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Experience in the Morphological Study of Dorsolumbar Spine Deformities in Women over 50 Years

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ABSTRACT

Introduction: Osteoporosis is characterized by a reduction in bone mineral density. Among the factors that can contribute to the onset of osteoporosis we can enumerate alcohol consumption, smoking, glucocorticoid therapy, or the presence of diabetes mellitus. The incidence of osteoporosis increases with age. **Materials and Methods:** A total of 183 women over the age of 50, with a mean age of 67.9 ± 7.74 years, were studied to visualize spinal column alterations. From this cohort, 103 patients underwent bone mineral density testing using dual-energy X-ray absorptiometry (DXA) and dorsolumbar radiography, while 80 patients did not undergo DXA testing. Assessment of the degree of vertebral involvement was performed using the Genant semiquantitative method. **Results:** The highest percentage of vertebral fractures was observed in patients aged >70 years (100%). Within the studied cohort, 28% of patients displayed multiple vertebral fractures associated with age ($p = 0.01$). The most common site for vertebral involvement was the dorsolumbar region (D11–L2) across all age groups ($p = 0.35$). No statistically significant correlation ($p = 0.22$) was identified between DXA values and the presence of vertebral fractures, despite a trend of increased incidence of fractures as the T-score decreased. **Conclusion:** Within the cohort, vertebral fractures were identified both in women with normal values of bone mineral density and in those with osteoporosis. Furthermore, the severity of these vertebral fractures did not correlate with bone mineral density values, highlighting the necessity of using both osteodensitometry and spinal radiographs for diagnosis.

Keywords: osteoporosis, osteodensitometry, dorsolumbar spine

INTRODUCTION

Osteoporosis is a pathological condition that predominantly affects the osseous skeleton, by altering both the microarchitecture and macroarchitecture of the bone. It is characterized by a reduction in bone integrity associated with decreased bone strength, resulting in a porous appearance.[1–4] Osteoporosis is defined as a decrease in bone mineral density (BMD), commonly expressed using the T-score or Z-score, both measured in standard deviations (SD).[1-3,5] Osteo-

porosis is considered a silent disease, often asymptomatic until it becomes the cause of fragility fractures.[2,3,6]

The etiology of osteoporosis is characterized by an imbalance in the bone remodeling process during adult life (bone turnover), with an increase in bone resorption and a decrease in bone formation. Moreover, this process leads to a significant loss of bone trabeculae, with notable differences in the bone microstructure of a patient with osteoporosis compared to a healthy individual. The quality of bone tissue is measured by BMD, which peaks around the age of 30. In women, estrogen helps keep BMD in the normal range, as it maintains a balance in the bone remodeling process. In the extremes of age, BMD is diminished, such that a child exhibits a risk similar to that of their grandmother in developing fractures.[1,7] Among the risk factors, we can enumerate diet, alcohol, smoking, glucocorticoid treatment, and diabetes mellitus.[1,2,6,8]

According to the criteria established by the World Health Organization, in 2010, among the entirety of the European population, approximately 22 million women and 5.5 million men were diagnosed with osteoporosis.[8,9] Advancing age increases the prevalence of osteoporosis.[3]

The diagnosis of osteoporosis and its complications, usually fragility fractures, encompasses several investigations: radiographs of the dorsolumbar vertebral column, hip, or forearm, BMD measurement using dual-energy X-ray absorptiometry (DXA), and histomorphometry.[1,6,8,10,11]

Fragility fractures can occur at any level of the osseous skeleton, but they are particularly prone to appear in the vertebral column, femoral neck, and radius (Colles fracture). In the absence of clinical signs, vertebral deformities, including morphological changes in case of fractures caused by low-intensity trauma, can be more easily observed in lateral incidence.[6,12] Based on the intensity of the injury mechanism, osteoporotic vertebral fractures are classified into three distinct categories: fractures due to minor trauma, in which the patients do not recall the triggering factor of the fracture; fractures due to moderate trauma, caused by forces such as supporting one's own body weight, including during upright posture; and fractures due to high-intensity trauma, which might have occurred even in a healthy bone, but in the osteoporotic bone, it leads to vertebral deformation.[3,6,13–16]

