Monte Carlo analysis of the human vertebra based on compressive loading

A.Zulkifli[a]*; A.K. Ariffin*[b]

[a]Centre of Sport Engineering, Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600, Pekan, Pahang, Malaysia

[b]Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 46300, UKM Bangi, Selangor, Malaysia

ABSTRACT

The objective of this study is to determine the probability of injury of human crack vertebra condition subjected to compressive loading. The model had been used in this study was reconstructed from image processing and develop using SolidWorks software. The three dimensional finite element model of lumbar vertebra was organized using Ansys software. In this work, all the model components were meshed using the tetrahedral solid element (SOLID186). In order to simplify it, all the components were modeled as an isotropic, elastic material and symmetry model. The model failure was occurred when the stress intensity factor (SIF) of the bone exceeds the fracture toughness. Biological structures as well as vertebrae inherent a lot of related uncertainties and should not be solved by deterministic analysis. A Monte Carlo Simulation (MCS) technique was performed to conduct the probabilistic analysis using a built-in parametric design language (APDL) module. The results discovered that the highest stress was found on adjacent pedicle to create the weakness area and probability of failure for cracked structure condition is 2%. Therefore, pedicle was become the most crucial area to be emphasize. In addition, any flaws exist on the model such as crack will give a huge impact to the results, especially fracture. Hence, the current study was very useful to examine how the bone toughness and bone characteristics capable of sustained compressive loading in terms of probabilistic approach.

KEYWORDS:

Crack; Finite element model; Lumbar spine; Monte carlo

REFERENCES

1. W. Gao, Song, C., and Tin-Loi, F., Probabilistic interval analysis for structures with uncertainty. Structural Safety, Vol. 32, n. 3, pp. 191-199, 2010

2. J.G. Hazenberg, Taylor, D., and Clive Lee, T., Mechanisms of short crack growth at constant stress in bone. Biomaterials, Vol. 27, n. 9, pp. 2114-2122, 2006.

3. D. Taylor, Modelling of fatigue crack growth at the microstructural level. Computational Materials Science, Vol. 25, n. 1, pp. 228-236, 2002

4. H. Wu, Zhong, Z., Benseddiq, N., and Imad, A., Numerical simulation of the crack shape for the thermo-mechanical loaded valve. Engineering Failure Analysis, Vol. 18, n. 6, pp. 1487- 1495, 2011

5. C.K. Fitzpatrick, Baldwin, M.A., Rullkoetter, P.J., and Laz, P.J., Combined probabilistic and principal component analysis approach for multivariate sensitivity evaluation and application to implanted patellofemoral mechanics. Journal of Biomechanics, Vol. 44, n. 1, pp. 13-21, 2011.