Preliminary Results on Trabecular Bone Score (Tbs) in Lumbar Vertebrae with Experimentally Altered Microarchitecture

M. Di Stefano[1], G.C. Isaia[1], D. Cussa[2], G.L. Panattoni*[2]

[1] University of Torino, Department of Medical Sciences, Geriatric Section
[2] University of Torino, Department of Neuroscience. *E-mail: gianluigi.panattoni@unito.it

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Abstract

The aim of this preliminary research is to investigate the reliability of a new qualitative parameter, called Trabecular Bone Score (TBS), recently proposed for evaluating the microarchitectural arrangement of cancellous bone in scans carried out by dual energy X-ray absorptiometry (DXA). Vertebral bodies of 15 fresh samples of lumbar spines of adult pig were analysed either in basal conditions and with altered microarchitecture of the cancellous bone obtained by progressive drilling. The examined bony areas do not show changes in bone mineral density (BMD), whereas TBS values decrease with the increasing alteration of the vertebral microtrabecular structure. Our preliminary data seem to confirm the reliability of TBS as a qualitative parameter useful for evaluating the microarchitectural strength in bony areas quantitatively analysed by DXA.

Introduction

Reduction in bone mineral density (BMD) and changes in trabecular bone microarchitecture are the main causes of skeletal fragility in osteoporosis, a metabolic disorder characterized by bone loss and increased risk of fractures mainly in postmenopausal women [1-2]. In addition to clinical factors, the classification of osteoporosis is based on values of BMD in the lumbar spine (in antero-posterior projection) and in the femoral neck. BMD is commonly measured by means of dual energy X-ray absorptiometry (DXA), that utilises two X-ray beams with different energy levels for calculating the different absorptions of soft tissues and bone. DXA is considered to be the most reliable densitometric technique as for spatial resolution, precision, and accuracy [3].

However, DXA is a quantitative method for the diagnosis of bone metabolic disorders and hence it does not allow to evaluate the quality of trabecular microarchitecture, which is a significant pathogenetic factor in osteoporosis [4-6]. Trabecular bone microarchitecture is evaluable by means of expensive techniques as high-resolution magnetic resonance (HRMR) or multislice computed tomography (MSCT) [7, 8]. In this regard, recently Pothuaud L. et al. [9] proposed a new method based on a software applied to DXA, that allows to obtain a parameter, called Trabecular Bone Score (TBS).

The aim of this preliminary study is to investigate the reliability of TBS on isolated bones with experimentally altered trabecular microarchitecture.

Materials and Methods

Analyses were made on 15 fresh samples of lumbar spines of adult pig, that were collected from slaughter and did not show any detectable malformations. Median sagittal scans of the spines were performed by means of a DXA Hologic QDR DiscoveryÒ densitometer.
The scans were carried out directly on 4 lumbar vertebrae of each spine without interposition of water or other media simulating soft tissues. A software specific for TBS evaluation (TBS Inside, MedimapsÒ) was applied to DXA analyses.
Each vertebra was analysed in basal condition and with progressive altered microarchitecture of the cancellous bone of the vertebral body, induced by a progressive drilling in 3 planes (cranial, middle and caudal), symmetric with respect to the intervertebral discs. The holes obtained by drilling measured 5 mm in length and 2 mm in width. BMD and TBS of each vertebral body was analysed in 4 conditions: basal and with 6, 12 and 15 holes (Fig. 1).
The results of DXA analyses were expressed as area (cm2), bone mineral content (BMC, g) and bone mineral density (BMD, g/cm2). TBS was expressed as a number directly proportional to the degree of microarchitectural strength in the examined bony area. (Fig. 2). For each lumbar spine, average BMD and TBS values among the examined vertebrae were calculated and compared to the ones measured in the other spines (paired Student's T test).
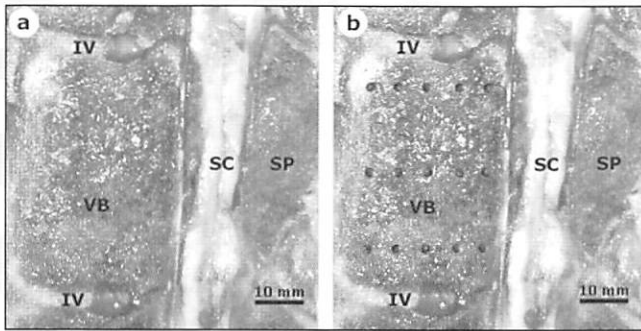
Figure 1. Median sagittal sections of a lumbar vertebral body (VB) of pig, in basal condition (a) and with 15 holes (b). IV: intervertebral disc; SC: spinal cord; SP: spinous process.

a)

TBS L1 - L4: 1.155

Region	TBS
L1	1.208
L2	1.125
L3	1.185
L4	1.103
L1 - L4	1.155
L1 - L3	1.173
L1 - L2	1.167
L2 - L4	1.138
L2 - L3	1.155
L3 - L4	1.144

b)

Figure 2. DXA scan (a) and TBS measurement (b) of lumbar spine with 15 holes in the cancellous bone of vertebral body.

