Determination of Mechanic Resistance of Osseous Element through Finite Element Modeling

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Introduction: the main goal of this study is to model and test a human femur through finite element technique, validating the results by comparison with experimental studies.

Anisotropic Bone Analysis: this work was developed using the anisotropic model guided for the next matrix:

$$C = \begin{bmatrix} c_{11} & c_{12} & c_{12} & 0 & 0 & 0 \\ c_{12} & c_{11} & c_{12} & 0 & 0 & 0 \\ c_{12} & c_{12} & c_{11} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{c_{11}-c_{12}}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{c_{11}-c_{12}}{2} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{c_{11}-c_{12}}{2} \end{bmatrix}$$

Where:

$$c_{11} = \frac{E}{1-\mu^2} \qquad c_{12} = \frac{\mu . E}{1-\mu^2}$$

The simulation was performed using the load configuration gives by Cody in order to compare the results objectively.

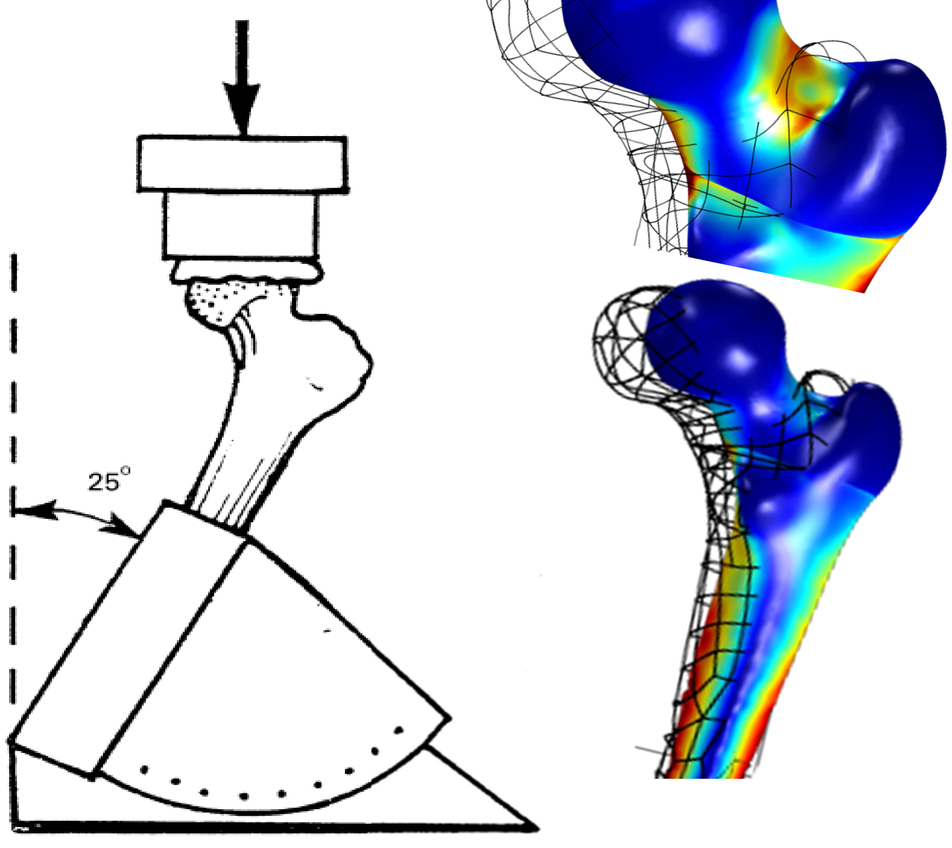

Figure 2: load reference and simulation results using Comsol Multiphysics

Results: the anisotropic model has better correlation to predict the fracture load. The table shown the correlation of the isotropic and the anisotropic models simulated with Comsol and the model of Cody:

