Original paper

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Vertebral fracture assessment, trabecular bone score and handgrip in a group of postmenopausal women with vertebral fractures – preliminary study

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Abstract

Objectives: The aim of our study was to determine a possible correlation between vertebral fractures (indicated by VFA – vertebral fracture assessment), TBS (trabecular bone score) and muscle strength (measured by means of handgrip strength test results) in a group of postmenopausal women.
Material and methods: The study was conducted between 2014 and 2015 in a group of patients of Krakow Medical Centre (KMC). Women who participated in the study were referred to KMC by an attending physician for suspected vertebral fracture. Apart from VFA, patients were additionally tested for bone density (including TBS), muscle strength (by means of a handgrip strength test) and height loss. Altogether 35 patients with an average age of 69.7 years (49–95, SD = 10.49) were included in the study.
Results: In the group of 35 women, VFA analysis demonstrated vertebral fractures in 17 patients (40%). Vertebral height loss suggesting a fracture was revealed in 77 vertebrae. The mean result of the TBS was 1.195 (0.982–1.409, SD = 0.09), which suggests high risk of fracture. The majority of the subjects (65.7%) displayed major bone microarchitecture degradation (TBS < 1.23) and also the highest number of fractures (n = 62, 80.5% of all). There was no correlation between the spine bone mineral density (BMD) score and the TBS result, which confirms studies showing that subjects with the same bone density may have completely different TBS. Bone density (spine BMD) was similar (osteopenic) in groups with or without vertebral fracture (in VFA). We noted a significant correlation (r = 0.45, p < 0.05) between the number of fractured vertebrae and the handgrip score.
Conclusions: VFA should be a part of a standard diagnostic procedure for patients with osteoporotic fractures. When it comes to identifying patients at risk of fracturing vertebrae, muscle strength (handgrip) may have potential use in clinical practice. The predictive value of the TBS in reference to vertebral fractures should be evaluated in bigger randomized studies.

Key words: vertebral fracture, vertebral fracture assessment, trabecular bone score, handgrip.

Introduction

Vertebral fractures associated with osteoporosis are a major diagnostic challenge. On one hand, they are the most common type of fractures in the course of osteoporosis, while on the other, as many as 60% do not present clinical symptoms, therefore remaining undiagnosed [1]. These fractures occur spontaneously as the result of gravity or daily activities such as getting up from bed. Falls are a direct cause of only 25% of vertebral fractures,

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whereas in the case of distal radius fractures it is almost 100% of incidents. The sections of spine at the greatest risk of fractures are those subjected to the highest loads (with low mobility), such as the thoracic-lumbar (Th12-L1) area and Th7-Th8 vertebrae [1, 2]. Radiograph scan (separate projections for Th and L spine) remains a basic diagnostic standard. But conventional radiograph can be replaced with a vertebral fracture assessment (VFA), which is an image of the lumbar and thoracic spine acquired on dual energy X-ray absorptiometry. Both methods have their advantages and disadvantages. Radiograph scan, currently recognized as a gold diagnostic standard for this type of fracture, requires an experienced radiology technician. In terms of radiation dose VFA has an advantage over X-ray. In the case of VFA the dose of radiation is smaller (approx. 20-fold) in comparison to a standard spine X-ray [3]. Radiographic examination in Poland, unlike some West European countries, is still less expensive than VFA. When it comes to VFA, patient's comfort is often mentioned (analysis can be performed routinely during the bone density examination) [4, 5]. At the same time numerous studies have proven that VFA has a high sensitivity (0.70–0.93) and specificity (0.95–1.0) [6–8]. The loss of height is one of the major indications for VFA or a control X-ray (according to ISCD guidelines – loss of ≥ 4 cm).

The trabecular bone score (TBS) algorithm, which was recently developed, is a modern tool allowing one to indirectly estimate the overall bone microarchitecture status using the images of lumbar spine dual X-ray absorptiometry (DXA). The score which serves as a result of the analysis is not an exact dimensional measure but a grey-level texture projection that quantifies variation from one pixel to the adjacent ones. While not being a direct measurement of bone microarchitecture, TBS is related to specific features such as the trabecular separation, trabecular number and the connectivity density [9–11]. The higher the TBS score, the better the bone histomorphometry is. Studies have revealed that various subjects with the same BMD but with various fracture risk may have different TBS values [11]. The TBS value is calculated on the basis of DXA spine results (L1–L4). It has been included in the FRAX's fracture risk probability calculations (thus enhancing the tool's efficiency) [12].