In the case of postmenopausal women, the diagnosis is more complex, necessitating the consideration of the following aspects: a BMD expressed through a T-score below −2.5 SD measured at the lumbar spine or femoral neck; history of vertebral or hip fracture regardless of the value of BMD or other risk factors; a T-score between −1.0 SD and −2.5 SD associated with any of the following: history of fracture localized at the proximal humerus, pelvis, or distal forearm.[1–3,7,8,17–19]

MATERIALS AND METHODS

We analyzed a cohort comprising 183 female patients over the age of 50, with a mean age of 67.9 ± 7.74 years, to visualize spinal column alterations. All patients underwent spinal radiographic examination in two projections (anteroposterior and lateral). From this cohort, 103 patients underwent BMD measurements (using DXA), and a subset of 80 radiographs were analyzed without DXA assessment. The spinal radiographs were performed at the Radiology Department of Dora Medicals medical center in Târgu Mureș using the Siemens Multix Select DX X-ray machine, and osteodensitometry was performed using a GE Lunar Prodigy densitometer.

We identified structural and morphological alterations of vertebral bodies. Vertebral fractures were graded using the semiquantitative Genant grading scheme.[6,20] The interpretation of osteodensitometry results was made based on the following criteria: T-score between 0 and −1 SD – normal values; T-score between −1 and −2.5 SD – osteopenia; T-score below −2.5 SD – osteoporosis.[8]

For statistical analysis we used GraphPad InStat 3 software, version 3.06 (GraphPad Software Inc., San Diego, USA). A significant association was taken into consideration at a p value of $< .05$, with a 95% confidence interval.

Ethics

This study was approved by the ethics committee of "George Emil Palade" University of Medicine, Pharmacy, Science and Technology of Târgu Mureș, Romania (no. 2330/17/05/2023). Written informed consent has been obtained from all participants regarding the publication of this study.

RESULTS

Prevalence of vertebral fractures

The presence of vertebral fractures was identified in 21.8% of cases (40 out of 183) (Figure 1). Among the 80 patients who underwent only spinal radiography, 16.25% (13 out of 80) displayed fractures, while out of the 103 patients who underwent both investigations, 26.21% (27 out of 103) displayed vertebral fractures. No statistically significant association was observed between osteodensitometry and the presence of fractures ($p = 0.85$).

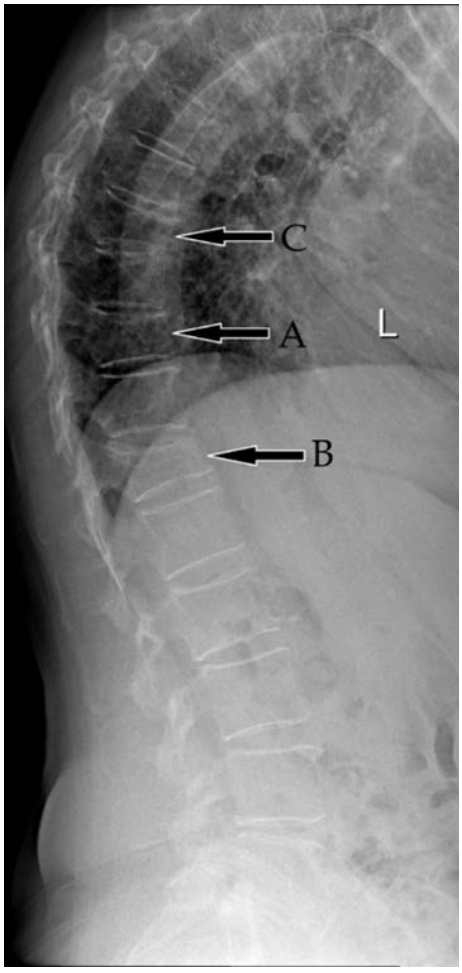

FIGURE 1. **A** – Grade 1 vertebral fracture; **B** – Grade 2 vertebral fracture; **C** – Grade 3 vertebral fracture

Based on the results obtained in the two patient groups (with and without DXA), we observed that there was no statistically significant correlation between the severity grade of vertebral fractures and these two patient categories (p = 0.16). Furthermore, from the total number of cases with vertebral fracture, approximately 52% were from the DXA group and 48% from the non-DXA group. Of the patients with grade 1 vertebral fracture, 60% underwent DXA. Grade 2 vertebral fractures were more frequently encountered among those who underwent bone densitometry, in approximately 80% of cases, while grade 3 fractures had a frequency similar to grade 1 fractures. There was no statistically significant association between bone densitometry and the severity grade of vertebral fractures (p = 0.16).

