GENDER DIFFERENCES IN THE IN-VIVO PREDICTIVITY OF BONE FRACTURES THROUGH FE-BASED BONE STRENGTH

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Introduction

Evidence based studies show that osteoporotic fractures significantly affect also men and not only women [Szulc, 2012]. In both genders, the predictivity of the quantitative tools (bone mineral density (BMD) and/or derived indices e.g. FRAX) routinely used to assess the risk of fracture of an individual, is far from ideal [Tremolliers, 2010].

Bone strength derived from CT-based finite element models (***FEBS***) has been recently tested as a bone fracture risk predictor on clinical cohorts [Amin, 2011; Keyak, 2011; Orwoll, 2009], showing a similar performance to BMD and no differences between genders.

A similar ***FEBS*** approach, but based on a different, validated FE modelling procedure [Schileo, 2008] has recently showed a possible improvement over BMD in a retrospective study on women [Falcinelli, 2012].

The aim of this work is to evaluate the clinical predictivity of ***FEBS*** (as per [Falcinelli, 2012]) on men and women in a nested case-control study taken from a longitudinal prospective study (AGES-Reykjavik Study).

Methods

A total of 105 subjects were included: i) 13 men and 21 women were randomly selected from those that suffered hip fracture (F) during the follow-up period; ii) 26 men and 45 women as control subjects (NF-age and gender matched with F and not statistically significant differences in weigth and heigth between 2 groups). Baseline proximal femur CT scans and simulated DXA aBMD values from QCT were available for all.

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 F and NF; 2) individually classify cases at risk.

Results and Discussion

Significant gender differences were observed in the FEBS (but not BMD) predictivity.

Women cohort: both ***FEBS*** and aBMD indices clustered F and NF cases, with a better performance for ***FEBS*** (mean in F 19% lower than in NF, p=0.0003) vs. neck, total, trochanteric aBMD indices (F 8%, 14% and 15% lower than NF, p 0.12, 0.01 and 0.004). Logistic regression models applied to test the ability to individually classify cases confirmed the result, with an AUC of the ROC curve of 0.78 for ***FEBS*** vs 0.72 for aBMD. AUC was 0.80 when combining ***FEBS*** and aBMD, but only ***FEBS*** was retained significant.

Male cohort: only a subset of the aBMD indices significantly clustered F and NF cases (F 13-17% lower than NF, p-value ranging from 0.056 to 0.0073), while ***FEBS*** was only 5% lower in F, with p-value not significant. In logistic regressions the max AUC was 0.76 for aBMD, while ***FEBS*** was not significant.

In summary, in women we confirmed, in a prospective study, an improvement of ***FEBS*** over BMD. The mean ***FEBS*** differences for F and NF were also higher than [Keyak, 2011], and ***FEBS*** estimate may be further improved by incorporating a bone remodelling model. Conversely, for men we can conclude (with a caveat related to the low sample numerosity) that BMD retained a similar predictive ability with respect to women, confirming what previously found in similar studies, while the proposed ***FEBS*** calculation was not able to discriminate cases from controls.

References

Amin et al, JBMR, 26:1593-1600, 2011
Bayraktar et al, J Biomech, 37: 27-35, 2004
Falcinelli et al, J Biomech, 45: S541, 2012
Keyak et al, Bone, 48: 1239-1245, 2011
Orwoll et al, JBMR, 24: 475-483, 2009
Schileo et al, J Biomech, 41: 356-367, 2008
Szulc et al, J of Osteoporosis, 2012
Tremollieres et al, JBMR, 25:1002-1009, 2010