Muscle strength is a crucial element of assessing fracture risk. Numerous studies have reported a correlation between a weak handgrip and an increased fall risk (and, in turn, higher fracture risk) [13, 14]. Also an association between handgrip strength and incident vertebral fractures has been demonstrated [15].

The aim of our study was to determine a possible correlation between vertebral fractures (indicated by VFA), TBS and muscle strength (measured by means of handgrip strength test results) in a group of postmenopausal women.

Material and methods

The study was conducted between 2014 and 2015 in a group of patients (n = 35) of Krakow Medical Centre (KMC). Women who participated in the study were referred to KMC by an attending physician for suspected vertebral fracture. Apart from VFA patients were additionally tested for bone density (including TBS), muscle strength (by means of a handgrip strength test) and height loss. Inclusion criteria were: gender (female), age (45+), suspected vertebral fracture and being an inhabitant of Lesser Poland Province. Exclusion criteria were male, BMI over 37 and impaired cognitive functions.

DXA scans (Hologic, Horizon W, Bedford, USA) were routinely performed at the spine (L1–L4) and at the hip (with one exception – where the scan was not available). On the basis of the spine BMD result it was possible to calculate the TBS. Thresholds for assessing the microarchitecture were taken from the meta-analysis of McCloskey et al. [16]. Handgrip strength was measured with a hydraulic hand-held dynamometer (Baseline, 12-0240, NY, USA). Ten patients did not complete the handgrip strength test due to various reasons (refusal, lack of a working dynamometer during a patient's visit). The threshold for handgrip strength was adopted from the European Working Group on Sarcopenia in Older People (EWGSOP) definition (> 20 kg for women regardless of age) [17]. Vertebral fractures identified by VFA were classified according to the Genant scale. Some data regarding handgrip and height loss were missing (10 cases of handgrip test and 14 cases of height loss). Data used in the analysis were blinded. All patients were under diagnostics for medical reasons, referred by their physician (suspected vertebral fracture).

Statistical analysis was performed using Statistica 12. Statistical tests used in the study included the Mann-Whitney U test, Student's t-test, analysis of variance (ANOVA and Scheffe post hoc test) and the Kruskal-Wallis test. In order to evaluate possible correlations Spearman's rank correlation coefficient and Pearson's correlation coefficient were used. The threshold set for statistically significant data was $p < 0.05$.

Results

Basic characteristics of the study group are presented in Table I.

Table I. Characteristics of the study group

	Whole group			Fracture VFA – yes, *n* = 17			Fracture VFA – no, *n* = 18			
	n	Average (range)	SD	*n*	Average (range)	SD	*n*	Average (range)	SD	*p**,**
Age (years)	35	69.6 (49–95)	10.6	17	72 (55–95)	10.1	18	67 (49–89)	10.9	0.228
Weight (kg)	35	64.1 (43.4–84.8)	11.2	17	61.9 (43.4–81.8)	11.7	18	66.1 (47–84.8)	10.7	0.268
Current height (m)	35	1.6 (1.56–1.72)	0.1	17	1.5 (1.4–1.6)	0.1	18	1.6 (1.5–1.7)	0.1	< 0.01
Height loss (m)	21	0.1 (0–0.225)	0.1	12	0.09 (0–0.22)	0.06	9	0.02 (0–0.05)	0.02	< 0.01
BMI (kg/m^2)	35	26.3 (19.8–34.6)	4.2	17	26.6 (19.8–34.6)	5.1	18	26 (22.2–32.9)	3.4	0.664
T-score neck	34	–2 (–3.1–0.4)	1	17	–2 (–3.8–0.6)	1.1	17	–1.9 (–3.1–0.4)	0.8	0.699
T-score spine	35	–2 (–3.8–2.9)	1.8	17	–2.2 (–3.8–2.9)	1.7	18	–1.8 (–3.8–2.5)	1.8	0.470
Handgrip (kg)	31	23.9 (13–31)	5	17	26 (20–31)	4.8	14	26 (18–31)	5.1	< 0.05
TBS	35	1.195 (0.982–1.409)	0.09	17	1.184 (0.982–1.369)	0.1	18	1.205 (1.033–1.409)	0.08	0.494

**Analysis of variance; **Analysis of variance, with the Scheffe post hoc test*

Table II. Fractures in vertebral fracture assessment divided according to Genant scale and trabecular bone score (TBS)