Severity of vertebral fractures

Analyzing the 50–59 age group, the absence of vertebral fractures was observed in 22% of cases. Of these patients, 41% were diagnosed with grade 1 vertebral compression, 30% displayed grade 2 fractures, and 7% exhibited vertebral fractures corresponding to grade 3. Among patients within the 60–69 age group, 9% exhibited no vertebral involvement, 26% had grade 1 vertebral fractures, 55% had grade 2 vertebral involvement, and only 10% showed grade 3 fractures. In the 70–79 age group there were no patients without vertebral involvement (0%), 13% exhibiting grade 1 vertebral fractures, 66% grade 2 vertebral fractures, and 21% vertebral deformities corresponding to grade 3. From

TABLE 1. Correlation between the severity of vertebral fractures, age, fracture site, and DXA

	Severity of vertebral fractures				p value
	Absent	Grade 1	Grade 2	Grade 3	
Age group (years)					
50–59	32	3	0	2	0.0048
60–69	58	8	2	1	
70–79	43	17	9	6	
80–89	9	3	3	2	
Fracture site					
D8		0	0	1	0.19
D9		1	0	0	
D10		1	0	0	
D11		3	3	4	
D12		13	6	0	
L1		10	2	4	
L2		3	3	4	
L3		2	1	2	
L4		0	1	0	
DXA total	75	20	13	9	0.75
Normal	18	3	3	3	
Osteopenia	38	9	4	3	
Osteoporosis	19	8	4	2	
Non-DXA total	67	13	3	6	0.16

TABLE 2. Correlation between the number of fractures, age, and DXA

	Number of fractures				p value
	Absent	Grade 1	Grade 2	Grade 3	
Age group (years)					
50–59	32	5	0	0	0.01
60–69	58	7	0	2	
70–79	43	10	9	3	
80–89	9	3	1	1	
DXA total	75	17	6	4	0.0658
Normal	18	4	1	1	
Osteopenia	38	3	5	1	
Osteoporosis	19	9	0	2	
Non-DXA total	67	8	3	2	0.43

patients over the age of 80, 19% did not have vertebral fractures, 9% had grade 1 vertebral fractures, 53% were diagnosed with vertebral involvement corresponding to grade 2, and 19% presented vertebral fractures corresponding to grade 3 (Table 1). A statistically significant correlation was observed between the severity grade of fractures and advanced age ($p = 0.0048$).

Number of injured vertebrae

Analyzing both groups, we observed a statistically significant association between the number of fractures and age ($p = 0.01$) (Table 2).

Investigating the relationship between the severity grade of vertebral fractures and the age of patients in the non-DXA group, we found no statistically significant correlation ($p = 0.09$). This indicates that with age, a decrease in the number of cases where patients do not exhibit any vertebral fractures can be observed, and fractures become more frequent. Among patients in the 50–59 age group, 28% did not have any vertebral involvement, 39% had grade 1 vertebral fractures, 27% of vertebral fractures were classified as grade 2, and 6% of patients had grade 3 vertebral fractures. In the 60–69 age group, 9% of cases had no vertebral involvement and grade 3 vertebral fractures, 27% of cases were classified as grade 1 fractures, and 55% of cases had grade 2 vertebral fractures. In the 70–79 age group, 67% of patients had grade 2 vertebral fractures, and 33% had grade 3 fractures.

Analyzing the DXA group, we observed differences in patient involvement concerning age categories, as per the results ($p = 0.22$). In the 50–59 age group, 18% of patients did not have any vertebral involvement, 42% had grade 1 fractures, 32% had grade 2 fractures, and 8% had grade 3 fractures. In the 60–69 age group, 10% of patients did not have any vertebral involvement, 25% had grade 1 fractures, 55% had grade 2 vertebral fractures, and 10% had grade 3 fractures. In the 70–79 age group, there were no patients without any vertebral involvement, 19% were diagnosed with grade 1 fractures, 62% had grade 2 fractures, and 19% had grade 3 vertebral fractures. In the 80–89 age group, 25% of patients did not have vertebral involvement, 13% had grade 1 fractures, 50% had grade 2 vertebral fractures, and 12% had grade 3 fractures.

