ABSTRACTS BOOK

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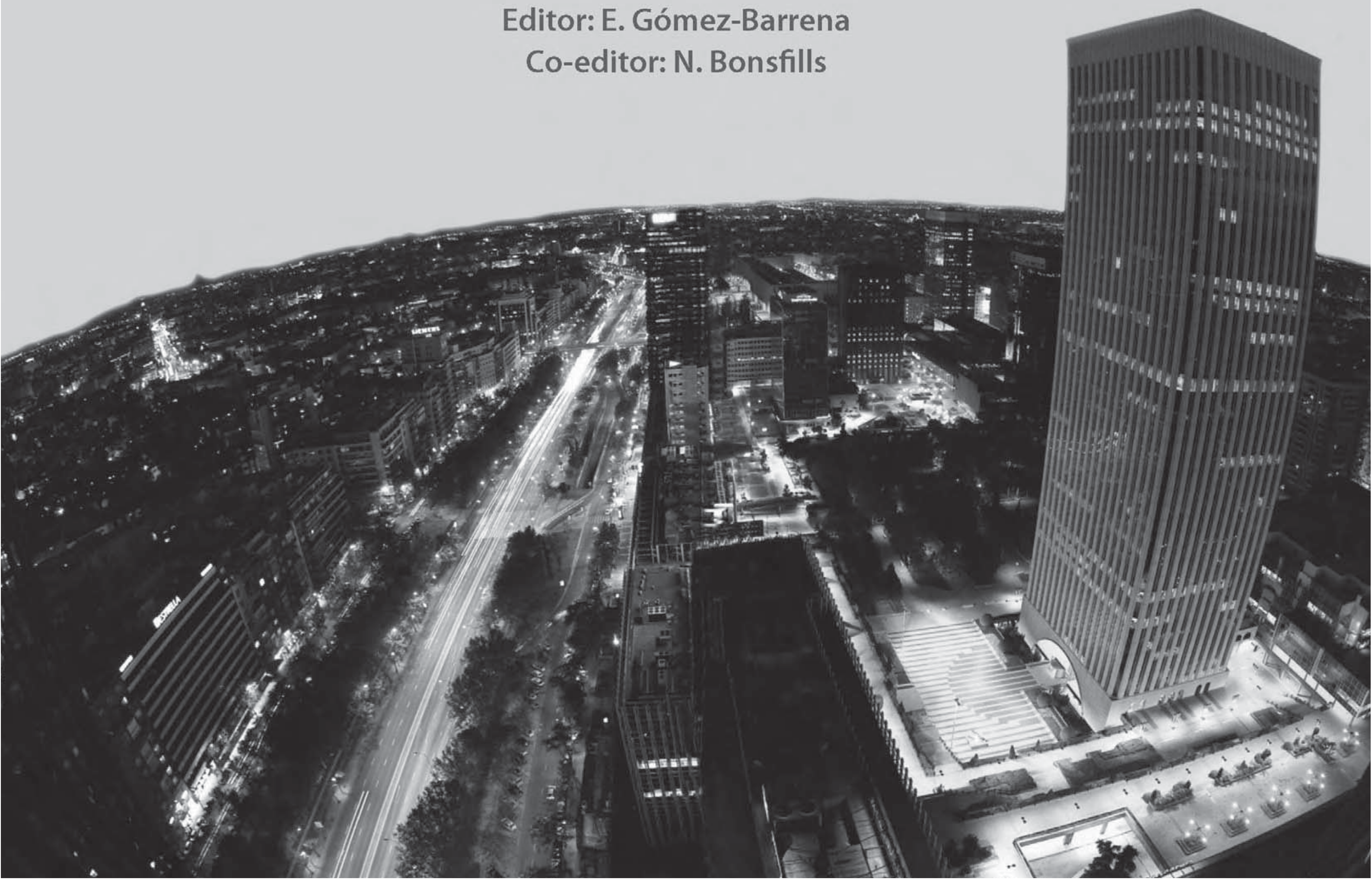

ORAL SESSION 1 **Aula Magna**
Hip Implants 1 **10:00 - 10:50 h O 001-005**

O-001

CASE SPECIFIC FINITE ELEMENT MODELS PREDICT FEMORAL FAILURE RISK BETTER THAN EXPERIENCED PHYSICIANS

J.B. van Aken (1); N. Verdonschot (1,2); H. Huizenga (1); J.G. Kooloos (1); E. Tanck (1)
1. Radboud University Nijmegen Medical Center, The Netherlands; 2. University of Twente, The Netherlands.
E.Tanck@orthop.umcn.nl