TBS result	Risk of fracture	Fracture degree – Genant scale			
		I (20–25%)	II (26–40%)	III (> 40%)	Total
1.23 and above	Low or intermediate	9	5	1	15
< 1.23	High	30	27	5	62
	Sum	39	32	6	77

Additionally a logistic regression analysis was performed in order to assess the potential influence of particular variables on fracture occurrence assessed by VFA. None of the variables proved to have a statistically significant influence on fracture occurrence and there was no correlation between them. A questionnaire conducted prior to each DXA scan showed that 7/36 patients (19.4%) had suffered a vertebral fracture. Patient history also revealed pre-existing non-vertebral fractures – 16 subjects (44.5%) reported a total of 18 prevalent fractures: hip (4), distal radius (4), proximal humerus (3) and other locations (7).

In the group of 35 women VFA analysis demonstrated vertebral fractures in 17 patients (40%). Vertebral height loss suggesting a fracture was revealed in 77 vertebrae (an average of 4.5 broken vertebrae per person with a vertebral fracture). The regions of spine with the highest risk of fracture were Th7 (*n* = 15), Th12 (*n* = 13), Th6 (*n* = 12), and Th8 (*n* = 10). These fractures accounted for 66% of all fractures observed in the study. Most likely they were wedge fractures (58%). A detailed distribution of fractures according to the Genant scale and TBS score is presented in Table II.

The mean result of TBS was 1.195 (0.982–1.409, SD = 0.09), which suggests major degradation of the bone microarchitecture (high risk of fracture). As a cut point for the analysis the score of 1.23 was used (with the score < 1.23 as a high risk of fracture). The results showed that only 12/35 patients had low or intermediate risk of fracture according to the TBS score (2/35 – 5.7% with TBS > 1.31 and 10/35 – 25.7% with TBS 1.31–1.23). 23/35 (65.7%) of subjects displayed major bone microarchitecture degradation (TBS < 1.23) and also the highest number of fractures (*n* = 62, 80.5% of all). In comparison the group of women with partially degraded spine or not degraded spine (TBS > 1.23–1.31) accounted for 15 fractures (19.5%). Despite the fact that most of the fractures and the most severe ones were reported in the group with TBS < 1.23 the difference was not statistically significant ($p = 0.08$ in Fisher's test). Also the analysis did not show a correlation between the fractures demonstrated in VFA and TBS results.

There was also no correlation between the spine BMD score and TBS result, which confirms studies showing that subjects with the same bone density may have completely different TBS. Bone density (spine BMD) was similar (osteopenic) in groups with or without vertebral fracture (in VFA). Differences between groups with high and low TBS scores were not significant, as shown in Table III.

Figure 1 presents a comparison of the TBS results in groups with and without a fracture in VFA that showed minor differences which were not significant.

Table III. Characteristics of the study group divided by the trabecular bone score

	High TBS (≥ 1.23), *n* = 12			Low TBS (< 1.23), *n* = 23			
	n	Average (range)	SD	*n*	Average (range)	SD	*p**
Age (years)	12	67 (49–95)	12	23	71 (55–89)	9.8	0.235
Weight (kg)	12	64.3 (46–79.8)	10.5	23	64 (43.4–84.8)	11.8	0.939
Current height (m)	12	1.6 (1.4–1.7)	0.1	23	1.6 (1.4–1.7)	0.1	0.267
Height loss (m)	8	0.03 (0–0.08)	0.02	13	0.08 (0–0.22)	0.07	0.073
BMI (kg/m^2)	12	25.8 (19.8–34.6)	3.9	23	26.6 (20.6–34.0)	4.5	0.597
T-score neck	12	–1.6 (–3.5–0.6)	1.1	22	–2.2 (–3.8–0.4)	0.9	0.126
T-score spine	12	–1.4 (–3.8–2.9)	2	23	2.4 (–3.8–2.5)	1.6	0.106
Handgrip	7	26 (20–31)	4.5	19	23 (13–30)	5.1	0.234

**Variance analysis*

Handgrip strength

The average handgrip strength test result in the study group was 23.9 kg (13–31, SD = 4.96). Subjects with the handgrip score below the threshold of 20 kg had a mean of 3.5 fractures per person, whereas in the subgroup with the score within the norm the mean number of fractures was 2.26 per person. Despite the lack of some data in both groups (with and without vertebral fracture), the number of patients was similar (12 vs. 14). The majority of the patients (*n* = 13, 37.2%) had a proper handgrip result (> 20 kg) and no fracture in VFA, as shown in Table IV. At the same time we noted a significant correlation ($r = 0.45$, $p < 0.05$) between the number of fractured vertebrae and the handgrip score, which is presented in Figure 2.