Sites of vertebral fractures

In the non-DXA group (Figure 2), we observed a statistically significant correlation ($p = 0.01$) between age and the location of the most frequently affected vertebral level, the dorsolumbar junction. In the 50–59 age group, a single vertebral site at D9 was affected. In the 60–69 age group, the dorsolumbar junction was predominantly affected, with a single vertebral involvement at D11, three cases of vertebral involvement at D12, and a fracture at L1. In the 70–79 age group, the same dorsolumbar junction was predominantly affected, with three cases of affected vertebrae at D11, four vertebral fractures at D12, and three affected vertebrae at L1. An additional case of vertebral involvement was identified at the L2 vertebral site and two cases at L3. In the 80–89 age group, we identified one vertebral involvement at D11, L2, and L3, respectively. Among patients in the 60–69 age group, D11, D12, and L1 were predominantly affected, while in the 70–79 age group, D11, D12, L1, L2, and L3 were the most frequently fractured.

In the DXA group (Figure 3), D12, L1, and L2 were affected across all age groups. D8, D9, and L4 fractures were identified only in the 70–79 age group. D11 involvement was identified in 80% of cases in the 70–79 age group and

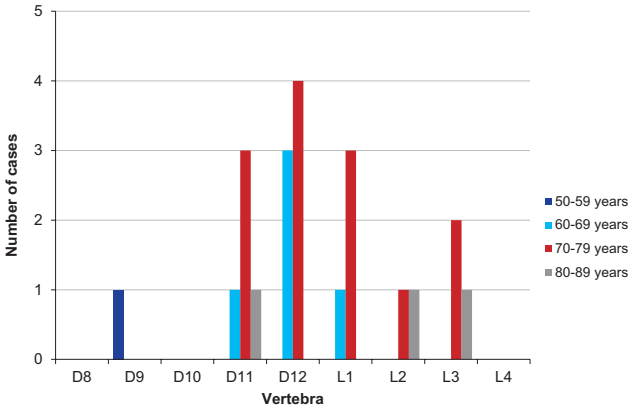

FIGURE 2. Fracture sites by age in the non-DXA group

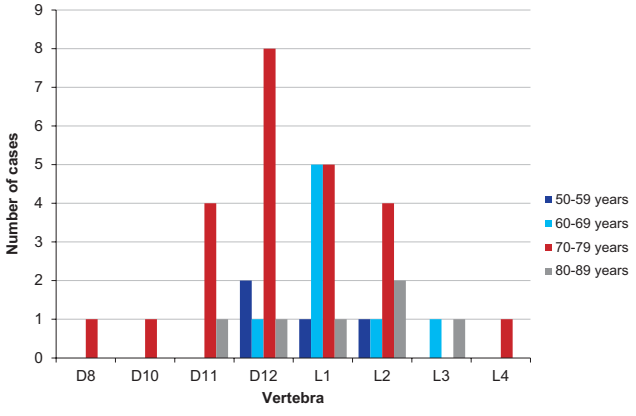

FIGURE 3. Fracture sites by age in the DXA group

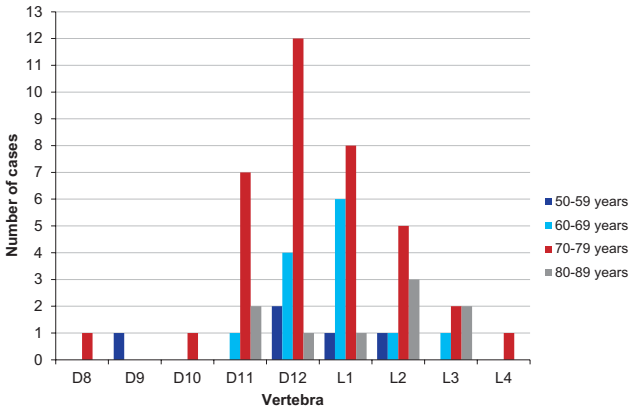

FIGURE 4. Fracture sites by age in all patients

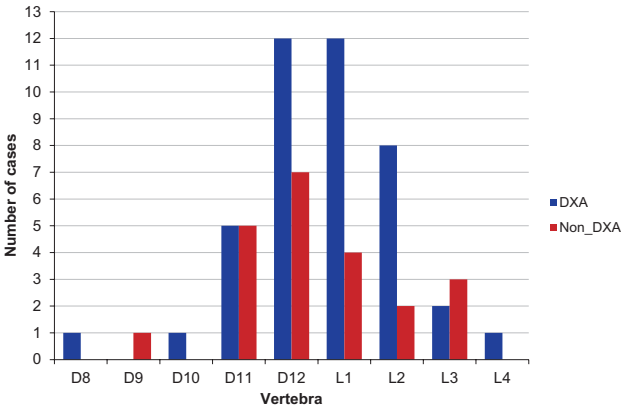

FIGURE 5. Comparison of fracture sites between the DXA and Non-DXA groups

20% of cases in the 80–89 age group. Vertebral site D12 was involved in 15% of cases in the 50–59 age group, 10% of cases in the 60–69 age group, 67% of cases in the 70–79 age group, and 8% of cases in the 80–89 age group. Vertebral site L1 was involved in 8% of cases in the 50–59 age group, 42% of cases in the 60–69 age group, 42% of cases in the 70–79 age group, and 8% of cases in the 80–89 age group. Morphological changes at the L2 vertebral site were identified in 12% of patients in the 50–59 age group, 13% in the 60–69 age group, 50% in the 70–79 age group, and 25% of patients in the 80–89 age group. Vertebral site L3 was equally affected (50%) in the 60–69 and 80–89 age groups. We found no statistically significant correlation in the DXA group between fracture sites and age ($p = 0.81$).

