MODELLING AND ANALYSIS OF THE HUMAN UPPER EXTREMITY IN VARIOUS FOREARM CONFIGURATIONS RESULTING FROM A FALL

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Introduction

Falls resulting from slips or trips are frequent accidents in the daily life of humans. Among the elderly falls often lead to injuries of the upper extremity. In the literature different numerical models of the upper extremity bones are proposed. However, usually only one bone (radius) is analysed to estimate the fracture risk. On the contrary to those models we propose a novel finite element (FE) model of all three upper extremity bones (humerus, radius and ulna) connected each other as one complex biomechanical system.

Methods

The used DICOM data obtained from 35 years old man have been imported to Mimics. All bones have been separated and, as a result, the meshed numerical FE models of the three bones (humerus, radius and ulna) have been obtained (see Fig. 1).

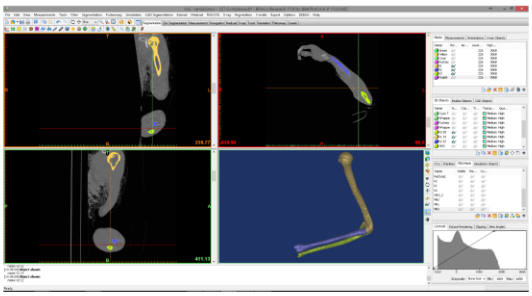

Figure 1: Determination of the upper extremity bones (humerus, radius and ulna) using the Hounsfield scale.

Using the tetrahedral SOLID185 FE, the realistic 3D model of the joined upper extremity bones has been obtained. Geometry and material properties (isotropic and linear-elastic) have also been modelled in Mimics by using the Hounsfield Unit (HU) scale [1]. Inhomogeneous distribution of the bone material Young' moduli E is illustrated in Fig. 2.

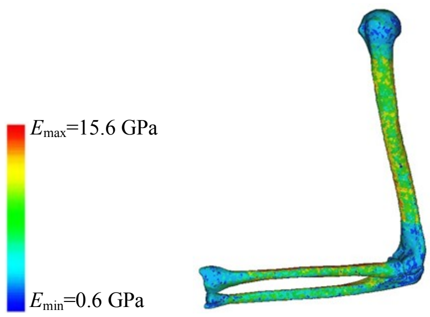

Figure 2: Solid model of the upper extremity showing distribution of the material properties.

Results

Strength analysis has been obtained for different forearm configurations [2]. In order to adopt the load conditions we used the time histories of the ground reaction forces (GRFs) presented in the paper [3].
Figure 3 presents distributions of the von Mises stresses under the applied loads and boundary conditions.

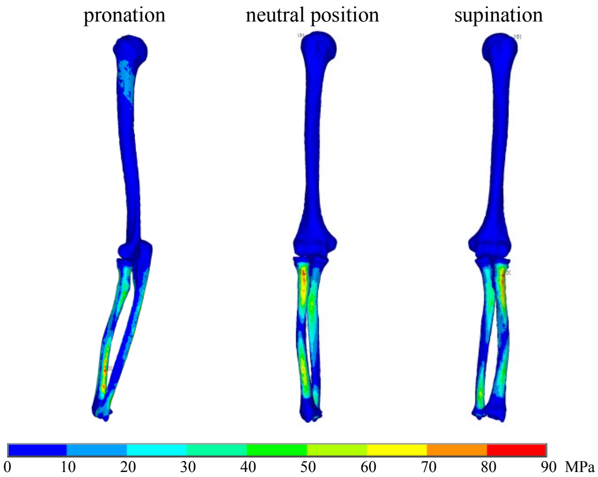

Figure 3: Maximum von Mises stresses of the upper extremity bones for different forearm configurations.

Discussion

For all forearm configurations the highest stress is observed in the radius bone, while the lowest stress is observed for the humerus one. In the cases of neutral and supination configurations the highest stress occurs in proximal radius, however the high fracture risk occurs in neutral position. Moreover, in the pronation position, which is the most common configuration during forward fall, the distal radius is characterized by the highest probability of the fracture. The obtained numerical simulations can be useful for the better treatment of patients, upper extremity bones remodelling, and developing new types of implants.

References

1. Rho et al, Med Eng Phys, 17:347-355, 1995.
2. DeFrate et al, Clin Biomech, 16: 895-900, 2001.
3. DeGoede and Ashton-Miller, J Biomech, 36:413-420, 2003.

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