COUPLING EFFECT OF AXIAL ROTATION AND LATERAL DEVIATION OF MOTION SEGMENTS IN IDIOPATHIC SCOLIOSIS

Behnam Heidari¹, David FitzPatrick¹, Keith Synnott² and Damien McCormack²

¹Department of Mechanical Engineering, University College Dublin, Dublin, Ireland
²Spinal Unit Research Group (SURG), National Spinal Centre, Mater Misericordiae Hospital, Dublin, Ireland
E-mail: bheidari@yahoo.com

INTRODUCTION

Scoliosis is a complex three-dimensional deformity that is usually considered in the frontal plane without references to curvature in other planes. An important feature of idiopathic scoliosis deformity is the horizontal plane rotation (vertebral axial rotation). This rotation is thought to be significant for initiation and progression of idiopathic scoliosis (Adams W, 1865). Somerville’s (1952) studies suggested that scoliotic spine exhibits lordosis as well as lateral curvature and horizontal rotations. Raof (1958) maintained that the deformities of idiopathic scoliosis could be explained on the basis of a primary rotation alone.

There is a lack of clear biomechanical analyses to explain the interaction of the lateral and axial deformity of the spine in idiopathic scoliosis and their coupling effect has yet to be effectively studied. This will allow description of scoliosis pattern and quantification of the deformity.

In the present study, only the geometry of scoliosis was of concern. Therefore, force and force-determination relationships were not considered. They undoubtedly play a significant role in the mechanics of scoliosis, but it seems reasonable to study first the kinematics of spinal deformity.

OBJECTIVES

The purpose of the present study is to investigate the relationship between axial rotation of the vertebral body and the resulting lateral deviation, sagittal deformity, and overall deformity of thoracic spine in scoliosis.

METHODS

Investigating the coupling effect of vertebral axial rotation and lateral deviation is essential in understanding the mechanism of scoliosis aetiology, progression, and correction. In this study a mathematical analog of the human thoracic vertebral column is constructed to model vertebral axial rotation and the associated lateral deviation and overall deformity of the spine. Thoracic spine curvature, with simplified cylindrical vertebral body geometry, is modeled by the use of anatomical data (Panjabi MM, 1991). In this model we assumed equal motion segments along the thoracic spine and the position of T-7 is considered at the apex of the curve.

We have adopted a global coordinate system for the thoracic spine and a local coordinate system on the vertebral body centroids. Geometrical data of the normal model is stored in a three-dimensional matrix. A homogeneous transformation matrix is employed to apply the vertebral rotation in each motion segment to the model. Different axial vertebral rotations were applied to the model to study the influence of rotational displacement on the overall configuration of thoracic spine and to investigate the required changes to bring a normal thoracic spinal column into the geometrical configuration of idiopathic scoliosis.
RESULT AND DISCUSSION

This study addresses a hypothesis that the development of scoliosis deformity is in association with the axial rotation of spinal motion segments. The initial results of the model demonstrate that: 1) vertebral axial rotation can deform the normal spinal curvature, 2) increase in the amount of axial rotation within spinal motion segments will increase the scoliosis deformity of the spine, and 3) the vertebral axial rotation before and after the apex of the curve are in opposite directions (i.e. clockwise and counter-clockwise direction) which is in accordance with the Raof (1958) findings.

Figure 1 illustrates the model with axial rotation of +5°(CW) and –5°(CCW) below and above the apex of the normal spine respectively. The three-dimensional results of the model demonstrate the important relationship between the axial rotation and the size of the scoliosis. The result shows the geometrical characteristics of the scoliotic spine and agrees with the studies of Kanayan et al. (1996).

Increasing axial rotation of the motion segments within the thoracic curve results in an increase in the lateral deviation of the spine in the coronal plane. In the thoracic region, our findings were in agreement with literature that scoliosis is accompanied by loss of sagittal curvature (Stokes IAF et al., 1987; Adams W, 1865).

Therefore, regardless of the precise aetiology of the scoliosis, results of our study demonstrate that the axial rotation of the motion segments directly affects the spatial curvature of the spine (i.e. the three-dimensional deformity produced) and implies that axial rotation could be a primary factor in development of scoliosis deformity.

Improved knowledge of the influence of axial rotation and the resulting lateral deviation will help in understanding the mechanism of scoliosis aetiology, progression and correction.

REFERENCES


ACKNOWLEDGMENTS

This research project is supported by a grant of the fund from Enterprise Ireland. First author wishes to thank Mr. Atid Shamaie for the computer programming assistance.