Unicortical And Bicortical Lateral Plate Fixation Offer Similar Stability And Load On The Endplate But Pedicle Screw Fixation Offers Better Stability And Load Reduction: A Finite Element Study

Sushil P. Sudershan[1], Anand K. Agarwal[1], Vijay K. Goel[1]
[1]Engineering Center for Orthopaedic Research Excellence (E-CORE), University of Toledo, Ohio

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INTRODUCTION: Lateral lumbar interbody fusion (LLIF) procedure has gained acceptance in recent years because the approach avoids major blood vessels and neural elements. The LLIF surgery can be performed with a spacer only but is supplemented with either plate or pedicle screw fixation. Unlike the pedicle screw system, lateral plate fixation can be inserted without additional posterior incisions which reduce blood loss and surgery time. Lateral plate screws can be used for unicortical and bicortical fixation [1]. The purpose of this study was to understand the biomechanical differences between unicortical and bicortical lateral plate fixation versus pedicle screw fixation.

METHODS: For this study, an L4-L5 ligamentous functional spinal unit (FSU) finite element model was obtained from a previously validated ligamentous lumbar spine model [3]. A 10 N*m moment was applied to the L4 superior endplate while the L5 inferior endplate was restricted to determine the FSU's range of motion (ROM): extension (ext), flexion (flex), left bending (lb), right bending (rb), left rotation (lr), and right rotation (rr). The extension and flexion motions were simulated again with a 400 N preload to simulate physiologic loading denoted as Wpext and Wpflex below. The intact model was modified to simulate the LLIF surgery that comprised of full nucleotomy and annulotomy on the insertion and contralateral sides. The L4 vertebra was appropriately distracted for implantation of a 14 mm (AP) x 62 mm (ML) x 15 mm height, PEEK cage into the disc space. After cage placement, a lateral plate with unicortical fixation (Cage + UNICORT), a lateral plate with bicortical fixation (Cage + BICORT), and a pedicle screw system (Cage + PSS) were simulated. For each model, the previous moment was applied to determine ROM and maximum endplate stress (MPa). Range of motion determined the stability of the construct and endplate stress determined the load on the endplate for each fixation model.

RESULTS: Results showed that the pedicle screw fixation offered the highest stability for segment motion out of all the fixations with less than 1 degree in all motions. Unicortical and bicortical plate fixation reduced motion to less than 1 degree motion in lateral bendings and axial rotations. But the motion was greater than 1 degree for extension, flexion, and 400 N extension and flexion but less than intact. See Figure 1 for ROM with respect to the intact FSU. The bicortical plate fixation produced higher endplate stresses in all loading conditions when compared against unicortical plate fixation but the values are comparable. The extension, flexion, and 400 N extension and flexion moments produced higher stress values than the lateral bendings and axial rotations for both plate fixation simulations. In the end, the pedicle screw fixation showed the lower stress than the other scenarios (See Table 1).

DISCUSSION: Results show that pedicle screw fixation offered the greatest reduction in motion as supported by literature [2]. The lateral plate with bicortical fixation produced lower segmental motion than the lateral plate unicortical fixation but values are comparable. The endplate stress magnitude determined load transfer for each type of supplemental fixation. The pedicle screw fixation produced the lowest amount of endplate stresses. There is little data that describes the effect on endplate load with various different supplemental plate fixation. Based on our data, we conclude that the unicortical plate fixation produced lower endplate stresses than the bicortical plate fixation but the magnitude is comparable for all motions.

SIGNIFICANCE: The unicortical fixation showed similar segmental motion and endplate stresses as the bicortical fixation. However, pedicle screw fixation produced lower segment motion and endplate stresses than lateral plate fixations. Future studies can compare two screws versus four screws plate design, variation in endplate thickness, and variation in material property of the endplate.

REFERENCES: [1] Le, T.V. et al, *Journal of Neurosurgery* (2012). [2] Basra, S. et al., *The Spine Journal* (2015). [3] Palepu V. (2013). Retrieved from https://etd.ohiolink.edu/.

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IMAGES AND TABLES:

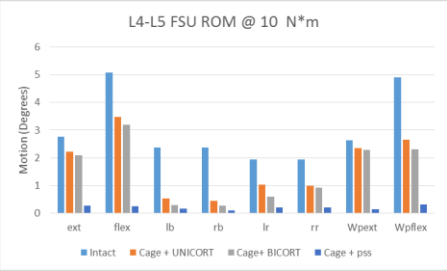

Figure 1: Comparison of range of motion for all types of fixation. Pedicle screw fixation offered the highest reduction in motion.

Endplate Stresses (MPa)	Cage + UNICORT	Cage+ BICORT	Cage + PSS
Extension	60.71	65.3	15.1
Flexion	74.36	79.61	31.92
Left bending	22	21.368	24.17
Right bending	21.269	29.593	19.64
Left rotation	38.35	41.31	18.7
Right rotation	22.18	31.62	26.04
400 N Pre-load extension	92.33	96.12	20.13
400 N pre-load flexion	82.73	81.25	51.37

Table 1: L5 peak endplate stress (MPa) for all of the loading conditions. The cage + PSS scenario effectively reduced the endplate stresses in all loading conditions.

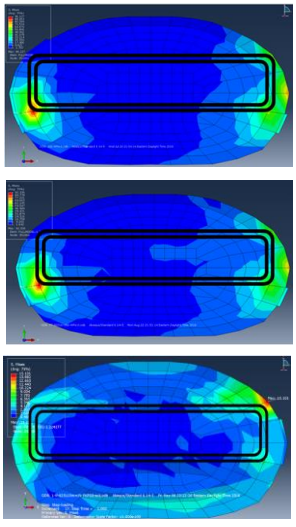

Figure 2: Images A, B, and C represent the stress contours for the 400 N preload extension (Wpext) motion for the respectively simulated cases: lateral plate bicortical fixation, lateral plate unicortical fixation, and pedicle screw fixation. Pedicle screw fixation showed the highest reduction in endplate stresses followed by unicortical plate and bicortical plate fixation.