A Finite Element Model Of The C2-C3 Segment – Gross Responses Under Physiological Loads

AIM
To develop and exercise a finite element (FE) model of the C2-C3 segment so as to describe its biomechanics under physiological loads.

BACKGROUND
Based on anatomical descriptions, the four neck sub-units are the atlas, axis, C2-C3 junction and lower cervical vertebrae. While studies abound delineating the structural response of the atlas, axis and lower cervical vertebrae, there remain a paucity of information in the C2-C3 functional spinal unit (FSU) biomechanics. The C2-C3 junction forms the transitional zone of the neck, being juxtaposed between the upper cervical spine (C1-C2) where most rotational motion of the neck and little flexion and extension occur, and the remaining typical cervical vertebrae (C3-C7) where the bulk of the motion is in the sagittal plane.

METHODOLOGY
A 3-dimensional FE model of the C2-C3 segment based on a 68-year old male cadaveric spine was developed. The model geometry was described via three-dimensional digitization. The C2-C3 segment was subjected to bending moments in the anatomic sagittal, frontal and transverse planes.

Five incremental loads of 300 Nmm each were applied uniformly across the superior articular surfaces of C2, while the inferior vertebral body of C3 was rigidly constrained in all directions. The rotational components of relative motion between the C2 and C3 segments under increment moment to maximal moments of 1500 Nmm were computed.

RESULTS
The model comprises 4580 “8-noded” solid elements for the definition of the bony structures and the intervertebral disc, and 181 tension cable elements represented the spinal ligaments.

Under applied moments in the sagittal plane, the C2-C3 model exhibited greater stiffness in the extension direction at high loads (>400 Nmm), but at low loads (0 – 400 Nmm), the spinal segment was stiffer under flexion. Coupled motions – for lateral bending and axial rotation in the frontal and transverse planes respectively – were observed.

RELEVANCE
By quantifying kinetics and kinematics, the model has the potential to supplement various in vitro and in vivo studies to further the understanding of human cervical spine biomechanics under different load vectors.

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