TBS ADDED-VALUE
IN CLINICAL CARE PATHWAYS

1- PRIMARY OSTEOPOROSIS

Osteoporosis is a common bone disease characterized by low bone mass and altered bone microarchitecture, resulting in decreased bone strength with an increased risk of fractures. The diagnosis of osteoporosis, currently based on bone mineral density (BMD) which considers only the density of the bone, doesn't provide a measure of bone microarchitecture. However, over 50% of fractures occur in patients non osteoporotic, which can be explained by microarchitecture defects that were not detected by the BMD alone[1]. Collecting information on the trabecular bone structure wasn't possible without complex procedures, expensive technology, pain, and/or extra radiation to the patient.

Trabecular bone score (TBS) is a texture parameter related to bone microarchitecture that provides skeletal information that is not captured from the BMD measurement[2]. TBS predicts osteoporotic fractures independently of BMD[3,4]. Added to the FRAX, the TBS's greatest utility lies in individuals whose BMD levels are close to an intervention threshold (up to 25% of the patients will then be impacted)[5].

TBS has been endorsed by many local, national and international medical societies and guidelines[6–11].

2- SECONDARY OSTEOPOROSIS

Secondary osteoporosis is caused by certain medical conditions or treatments that cause alterations of bone strength, involving bone mass and mostly bone microarchitecture deterioration and resulting in bone fragility and fracture. Since BMD only measures bone mass, providing no information on bone microarchitecture, which is also adversely affected in Secondary Osteoporosis, it can underestimate fracture risk and therefore it may not be sufficient by itself to investigate bone status in these patients[12].

TBS is an important aid in the diagnosis of secondary osteoporosis, and ultimately in the assessment of fracture risk[6,13]. TBS has been proven to be of great value in patients with medical conditions leading to increased fracture risk that cannot be fully explained by the BMD[13]. Main diseases of interest, classified by specialty, are the following:

2.1 ENDOCRINOLOGY

2.1.1 DIABETES

Diabetic patients with poor glycemic control present an elevated risk of fracture but paradoxically their BMD is higher than in healthy patients[13,14]. Poor glycemic control has been associated with high fracture risk and lower TBS values[15,16]. TBS has been shown to be an excellent predictor of fracture risk in diabetic patients, independent of the BMD[17].

The added value of TBS in patients with Diabetes is to better estimate the fracture risk, hence improving the osteoporosis management. As such TBS has been included in the guidelines for the management of Diabetes by the International Osteoporosis Fundation[18].

2.1.2 HYPERPARATHYROIDISM

Primary hyperparathyroidism (PHPT) is a common endocrinopathy often accompanied by bone fragility and elevated risk of fracture which is not fully captured by the BMD[19].

TBS is lower in PHPT patients and associated with vertebral fractures[20]. TBS helps to identify the PHPT patients that are under a risk of fracture[20] to improve the osteoporosis management as such it has been included in the guidelines for the management of Osteoporosis and PHPT[6,21].

2.1.3 TREATMENT WITH GLUCOCORTICOIDS

Glucocorticoids (GCs) are therapeutically used to suppress various allergic, inflammatory and autoimmune disorders and it is one of the most common cause of secondary osteoporosis. GCs treatment increases fracture risk, which is not entirely captured by the BMD[22].

TBS is lower in GCs-treated patients, especially in those with osteoporotic fractures[23]. The added value of TBS in these patients is to help to identify the GCs-treated patients that are under risk of fracture.

2.1.4 CHRONIC KIDNEY DISEASE (CKD)

Patients under advanced stages of CKD have an increased risk of fragility fractures due to alterations on bone strength, involving both bone mass and bone microarchitecture deterioration[24]. As BMD only measures bone mass, providing no information on bone microarchitecture, which is also adversely affected in CKD fracture risk can be underestimated in these patients.

TBS has found to be lower in these patients and it was shown to be a good and independent predictor of fragility fractures in patients with CKD or who underwent kidney transplantation[24,25]. The added value of TBS in CKD clinical practice is to be an assessor of bone microarchitecture and a fracture risk predictor.

2.1.5 ACROMEGALY

Acromegaly is characterized by overproduction of growth hormone, which is associated with increased bone turnover that can lead to increased fracture risk which is not fully captured by the BMD[26], even after treatment[27].

TBS was lower in acromegaly patients than in controls in both genders[26]. Alterations in trabecular bone architecture may explain the persistent fracture risk despite the increase in BMD after treatment[27].

2.2 RHEUMATOLOGY

2.2.1 REUMATOID ARTHRITIS

Patients with Reumatoid Arthritis (RA) are especially prone to develop osteoporosis and fractures, however, most of them occur in patients with bone density above the osteoporotic threshold[28]. This discrepancy may be related to alterations of bone, which are not captured by BMD, that is, changes in bone quality.

