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Comparison of the total and best regional trabecular bone scores and the value of adding the trabecular bone score with bone-mineral densitometry

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Abstract

- Introduction: Osteoporosis is one of the most common disorders. It affects many people, especially older women. Thus, an accurate diagnosis of osteoporosis is important. Bone-mineral densitometry (BMD) and trabecular bone score (TBS) are two methods that can be used to diagnose osteoporosis.
- Objectives: The aim of this study was to investigate the similar rule of BMD in TBS.
- Patients and Methods: This retrospective descriptive study was performed on 2,106 patients who had been referred to a hospital in Iran. The age, gender, body mass index (BMI), and TBS values for L1 to L4 and L1–L4 were recorded from the patients' files. The data were then compared.
- Results: Four hundred patients were enrolled in the study. Around 13.8% were male and 86.3% were female. The mean age of the females was 53.83 years ± 10.16 years, while the mean age of the males was 54.04 years ± 10.92 years. There was a statistically significant difference in the mean TBS from all regions between the research groups (P = 0.001). The mean TBS in females < 50 years old was significantly higher than the mean TBS in females > 50 years old and in males (P < 0.001). There was also a statistically significant difference in the best regional mean TBS between the research groups (P < 0.001). The lumbar spine TBS had a negative correlation with BMI in females, but not in males.
- Conclusion: For the majority of patients, TBS can be used according to the BMD guidelines or it can be used separately to diagnose osteoporosis.
- Keywords: TBS, BMD, osteoporosis

Implication for health policy/practice/research/medical education:

- Although bone-mineral densitometry is a basic method used for the diagnosis of osteoporosis, trabecular bone score is a new technique that can also be used. In this study, we aimed to investigate the differences between trabecular bone score and bone mineral density, and to determine the factors that correlated with trabecular bone score.

Introduction

Osteoporosis is a skeletal disorder that is associated with weakened bones and an increased susceptibility to fractures. It is a major global health concern (1, 2). Bone mineral density (BMD) is commonly used to diagnose osteoporosis and to assess the need for therapy in at-risk patients. BMD is also used to assess the treatment responses of patients. Clinical studies use BMD to evaluate the effectiveness of osteoporosis treatments (3). At any point in a person's life, the adult bone mineral content depends on the peak bone density reached during growth and subsequent bone loss. Thus, a low BMD can result from a lack of bone absorption, rapid bone loss, or both (4). The gold standard for diagnosing osteoporosis is bone densitometry (5, 6). When the BMD is low in untreated, postmenopausal women, the risk of fracture is high (7). With the exception of measurements taken from the spine and hip, which have better predictive abilities for fractures in the spine and hip, respectively, most BMD measurement sites have a similar predictive ability for fractures. It should be noted that there is a broad overlap in BMD scores between patients who have sustained osteoporotic fractures and those who have not sustained fractures. Studies on osteoporotic fractures have found that more than 50% of postmenopausal women who have a hip fracture had T-scores higher than –2.5 (8, 9).

One limitation of BMD measurements is that the intervention thresholds vary depending on patients underlying condition. For example, patients with glucocorticoid-induced osteoporosis may have a higher risk of developing fractures than their postmenopausal counterparts with similar BMD values. In addition, compared with age-matched controls, patients with type 2 diabetes and a high mean BMD are more at risk of non-vertebral fractures, such as the hip, proximal humerus, and foot, but not vertebral fractures (10, 11).

The trabecular bone score (TBS), which is determined using a special imaging technique, is a bone texture index that provides additional skeletal information to the standard BMD measurements (12). TBS is a gray-level texture measurement that is obtained from 2D-projection image experimental variograms, and involves quantifying. The gray-level texture variation from one pixel to adjacent pixels. The gray-level texture represents what different compound of values of pixel or gray levels co-occur in a photograph (13). TBS is not a direct assessment of bone microarchitecture, but is related to 3D bone characteristics, such as the trabecular number, trabecular separation, and density of connectivity (14, 15). Similar to the BMD, the TBS for the lumbar spine is an age-dependent predictor of osteoporotic fractures (16).

