DEVELOPMENT OF A METHOD TO VALIDATE COMPUTER MODELS OF THE SPINE FOR SCOLIOSIS CORRECTION SURGERY SIMULATION

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Introduction

Endoscopic single rod anterior fusion surgery for the treatment of adolescent idiopathic scoliosis (AIS) offers the advantages of improved cosmetic results, the fusion of fewer segments and faster patient rehabilitation. The development of a patient-specific finite element model of the spine to be used to predict post-operative biomechanical outcomes of anterior AIS surgery will improve the pre-operative planning and performance of scoliosis instrumentation. This study aims to develop a methodology for validating the finite element modelling approach to scoliosis surgical planning by producing biomechanical data for movements of ovine lumbar spines both with and without anterior rod scoliosis instrumentation.

Methods

Ovine lumbar spine specimens were CT scanned, dissected and instrumented across four levels (L2-L5) with a generic anterior single rod and screw implant for scoliosis correction. A displacement controlled 6 degree-of-freedom robotic facility was used to perform biomechanical testing on the spine segments for rotations of ±4 degrees in flexion/extension and lateral bending, and ±3 degrees in axial rotation. The tests were repeated with the rod removed. Resistive force and moment data was recorded using a force transducer and strain gauges on the surface of the rod yielded torsion and bending moment strain data, recorded on a data logger. All data was synchronised with the robot position data and filtered using moving average methods. The stiffness of the spines for each movement was calculated in units of Nm/degree of rotation.

Results

As expected the results reflect the variability found in biological materials. The similarities of behaviour profiles however, support the use of this method for FE model validation. The addition of the rod caused an increase in stiffness for each movement. This increase was 17±7% and 23±10% for left and right axial rotation, 93±35% and 73±50% for left and right lateral bending, and 78±46% and 67±35% for flexion and extension respectively. Recorded strains on the rod surface did not exceed 400με.

Discussion

The outcomes of this study have provided an experimental method for validating behaviour predicted by finite element models of the spine fitted with anterior scoliosis instrumentation. Using the CT scans of the ovine spines along with documentation of the experimental positioning of the specimens, the testing conditions can be simulated in a finite element model and the experimental and predicted biomechanical outcomes compared. The study also offers comparative information about the relative stiffness of the spine with and without scoliosis instrumentation.