TBS has been shown to be lower in patients with RA[28–30], and an excellent predictor of vertebral fractures[29,30], specially in osteopenic patients having RA[29], or on those having glucocorticoids[30].

2.2.2 OSTEOARTHRITIS

The presence of Osteophytes, a common disorder in older patients and those with osteoarthritis, can falsely elevate the BMD measurements leading to misdiagnosis[31].

Unlike BMD, TBS results has been demonstrated to be minimally affected by the presence of osteophytes, providing a more accurate fracture risk assessment[31,32].

2.2.3 SPONDYLOARTHRITIS

Patients with spondyloarthritis (SpA) are at increased risk of pathological vertebral fracture. These patients usually present syndesmophytes, a bony growth inside the ligament, which often results in overestimation of the BMD measurements leading to misdiagnosis[33].

Individuals with axial SpA and fractures had lower TBS scores and the disease activity was associated with low TBS values[33–35]. TBS is not influenced by the syndesmophytes[33] therefore it can help to assess bone quality in this population.

2.3 GYNECOLOGY

2.3.1 MENOPAUSAL HORMONE THERAPY

Menopausal hormone therapy (MHT) is the first-line therapy in the prevention of postmenopausal osteoporosis for the prevention of bone loss in at- risk women before age of 60 or within 10 years after menopause. To maximize anti-fracture efficacy, this treatment should ideally have an effect on both bone mass and bone quality[36].

MHT has been shown to be associated with bone microarchitecture preservation, as assessed by TBS[36]. The added value of TBS in these patients is to monitor the effect of MHT on bone quality.

2.3.2 AROMATASE INHIBITORS TREATMENT

Breast cancer patients treated with aromatase inhibitors are known to have an increased risk of fracture.

These patients present a decrease in TBS independently of BMD[37]. The combination of FRAX®, TBS, and BMD maximizes the identification of patients with risk fracture. The added value of TBS in breast cancer patients is to enhance the detection of patients under risk of fracture[38].

2.4 OTHERS

2.4.1 CARDIOLOGY

Several biological and physiologic evidences have shown a correlation between cardiovascular diseases (CVD) and osteoporosis and fracture risk[39].

TBS has been shown to be lower in patients with CVD[40] or that were under risk (since they showed high levels of CVD markers[39]). TBS can help to assess bone quality in these patients.

2.4.2 SARCOPENIA

Sarcopenia is the loss of muscle mass leading to decreased muscle mass and strength, physical disability, and increased mortality. There has been described a cross-sectional association between osteoporosis and sarcopenia, with the presence of sarcopenia increasing the risk of the osteoporosis by 5 fold[41].

TBS has been found to be significantly correlated with muscle mass, muscle performance, muscle strength and physical performance[41,42]. TBS may help to identify sarcopenic individuals at risk of osteoporosis due to its correlation with declined muscle function.

2.4.3 NEUROFIBROMATOSIS

Neurofibromatosis 1 (NF1) is a genetic disorder that causes tumors to form on nerve tissue. NF1's complications include skeletal problems such as osteoporosis and increased fracture risk[43].

TBS has been shown to be lower in patients suffering Neurofibromatosis[43,44], indicating that TBS could be useful during follow-up for better characterizing bone impairment in these patients.

2.4.4 HIV

HIV-infected patients have an increased fracture risk due to the HIV infection itself and the antiretroviral therapy. However, the risk of fracture is not fully captured by BMD[45,46], indicating that other factors affecting bone strength, such as bone microarchitecture, may be involved.

It has been shown that these patients had lower TBS which is associated with vertebral fractures[45,46]. The added value of TBS in HIV patients is to predict fracture risk more accurately.

2.4.5 ANOREXIA

Patients with anorexia nervosa (AN) exhibit skeletal or fragile bones, and a significantly higher risk of fractures compared to healthy controls. TBS has been shown to be very low in anorexic patients[47], even in those with normal levels of BMD[48].

3- SPORTS

Monitoring bone health is very important in athletes to prevent injuries. TBS helps to monitor bone health in athletes undergoing different types of sports[49,50]. A pilot study has demonstrated that TBS could predict stress fractures in elite sports players[51].

4- ORTHOPEDICS

Since orthopedic implants are fixed in the trabecular bone area, monitoring bone quality is key.

TBS has been related with different parameters of bone strength and bone quality[2]. Bone microarchitecture is related to the mechanical strength of bone and hence its greater or lesser risk of fracture[2,52]. The added value of TBS in Orthopedics is to assess and monitor bone quality in patients undergoing orthopedic surgery. TBS has been recently acknowledged in the ISCD guidelines for Orthopedic Surgery[53].

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