Comparison of Standalone PLIF expandable cage and TLIF standard cage: an in vitro and finite element study

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INTRODUCTION
Spinal fusion has been the gold standard for treatment of degenerative disc disease. Over the years, numerous surgical techniques and various implants (expandable versus non-expandable) have been developed to increase fusion rates and decrease operative and recovery time. The purpose of this study was to evaluate the stability of TLIF standard surgical technique and cage versus the PLIF surgical technique with expandable cage. Kinematics and endplate stresses will be recorded to evaluate which implant might better promote bone fusion.

METHODS
Six L23 (TLIF) and six L45 (PLIF) ligamentous functional spinal units (FSUs) were used for the study. The caudal end was fixed to the testing apparatus while pure moments up to 10 N*m were applied to the cranial end in extension (Ext), flexion (Flex), left (LB), and right (RB) lateral bending, and left (LR) and right (RR) axial rotation. Specimen motion was recorded using Optotrak motion capture (NDI, Waterloo, Canada). A previously validated whole spine model was used to obtain the necessary L23 and L45 segments for finite element analyses, wherein respective surgeries were simulated. TLIF simulation involved complete facetectomy and nucleotomy. PLIF simulation involved bilateral partial laminectomy and bilateral cage placement. In each surgical simulation, the disc space was distracted until the cage was in contact with both endplates, after which a 10 N*m pure moment was applied. Cadaveric and finite element range of motion results and endplate stresses were compared.

RESULTS AND DISCUSSION
Cadaveric results demonstrated standalone TLIF increased motion in extension, left and right bending, left and right rotations, and flexion with pre-load (Fig. 1). Finite element analysis revealed that the TLIF group showed increased extension, flexion, left and right bending, extension with preload, and flexion with preload but decreased axial rotation. The PLIF group demonstrated decreased motion in all loading conditions (Fig. 2) as was further substantiated by finite element analysis. The differences in motion between cadaver and finite element motion are listed in Table 1.

Figure 1: TLIF range of motion results for cadaver and finite element model

Figure 2: PLIF range of motion results between cadaver and finite element model.
Differences in range of motion can be attributed to surgical technique and implant type. The TLIF approach required total facetectomy. As the facets, in conjunction with the capsular ligaments, are responsible for limiting motion in extension, left and right bending, and left and right axial rotation, performing the facetectomy altered the center of rotation for all loading conditions. The bilateral expandable cage placement has two advantages: endplate contact and fit. The cage can be expanded for proper fit with both endplates and provides a greater surface contact area.

### Table 1: Table below shows the reduction in motion for all of the loading conditions between cadaver and finite element.

<table>
<thead>
<tr>
<th>Motion</th>
<th>Ext</th>
<th>Flex</th>
<th>LB</th>
<th>RB</th>
<th>LR</th>
<th>RR</th>
<th>WP Ext</th>
<th>WP Flex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadaver TLIF</td>
<td>-21%</td>
<td>-8%</td>
<td>+11%</td>
<td>-9%</td>
<td>-20%</td>
<td>-27%</td>
<td>-20%</td>
<td>+14%</td>
</tr>
<tr>
<td>FEA TLIF</td>
<td>-33%</td>
<td>-20%</td>
<td>+15%</td>
<td>-10%</td>
<td>-30%</td>
<td>-37%</td>
<td>-45%</td>
<td>+14%</td>
</tr>
<tr>
<td>Cadaver PLIF</td>
<td>-36%</td>
<td>-70%</td>
<td>-60%</td>
<td>-50%</td>
<td>-22%</td>
<td>-9%</td>
<td>-41%</td>
<td>-70%</td>
</tr>
<tr>
<td>FEA PLIF</td>
<td>-70%</td>
<td>-70%</td>
<td>-42%</td>
<td>-47%</td>
<td>-53%</td>
<td>-55%</td>
<td>-70%</td>
<td>-70%</td>
</tr>
</tbody>
</table>

The TLIF group (Fig. 3) demonstrated higher endplate stresses than the PLIF group (Fig. 4). The TLIF model yielded an average stress of 186.5 MPa as compared to 97.5 MPa in the PLIF model. Under higher stresses, bone growth is more likely to occur. However, higher stresses may be problematic if the bone is osteoporotic; leading to cage subsidence.

### CONCLUSIONS
The results showed that the PLIF expandable cage stabilized the functional unit better than the non-expandable TLIF cage. Furthermore, the TLIF non-expandable cage demonstrated higher contact stresses than the expandable PLIF cage. Future work will focus on interrogating the pedicle screw system via a similar approach and on the effect of device contact footprints on the endplate stresses and load transfer.

### REFERENCES

### ACKNOWLEDGEMENTS
Work supported in part by Apex Spine and the NSF Industry/University Cooperative Research Center at the University of California at San Francisco and University of Toledo, Toledo (www.nsfcdmi.org)