Introduction

Bone metastases occur in about 15% of all cancer cases. Pathological fractures that result from these tumours most frequently occur in the femur. Unfortunately, it is extremely difficult to determine the fracture risk with the current X-ray methods, even for experienced physicians. As a result, many patients are surgically over-treated, whereas some patients, who are defined to be at low risk, may fracture their bones [1]. The purpose of this study was to develop a femur (patient) specific finite element model to improve the prediction of failure risk under stance loading. In addition, we tested if our model was better in predicting failure risk under stance loading than experienced physicians.

Methods

Eight human cadaver femora, with and without simulated metastases, were CT-scanned (Philips, ACQsim, 120kV, 220mAs, 3mm slices). A solid calibration phantom (Image Analysis, 0, 50, 100 and 200 mg/ml calcium hydroxyapatite) was included in each scan. From the scans, eight finite element (FE) models were generated using brick elements with sizes of about 1x1x3 mm. The ash density of each element was computed from the calibrated CT scan data. Using ash densities, non-linear isotropic mechanical properties were implemented [2].
After scanning, laboratory experiments were performed. The femora were loaded under compression until failure. During the experiments the failure forces and the course of failure were registered. These experiments were simulated in the FE-models, in which plastic deformation simulated failure of the bones. The relationship between the experimental failure force and predicted failure force was determined using Pearson's correlation.
Five experienced physicians, three orthopaedic surgeons, one musculoskeletal radiologist and one radiation oncologist, were asked to rank the femora on strength using X-rays (AP and ML) and additional information on gender and age.
The Spearman's rank correlation coefficients was calculated between prediction and experiment for both the FE-model and the expert rankings to compare the performance of the physicians.

Results

A strong correlation (r2 = 0.93) was found between the experimental failure force and predicted failure force (Fig 1). The course of failure, visible by the plastic deformation, showed similarities with the failure locations found in the experiments (Fig 2).

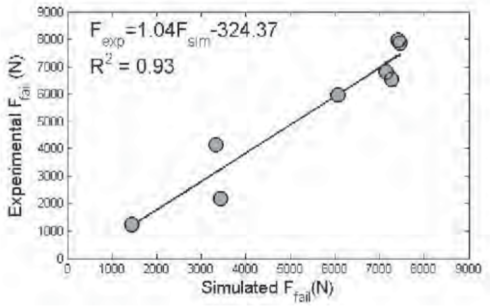

Fig1: Pearson's correlation between experiment and FE-simulation was r2= 0.93.

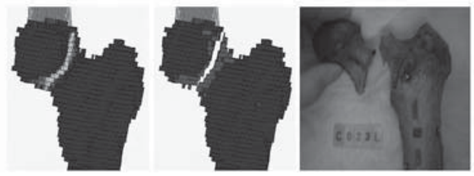

Fig2: Failure location in FE-model and experiment

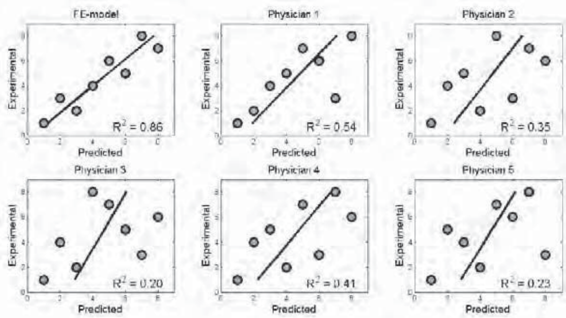

Fig3: The FE-model shows the best Spearman's rank correlation between the experiment and prediction

The Spearman's rank correlations between experiment and predictions ranged between r2=0.23 and r2=0.54 for the physicians, whereas it was significantly higher, r2=0.86, for the FE-model (Fig 3).

Discussion

In daily practice, the prediction of fracture risk has been mainly based on X-rays. We showed that femur specific FE models better predicted femoral failure risk under axial loading than experienced physicians. When the model is further improved by adding, for example, other loading conditions, it can be clinically implemented to predict in vivo fracture risk for patients suffering, for example, bone metastases or osteoporosis.

References

1. *Van der Linden et al, JBJS, 86B:566-573, 2004.*
2. *Keyak et al, Clin Orthop Rel Res, 437:219-28, 2005.*