INTRODUCTION

Degenerative adult scoliosis results from age related changes leading to segmental instability, deformity and stenosis.[1] Spinal fusion is a standard method of surgical treatment for deformity.[2] Loss of native lumbar lordosis, abnormal loading and increased mobility in adjacent segments, may alone or in combination explain the development of adjacent level deterioration.[3] Finite element (FE) model studies have made important contributions to the understanding of functional biomechanics of the lumbar spine.[4] In comparison to in vitro or in vivo approaches, computational methods eliminate the issues with cadaver use, animal use and clinical human studies, in addition to being cost efficient, time efficient, and an accurate surrogate.[5] The purpose of this study was to develop a finite element model of a lumbar scoliotic spine, and investigate the effect of adjacent load transfer before and after fusion surgery.

METHODS

Two three-dimensional nonlinear finite element models of the lumbosacral spine were created from a 73-year old male subject’s pre and post scoliosis surgery CT scans (Fig. 1). Pedicle screws and rods were implanted during surgery at the L2 to S1 levels. The FE spine models were developed encompassing the T12 to S1 levels, along with the screws and rods for the post surgery model (Fig. 2). 3D Slicer software was used to generate the outer shell virtual model of each individual vertebrate and disc. This was followed by a smoothing process to smooth these outer surfaces and fill in holes using Geomagic Studio software. These modified virtual models from T12 to S1 were imported into Truegrid and Hyperworks software to form 3D solids and these solids were meshed. Finally these meshed models were input into LS-DYNA for FE analysis under different loading conditions.
For the analysis the S1 level of the model was fixed. Seven ligaments and local muscle forces were added to this model.[6] A 500N compressive follower load and six different moments were applied to this model: (1) flexion bending moment; (2) extension bending moment; (3) right lateral bending moment; (4) left lateral bending moment; (5) right axial rotation moment; and (6) left axial rotation moment. The compressive follower load was applied to represent the subject’s upper body weight. The six types of bending moment represent the six movements of the spine. The following values for pre- and post-surgery were compared for each load condition: intradiscal pressure and intersegmental rotation (flexion, extension, lateral bending, and axial rotation) at the L1-2 level.

RESULTS AND DISCUSSION

The extent of intersegmental rotation in degrees and the extent of the intradiscal pressure at the L1-2 level post surgery increased or stayed the same under the six loading conditions compared to the pre surgery condition (Fig. 3, Table. 1). The post surgery pressure contours on the L1-2 intervertebral disc varied with the different applied moments for the pre-and post-surgery (Table 1).

CONCLUSIONS

With this study we were able to develop a finite element model of a lumbar scoliotic spine, and investigate the effect adjacent load transfer before and after fusion surgery. The results of this study will help define the variables contributing to adjacent level deterioration in the clinical environment. With this information a surgeon can plan the most appropriate surgical strategy pre surgery to prevent mid and long term adverse outcomes associated with adjacent level deterioration.

REFERENCES


<table>
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<th>Flexion</th>
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<td>Pre intersegmental rotation (Degree)</td>
<td>-4.347</td>
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Table 1. Intersegmental rotation and intradiscal pressure at level L1-2 follower by 500N compressive load and six different types of moments.