DEVELOPMENT OF A FEMALE FINITE ELEMENT MODEL OF THE CERVICAL SPINE

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Introduction

The cervical spine a common site of injury in the vertebral column, with severe injuries resulting in permanent disabilities. However, most are minor with a low threat to life. One of the most common neck injuries is whiplash, and the plethora of clinical symptoms and sequelae have been classified as whiplash-associated disorders (WAD). The risk of sustaining WAD has been shown to be significantly influenced by gender. Females are at higher risk of developing symptoms [1]. Additionally, finite element human body models have proven to be fundamental tools for better understanding injury mechanics. As such, the aim of this work is to create a new finite element of the female cervical spine that will more accurately represent the group most affected by such injuries.

Methods

The initial geometry of the created model was obtained from the CT scans of a 49-year-old female subject and was generated using a hybrid methodology of combining medical images and parametric studies. Four different components were modelled, the vertebrae, the intervertebral discs, the facet joints, and the ligaments.

Initially, all components were assumed to be isotropic materials with linear elastic properties to simplify the first simulations. Additionally, all ligaments were set to work only in tension.

Due to the high element and node number of the complete model, a full simulation would take a significant amount of time. As seen in previous studies, it is possible to analyse and validate sections of the spine before simulating the entire model. As such, the model was divided into functional spinal units (FSU), consisting of pairs of vertebrae. The FSUs were subjected to six moments of pure moments of 1Nm working in flexion, extension, axial rotation, and lateral bending. Throughout the applications of the loads, the range of motion (ROM) was monitored.

Results

The accuracy of the developed model was validated by comparing output predictions with previously published experimental data. The results for flexion and extension were compared with the studies from Nightingale et al.[2] and Panjabi et al.[3]; the results for axial rotation and lateral bending were compared only with the study from Panjabi et al.[3].

As of the time of writing, only one FSU, the C6-C7 segment, has been completely validated. These first simulations show satisfactory outcomes, as seen in Figure 1. The only test that shows results outside of the experimental range is lateral bending. However, this stiffness has been found in previously validated FE models [4,5].

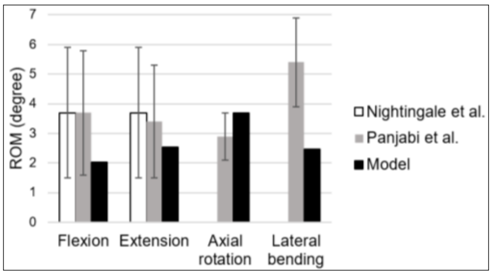

Figure 1: Comparison of the FSU (C6-C7) response against experimental data [4,5].

Discussion

The validation of the first FSU shows promising results for the complete validation of the developed cervical spine model. The deviation of the lateral bending results can be attributed to ligament positioning or misalignment between the applied moment and the vertebrae. The next step in this research, besides the conclusion of the validation process, is the addition of more realistic material behavior for most of the components.

References

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Acknowledgements

This work was supported by the Portuguese Science Foundation under grants PTDC/EME-EME/1239/2021, UIDB/00481/2020 and UIDP/00481/2020; and CENTRO-01-0145-FEDER-022083 - Portugal Regional Operational Programme (Centro2020) under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund.