An In Vitro Comparison of Three Posterior Dynamic Motion-Sparing Lumbar Stabilization Devices

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Introduction

Preclinical data is required to select among various posterior dynamic stabilization devices on the market today. Unfortunately, very little is available. The purpose of this biomechanical study was to compare the kinematics, foraminal areas, and disc heights in cadaveric lumbar spines treated with three types of posterior dynamic stabilization devices: PercuDyn (Interventional Spine, Inc.), X-Stop (St. Francis Medical Technologies), and Isobar (Scientix).

Methods

Following radiographs and DEXA analysis to exclude specimens of abnormally poor bone or disc quality, 12 functional spine units (L4-L5 and L2-L3) were dissected from nine human cadaveric lumbar spines. Each specimen was potted in epoxy resin and fixed in custom cylindrical pots after alignment using four planar orthogonal laser beams. Specimens were tested in an MTS-858 Servo-hydraulic load frame (MTS, Eden-prairie, MN) equipped with an 8 degree-of-freedom Flex Test unit for spine kinematics testing. Four combinations of loading and motion were applied: (1) Axial Rotation (left and right), (2) Lateral Bending (left and right), (3) Flexion/Extension, (4) Flexion/Extension with a 700 N follower load. For each motion, pure moments were applied cyclically and increased at a rate of 0.1 Nm/sec to a maximum of 8 Nm. Each specimen was tested (1) intact, (2) with a simulated injury, and (3) implanted with one of the three posterior dynamic stabilization devices. The disc injury consisted of a postero-lateral radial tear and a ventral lateral rim lesion, both through the annulus, using a scalpel. ANOVA was used to compare range of motion, foraminal area, and disc height as a function of the implant type.

Results

As expected, the simulated disc injury increased range of motion (ROM), typically by 20-40%. Without a follower load, all three decreased ROM in extension, compared to injured conditions. In particular, the PercuDyn decreased extension by 27% (P=0.13). In extension with a follower load, both the X-Stop and the PercuDyn substantially decreased ROM as compared to injured conditions, by 70% (P = 0.16) and 52% (P=0.07), respectively. In contrast, the Isobar did not decrease ROM from the injured condition, with ROM remaining 15% above the intact condition. Under flexion/extension, compared to injured conditions, the X-Stop increased foraminal area by 24-28% (P=0.04). The Isobar consistently increased disc height compared to injured conditions; specifically, under neutral unloaded conditions, anterior disc height increased by 15% ± 11% (P=0.08). Plots of device performance for ROM, foraminal area, and disc height, under loaded extension are provided below. Data were normalized by dividing injured and implanted values by corresponding intact values to control for patient specimen variation.

Discussion

Overall, the PercuDyn was the most effective of the three devices in consistently reducing ROM in extension. Specifically, under a 700 N follower load, extension with a simulated injury was reduced by more than 50%. As expected, the PercuDyn did not affect range of motion in flexion. In contrast, the X-Stop was the most effective in increasing foraminal area, as it induced a residual amount of flexion upon insertion. The Isobar was the most effective in increasing disc height, as the disc was distracted during implantation. While all three devices were effective in improving the kinematics, considering the ease of percutaneous implantation, the PercuDyn functions as intended for the treatment of degenerative disc disease in the early stages, while preserving the integrity of the disc.

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