GRAVITY-INDUCED TORSION AND VERTEBRAL ROTATION IN IDIOPATHIC SCOLIOSIS

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INTRODUCTION

Vertebral rotation is an important aspect of spinal deformity in scoliosis, associated with ribcage deformity (rib hump). Although both lateral curvature and axial rotation appear to increase together in progressive scoliosis, the mechanisms driving vertebral rotation are not clearly established and it is not known whether lateral curvature precedes rotation, or vice versa. This study investigates the hypothesis that intravertebral (within the bone) rotation in idiopathic scoliosis is caused by growth in the presence of gravity-induced torsions, the twisting moments generated by gravitational forces acting on the scoliotic spine.

METHODS

The twisting moment T_p acting at an arbitrary point P on a three-dimensional spinal curve is given by

$$T_p = M_p \cdot \hat{a},$$

where $M_p = r \times F$ is the total moment due to gravity force F acting at (vector) distance r, and $\hat{a}$ is the tangent to the spinal curve at P (Figure 1).

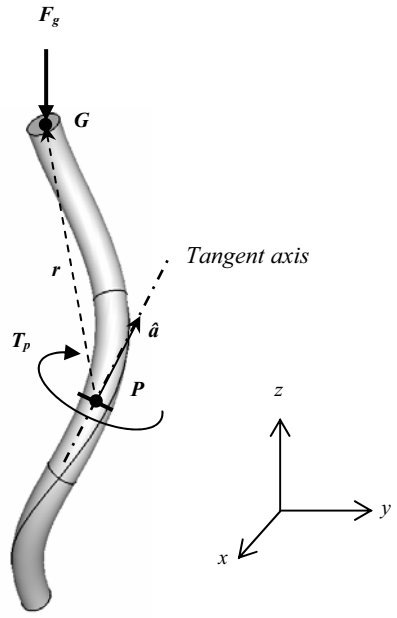

Figure 1: Torque T_p about a 3D curved column due to gravity loading F_g

Standing radiographs for five idiopathic scoliosis patients were used to define three-dimensional curves representing the approximate axes of rotation of each spine, running along the anterior edge of the neural canal from T1 to S1. The equilibrium equations above were then solved to calculate gravity-induced torsions exerted by head and torso weight about the spinal axes for each patient. Intravertebral rotations were measured for the same patients using Aaro & Dahlborn's technique [1] with reformatted computed tomography images in the plane of superior and inferior endplates of each vertebra. The gravity-induced torsion curves were compared with intravertebral rotation measurements to see whether gravity-induced torsion is a likely contributor to intravertebral rotation.

RESULTS AND DISCUSSION

Gravity-induced torques as high as 4 Nm act on the spines of idiopathic scoliosis patients due to static body weight in the standing position. Maximum intravertebral rotations (for a single vertebra) were approximately 7°. There appears to be general agreement between the measured intravertebral rotations and profiles of gravity-induced torsion along the length of the spine (Figure 2). Rotation measurements confirm the finding of previous authors [2] that maximum intravertebral rotations occur at the ends of a scoliotic curve (with little relative rotation at the apex), and this finding is consistent with the gravity-induced torsion profiles calculated.

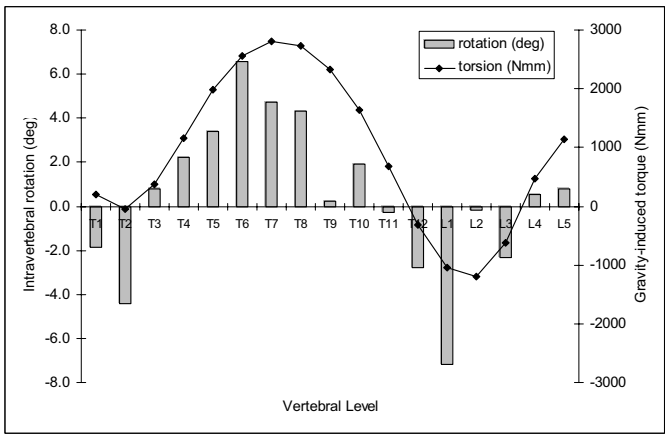

Figure 2: Comparison of gravity-induced torsion and measured intravertebral rotation for a single patient

CONCLUSIONS

Gravity-induced torsion is a potential cause of vertebral rotation in idiopathic scoliosis. Since the spine must be curved in three-dimensions (out of plane) to produce such torques, vertebral rotation would be expected to occur subsequent to an initial lateral deviation, suggesting that coronal curvature precedes axial rotation.

REFERENCES

1. Aaro S & Dahlborn M. *Spine* **6**, 460-7, 1981.
2. Birchall D et al. *Spine* **22**, 2403-7, 1997.