Human Body Model Cervical Spine Curvature and Extracted Motion Segment Model in Tension, Compression, and Flexion

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Abstract

Introduction:

Spine repositioning of finite element Human Body Models (HBMs) is important to integrate models into vehicle crash scenarios and to investigate the implications of different postures in impact scenarios. Morphing such models is a complex task due to the soft tissue that surrounds the spine and the intervertebral discs, which need to be deformed to fill the volume between the vertebrae.

This study will present a repositioned Global Human Body Models Consortium (GHBMC) 50th percentile male detailed HBM (M50-O, version 4.5) and assess the effect of spinal curvature on response using the motion segment at the level of the fourth and fifth vertebra (C4-C5) under flexion, extension, and tension.

Objective:

Previous studies (Barker 2017) have suggested there may be a contribution of spinal curvature to the kinetic and kinematic response of the cervical spine motion segments. The goal of this study was to assess the effect of spine curvature on the response of the C4-C5 motion segment. Three curvatures will be studied: the current GHBMC M50-O, a repositioned spine representing the average population, and a curvature more pronounced than the average.

Methodology:

In this study, a spline was used as input to define the repositioned spine curvature; after, using repositioning software (PIPER), a simulation was performed to achieve the given posture. During the simulation, a set of springs with a prescribed stiffness at the centroids of the vertebra cause motion to match the target spline. Different time steps and spring stiffness were assessed to observe the effect in the mesh quality of the repositioned model. Also, different mesh enhancement tools with custom parameters where used in the PIPER environment to achieve an acceptable final mesh quality. A number of modifications had to be made to the metadata, spine predictor in-code parameters, Fine Positioning module, and Smoothing module.

After achieving an acceptable mesh quality and acceptable intervertebral disc geometry, the C4-C5 motion segment was extracted and evaluated using LS-DYNA. Different boundary conditions corresponding to tension, compression, and flexion were applied to compare the kinetics and kinematics of the repositioned motion segment.

Data to be included:

A summary of the repositioning methodology and a comparison of the response of the cervical segment for three different spinal curvatures will be presented. The results will be compared with available experimental data.

Preliminary Results and current conclusions:

The morphing methodology allows the model to be repositioned, but requires significant intervention to ensure mesh quality is retained. The current C4-C5 motion segment models are more compliant in extension and stiffer in flexion (Barker et al., 2017) compared to the experimental data, and this could be attributed in part to the straighter spine curvature in the computational model compared to the average spinal curvature. This study will demonstrate the effect of spine curvature on motion segment response.