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3D Reconstruction and Meshing of Thoracic Spine

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Extended Abstract
Background

The thoracic spine is the largest portion of the human spine which consists of 12 vertebras and is extremely crucial for the proper transfer of loads between upper and lower extremities. Additionally, the rib cage, which protects the vital organs like heart and lungs, is attached to the thoracic spine. Finite Element (FE) models of thoracic spine provide significant advantages for analysis. Firstly, FE model is preferable for analysis of stress, strain, forces and pressure on thoracic spine, as opposed to cadaver. Secondly, FE can be developed cheaply and is easily accessible. Thirdly, FE can be used repeatedly without getting any permanent damage whereas a cadaver can be used only for one experimental setup.

Objective

This study aims to perform image reconstruction by processing computed tomography (CT) scans of thoracic spine. Surfaces of thoracic vertebra and intervertebral discs were developed to obtain a more realistic representation and to create finite element mesh of thoracic spine.

Methods

We used Mimics® Version 14.1 (Materialise, Inc., Leuven, Belgium) to create 3D surfaces. CT scans (transverse slices 1.5 mm thick) of a healthy female were used for the process. In the first step, the entire thoracic scans were masked. Refinement of the scans was carried out by removing ribs and bone fragments present in the images. Masks were converted to 3D objects which yielded vertebral surfaces. Vertebras were separated one by one such that 12 individual vertebra surfaces were created. In second step, intervertebral discs were manually created. Since discs are soft tissues, they are not captured on CT scans. A cylinder which mimicked disc was inserted between two consecutive vertebra surfaces. Mask was applied on the cylinder, and it was trimmed and refined until it fits the space between vertebral cortical bones. Surfaces were converted to STL format and exported to IA FE-MESH (University of Iowa, IA) for mesh creation. In order to create mesh, nodes were placed on the surfaces. Endplates of vertebra and discs were given radial node configuration. Nodes were placed as close to surfaces as possible so that surface morphology can be captured with precision (Erbulut et al., 2014). Meshed surfaces were exported in inp format to be used in next stage of model development.

Result

3D surfaces of the thoracic vertebra and intervertebral discs were created and smoothed to an optimal level in order to have a real thoracic spine-like image. Mesh was created on the 3D surfaces. Intervertebral disc nucleus consisted of around 35% of disc volume and was surrounded by 3 layers of annulus. Endplates of vertebra contain mesh similar to disc to facilitate merging of nodes in next stage of model development.

Conclusion

Thoracic spine is vital part of human spine and any disorder in this part needs to be investigated. FE model provides cost effective way to predict biomechanical parameters of thoracic spine. A finite element mesh has been developed in current study which will be used in later studies of creating asymmetrical thoracic spine finite element assembly.

Reference

Erbulut, D. U., Zafarparandeh, I., Lazoglu, I., Ozer, A. F. Application of an asymmetric finite element model of the C2-T1 cervical spine for evaluating the role of soft tissues in stability. *Medical Engineering & Physics*. In Press.