Objectives

- The aim of this study was to assess the similar rule of BMD to TBS.

Study design

- In this retrospective descriptive study, we assessed the TBS in a discrete manner for BMD. We reviewed the BMD and TBS values of 2,106 patients who had been referred to Resalat and Loghman Hakim hospitals, Tehran, Iran. Of 2,106 patients, 400 were enrolled in the study. The inclusion criteria were as follows; the patients were 20–70 years old; and the BMD rule was observed. The BMD rule applies when the value is lower than 1.200 and indicates that it increases from L1 to L3 and decreases from L3 to L4. The exclusion criteria were that the patients were > 70 years old or < 20 years old, and that they did not follow the BMD rule.
- After choosing participants for the study, we recorded the age, gender, body mass index (BMI), and TBS values for L1, L2, L3, and L4, and for L1–L4. The best region for the TBS was determined to be the region in which the value increased from L1–L3 or decreased from L3 to L4. If any of the values did not follow the rules, the previous region was determined to be the best region. If all the vertebrae followed the rule, L1–L4 was determined to be the best region. The result region was determined to be the TBS value from L1–L4 based on the following scoring. In addition, the TBS value was taken from the best region based on the following scoring. Patients were classified into three categories on the basis of the TBS values; the normal microarchitecture (NM) group had a TBS > 1.350; the partially degraded microarchitecture (PDM) group had 1.200 < TBS < 1.3500; and the fully degraded microarchitecture (FDM) group had a TBS < 1.200. All data were recorded and analyzed.

Ethical issues

- The research followed the tenets of the Declaration of Helsinki. The ethics committee of Shahid Beheshti university of medical sciences approved the study protocols, as well as this study. Written informed consent was provided by all participants before any interventions were performed.

Results

This study involved 400 people: 55 males (13.8%) and 345 females (86.3%). The mean age of the participants was 53.85 years ± 10.26 years; the youngest patient was 21 years old and the oldest patient was 76 years old. The mean age of the males was 54.04years ± 10.92 years and the mean age of the females was 53.83 years ± 10 years. A total of 129 patients (32.3%) had a normal BMI and 271 (69.1%) had an abnormal BMI, since 4 patients (1%) were underweight, 164 patients (41%) were overweight, and 103 patients (25.8%) were obese.

The patients were divided into three groups. Group 1 consisted of 103 females (25.8%) who were < 50 years old. Group 2 consisted of 242 females (60.5%) who were ≥ 50 years old. Group 3 consisted of 50 men (13.8%). Evaluations were performed on these three groups.

Some patients in each group had an abnormal BMI . Around 63 females (61.2%) in group 1; 170 females (70.2%) in group 2; and 38 males (69.1%) in group 3. There was no statistically significant difference in the ratios of individuals with an abnormal BMI between the three study groups (P = 0.249; Figure 1).

Table 1 shows the mean TBS taken from different regions for each study group. The mean TBS for group 1 in L1 was 1.42 ± 0.104, 1.45 ± 0.098 for L2, 1.44 ± 0.094 for L3, 1.38 ± 0.092 for L4, and 1.42 ± 0.083 for L1–L4. The mean TBS for group 2 was 1.31 ± 0.127 for L1, 1.35 ± 0.109 for L2, 1.33 ± 0.099 for L3, 1.28 ± 0.105 for L4, and 1.32 ± 0.094 for L1–L4. There was a statistically significant difference in the mean TBS between the study groups for all areas (P<0.001). In addition, the results of Tukey's multiple comparison tests for each region showed that the mean TBS in group 1 was significantly higher than the mean TBS for the other groups (P < 0.001 was observed for all binary comparisons between group 1 and groups 2 and 3).

There was no significant linear relationship between age and TBS for the different regions in males. However, the TBS decreased significantly with age in females(r = –0.473 for L1, r = –0.471 for L2, r = –0.511 for L3, r = –0.454 for L4, and r = –0.541 for L1–L4). The results are shown in Table 2.