Table IV. Patients divided by the handgrip result and a fracture in vertebral fracture assessment

	Fracture VFA yes	Fracture VFA no	Sum
Handgrip low	4	1	5
Handgrip high	8	13	21
Sum	12	14	26
All (%)	46.2	53.80	100

There was a correlation ($r = 0.44$) between the handgrip score and TBS result (but it was not significant). Further analysis of TBS in the groups with normal and lowered results showed a significant difference, presented in Figure 3, in which the subjects with a reduced handgrip score have lower TBS.

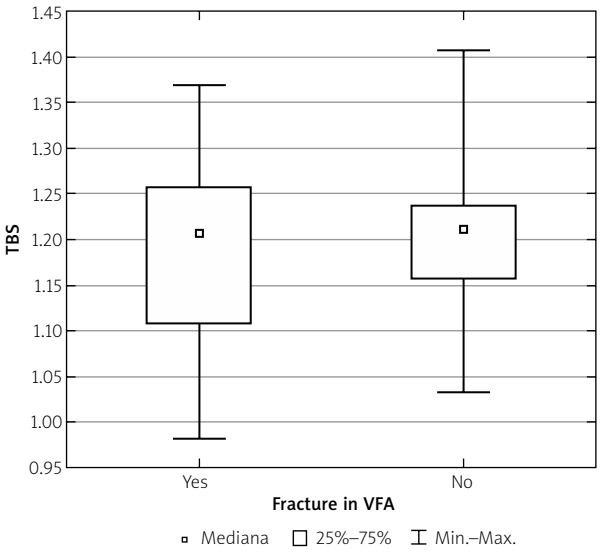

Fig. 1. Trabecular bone score (TBS) results in groups with and without vertebral fractures in vertebral fracture assessment (VFA).

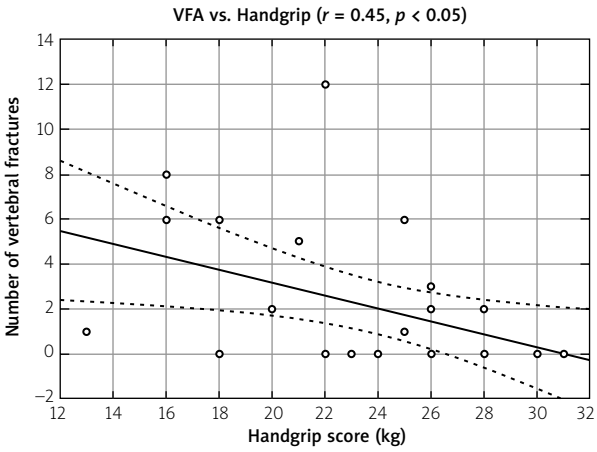

Fig. 2. Correlation between the number of fractured vertebrae and muscle strength measured by handgrip ($p < 0.05$).

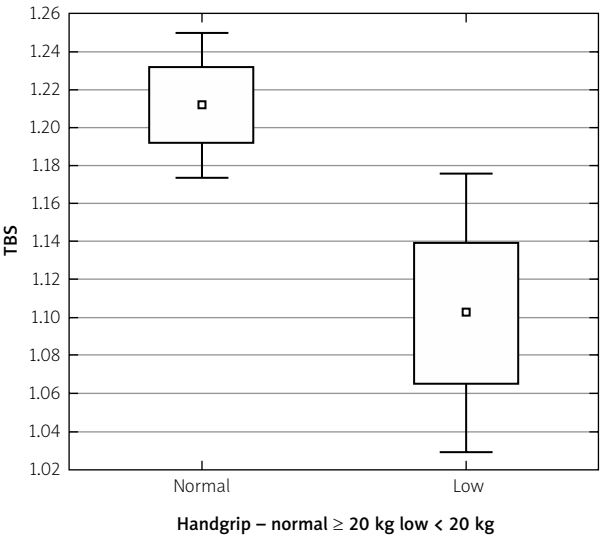

Fig. 3. Comparison of trabecular bone score (TBS) results in groups with normal and lowered handgrip score ($p < 0.05$).

