MODELING SKELETAL SHAPE CHANGES AND GROWTH IN SCOLIOSIS

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INTRODUCTION

Idiopathic scoliosis is known as a spinal irregularity with lateral curvatures. Considering function of the spine supporting body, investigation from mechanical aspect lays the foundations for investigation of etiology and development of treatments. However, the structure of spine is not so simple. So the finite element modeling and analysis play a key role as means of the investigation. This presentation describes how to construct a finite element model of the spine, how scoliotic deformations emerge and grow, and how to reinforce the spine structure to prevent the scoliotic deformations from the purely mechanical aspect.

HOW TO CONSTRUCT SPINAL FINITE ELEMENT MODEL

The spinal finite element model was constructed using a commercial spine surface data (Viewpoint Premier, catalog num. VP2886 and VP361). The material properties of bones were assumed using data by Yamada (1970). Material properties of disks and joints were identified by comparing with the experimental results by Lucas and Bresler (1961), Markolf (1972) and Schultz et al (1974) (Takeuchi et al 2001).

HOW SCOLIOTIC DEFORMATIONS EMERGE AND GROW

Using the spinal finite element model, bucking phenomena caused by the growth of vertebral bodies were analyzed by a commercial finite element analysis program (MSC.Nastran v.70). The growth was simulated by generating initial strain (thermal strain). Displacement was fixed only on the adjacent surface with sacrum. Figure 1 shows part of the results of the fourth and the sixth buckling modes. The shapes of the fourth and the sixth buckling modes accorded with the clinical shapes of single and double curves respectively.

A simulation of the progression of scoliosis was demonstrated by the authors (Goto 2000).

HOW TO REINFORCE TO PREVENT THE SCOLIOTIC DEFORMATIONS

If the buckling hypothesis is acceptable, sensitivity function with respect to the critical growth of thoracic vertebrae on the maximization problem of buckling load with the fourth and the sixth buckling modes gives us useful information to improve and develop treatments for the idiopathic scoliosis. Figure 2 shows part of the computational results of the sensitivity function.

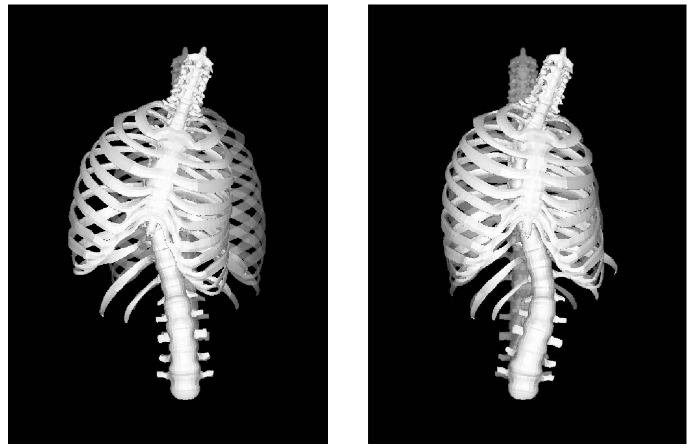

Fig. 1 Buckling modes: Fourth mode caused by growth of T4 to T10 (left) and Sixth mode by growth of T1 to L5 (right) (Takeuchi, et al. 2000).

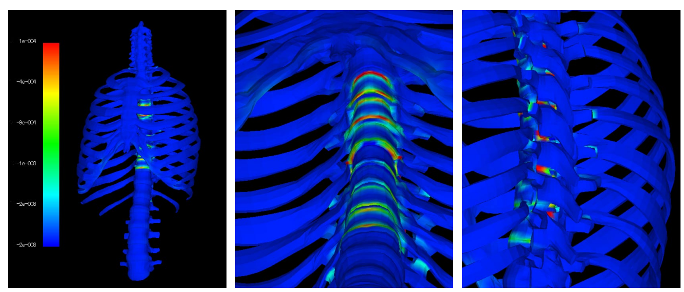

Fig. 2 Distribution of sensitivity with respect to fourth buckling mode caused by growth of T4 to T10 (Takeuchi et al 2001).

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