For group 1, there was no statistically significant difference between the BMI and the mean TBS in L1 (P = 0.224). However, the mean TBS in females with a normal BMI was statistically significantly higher than in females with an abnormal BMI for all other regionsL2 (P = 0.009), L3 (P = 0.007), L4 (P = 0.034), and L1–L4 (P = 0.013).

In group 2, there was no statistically significant difference in the mean TBS in L2 between females with a normal or an abnormal BMI (P = 0.125). However, the mean TBS for the other regions was statistically significantly higher in females with a normal BMI than in females with an abnormal BMI in L1 (P = 0.027), L3 (P = 0.004), L4 (P = 0.001), and L1–L4 (P = 0.005).

In group 3, the mean TBS was higher in males with a normal BMI compared with males with an abnormal BMI. However, there was no statistically significant difference for all regions: L1 (P = 0.184), L2 (P = 0.613), L3 (P = 0.991), L4 (P = 0.129), and L1–L4 (P = 0.332). The results are shown in Table 3.

Of 400 patients, 27 (6.75%) did not have a best region because their TBS did not follow the rule; 7 patients were in group 1, 19 patients were in group 2, and 1 patient was in group 3. There was a statistically significant difference for the mean TBS from the best region between all groups (P < 0.001). It was significantly higher in group 1 than in group 2 (P < 0.001) and group 3 (P <0.001).

In addition, there was no statistically significant difference in the mean TBS from the best region in terms of BMI for group 1 (P = 0.741), group two (P = 0.240), and group 3 (P = 0.304). The results are shown in Figure 2.

In terms of the classification of patients using the TBS results, in group 1, 7 patients (6.8%) were unknown because their TBS did not follow the rule, 81 patients (76.8%) were NDM , 13 patients (12.6%) were PDM, and 2 patients (1.9%) were FDM. The result region in 88 patients (85.4%) was NDM, in 14 patients (13.6%) was PDM, and in one patient (1%) was FDM. For the classification of group 2 according to the TBS results, 19 patients (7.9%) were unknown, 103 patients (42.6%) were NDM, 93 patients (38.4%) were PDM, and 27 patients (11.2%) were FDM. The result region in 92 patients (38%) was NDM, in 124 patients (51.2%) was PDM, and in 26 patients (10.7%) was FDM. The classification for group 3, based on the TBS results, was as follows; one patient (1.8%) was unknown, 21 patients (38.2%) were NDM, 30 patients (54.5%) were PDM, and three patients (5.5%) were FDM. The result region in 22 patients (40%) was NDM, in 29 patients (52.7%) was PDM, and in four patients (7.3%) was FDM. There was a significant agreement between the results of these two quantities in terms of weighted kappa. Therefore, for women < 50 years old (group 1), the weighted kappa = 0.881, 95% CI (0.769–1; P <0.001); for women > 50 years old (group 2), the weighted kappa = 0.715, 95% CI (0.637–0.794; P < 0.001); and for men (group 3), the weighted kappa = 0.845, 95% CI (0.714–0.976; P <0.001). Figure 3 shows the results.

The data showed that the TBS decreased from L1 to L2 in 116 patients (29%), remained unchanged in two patients (0.5%), increased by a maximum of 10% in 227 patients (56.8%), and increased by more than 10% in 55 patients (13.8%). The TBS decreased from L2 to L3 in 238 patients (59.5%), remained unchanged in five patients (1.3%), increased by a maximum of 10% in 145 patients (36.3%), and increased by more than 10% in 12 patients (3%). The TBS decreased by a maximum of 10% from L3 to L4 in 102 patients (25.5%), decreased by a maximum of 10%, and decreased by more than 10% in 53 patients (13.3%). In total, changes in L1 to L3 were associated with an increase in TBS in 233 patients (58.3%), while changes in L3 to L4 were associated with a decrease in TBS in 298 patients (74.5%). The TBS increased in 197 patients (49.3%) from L1 to L3 and decreased from L3 to L4.