Analyzing all 183 patients included in the study (Figure 4), similarly to the DXA group, the dorsolumbar junction was affected in all age groups; however, there was no statistically significant association between fracture sites and age ($p = 0.35$).

The most common fracture site was the dorsolumbar junction, with significantly more fractures at the D12–L2 level in the DXA group. We found no statistically significant association between the DXA and non-DXA groups regarding the site of vertebral fractures ($p = 0.47$) (Figure 5).

Interpretation of bone densitometry values

From the 103 patients who underwent both spinal radiography and bone densitometry, patients diagnosed with osteoporosis represented 31.06% of the total of cases that underwent bone densitometry, those with osteopenia represented 45.63%, and those with normal values accounted for 23.30%. The age of the patients was significantly correlated with bone densitometry values ($p = 0.05$). The distribution of bone densitometry values is represented in Figure 6. From the patients in the 50–59 age group, 41% had bone densitometry values within normal limits, 41% had values indicative of osteopenia, and 18% had values indicative of osteoporosis. In the 60–69 age group, 29% of patients had normal values, 33% had bone densitometry values indicative of osteopenia, and 38% had osteoporosis. In the 70–79 age group of, 10% of cases had normal bone densitometry values, 62% had values indicative of osteopenia, and 28% had values indicative of osteoporosis. In the 80–89 age group, 25% had normal values, 25% had values indicative of osteopenia, and 50% had values indicative of osteoporosis. Therefore, it can be stated that the incidence of osteoporosis increases with age, ranging from 18% between 50 and 59 years to 50% between 80 and 89 years. Similarly, the incidence of normal values decreases from 41% between 50 and 59 years to 25% between 80 and 89 years.

We found bone densitometry values to be correlated with fragility fractures, as 73.78% of patients in the DXA group did not exhibit deformities, and only 26.21% had vertebral

