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Inverse Model of Human Lumbar Spine Based on CT Image and Finite Element Analysis[1]

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Abstract—In order to accurately analyze the most vulnerable fracture points of normal human lumbar vertebrae under upright position, walking and left-right rotation, the spiral computer tomography (CT) was used to scan the segment from the upper edge of lumbar vertebra L1 to the lower edge of lumbar vertebra L5. After reading CT images with Mimics software, the threshold analysis, area segmentation and the whole filling were carried out. The generated 3D geometric model was reconstructed using the Finite Element Analysis (FEA) module of Mimics, and the 3D lumbar model with intervertebral disc established by UG software was used. The model was imported into ANSYS Workbench for finite element analysis. The results showed that when the human body was upright, the displacement of the vertebral body was larger than that of the articular process. The displacement of the leading edge of the upper surface of the disc was the largest and equal to 0.161 mm. The equivalent stress is concentrated on the articular process and spinous process, and the stress on the lower articular process of the L4 is the largest (15.073 MPa) indicating that the relative error between the finite element analysis result and the theoretical calculation result is small. Hence, it proves that the method is correct and feasible.

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1. INTRODUCTION

The human lumbar spine is composed of complex structures carrying huge loads and providing support for human movement. According to a large number of survey data, more than 80% of human beings have suffered from lumbar pain of different degrees, which is second only to the incidence of cold [1].

With the increasing working pressure nowadays, the incidence of lumbar problems is increasing year by year. Through the analysis of the pathogenesis of lumbar disease, it is found that when human body's lumbar support is too large or uneven, the corresponding force can easily lead to the degeneration and slippage of lumbar intervertebral disc, and then to lumbar injury. Among the lumbar vertebrae that make up the spine, the fourth (L4) and fifth (L5) lumbar vertebrae experience the largest force and range of motion, so these two lumbar vertebrae are more vulnerable to injury [2].

The establishment of a complete model of the lumbar spine is the premise in biomechanics studies. In previous studies, it was revealed that the modeling of lumbar spine belongs to one of the difficulties in the study of the lumbar spine biomechanics. With the continuous development of science and technology and the computer knowledge becoming unceasingly rich, it became possible to use the finite element method in such fields as medicine and engineering, and to create gradually a new type of bone reconstruction technology.

Due to the spine to the aspects of material properties of the spine and the complexity of its anatomical organization, and the use of previous experimental methods, such as the photoelastic method, electrical measuring method, etc., it is difficult to get comprehensive information, but with the use of the finite element analysis method in the field of spinal biomechanics study we can obtain material advantages in comparison with the previous experimental methods:

[1] Preliminary materials of this article were reported at the conference Futuristic Trends in Networks and Computing Technologies FTNCT (Nagar, 2019).

CONFLICT OF INTEREST

The author declares that they have no conflict of interest.

ADDITIONAL INFORMATION

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