Effect of Increasing Prodisc-L Prosthesis Height On Lumbar Spine Kinematics and Foraminal Size

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Introduction: Lumbar total disc replacement (TDR) have been shown to preserve motion in the lumbar spine both in biomechanical and clinical studies. In order to maximize the motion a TDR will provide and replicate near normal kinematics, the appropriate sized implant should be used. There have not been any biomechanical studies that have investigated the implant size with regard to motion or with regard to foraminal size in the lumbar spine. We investigated the effect of ProDisc-L prosthesis height on the kinematics of the implanted segment and the size of the neural foramina at the implanted segments.

Materials and Methods: Seven fresh-frozen human lumbar spines (age:54±11.4, L1–sacrum) were tested. The spines had no previous spinal surgery and no serious bone pathology or bridging osteophytes. The spines were stripped of soft tissue leaving discs, facets, and ligaments intact. The spines were tested intact and after discectomy at L4-5 and sequential insertion of ProDisc-L implants of increasing heights (10, 12, and 14mm implants). The specimens were tested in flexion (8Nm) and extension (~6Nm) with and without a physiologic 400N follower preload in flexion-extension, 33±18% in lateral bending, and 29±28% in axial rotation.

The increase in foraminal size, while significant, was only 4.6±3.2%. This suggests that although using a taller prosthesis may increase the foraminal size, this is to such a small degree that it most likely will not be clinically useful for patients. A possible explanation for the relatively small increase in the foraminal size with increasing implant height is that increasing implant height also increases segmental lordosis, thus minimizing the effects of distraction.

Discussion: This study shows that increasing implant height significantly decreased ROM by up to 37±21% in flexion-extension, 33±18% in lateral bending, and 29±28% in axial rotation. The loss of range of motion with a taller prosthesis suggests that “over-stuffing” the disc space decreases the proposed benefits of the motion preserving procedure. When possible we recommend using the smallest prosthesis that will still give you sufficient clinical stability. This will give the most motion and allow for more physiologic motion at the implanted segment.

The limitations of this study include its design. It is not possible to draw direct clinical relevance from an in vitro study. The loss of range of motion with increasing implant height seen in this study may not have clinical relevance. Another important consideration is that the foraminal measurement with cylindrical probes does not replicate the exact shape, and thus the size, of the neural foramina. This could cause an overall underestimation of the foraminal size. However, the fact that the same probes were used in all conditions should still show a relative change in size of the neural foramina from one height to another.

In conclusion, this study shows that it is important for surgeons who implant TDR’s in the lumbar spine to avoid “over-stuffing” the implant in order to preserve motion. A smaller implant height should be selected to optimize the ROM of the implanted segment. Although neuroforaminal size can be increased with increasing implant height, the amount of increase is not significant enough to account for the loss of motion that increasing implant height creates. We believe any neuroforaminal decompression that is needed should be accomplished via direct decompression rather than distraction with a larger implant. This will allow a smaller implant to be used to allow for this to be a motion preserving procedure.

Results: As implant height increased, the amount of flexion-extension and lateral bending significantly decreased. Under a 400 N follower preload in flexion-extension with a 10mm Prodisc-L implant at L4-5, the specimens averaged 9.2±1.9 degrees of motion compared to 7.7±2.0 degrees with a 12mm implant (p<0.05) and 5.8±2.4 degrees with a 14mm implant (p<0.05). Lateral bending with a 10mm implant at L4-5, the specimens averaged 5.7±2.8 degrees of motion compared to 4.6±2.6 degrees with a 12mm implant (p<0.05) and 3.6±1.7 degrees with a 14mm implant (p<0.05). Axial rotation with a 10mm implant at L4-5, the specimens averaged 3.9±1.9 degrees of motion compared to 3.2±2.0 degrees with a 12mm implant (p<0.05) and 3.0±2.2 degrees with a 14mm implant (p=0.147). Foraminal size also significantly increased with increasing implant size. Foraminal size with a 10mm implant at L4-5, the specimens averaged 9.42±1.25mm compared to 9.65±1.34mm with a 12mm implant (p<0.05) and 9.87±1.43mm with a 14mm implant (p<0.05).