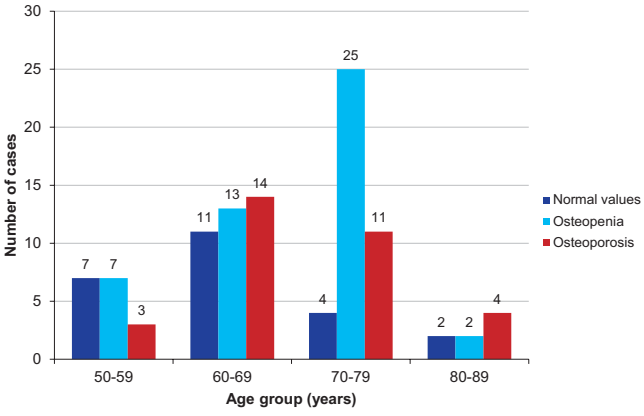

FIGURE 6. Bone densitometry results

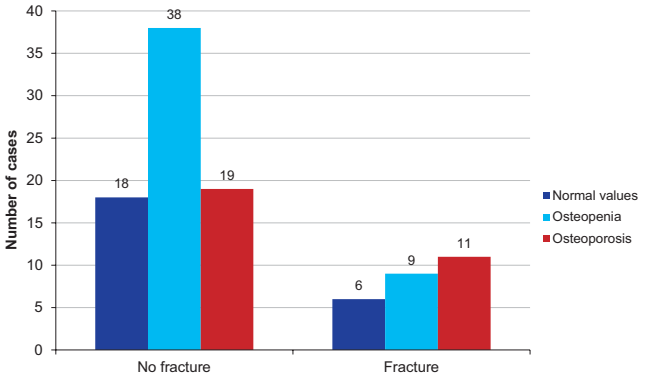

FIGURE 7. Presence of vertebral fractures based on bone densitometry values

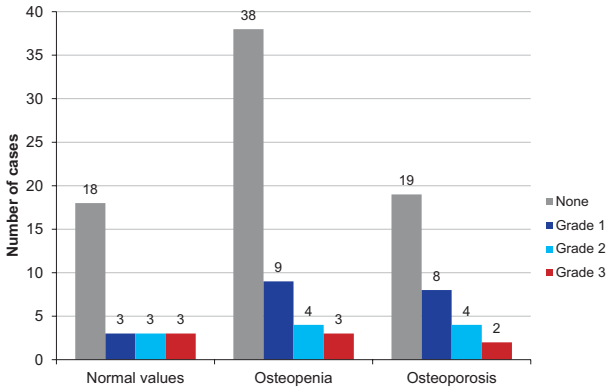

FIGURE 8. Correlation between the number of fractured vertebrae and DXA

fractures. Among patients with vertebral fractures, 25.92% had normal bone densitometry values, 33.33% had values indicative of osteopenia, and 40.74% had values indicative of osteoporosis. Among those without vertebral fractures, 23.68% had normal values, 51.31% had values indicative of osteopenia, and 25% had values indicative of osteoporosis (Figure 7). Although the number of cases with fracture increased with a decreasing T-score, we found no statistically significant correlation between DXA values and the presence of vertebral fractures ($p = 0.22$).

Figure 8 suggests that there is an almost statistically significant correlation ($p = 0.0658$) between osteoporosis and the number of vertebral fractures, indicating that as the T-score value decreases, the number of affected vertebrae increases.

In the analyzed cohort, 75% of patients did not display any vertebral involvement and their bone densitometry values were normal, 17% of patients had a single affected vertebra, 4% had two affected vertebrae, and 4% of patients had three or more affected vertebrae. In the case of patients exhibiting values indicative of osteopenia, 81% had no vertebral involvement. From these patients, 5% had one affected vertebra, 11% had two affected vertebrae, and 2% had three or more affected vertebrae. Regarding patients diagnosed with osteoporosis, 62% had no vertebral involvement, in 31% a single vertebra was affected, and 7% had three or more affected vertebrae.

Regarding the relationship between bone densitometry values and the most frequent fracture sites (Figure 9), we observed that vertebral fractures were predominantly present in the D11–L3 segment in patients with normal or osteopenic bone densitometry values. In cases of osteoporosis, along with these vertebrae, distant vertebrae from the dorsolumbar junction, such as D8–D10 or L4 were also affected.

The statistical analysis showed that 100% of the time when the D8, D10, and L4 vertebrae were affected, osteodensitometry values were specific to osteoporosis. Of the patients with D11 involvement, 20% had normal bone density values, 60% had osteopenia, and 40% had osteoporosis. Of the patients with D12 involvement, 25% had normal osteodensitometry values, 40% had osteopenia, and 35% were diagnosed with osteoporosis. Of the patients with L1 vertebral involvement, 18% had normal osteodensitometry values, 32% had osteopenia, and 50% had osteoporosis. Of the patients with L2 involvement, 38% had normal bone density values, 37% had osteopenia, and 25% had osteoporosis. When the L3 vertebra was affected, 50% of patients had normal osteodensitometry values and 50% had osteoporosis. However, we found no statistically significant correlation between bone densitometry values and fracture sites ($p = 0.81$).

