ANALYSIS OF CERVICAL SPINE INJURY RISK IN SPORTS USING FINITE ELEMENT METHOD

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INTRODUCTION: Approximately 10,000 cervical spine injuries occur annually in the United States, with about 1,000 of these injuries resulting from sport-related events (Davis & McKelvey, 1998). In this study, we developed and validated the finite element model of cervical spine, and analyzed cervical spine injury risk using the model.

METHOD: A finite element model of healthy cervical spine from C2 to C7 was developed from CT images. The model consists of cortical and trabecular bone, nucleus pulposus, annulus ground substance, five annulus fibrosus layers, and six kinds of major ligaments. To validate the developed finite element model of cervical spine, C7 was completely fixed in all directions and 1.5 Nm of flexion, extension, left and right lateral bending, and left and right torsion moments were applied on superior plate of C2. The results were compared with previous experimental and computational studies (Panjabi et al., 2001; Hong-Wan et al., 2004). To analyze injury risk of cervical spine, segmental motions, stresses on ligaments, and facet joint forces in hyper flexion and extension were analyzed by comparing with those in normal motion, which are under 1 Nm of moment and 50 N of pre compressive load.

RESULTS: In normal flexion and extension motions, global rotation angle was about 13° and 15°, respectively. Rotation angle of each motion segment were well distributed in flexion. However, in extension, C6-C7 motion segment showed much higher rotation angle than other segments. In both hyper flexion and extension, the global rotation angles increased in proportion to the applied moments. Stress on each ligament was highly elevated according to the increase of flexion or extension moment and the facet joint force in extension was proportional to the applied moment.

DISCUSSION: Excessive segmental rotation, ligament stress and facet joint force in cervical spine could cause the injury. The results of this study showed that the injury risk could be substantially high in hyper flexion or extension that could be applied to the cervical spine during sport-related events. The finite element analysis could be useful to analyze the cervical spine injury risk by applying the various simulated sport activities to the developed cervical spine model.

REFERENCES:

Davis, P. M. & McKelvey, M. K. (1998). Medicolegal aspects of athletic cervical spine injury. *Clinics in Sports Medicine*. 17, 147-54.

Panjabi, M. M., Crisco, J. J., Vasavada, A., Oda, T., Cholewicki, J., Nibu, K., & Shin, E. (2001). Mechanical properties of the human cervical spine as shown by three-dimensional load-displacement curves. *Spine*. 26, 2692-700.

Hong-Wan, N., Ee-Chon, T., & Qing-Hang, Z. (2004). Biomechanical effects of C2-C7 intersegmental stability due to laminectomy with unilateral and bilateral facetectomy. *Spine*. 29, 1737-45.

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