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Discussion

- In this retrospective descriptive study, we assessed the TBS and BMD data of 400 patients. We observed that there was a relationship between younger women and high TBS values. In fact, the TBS was higher for all regions in women < 50 years old. Schousboe et al also observed a relationship between high TBS and age (17). Thus, our study was similar in terms of the effect of age on the TBS.
- Ho-Pham et al found that the average TBS was higher in men than in women (18). In the current study, women < 50 years old had higher mean TBS values than men. These results showed the effect of menopause on the TBS because both studies found that patients who were > 50 years old were associated with a lower TBS. The present study found that there was a statistically significant relationship between age and decreasing TBS in women, although there was no similar relationship in men. Dufour et al found that TBS decreased with increasing age in both genders, which conflicted with the results of our study (19). However, Dufour et al also reported that patients with a high BMI had a lower TBS, which agreed with the findings of the current study. In the current study, we also found that patients with a normal BMI had a higher TBS.
- Kim et al found that there was a significant relationship between BMI and TBS in both sexes (20). They also reported that the correlation coefficient increased in the male participants from the normal group to the osteoporosis group. They found a significant positive correlation between height and TBS in females, while a significant negative correlation was found between weight and TBS in males. These results differed from our findings, which indicated that BMI had no significant correlation with TBS. However, because the BMI is related to height and weight, there should be a correlation between TBS and height and weight, as reflected in the BMI. In the current study, we observed no correlation between BMI and TBS in males, although there was a significant correlation between BMI and TBS in females. This correlation was similar to the findings of Kim et al(20).
- In the current study, the TBS values associated with lumbar vertebrae were assessed. More than 65% of patients showed an increase of 10% or greater in TBS from L1 to L2. From L2 to L3, 39% of patients showed an increase of 10% or more in TBS, while 60% of patients demonstrated a decrease in TBS. From L3 and L4, 75% of patients showed a decrease in TBS.
- Roux et al observed that there was no correlation between TBS and BMD (21). However, we observed that TBS can be used as a measure of bone marrow structure. The values of TBS in the patients in the current study were very similar to the values of BMD.

Conclusion

- The TBS of the lumbar spine had a negative correlation with the BMI in women, but did not have any correlation with the BMI in men. There was a significant difference in the values of TBS in women who were < 50 years old and those > 50 years old; younger women had a higher TBS in their lumbar vertebrae than older women. Additionally, there was no relationship between age and TBS values in the lumbar vertebrae of men. TBS followed a similar rule as BMD in most patients and, thus, can be used as a solitary.

Table 1. Mean TBS from different regions by study group

Group	Female < 50 years old	Female ≥50 years old	Males	P value
Variable	Mean ± SD	Mean ± SD	Mean ± SD	
L1	1.42 ± 0.104	1.31 ± 0.127‡	1.31 ± 0.111‡	< 0.001
L2	1.45 ± 0.098	1.35 ± 0.109‡	1.37 ± 0.104‡	< 0.001
L3	1.44 ± 0.094	1.33 ± 0.099‡	1.36 ± 0.098‡	< 0.001
L4	1.38 ± 0.092	1.28 ± 0.105‡	1.32 ± 0.099‡	< 0.001
L1–L4	1.42 ± 0.083	1.32 ± 0.094‡	1.34 ± 0.099‡	< 0.001

‡Statistically significant compared with group 1.

Limitations of the study

One limitation of this study was the patients' dissatisfaction with participating in the project.

Authors' contributions

AR, PD, SH were the principal investigators of the study. AR and SH developed the concept and the design; AR, PD, and SH revisited the manuscript and critically evaluated the intellectual contents. All authors participated in revising the manuscript, preparing the final draft, and critically evaluating the intellectual contents. All authors read and approved the content of the manuscript and confirmed the accuracy and integrity of the work.

Ethical considerations

Ethical issues, including plagiarism, data fabrication, and double publication, have been completely observed by the authors. .

Conflict of interests

All authors declare they have no conflict of interests.

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