We analyzed the correlation between the severity of vertebral fractures and osteodensitometry values (Table 1). Of the patients who did not have vertebral fractures, 25% had normal bone density values, 50% had values in-

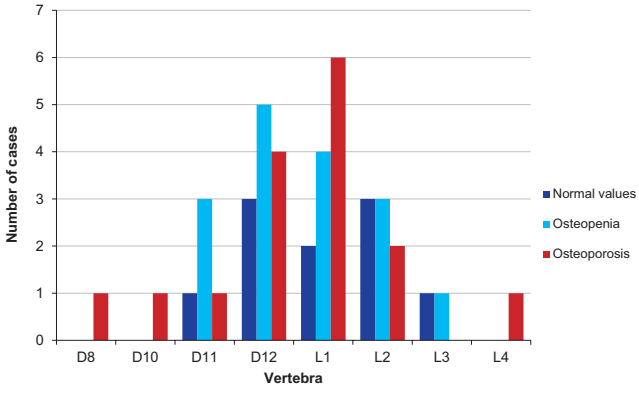

FIGURE 9. Correlation between DXA and fracture sites

TABLE 3. Bone densitometry data in our study and in the literature

DXA	Yang *et al.*[21]	Alshaali *et al.*[22]	Cai *et al.*[23]	Present study
Osteoporosis	31.50%	48.30%	51.19%	31.06%
Osteopenia	42%	40.90%	40.20%	45.63%
Normal values	26.50%	10.80%	8.56%	23.30%

TABLE 4. The number of fractured vertebrae in comparison with our study

No. of fractured vertebrae	Present study	Alshaali *et al.*[22]
1 vertebra	60.97%	58.8%
2 vertebrae	24.39%	29.4%
3 or more vertebrae	14.63%	11.8%

dicative of osteopenia, and 25% were diagnosed with osteoporosis. In the case of patients with grade 1 fractures, 15% had normal values, 45% had osteopenia, and 40% had osteoporosis. Of the patients with grade 2 fractures, 28% had normal values, 34% had osteopenia, and 38% had osteoporosis. Regarding patients with grade 3 fractures, 38% had normal osteodensitometry values, 35% had osteopenia, and 27% had osteoporosis.

DISCUSSION

Analyzing dorsolumbar spinal radiographs and bone densitometry results in women over 50 years of age, we observed that the number of osteoporosis cases, the number of affected vertebrae, and the degree of severity of vertebral fractures increased with age. We compared our findings with results from other studies in the literature (Table 3).

In the meta-analysis conducted by Yang *et al.*, it was reported that the incidence of osteoporosis ranged from 6% to 57%, with a mean of 31.5%, and that of osteopenia ranged from 25.1% to 58.9%, with a mean of 42%.[21] The frequency of osteoporosis was higher in the study by Alshaali *et al.*, while cases of osteopenia were similar to the data obtained in the present study.[22] In contrast to the findings of Yang *et al.* and Alshaali *et al.*, normal values were more frequently encountered in our study.[21,22] The studies by Alshaali *et al.* and Cai *et al.* yielded different results from ours.[22,23] In the study of Cai *et al.*, the incidence of osteoporosis was 51.19%,[23] compared to our study where it was 31.06%. In the same study, the incidence of osteopenia was 40.2%,[23] which was lower than in our study, at 45.63%.

The study of Kanis *et al.* presents data related to the prevalence of osteoporosis in women over the age of over 50 in 27 European countries, including Romania.[24] According to this study, the prevalence of osteoporosis in Romania is 20.5%, lower than in other Eastern European countries such as Hungary (21.1%), Bulgaria (20.9%), Austria (22.2%), and Slovenia (21.5%). The mean prevalence of osteoporosis in the 27 studied European countries was 22.1%.[24]

A meta-analysis conducted in 2021 by Salari *et al.* reports a prevalence of osteoporosis of 19.8% among European women who participated in the study. On a global scale, across all age groups, this value was found to be 23.1% (Figure 10).[5]

Comparing results from various studies, we observed that the number of cases of osteoporosis associated with the presence of vertebral fractures varies between 29% and 75% (Figure 11). In the study conducted by Cai *et al.*, the incidence of fractures due to osteoporosis was 73.45%, contrasting with our study where this value was significantly lower at 42%.[23] Regarding osteopenia, vertebral deformities were encountered in 22.83% of cases, as opposed

