Comparison of Supplementary Posterior Fixations for Two-Level ALIF with Stand-Alone Cages

INTRODUCTION:
Structural cages have been widely used in recent years to maintain motion segment height and stability in anterior lumbar interbody fusion (ALIF). High rate of clinical success and radiological fusion rate have been reported following single-level fusion using these cages. However, many biomechanical studies report insufficient stability, especially with extension loading. Posterior instrumentations, such as pedicle screw/rod fixation, translaminar facet screw fixation and transfacet screws, have been used to supplement ALIF with cages. Biomechanical studies on single-level ALIF show that stand-alone cages supplemented with posterior translaminar facet or transfacet screw fixation exhibit comparable stability to those supplemented with pedicle screw/rod fixation. Investigations of ALIF cages are mostly focused single-level fusion. The stability of multi-level ALIF with stand-alone cages and the improvement brought on by supplemental posterior fixation is currently unknown. The objectives of this study are to compare the stability afforded by these three supplemental posterior instrumentations in 2-level ALIF procedure. The effects of the longer fusion segment on the adjacent levels behaviors are also investigated.

METHODS:
Specimens:
Eighteen fresh frozen calf lumbar spine specimens (L1-L5) were used in this study because of their easy availability and good inter-specimen consistency. The calf spine has been shown to have similar anatomic and biomechanical properties as the human cadaver spine in its intact stage, and is a commonly accepted substitute for the human spine in biomechanical testing. One recent study showed that calf lumbar spine has comparable flexibility response to human cadaveric lumbar in flexion and extension following identical stabilization procedures of grafted ALIF with and without pedicle screw/rod fixations.

Flexibility Testing Protocols:
The spinal segment was mounted on a customized loading frame for flexibility test. Pure moment up to 7.5 Nm in flexion, extension, lateral bending, and axial rotation was applied through the most cranial vertebra using a pulley-weight system in six steps. A six-axis load cell (Model MC3, AMTI) was mounted in series to the caudal vertebra to verify the moments and forces applied. Constant compressive preload of 200 N was applied to the spine along the path that follows the lordotic curve of the spine to minimize its contribution to the shear and bending forces. Spinal motion at each lumbar level was measured with an optical based motion tracking system (Optotrak Certus, NDI, Waterloo, Ontario, Canada) at each loading step. Rotation at each lumbar level was obtained and the corresponding stiffness was derived from the linear portion of the load-displacement curves.

Flexibility test in six directions were performed on all eighteen spines in two stages: 1) intact and 2) after implantation of a stand-alone PEEK lumbar spacer (Synthes, Inc) at the L3-L4 and L4-L5 respectively. Following the two stages of testing, the spines were randomly divided into three equal groups of six spines: Group 1 were instrumented with pedicle screw/rod (Medtronic) from L3-L5, Group 2 were instrumented with translaminar facet screw fixation at both L3-L4 and L4-L5 levels, and Group 3 was instrumented with transfacet screw fixation at L3-L4 and L4-L5 levels. A set of 4.5 mm cortical screws were used in translaminar facet fixation (46 and 50 mm long) and transfacet fixation (26 mm long). Following posterior instrumentation, all three groups of spines were tested again using the same protocols.

Data Analysis:
The stiffness results of the spines after instrumentations (two-level ALIF with cages alone, and two-level ALIF supplemented with one of the posterior fixations) were normalized with respect to the intact spine to minimize the effect from inter-specimen variations. Analyses of variance (ANOVA) and in case of significant finding, post-hoc PLSD Fisher’s tests were conducted to compare the differences in stiffness among the three groups. Changes at the adjacent segments before and after instrumentations were also compared using repeated measure ANOVA. Significant level for all statistical analysis was set at 0.05.

RESULTS:
The stiffness of the fusion segments after posterior fixation increased significantly over those with the cage alone (Figures 1, 2 & 3). The differences between the three types of posterior fixation are statistically significant in extension and lateral bending (Figures 2 & 3), where the pedicle screw/rod group was significantly stiffer than the translaminar facet fixation (p=.047) and transfacet fixation (p=.031) in extension, and the pedicle screw/rod group was also significantly stiffer than the transfacet fixation (p=.009) in lateral bending. None of the changes in stiffness at the two adjacent segments was statistically significant.

DISCUSSION:
The results show that posterior fixation significantly increased stability of 2-level ALIF when compared to the same procedure with stand-alone cages. Pedicle screw/rod system is still the “gold standard” in providing supplemental stability, and does not pose significant alteration to the adjacent mobile segments. However, both translaminar facet screws and transfacet screws are good alternatives to provide adequate fixation, even though they are not as stiff as the pedicle screw/rod in extension and lateral bending.

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