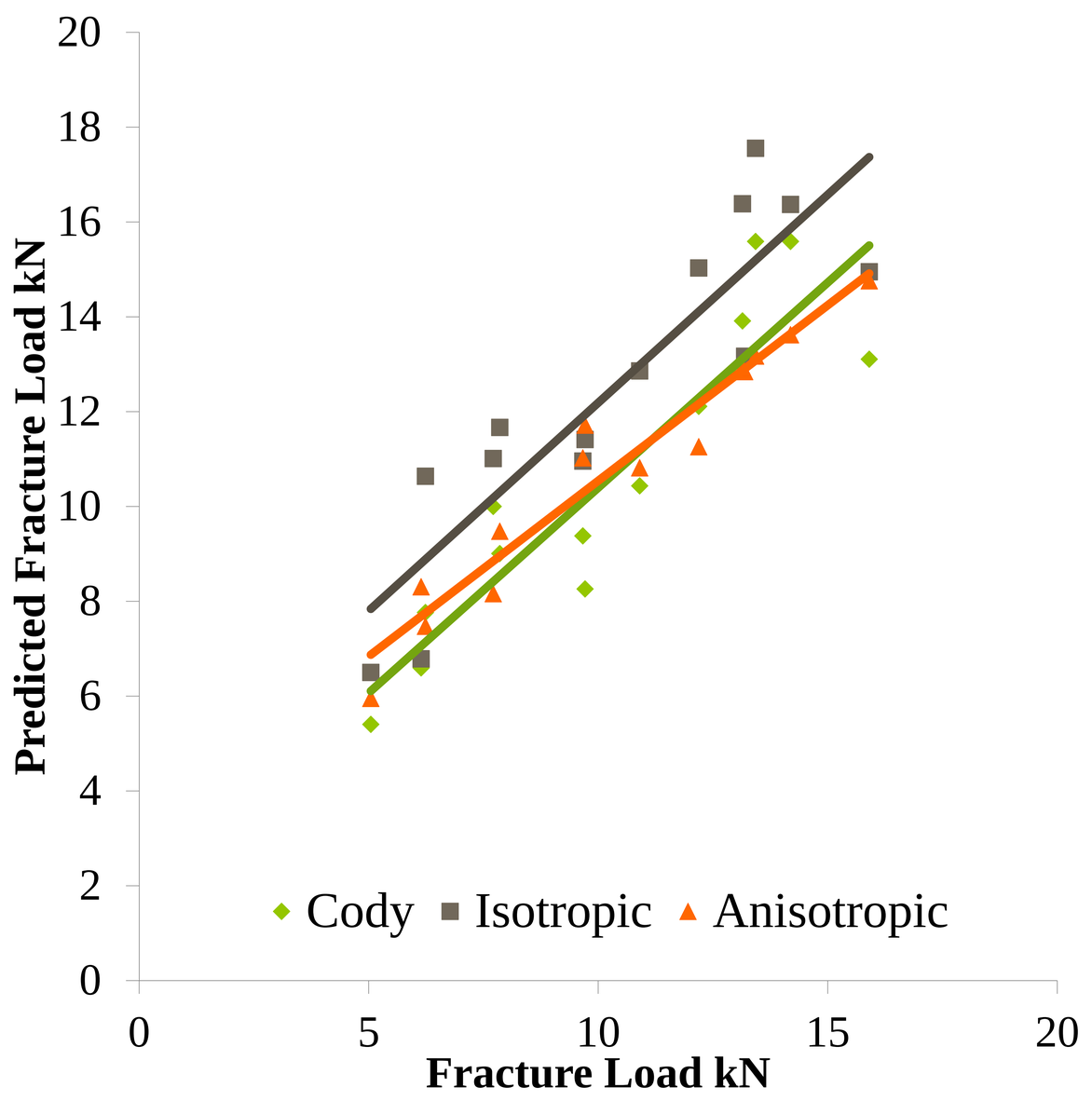

Figure 3: plotted results and comparison with empirical test over real human bones

	Cody	Isotropic	Anisotropic
R^2	0.8354	0.6885	0.9123

Conclusions: the anisotropic model is better to predict the femur fracture. In comparison with other models and the empirical test, the anisotropic model deliver more accurate results.

The mechanical parameter used to develop the simulations was determined as a function of the bone density, giving to this work a parametrical approach to predict the femur failure.

References:

D. Cody, *et al.* Femoral Strength is Better Predicted by Finite Element Models than QCT and DXA. *Journal of Biomechanics.* **Volume 32.** pp. 1013-1020. (1999).

D. Wirtz, *et al.*Critical Evaluation of Known Material Properties to Realize Anisotropic FE-Simulation of the Proximal Femur. *Journal of Biomechanics.* **Volume 33**. pp. 1325-1330. (2000).