World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:9, No:11, 2015

Finite Element Analysis of Human Tarsals, Meta Tarsals and Phalanges for Predicting probable location of Fractures

Authors : Irfan Anjum Manarvi, Fawzi Aljassir

Abstract : Human bones have been a keen area of research over a long time in the field of biomechanical engineering. Medical professionals, as well as engineering academics and researchers, have investigated various bones by using medical, mechanical, and materials approaches to discover the available body of knowledge. Their major focus has been to establish properties of these and ultimately develop processes and tools either to prevent fracture or recover its damage. Literature shows that mechanical professionals conducted a variety of tests for hardness, deformation, and strain field measurement to arrive at their findings. However, they considered these results accuracy to be insufficient due to various limitations of tools, test equipment, difficulties in the availability of human bones. They proposed the need for further studies to first overcome inaccuracies in measurement methods, testing machines, and experimental errors and then carry out experimental or theoretical studies. Finite Element analysis is a technique which was developed for the aerospace industry due to the complexity of design and materials. But over a period of time, it has found its applications in many other industries due to accuracy and flexibility in selection of materials and types of loading that could be theoretically applied to an object under study. In the past few decades, the field of biomechanical engineering has also started to see its applicability. However, the work done in the area of Tarsals, metatarsals and phalanges using this technique is very limited. Therefore, present research has been focused on using this technique for analysis of these critical bones of the human body. This technique requires a 3-dimensional geometric computer model of the object to be analyzed. In the present research, a 3d laser scanner was used for accurate geometric scans of individual tarsals, metatarsals, and phalanges from a typical human foot to make these computer geometric models. These were then imported into a Finite Element Analysis software and a length refining process was carried out prior to analysis to ensure the computer models were true representatives of actual bone. This was followed by analysis of each bone individually. A number of constraints and load conditions were applied to observe the stress and strain distributions in these bones under the conditions of compression and tensile loads or their combination. Results were collected for deformations in various axis, and stress and strain distributions were observed to identify critical locations where fracture could occur. A comparative analysis of failure properties of all the three types of bones was carried out to establish which of these could fail earlier which is presented in this research. Results of this investigation could be used for further experimental studies by the academics and researchers, as well as industrial engineers, for development of various foot protection devices or tools for surgical operations and recovery treatment of these bones. Researchers could build up on these models to carryout analysis of a complete human foot through Finite Element analysis under various loading conditions such as walking, marching, running, and landing after a jump etc.

Keywords : tarsals, metatarsals, phalanges, 3D scanning, finite element analysis
Conference Title : ICCB 2015 : International Conference on Computational Biomechanics
Conference Location : Paris, France
Conference Dates : November 19-20, 2015