provide superior support because the graft is in line with axial loads and posterior elements are left intact [1,2]. However, employing posterior instrumentation with anterior grafting requires execution of two surgical procedures. Furthermore, use of a posterior approach to place an interbody graft requires considerable compromise of the posterior elements, although it reduces the surgery time. It would be advantageous to minimize surgical labor and structural damage caused by graft insertion into the disc space via a posterior approach. We addressed this issue by preparing an interbody bone graft using morselized bone.

Morselized bone has been shown to have high osteoinductive potential [3], and its pastelike consistency offers advantages over bone chips, such as in filling defects [3] or as a cement [4]. Morselized bone has been used to augment the acellular cup in hip replacement [5] and as a grafting tool for knee joint repair [6]. Curry obtained effective spinal arthrosis in rabbit spines by incorporating morselized iliac crest with autogenous bone marrow [7]. Thus, reports focusing on morselized bone as a spinal fusion tool have been limited although its usefulness has been shown. In this study we examine the immediate effectiveness of a morselized bone filled bag device in stabilizing a loaded lumbar spinal spine. This device is a gauze bag of dacron that is inserted into the disc space, filled with morselized bone, and tied shut.

METHODS: In vitro testing measured the rotations of each vertebral level of mechanically loaded cadaver lumbar spines, both in intact and experimental conditions. The motions of the implanted level were compared between test conditions to assess stability.

Eight fresh L3-S1 lumbar spine segments were obtained, all of which had A-P and lateral radiographs taken to rule out excessively degenerated or abnormal specimens. All had DEXA readings above 0.6 g/cm², average 0.75 g/cm². Group A included four spines implanted with bag devices filled with morselized bone only, and Group B included four spines implanted with devices filled with a mixture of hydroxyapatite beads (2 mm dia.) and morselized bone, in equal volume portions. The sacrum and L3 were cast into a rigid polymer mixture. An optoelectronic tracking system (Selspot II) recorded 3D displacement data while the spines were loaded to 6 N-m (1.5 N-m increments) in flexion (FEX), extension (EXT), left and right axial rotation (LAR, RAR), and left and right lateral bending (LLB, RLB), while under 100 N compressive pre-load. The spines were also loaded to 200 N in pure compression. First, the spines were tested intact. Then, a unilateral laminectomy and a 10 mm hole in the annulus were created to remove the nucleus. A Mercilene tape band was tied across the L4-L5 spinous processes and drawn tight, extending that segment. The spines were tested. Next, the tension band was removed and the unfilled bag device inserted into the disc space. It was filled under pressure with morselized bone which was obtained from a young bovine vertebral body and acetabular reamer. The spines were tested. Next, the tension band was reapplied and the spines were tested again. Lastly, the spines were fatigued for 5000 cycles in axial compression from 20 to 200 N at 2 Hz via an MTS. The spines were tested one last time. All spines were x-rayed to determine placement and size of the device in the disc space. Load-displacement data of the L4-L5 segment were determined (mean +/- 1 standard deviation).

RESULTS: With the tension band alone, motion was restored to the intact case, except in extension where it was reduced, Figure 1. With the graft implant motion was restored to intact in all of the loading modes, except in flexion where it was reduced. With the tension band and graft motion was again restored to intact except in flexion and extension where it was reduced. No significant differences were found between the specimens filled with bone only and those filled with bone and beads. In axial compression, however, specimens with bead and bone bag implants exhibited greater stability than bone only specimens after cyclic loading (Figure 2).

DISCUSSION: We have analyzed the stabilizing effect of a nuclear replacement using morselized bone in the lumbar spine. In vitro results suggest that a tension band increases stability in extension, while the bag device alone seems to provide increased stability in flexion. The implanted bag filled with morselized bone, with or without beads, in combination with a posterior tension band, restores intact stiffness. In addition, in flexion and extension motion is reduced below intact. Morselized bone and hydroxyapatite beads provided better fatigue resistance than bone paste alone, maintaining stiffness due to the bead presence. Post-cyclic results in axial compression suggest that the morselized bone in the bone-only specimens either consolidates or extrudes from the cavity despite confinement. Motion restoration or reduction as tested here is relevant both to graft incorporation and segment biomechanics.

The posterior interbody grafting method using morselized bone (with or without beads) is amenable to orthoscopy. It produces an interbody graft without an anterior surgical approach. In addition, this technique greatly reduces surgical exposure with minimal blood loss and no facet compromise. This study shows that the bag device with posterior instrumentation effectively stabilizes spines which have undergone discectomies. This technique would be a viable alternative to current 360° techniques pending animal tests and clinical trials.


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Figure 1: Average rotation +/- 1 SD for all load cases under 6 N-m load with 100 N compressive pre-load (COM=200 N compression only)

Figure 2: Flexion rotation under pure compression for bead and bone and bone only specimens after loading 20 to 200 N for 5000 cycles at 2 Hz.