FEA applications in clinical orthopaedic oncology - Patient-specific quantitative fracture risk assessment in patients with metastatic tumors in their femur

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ABSTRACT

Patient-specific QCT-based high-order finite element models (*p*-FEMs) accurately predict ex-vivo experimental observations on human femurs, including risk of fracture [1,2]. They account for the exact geometry and inhomogeneous material properties, are created in a semi-automated manner from QCT scans and validated on a large cohort of fresh frozen femurs. QCT-based *p*-FEMs were applied to predict bone strength in patients with bone metastases to their femur [3], demonstrating excellent prediction capabilities. The first part of the talk addresses the methodology to semi-automatically generate the femurs' FEM from CT scans, assign material properties, apply the stance position load and interpret the FE results according to surgeon's need.

Application of FE methodology in clinical practice is subject to obstacles and surprises, however, at the same time is accompanied by tremendous satisfaction when it helps patients and saves pain and agony. The second part of the talk will address the steps required to bring the methodology into clinical practice beginning with a retrospective clinical trial on 33 patients with metastatic tumors to their femur on whom prophylactic surgery was planned. For example, in Figure 1 a radiograph and a *p*-FEA of a 43 years old patient with metastatic breast cancer to the right femur is shown. The prophylactic surgery, may have been unnecessary, based on bone strength analysis. Cases analyzed during the clinical trial and the potential use of *p*-FEA in clinical practice will be presented.

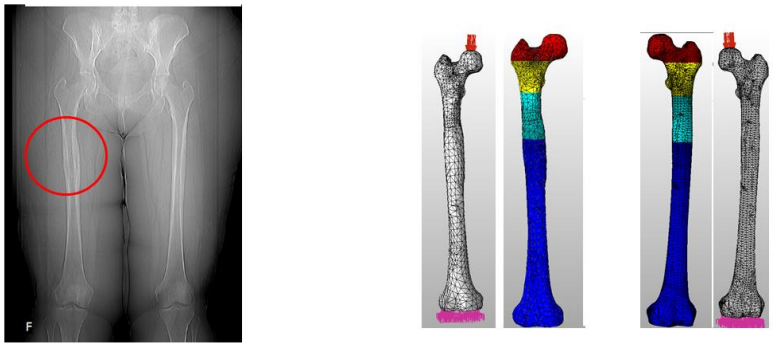

Figure 1. Left: Radiograph of a 43 years old female (weight of 120kg) with metastatic tumor in the right femur. Right: p-FEA of the femurs representing stance position (colors - vertical displacements).

REFERENCES

[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.

[2] Z. Yosibash, et al. Predicting the yield of the proximal femur using high order finite element analysis with inhomogeneous orthotropic material properties. *Phyl. Tran. of the Roy Soc.: A*, **368**:2707-2723, 2010.

[3] Z. Yosibash, et al. Predicting the stiffness and strength of human femurs with realistic metastatic tumors. *Bone*, **69**:180-190, 2014.