BONE FRACTURE RISK: DENSITY AND MICROARCHITECTURE

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1. Introduction

Osteoporosis (OP) is a systemic skeletal disease where an increase in bone fragility is due to low bone mass and micro-architectural deterioration of bone tissue [1], which occur over a long period of time without clinical significance.

Currently, OP diagnosis is mainly based on bone densitometric measurements (BMD in DXA scans) at various sites, but over half of the fragility fractures in the population arise in women that would not be considered at risk based on BMD alone [2]. Therefore, other tools like FRAX [3], which may or may not include BMD, where mainly developed to validate treatment prescriptions. Bone turnover markers are indices of bone remodeling, useful for monitoring the patient assessing the response to therapy and treatment adherence [4].

The cortical BMD accounts for 80% of our skeleton, but bone mechanical resistance strongly depends also on the internal spatial arrangement of bone structure, that has long been considered the second key factor of bone load-bearing capacity, in addition to bone density, Fig.1.

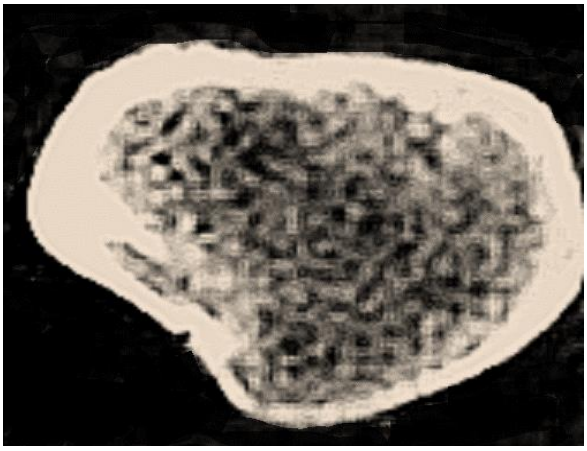

Fig. 1. TC scan femoral neck section from: outer compact part and internal spongeous structure.

In effects, most fractures occur in patients whose T-score is outside the osteoporosis range. DXA might not represent the elective exam, or be completely reliable [5], leading to the hypothesis that fracture risk depends not only on mass loss, but also on bone architecture, whose alterations are an independent factor of increased fragility.

1.1 Bone Elastic Structure Test

The Bone Elastic Structure Test, BESTEST®, is a recently introduced analysis that can be used to quantify the quality of bone micro-architecture and its pathological alterations induced by age, pathological conditions or lack of exposure to physiological mechanical stimuli. The test is based on an application of the Cell Method, a recent discrete method which is particularly effective from the point of view of computation time, memory requirements and accuracy of the results [6,7]. A radiographic virtual biopsy of the patient, acquired in the proximal phalanges of the non-dominant hand, is converted into a structural model and the response to compressive loads along the orthogonal axes is computed, Fig.2.

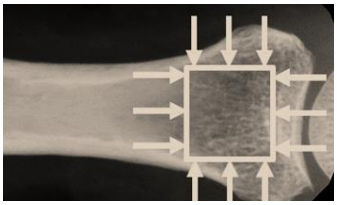

Fig. 2. Virtual biopsy of the patient and simulations.

The results are then combined in an index that gives an indication of the quality of the bone structure, the BSI (Bone Structure Index) [8,9]. Similarly to DXA, the BESTEST results are expressed in terms of BSI_T-score, which compares the patient's BSI with the mean BSI value for young Caucasian women (age 20-45) and measures this difference in number of standard deviations (SD).

Interpretation of BSI results match those typically used in bone density, as shown in Tab.1.

Table 1. Clinical reading of BSI

BSI T-score	Bone Structure Quality
≥ - 1	Normal
< -1 and > 2.5	First level deficiency
< 2.5	Significant worsening

The aim of this study is the comparison of DXA and BESTEST results in a clinical application.

2. Study population.

The examined population consists of 12 Caucasian women, age 39 - 74, Mean (SD) value 62.4 (10.8) years, with a normal or osteopoenic DXA femoral neck and lumbar T-score and a recent osteoporotic fracture. The control population consists of 15 Caucasian women, age 47 - 74, Mean (SD) value 64.7 (8.4) years, who had not suffered from osteoporotic fractures before the bone evaluation in 2015 described in [8], nor in the following three years (as confirmed by interview). The BSI T-score and the DXA femoral neck T-score were available for all the examined subjects.

3. Results

Results are summarized in Figures 2 to 5. As in in previous works [8, 9], there is no correlation between BSI and DEXA- T score. The DEXA T-score (neck) of the two groups was not significantly different (p=0.05). The BSI T-score of the two groups was significantly different (p= 0.0001).

4. Conclusions

Despite the small number of subjects, these data seem to confirm that the BSI could be helpful for predicting fragility fractures and patient monitoring.

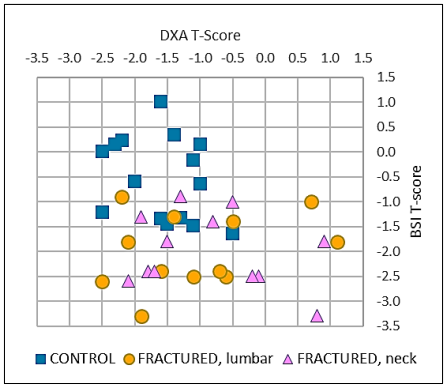

Fig. 2. DXA vs. BSI results are independent.

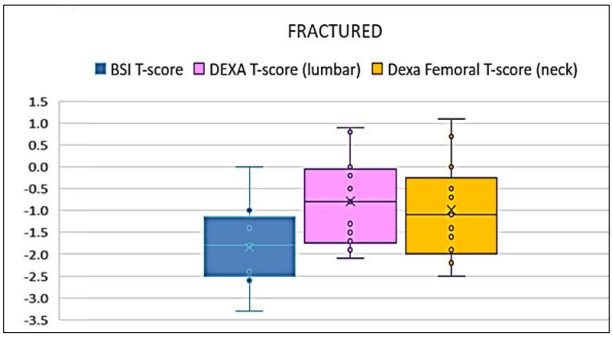

Fig. 3. Fractured group: min, max, mean, SD.

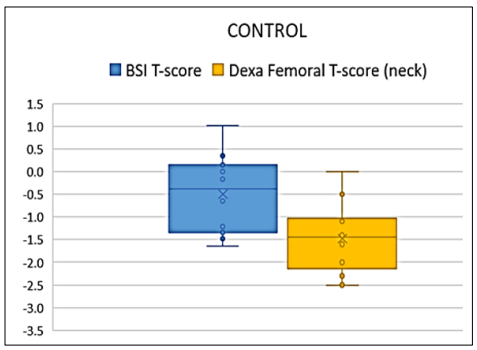

Fig. 4. Control group: min, max, mean, SD.

Conflicts of interest

This work would not have been possible without the cooperation of the patients.

Disclosure: FC is co-founder of M2TEST srl.

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