Results

Paired Student's T test showed that the average BMD value of the spines in basal condition (0.49, SD=0.13) did not vary significantly with respect to the ones with 6 holes (0.48, SD=0.12), with 12 holes (0.48, SD=0.11) and with 15 holes (0.49, SD=0.14). In percentage terms, the differences between TBS in basal and altered condition was: basal vs 6 holes: -0.61%; basal vs 12 holes: 0.37%; basal vs 15 holes: 1.74%.

On the contrary, the average TBS value of the spines in basal condition (1.2, SD=0.1) showed differences with respect to the ones with 6 holes (1.17, SD=0.11), with 12 holes (1.14, SD=0.11) and with 15 holes (1.1, SD=0.11). However, these data do not reach statistical significance (p $\geq$ 0.05). In percentage terms, the differences between TBS in basal and altered condition was: basal vs 6 holes -3.42%; basal vs 12 holes: -6.58%; basal vs 15 holes: -9.39%.

Discussion

TBS measures the grey levels variation in 2D images of trabecular bone with the same density, but different microarchitectural arrangement. TBS is obtained by re-analysis of the same bony region of a DXA scan and hence it can be compared to BMD of the aforesaid region [10]. The odds of vertebral fractures in postmenopausal women with low values of BMD, were analysed by TBS measurement [11, 12]. According to these researches, TBS is a reliable parameter for the qualitative assessment of trabecular bone microarchitecture in addition to quantitative DXA analysis.

In our preliminary results obtained on artificially altered vertebral bodies of pig, TBS varies indipendently of BMD. In fact, TBS values decrease with the increasing of the number of holes, while BMD values do not show significant modifications. In this regard, since in our samples statistical dispersion of BMD and TBS values in basal conditions was high, we calculated the percentage differences between these values and the ones in altered conditions. Therefore, our findings seem to confirm the data of literature on the reliability of TBS as a qualitative parameter useful to evaluate the microarchitectural strength in bony areas quantitatively analysed by DXA; however, further experimental studies on a larger number of vertebral samples will be needed to assess with more accuracy its clinical application.

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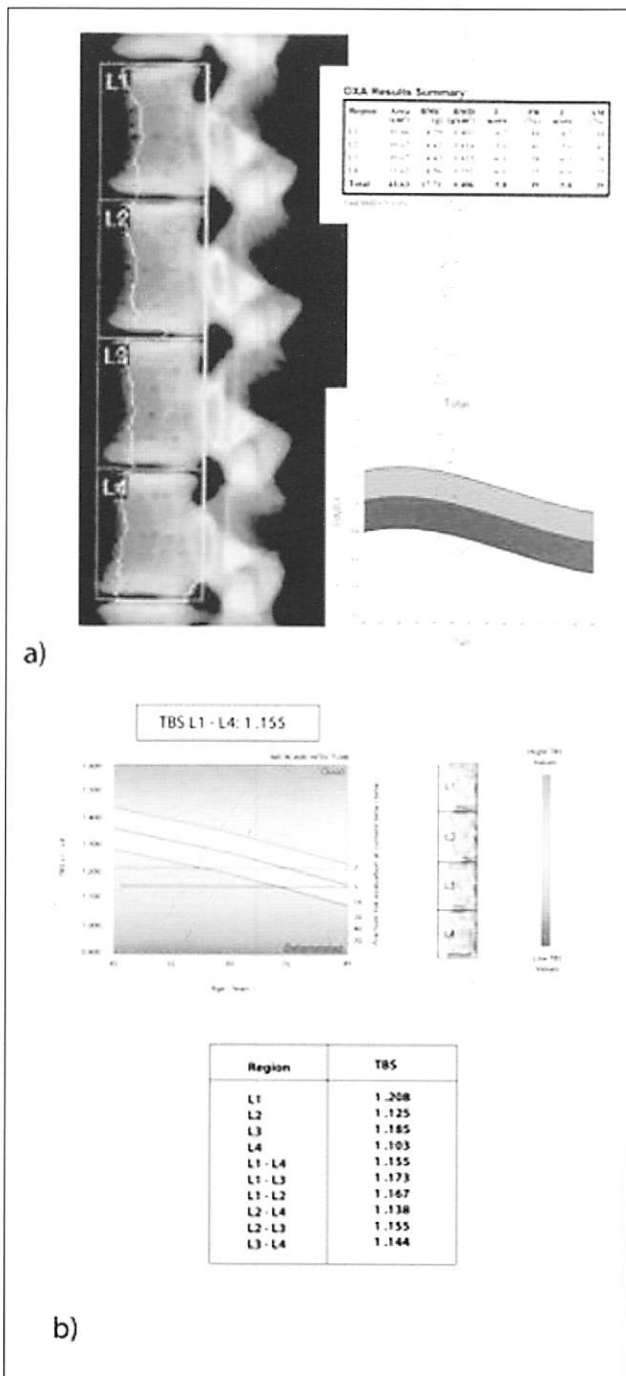
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