

Determination of the Ideal Strain for Lumbar Fusions: Biomechanical Validation of a Finite Element Model of the Sheep Spine

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Lumbar sacral fusions are performed in conjunction with a variety of surgical procedures. It is unfortunate, but generally accepted, that the nonunion rate for single level in a young healthy adult is 5% to 10%. The sheep model has been suggested to simulate and study the conditions which may contribute to nonunion; however relatively little is known about the biomechanics of the sheep spine motion segments. The current project is to define the exact anatomy and density of sheep lumbar spines and from this data develop a finite element model of this region of the sheep spine. The model was validated against biomechanical tests of sheep midlumbar regions defining the normal range of motion.

Two genetically similar, mature sheep lumbar spines were radiographically assessed to determine anatomic geometry and specimen condition. Quantitative computed tomography (QCT) studies were obtained for each spine using a Picker 1200 CT Scanner. The cross-sectional area and vertebral bone density were measured from each scan image. The specimens were dissected into mechanical test segments, L1-2, L3-4 and L6-S1 and mounted in polyester resin. Nondestructive pure compression and compression-flexion tests were conducted on a multitaxis testing machine (MTS Bionix 858). A 100N load was applied to each test segment using a 10 second ramp. Three dimensional finite element models of the L1-2, L3-4 and L6-S1 motion segments were developed using the modeling programs PATRAN and ABAQUS.

Both the experimental data and the finite element analyses indicated that for the same loading, the L6-S1 segment demonstrated two to three times as much strain as the upper lumbar region. Small variations in the test geometry produced significant differences in the specimens' loading and displacements predicted and validated through the finite element model. Overall, the models correlated well with the biomechanical analysis of both motion segments and a significant increase in the motion over the lumbar-sacral junction occurred when compared to the upper lumbar motion segments.