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Biomechanical Evaluation for Minimally Invasive Lumbar Decompression: Unilateral Versus Bilateral Approaches

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Abstract : Unilateral laminotomy and bilateral laminotomies were successful decompressions methods for managing spinal stenosis that numerous studies have reported. Thus, unilateral laminotomy was rated technically much more demanding than bilateral laminotomies, whereas the bilateral laminotomies were associated with a positive benefit to reduce more complications. There were including incidental durotomy, increased radicular deficit, and epidural hematoma. However, no relative biomechanical analysis for evaluating spinal instability treated with unilateral and bilateral laminotomies. Therefore, the purpose of this study was to compare the outcomes of different decompressions methods by experimental and finite element analysis. Three porcine lumbar spines were biomechanically evaluated for their range of motion, and the results were compared following unilateral or bilateral laminotomies. The experimental protocol included flexion and extension in the following procedures: intact, unilateral, and bilateral laminotomies (L2–L5). The specimens in this study were tested in flexion (8 Nm) and extension (6 Nm) of pure moment. Spinal segment kinematic data was captured by using the motion tracking system. A 3D finite element lumbar spine model (L1-S1) containing vertebral body, discs, and ligaments were constructed. This model was used to simulate the situation of treating unilateral and bilateral laminotomies at L3-L4 and L4-L5. The bottom surface of S1 vertebral body was fully geometrically constrained in this study. A 10 Nm pure moment also applied on the top surface of L1 vertebral body to drive lumbar doing different motion, such as flexion and extension. The experimental results showed that in the flexion, the ROMs (±standard deviation) of L3–L4 were 1.35±0.23, 1.34±0.67, and 1.66±0.07 degrees of the intact, unilateral, and bilateral laminotomies, respectively. The ROMs of L4–L5 were 4.35±0.29, 4.06±0.87, and 4.2±0.32 degrees, respectively. No statistical significance was observed in these three groups ($P>0.05$). In the extension, the ROMs of L3–L4 were 0.89±0.16, 1.69±0.08, and 1.73±0.13 degrees, respectively. In the L4-L5, the ROMs were 1.4±0.12, 2.44±0.26, and 2.5±0.29 degrees, respectively. Significant differences were observed among all trials, except between the unilateral and bilateral laminotomy groups. At the simulation results portion, the similar results were discovered with the experiment. No significant differences were found at L4-L5 both flexion and extension in each group. Only 0.02 and 0.04 degrees variation were observed during flexion and extension between the unilateral and bilateral laminotomy groups. In conclusions, the present results by finite element analysis and experimental reveal that no significant differences were observed during flexion and extension between unilateral and bilateral laminotomies in short-term follow-up. From a biomechanical point of view, bilateral laminotomies seem to exhibit a similar stability as unilateral laminotomy. In clinical practice, the bilateral laminotomies are likely to reduce technical difficulties and prevent perioperative complications; this study proved this benefit through biomechanical analysis. The results may provide some recommendations for surgeons to make the final decision.

Keywords : unilateral laminotomy, bilateral laminotomies, spinal stenosis, finite element analysis
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