ESTIMATION OF FEMORAL FE STRENGTH FOR THE FRACTURE PREDICTION IN RETROSPECTIVE AND PROSPECTIVE STUDIES

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Introduction

Finite element (***FE***) models (***FEM***) from CT data are promising to assess bone strength (***FEBS***) and the risk of fracture in-vivo. They have demonstrated a high accuracy in predicting bone strains and bone strength in-vitro. However, when tested on clinical cases [Amin, 2011; Keyak, 2011; Orwoll, 2009] they did not show a clear superiority over areal bone mineral density (aBMD). The aim of this work is to explore the clinical predictivity of ***FEBS*** derived from a validated subject-specific ***FEM*** procedure [Schileo, 2008] in a case-control retrospective study (***RS***) and in a nested case-control prospective study (***PS***).

Methods

Retrospective Study: 22 incident low trauma proximal femur fractures (***F***) and 33 controls (***NF***) were enrolled at Istituto Ortopedico Rizzoli. All patients were osteopoenic or osteoporotic and received a full femoral CT (in acute conditions for fractured cases) and a DXA exam.

Prospective study: 21 women on which proximal femur fractures (***F***) were prospectively observed, and 45 sex and age-matched controls (***NF***) were selected from the AGES-Reykjavik Study. For each individual, baseline proximal femur CT scans and simulated DXA aBMD values from QCT were available.

The ***FE*** models were generated from CT [Schileo, 2008]. ***FEBS***, evaluated in a number of quasi-axial configurations to mimic the in-vivo variability of hip reactions, was defined as the minimum load inducing on the femoral neck surface an $\varepsilon > \varepsilon_{lim}$ [Bayraktar, 2004].

We tested the ability of ***FEBS*** and aBMD to: 1) discriminate between fracture cases and controls; 2) individually classify cases at risk.

Results and Discussion

In both studies, ***FEBS*** had a limited correlation with aBMD (Spearman r~0.5 vs ~0.8 reported in [Orwoll, 2009; Amin, 2011]).

FEBS and aBMD showed a lower mean value in ***F*** group compared to the ***NF*** group in both studies. The mean differences were: 1) notably higher for ***FEBS*** in the ***RS*** (33%, $p < 0.0001$, vs 12% for aBMD, $p = 0.01$); 2) slightly higher for ***FEBS*** in the ***PS*** (19%, p-value <0.0003, vs 15% for aBMD, p-value <0.004). The mean ***FEBS*** differences were higher than [Keyak, 2011].

To test the ability of ***FEBS*** and aBMD to individually classify cases, logistic regressions and ROC curves were derived for ***FEBS*** and aBMD obtaining: 1) in the ***RS***, a superiority of ***FEBS*** vs aBMD in classifying ***F*** and ***NF*** (AUC=0.88 vs 0.71, higher than [Amin, 2011]) and 2) in the ***PS***, a slightly better performance for ***FEBS*** than aBMD (AUC=0.78 vs. 0.72). though the maximum classification ability reached so far in this study (AUC=0.80, combining ***FEBS*** and aBMD in the regression) does not improve over the existing literature. However, when including both ***FEBS*** and aBMD in the regression, in both studies only ***FEBS*** was retained as statistically significant.

These results confirm the potential of the proposed ***FE*** method to clinically identify fractured cases, despite two limitations: 1) in the ***PS***, the change of bone material properties with time was not modelled (future work); 2) in both ***RS*** and ***PS***, falls to the side were not modelled (ongoing).

References

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