Finite element model

Advanced neck finite element modeling and development of neck injury criteria are important for the design of optimal neck protection systems in automotive and other environments. They are also important in virtual tests. The objectives of the present study were to develop a detailed finite element model (FEM) of the human neck and couple it to the existing head model, validate the model with kinematic data from legacy human volunteer and human cadaver impact datasets, and derive lateral impact neck injury risk curves using survival analysis from the upper and lower neck forces and moments. The detailed model represented the anatomy of a young adult mid-size male. It included all the cervical and first thoracic vertebrae, intervening discs, upper and lower spinal ligaments, bilateral facet joints, and passive musculature. Material properties were obtained from the literature. Frontal, oblique, and lateral impacts to the distal end of the model were applied based on human volunteer and human cadaver experimental data. Corridor and cross-correlation methods were used for validation. The CORrelation and Analysis (CORA) score was used for objective assessments. Forces and moments were obtained at the occipital condyles (OC) and T1, and parametric survival analysis was used to derive injury risk curves to define human neck injury tolerance to lateral impact. The Brier Score Metric (BSM) was used to determine the hierarchical sequence among the injury metrics. The CORA scores for the lateral, frontal, and oblique impact loading conditions were 0.80, 0.91, and 0.87, respectively, for human volunteer data, and the mean score was 0.7 for human cadaver lateral impacts. Injury risk curves along with ±95% confidence intervals are given for all the four biomechanical metrics. The OC shear force was the optimal metric based on the BSM. A force of 1.5 kN was associated with the 50% probability level of AIS3+ neck injury. As a first step, the presented risk curves serve as human tolerance criteria under the lateral impact, hitherto not available in published literature, and they can be used in virtual testing and advancing restraint systems for improving human safety [1)].

Cervical myelopathy is a common and debilitating chronic spinal cord dysfunction. Treatment includes anterior and/or posterior surgical intervention to decompress the spinal cord and stabilize the spine, but no consensus has been made as to the preferable surgical intervention. The objective of this study was to develop an finite element model of the healthy and myelopathic C2-T1 cervical spine and common anterior and posterior decompression techniques to determine how spinal cord stress and strain is altered in healthy and diseased states.

A finite element model of the C2-T1 cervical spine, spinal cord, pia, dura, cerebral spinal fluid, and neural ligaments was developed and validated against in vivo human displacement data. To model cervical myelopathy, disc herniation and osteophytes were created at the C4-C6 levels. Three common surgical interventions were then incorporated at these levels.

The finite element model accurately predicted healthy and myelopathic spinal cord displacement compared to motions observed in vivo. Spinal cord strain increased during extension in the cervical myelopathy finite element model. All surgical techniques affected spinal cord stress and strain. Specifically, adjacent levels had increased stress and strain, especially in the anterior cervical discectomy and fusion case.

This model is the first biomechanically validated, finite element model of the healthy and myelopathic C2-T1 cervical spine and spinal cord which predicts spinal cord displacement, stress, and strain during physiologic motion. Our findings show surgical intervention can cause increased strain in the adjacent levels of the spinal cord which is particularly worse following anterior cervical discectomy and fusion

[2].

[1]

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