A COMPUTER MODEL TO SIMULATE SCOLIOSIS SURGERY

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INTRODUCTION

Use of patient-specific computer models as a pre-operative planning tool permits predictions of the likely deformity correction and allows a more detailed investigation of the biomechanical influence of different surgical procedures on the scoliotic spinal anatomy. In this paper, patient-specific computer models are used of adolescent idiopathic scoliosis patients who underwent a single rod anterior procedure at the Mater Children's Hospital in Brisbane, to predict deformity correction and to investigate the change in biomechanics of the scoliotic spine due to surgical compressive forces applied during implant placement.

METHODS

Patient-specific computer models simulating the osseo-ligamentous anatomy for the spine and ribcage of seven patients were generated from low-dose computed tomography data obtained before surgery. Material properties derived from the literature for adult tissues were used to simulate the stiffness of the bone and ligamentous structures [1]. The rod and screws were represented using material data for titanium. Loading conditions representing the in vivo compressive loads applied by the surgeon intra-operatively were obtained from the study by Fairhurst et al. [2]. Three separate loading 'profiles' were derived from these data; with profile B representing the median compressive forces applied at the instrumented joints; profile A representing compressive forces one standard deviation above the median; and profile C representing compressive forces one standard deviation below the median. Data for the clinically observed deformity correction (Cobb angle) were compared with the model-predicted corrections and the model results investigated to better understand the influence of increased compressive forces on the biomechanics of the instrumented joints.

RESULTS

Increases of 62% (profile B) and 124% (profile A) in the total compressive force applied to the spine, relative to profile C, resulted in increases in the mean instrumented Cobb correction from 35% (range, 22-55%) for profile C to 51% (range, 35-78%) for profile B and 67% (range, 47-93%) for profile A. In general, the highest segmental correction in the instrumented curve (expressed relative to the total deformity correction) was predicted at the apex of the curve (approximately 23%) or the joint immediately above the apex, with diminishing corrections caudal and cephalic to this level.

DISCUSSION

This study demonstrated there is a direct relationship between intra-operative joint compressive forces and the degree of deformity correction achieved. However, with increased compressive joint forces the segmental correction achieved does not necessarily increase proportionally and the majority of the deformity correction will occur at or in the adjacent levels to the apex. Future work will focus on calculating the potential for tissue overload due to intra-operative compressive forces and predicting the likelihood of surgical complications including screw pullout and rod breakage.

REFERENCES

1. Little JP, Adam CJ, 2011. Int J Numer Meth Biomed Eng 27:347-56.
2. Fairhurst H, et al, 2011. 22nd Annual Meeting of Spine Society of Australia, Melbourne.