Discussion

Population ageing results in fragility fractures becoming a major challenge for the public healthcare systems. Among all types of fractures, vertebral fractures are unique: common, mostly asymptomatic and with severe consequences for the patient's health. Our study proved that vertebral fractures are a major concern for the elderly. Despite the small study group ($n = 35$) VFA analysis revealed 77 fractures, of which almost 50% were of grade II and III in the Genant scale (32 and 6 respectively).

Our study confirms that there are no major differences in BMD distribution between the groups with and without vertebral fractures. It should be, however, emphasized that for all patients referral for VFA was the next step in fracture diagnostics after an initial consultation with their PG. It should also be pointed out that the average age of the study group was rather high – 69.6 years. In some cases patients from this age group may have an overestimated BMD score as a result of widespread osteoarthritis, especially in the spine area (osteoarthritis morbidity after the age of 60, depending on location and age, may vary from 10 to 80%) [18, 19].

The trabecular bone score, which is being gradually introduced into clinical practice, is a bone microarchitecture index calculated on the basis of the DXA scan and yet independent of the BMD score and clinical risk factors. Most importantly, spondylosis does not influence the result of the TBS [20]. Studies by Padlina et al. [21] showed that BMD results of patients over the age of 62 with spondylosis may be higher, but the TBS may decline with age. In our study group the TBS was generally low (an average of 1.197). We were able to confirm the lack of correlation between the bone density and TBS result. We were unable to find any correlation between the TBS result and fractures noted in VFA. We did however confirmed that women with weak handgrip show low TBS results ($p < 0.05$). Additionally a statistically significant correlation between muscle strength (handgrip) and the number of fractured vertebra was found. The outcome of our study may suggest a potential for using a relatively cheap examination like the handgrip strength test as a potential method of identifying patients with high fracture risk. Our research results are consistent with other studies indicating that muscle strength may be an independent fracture risk factor and with studies that show a correlation between muscle strength, fragility fractures and osteoporosis [15, 22, 23].

Low muscle strength (especially in sarcopenia) is mentioned as one of the major factors of fracture risk [24, 25]. On one hand, it is because of an increased fall risk, while on the other, it is because of endo- and paracrine muscle activity that affects the bone function. IGF-1 secreted by muscles plays an important role in the correct function of the skeleton as it improves proliferation and osteoblast growth, and increases collagen I synthesis, activity of phosphatase alkaline and the production of osteocalcin. Low concentration of IGF-1 and its binding protein may be responsible for low BMD. Studies revealed the existence of a BMD-independent correlation between low IGF-1 concentration in the serum and an increased risk of fracture in postmenopausal women. Moreover, low muscle strength is associated with decreased physical activity, which is crucial for healthy bones. Weight-bearing activities stimulate the osteoblasts and affect the vascularization. Lack of activity triggers the release of sclerostin and slows osteoblast function [26, 27].

To summarize, radiological scans, which currently serve as a gold standard in diagnostics, expose the patient to radiation and are technically difficult. VFA, which is a radiographic tool based on DXA and has a proven recurrence, sensitivity as well as specificity, does not involve high doses of radiation. Although BMD is an important factor in fracture risk assessment (including vertebral fractures), recent studies show that the bone density value alone, usually presented in the form of a T-score index (calculated by referring the BMD result to young adults), may be insufficient. Studies confirm that a high percentage of fractures occur in people with a normal T-score (> –2.5) [28, 29]. This is due to the fact that bone strength and its resistance to fractures are determined by various factors including bone microarchitecture, its micro-

damage and bone turnover [9]. Therefore the use of additional data such as muscle strength (using handgrip) may improve the fracture risk assessment.

Our study had a few limitations that should be mentioned in this paper: the study group was rather small (n = 35) and we did not have all the information about possible antiresorptive therapy in the past. We were lacking some data on the handgrip results (9/35). Also some guidelines suggest that a first degree vertebral fracture in VFA should not be considered in diagnostics. To the best of our knowledge this study is the first attempt to find a correlation between the TBS and handgrip results.

Conclusions

Vertebral fracture assessment analysis revealed 77 fractures in a group of 35 women, hence providing evidence for its effectiveness in clinical practice. Therefore we believe it should be a part of a standard diagnostic procedure for patients with osteoporotic fractures. When it comes to identifying patients at risk of fracturing a vertebra, muscle strength (tested with handgrip) may have potential use in clinical practice. In order to assess major factors that may influence the predictive value of TBS in reference to vertebral fractures further studies on bigger groups of patients are required.

Didier Hans is co-owner of the TBS patent and has corresponding ownership of the Medimaps.

The other authors declare no conflict of interest.

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