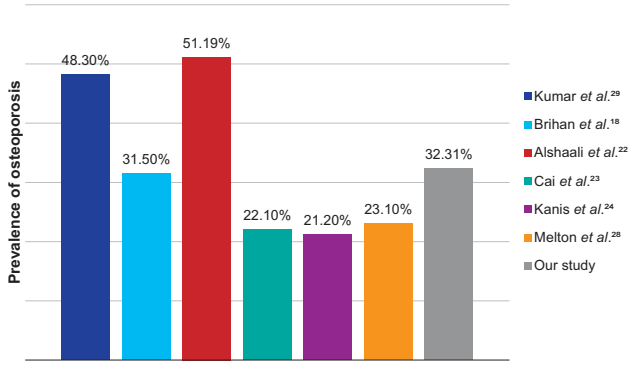

FIGURE 10. Prevalence of osteoporosis

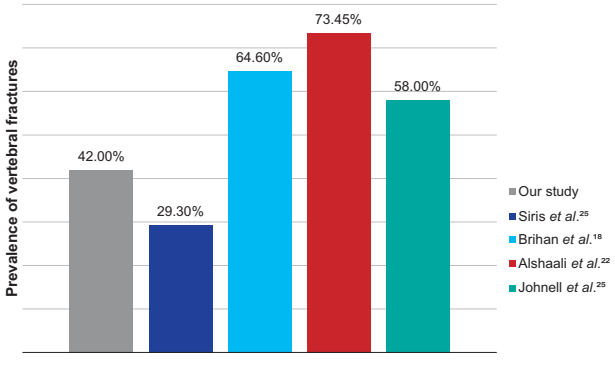

FIGURE 11. Prevalence of vertebral fractures based on bone densitometry

to the cohort analyzed by us, where this value was 30%. The study of Johnell *et al*. reports a prevalence of vertebral fractures of 58% among patients with osteoporosis.[25]

In the case of asymptomatic women, vertebral deformities have been discovered through dorsolumbar spinal radiography or vertebral fracture assessment.[21–23] In the present study, the prevalence of asymptomatic fractures detected through dorsolumbar spinal radiography without undergoing DXA was 16.25%. In the study ofAlshaali *et al*., this figure was 14.2%, in the study of Yang *et al*. it was 28%, and the study of Cai *et al*. it was 31.06%.[21–23] The meta-analysis conducted by Yang *et al*. analyzed multiple cohorts in various geographic regions and reported that in a cohort of 478 postmenopausal asymptomatic women, the incidence of vertebral deformities diagnosed through spinal radiography (lateral incidence) was 29.7%.[21] Similarly to the present study, they observed that the prevalence of fractures in asymptomatic women increased with age. Other studies also demonstrated that most fractures occur in women over the age of 50.[13,21,26,27] According to the study conducted by Melton *et al*., approximately 75% of osteoporosis-related vertebral fractures occur after the age of 65, and compared with our study, it can be observed that although the incidence is on the rise, it is significantly higher beyond this age.[28]

According to several studies, the most frequent fracture sites are the D12 and L1 vertebrae.[18,22,29] Similar results were obtained in the present study. In the study by Alshaali *et al*., the D12 vertebra exhibited deformities in 25% of cases and the L1 vertebra in 21.40%. In comparison, the study by Yang *et al*. did not describe changes in the D12 vertebra, as it focused primarily on pathological alterations in the lumbar spine; however, the L1 vertebra exhibited alterations in 18.37% of cases.[21,22] In the study conducted by Cai *et al*., the D12 vertebra displayed pathological changes in 18.55% of cases, while the L1 vertebra was affected in 17.10% of patients.[23] The number of affected vertebrae in the present study was consistent with that described in the literature (Table 4).

The study by Takahashi *et al*., conducted on a cohort of 185 patients with a mean age of 76.9 ± 7.5 years, suggests that BMD does not decrease in the case of fractured vertebrae, even for patients younger than 75 years.[30] The authors found is no statistically significant association between BMD and the degree of vertebral involvement.[30] The study by Yang *et al*., which predominantly examined morphological changes in the lumbar spine between levels L1 and L4, reported that there was no statistically significant association between mean BMD and the increase in the number of fractured vertebrae.[21]

CONCLUSIONS

In the studied cohort, approximately 25% of patients with normal BMD values exhibited vertebral fractures. Of those without vertebral fractures, approximately 25% had BMD values indicative of osteoporosis. Nearly half of all patients with osteoporosis displayed vertebral fractures. The severity grade of these fractures did not correlate with BMD values. In this context, for the diagnosis of osteoporosis, along with performing bone densitometry, other noninvasive paraclinical investigations, such as spinal radiography, are recommended.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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