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Patient-specific simulations of human bones: CT data and bone remodelling models

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Abstract

Patient-specific finite element models (FEM) are standard tools for the analysis of the biomechanical behaviour of human bones. Patient-specific simulations mainly used computerized tomography (CT) images which may provide fairly accurate quantitative information on bone geometry that can be related to the mechanical properties of bone tissues. However, they greatly simplify the complex behaviour of bone. On the other hand, bone remodelling models have been extensively used providing important structural information, for example, bone anisotropy.

Materialise with its software MIMICS may help to combine patient-specific FE modeling by CT data with a remodeling model to predict the bone density distribution of certain human bones.

The human bones (mandible, radius, femur and tibia) were scanned using a 64 slice multi-detector CT scanner (Philips Healthcare, The Netherlands) and the images used to reconstruct the joint geometry (MIMICS). Then, the FE mesh and the analyses were performed in Abaqus v.6.9 (Fig. 1). On the one hand, the FE mesh was imported into MIMICS again and different material properties were assigned relating the bone mineral density with the Hounsfield Units (HU) (Fig. 1b). On the other hand, an anisotropic bone remodeling model was used to predict the density distribution through the application of the corresponding loads and boundary conditions (Fig. 2). Finally, a comparison between both approaches was computed.

Good agreement was obtained (qualitatively and quantitatively) between approaches. Despite, the limitations of the methodology we can summarize that bone remodeling models in combination with CT data (MIMICS) are useful tools when the goal of the study needs to incorporate the complex behaviour of bone physiology (anisotropy, osteoporotic tissue, etc.).

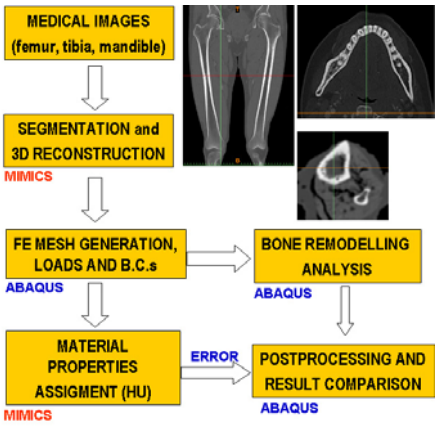

Fig 1. Scheme followed for the reconstruction

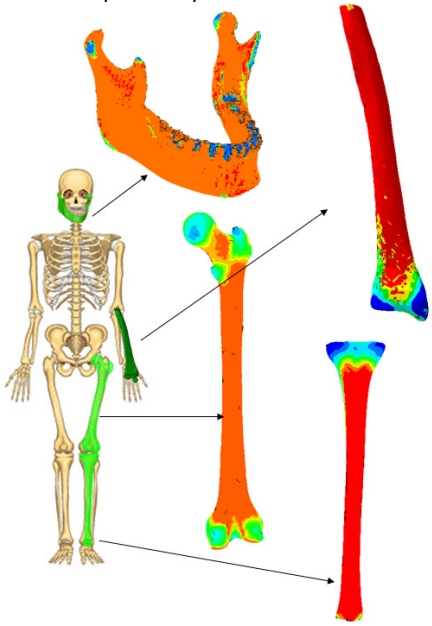

Fig. 2. Bone density distribution predicted using a bone remodelling model.

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