

Prediction of femoral strength using 3D finite element models reconstructed from DXA images: validation against experiments

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Published in: Biomechanics and Modeling in Mechanobiology, 2016

Osteoporosis is a disease of bone which causes many fractures (3.5 million recorded fracture case in the EU in 2010), especially in elderly and women. 3D computational models can provide a more accurate estimation of the specific fracture risk for each individual, thus helping the doctors in better addressing drug therapies to reinforce bones in osteoporotic patients. However, 3D computed tomography (CT) images are needed to build such computational models. A single, 2D, dual-energy X-ray absorptiometry (DXA) image is instead typically acquired in the clinics to diagnose osteoporosis and assess fracture risk.

This paper develops a new procedure to model a subject-specific thigh bone starting from a single 2D DXA image. First, the 3D shape and mineral density distribution of the thigh bone are reconstructed from the 2D image using a statistical tool. Then, 3D computational models are built from the reconstructed images.

The predictions of the numerical model in terms of strains at the surface, and of predicted fracture load are compared against experimental measurements performed on cadaver bones. The results show a good agreement between the computational models and the experimental data. Although our study was performed only on three samples, the proposed method showed the potential to predict bone strength with good accuracy when using computational methods that can easily be combined with the current clinical practice, since they do not require any additional imaging for the patients.