Analysis of Biomechanical Stability and Cage Motion in a Lumbar Spine Instrumented at Two Levels with Lateral Inter-body Cages with Lateral Plate Fusion Construct

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Study design: Cadaveric biomechanical study.
Objective: This study aims to evaluate effectiveness of the lateral cage + lateral plate fusion construct in the following ways:
a) Kinematic assessment of biomechanical stability across instrumented levels
b) Characterize cage migration (or motion) during representative cyclic loading

Materials and methods: Eight fresh frozen human cadaveric lumbar spines (L1-S1) were denuded of any musculature and were rigidly potted at L1 and S1. Specimens were subjected to incremental quasi static pure moment loading in flexion/extension {F/E} (with and without preload), right and left lateral bending {L/B} and axial rotation {A/R} up to 7.5 Nm. Specimens were instrumented with laterally placed cage + lateral plate at L3-L4 and L4-L5 levels. Kinematic signatures were recorded pre- and post-op using the Optotrak motion measurement system. Following post-op kinematic testing, each specimen was cyclically loaded on a biaxial testing machine for 2500 cycles in F/E (4.0 Nm + 400N follower load), L/B (2.0 Nm) and A/R (5.0 Nm) using specially designed fixtures. Custom designed rigid body markers were developed to firmly attach to the cage (laterally, opposite to plate fixation end) to continuously track cage motion along all three planes (anterior-posterior {A/P}, medial-lateral {M/L} and inferior-superior {I/S}) during each cyclic loading mode.

Results: Kinematic results across both instrumented levels (L3-L4 & L4-L5): Average F/E motion showed a significant decrease of 39% (pre-op: 10.9°; post-op: 6.7°; p = 0.0005). A/R showed a significant average decrease in motion of 48% (pre-op: 4.6°; post-op: 2.4°; p = 0.004). L/B motion recorded significant decrease of 57% (pre-op: 11.4°; post-op: 4.9°; p = 0.0001). F/E with 400N preload showed an average decrease in motion of 34% post-op, (pre-op: 6.8°; post-op: 4.5°; p = 0.087), but this was not significant. Cage motion from cyclic loading data: Axial rotation showed largest cage motion in A/P compared to the I/S and M/L directions (1.51mm, 0.51 mm and 0.73 mm respectively with p< 0.006). Flex/Ext recorded maximum average motion in A/P compared to M/L directions and I/S directions (0.71 mm, 0.41 mm and 0.1 mm respectively with p< 0.0033). Lateral bending recorded maximum average motion in M/L direction, however this not significantly higher than A/P or I/S motions (1.47 mm, 1.2 mm, 0.6 mm respectively).

Discussion and conclusion: Fusion constructs are designed to provide maximum stability to allow bone growth and complete fusion at instrumented levels. Up to 60-70% motion was still observed post-op across both instrumented levels (L3-L4 & L4-L5) for various loading modes along with quantifiable cage motion in various planes during cyclic loading. The results indicate that the lateral cage + lateral plate fusion construct did not provide rigid fixation at the instrumented levels. To the author's knowledge, this is a unique study that incorporates non-radiographic method to analyze cage motion. Further biomechanical studies should be performed to evaluate and compare different constructs in providing maximal stability and fixation.