7th World Congress of Biomechanics

3D parametric model of the proximal femur incorporating geometric and material properties: Patient-specific prediction of fracture risk

M. A. Pérez[1], M. Remacha[1], A. Alberich-Bayarri[2]

1 Aragón Institute of Engineering Research (I3A), Department of Mechanical Engineering, University of Zaragoza, Zaragoza, Spain
2 Grupo Hospitalario Quirón, Valencia, Spain

*e-mail: angeles@unizar.es, web page: http://m2be.unizar.es

ABSTRACT

The vast majority of orthopaedic computational studies use a single or limited number of bone models. The derived results are then extrapolated to try to draw conclusions for the population as a whole. This sacrifices quantitative accuracy by ignoring natural interpatient variability. Current applications of the finite element (FE) models are limited by the need of creating a new model from scratch in each new patient; furthermore, only small gains in efficiency are obtained by this approach. This work describes the development of a three-dimensional parametric FE model of the proximal human femur incorporating geometric and material properties. The model is constructed from the value of 9 parameters that can be easily measured through a radiograph. The parametric patient-specific model is validated comparing the mechanical behavior of the real femur and its corresponding parametric model under different loading cases. The equivalent strains and bone density distribution were qualitative and quantitatively computed, obtaining that the parametric results were within the real ones.

Additionally, the study predicted the fracture risk [1] under the impact of an oblique fall to the side, a scenario known to account for a large proportion of hip fractures in the elderly and have a lower fracture load than alternative loading approaches. The likely fracture location was indicated to be intertrochantic. Comparison to previous computational, clinical and experimental work revealed support to these findings. The influence of each model parameter on the fracture prediction was also analysed.

In conclusion, this study illustrates a methodology with the potential to generate patient-specific proximal femur models incorporating material properties. The results demonstrate that the presented method is an advance stage, and can be used in clinical studies of femoral neck fracture risk prediction. The use of parametric modelling methods would greatly reduce time required to construct a model of an individual's femur and, by preserving model fidelity, would not negatively impact the predictive accuracy of the model.

REFERENCE

[1] Gomez-Benito MJ, Garcia-Aznar JM, Doblare M. Finite element prediction of proximal femoral fracture patterns under different loads. J Biomech Eng 2005; 127(1): 9-14.

Acknowledgements
The research leading to these results has received funding from the (European Commission) Seventh Framework Programme (FP7/2007–2013) under grant agreement n286179 and the Spanish Ministry of Economy and Competitiveness through research project DPI 2011–22413