CT-based finite element analysis for predicting contralateral hip fractures

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ABSTRACT

Fractures of the proximal femur after minor sideway falls or twisting injuries are among the most common fractures in the elderly. Non simultaneous contralateral hip fractures (a second fracture in the contralateral femur following the first fracture) have been reported to occur in 5%–15% of the patients within the following two to five years after the first fracture. There is no measure nowadays to identify those at higher risk to sustain a contralateral fracture. The need of a reliable, robust and patient specific tool that pinpoints the personalized risk of a contralateral fracture is of great importance as it might guide a proper and effective prevention care. Verified and in-vitro validated patient-specific simulations based on quantitative CT (QCT) scans, were developed by the authors using p-FEMs, demonstrating an unprecedented prediction capability [1]. QCT can be used to extract bone geometry and determine its material properties; these being the two key ingredients for FE models of bones.

Coupling the engineering and clinical disciplines, this presentation reports on a clinical trial conducted on patients who sustained a first hip fracture. QCT-based patient specific finite element models were generated to simulate a sideway fall on the uninvolved hip causing the same fracture pattern as observed in the QCT scan. The fracture risk is based on strain distribution along the femur and the principle strains yielding criteria. The analysis results shows which area is at high risk of sustaining a fracture in the uninvolved femur and the exact loading magnitude and configuration that cause the fracture. The fracture load correlated with previous studies, ranged from 1 to 3 KN, approximately ~2.5 of patient's body weight. Intracapsular neck of femur fractures and simple intertrochanteric fractures were well predicted by the analysis and showed very good compatibility with the observed fracture pattern of the involved femur in the CT-scan. Subtrochanteric fractures are not well predicted by the analysis, indicating possible different physiological loads during a fall. An example of such and analysis is shown in Figure 1. This talk will report on the clinical trials and their outcome.

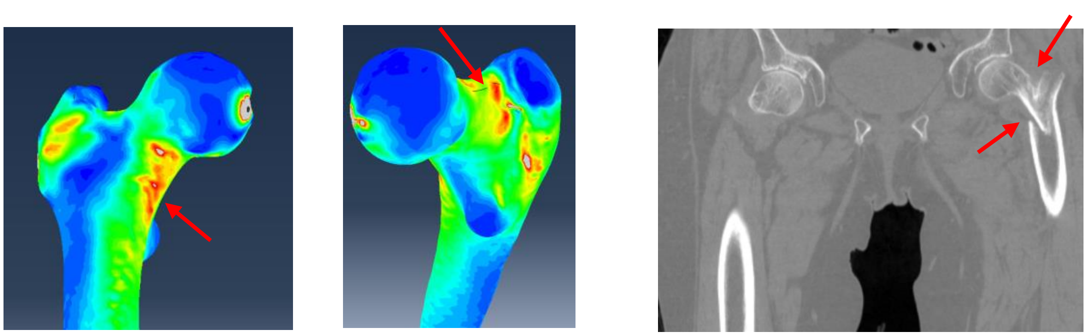

Figure 1. Left: Radiograph of a 84 years old female (weight of 80kg) with a fracture in her left femur. Right: FEA results representing strain distribution along the right intact femur

[1] N. Trabelsi et al. Patient-specific finite element analysis of the human femur - a double-blinded biomechanical validation. *J. Biomech.*, **44**:1666-1672, 2011.