Osteoporotic/Osteopenic Non-operative Thoracolumbar Burst Fracture: Radiologic and Clinical Analyses in View of Bone Mineral Density and the OF Classification

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Objective: We analyzed the radiologic and clinical outcomes of thoracolumbar burst fractures to elucidate the relationship between bone mineral density, the Osteoporotic Fracture (OF) classification, and outcomes of conservative treatment. It is expected that severe osteoporosis would have unfavorable outcomes after conservative treatment in stable burst fractures; however, precise data are unavailable.

Methods: From January 2009 to May 2017, patients older than 50 years with thoracolumbar burst fractures and who were conservatively treated were included. Radiologic parameters were collected from radiographs and MRI scans at baseline and the 2-year follow-up.

Results: 52 patients (11 men and 41 women) were included. The most frequent location of fracture was L1 (46.2%); slip down (57.7%) was the most common mechanism of traumatic injury. According to the OF classification system, all patients were classified as OF 3 or above; there were 21 patients classified as OF3, 29 as OF4, and 2 as OF5. BMD and the OF score showed a strong correlation with the radiologic parameters of delayed vertebral collapse. On final radiographs, a lower T-score and higher OF score indicated a higher compression rate. Conversely, the final visual analog scale was not different between patients with a high T-score and those with a low T-score, as well as between the OF3 and OF4 groups.

Conclusion: Many osteoporotic fractures can be treated conservatively even in patients with an OF score of 4. Radiologically, a low BMD and higher OF score are related to initial and delayed vertebral collapses.

Key Words: Bone mineral density, Spinal compression fractures, Osteoporosis, Thoracolumbar vertebra, Metabolic bone diseases

INTRODUCTION

Burst fractures indicate vertebral compression fractures presenting a middle-column compromise. Despite the proximity of fractured bone fragments to neural structures, there are many stable cases that can be successfully treated with only non-operative treatments^{2,25,29,30}. Vaccaro et al. suggested a scoring system for thoracolumbar fractures, i.e., the thoracolumbar injury classification and severity score (TLICS)^{25,26}. According to this system, patients with burst fractures without injury of the posterior ligamentous complex or neurologic deficit

are not indicated for surgery^{25,26}. Although the TLICS is a very simple and useful scoring classification, which includes both morphologic and neurologic statuses, it does not include consideration for advanced age and osteoporosis^{25,26}. Approximately 20-30% of postmenopausal women have osteoporosis^{9,16}. Physicians have reported that the actual number of men with osteoporosis is obscure and that osteoporosis is still largely underdiagnosed^{8,28}. It is widely accepted that a low T-score, particularly lower than -2.5, is related to an increased risk of fracture. Moreover, osteoporotic spines have a weaker pull-out strength, and many surgeons have emphasized that bone mineral density (BMD) should be considered before spinal instrumentation^{6,17,22}. Therefore, considering the increased risks of general anesthesia and instrumentation failure in older patients, it is unreasonable to apply the same rule to patients with senile osteoporosis⁴. Conversely, it is expected that a low BMD would be associated with unfavorable outcomes after conservative treatment of thoracolumbar burst

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fractures, but precise data have not been established.

In 2018, the Spine Section of the German Society for Orthopaedics and Trauma proposed a simple and intuitive classification system for osteoporotic thoracolumbar fractures called the OF classification, which consists of 5 subgroups based on magnetic resonance imaging (MRI) findings²¹⁾. Although Schnake et al. suggested that OF4 and 5 are clear indications for surgery²¹⁾, this novel classification system has not yet been sufficiently verified for determining the indications for surgery.

In the current retrospective study, we reviewed and analyzed the radiologic and clinical outcomes of non-operative treatment using BMD and the OF classification for decision-making in patients with senile osteoporotic thoracolumbar burst fractures.

MATERIALS AND METHODS

1. Patients and Method

From January 2009 to May 2017, patients older than 50 years who were diagnosed with thoracolumbar osteoporotic burst fractures and conservatively treated were included in this study. Osteoporosis was diagnosed if any T-score measured at the lumbar vertebra or femur was -2.5 or lower. Each patient was diagnosed based on MRI findings, and burst fracture was defined as a vertebral body fracture encroaching the spinal canal with anterior-column and middle-column involvements. The exclusion criteria were as follows: pathologic fractures, such as cancer- or spondylitis-induced fractures; history of surgery, vertebroplasty, or kyphoplasty; no bone densitometry data; and inability to complete the 2 years of follow-up.

2. Treatment

Treatment decision was made in accordance with the TLICS. After classification of the non-operative cases, all patients were treated with medications, including analgesics, muscle relaxants, and drugs for osteoporosis. After 1 or 2 weeks of bed rest, weight bearing was attempted using a brace. If the patients could tolerate ambulation, they were then discharged, and their brace was maintained for 6 weeks. If the patients did not improve, we performed nerve blocks, including medial branch, selective nerve root, and gray ramus communicans blocks.

3. Acquisition of Data

We conducted this study in compliance with the principles

of the Declaration of Helsinki. The study's protocol was reviewed and approved by the Institutional Review Board of our hospital (IRB approved no., 2018AS0034). Written informed consent was waived by the board. Patients' medical charts were reviewed to assess their demographic and clinical outcomes. Radiologic parameters were measured from simple lateral radiographs obtained with patients in the lateral decubitus position at baseline and the final follow-up after 2 years. The anterior and posterior vertebral body heights and wedge angles were measured at the fractured vertebra, and the compression rate was calculated by comparison with the mean anterior height of the adjacent vertebrae (Fig. 1). The Cobb angle was measured from the upper endplate of the cranial adjacent vertebra to the lower endplate of the caudal adjacent vertebra (Fig. 1). BMD was defined as the mean T-score of the two lowest levels of the lumbar vertebrae from anteroposterior spine dual-energy X-ray absorptiometry (DXA). Patients were classified into OF1-5 groups according to the OF classification system used in a previous publication²¹⁾. The representative MRI scans are shown in Figures 2A-2C.

4. Statistical Analysis

To assess the correlation between patients' BMD and outcomes, simple regression and comparative analyses were performed. To compare patients with mild and severe osteoporosis and to ensure use of the cut-off value of the T-score for burst fractures, we divided the patients based on T-scores of

Fig. 1. Radiologic measurements.

A: Cobb angle

B: Wedge angle

C: Anterior vertebral body height

D: Posterior vertebral body height

E: Compression rate = $100 - C/[(E1 + E2)/2] \times 100$

Fig. 2. (A) OF3: Deformation with distinct involvement of the posterior wall (>1/5). Incomplete burst fracture affects only one endplate. (B) OF4: Loss of integrity of the vertebral frame structure. Complete burst fracture involves both endplates and the posterior wall. (This patient is the same person shown in Fig. 1). (C) OF5: Injuries with distraction or rotation. Fracture with bony and ligamentous injury of the posterior column (white arrows).

The OF classification consists of 5 groups
 OF 1. no vertebral deformation (vertebral edema)
 OF 2. deformation with no or minor (<1/5) involvement of the posterior wall
 OF 3. deformation with distinct involvement (>1/5) of the posterior wall
 OF 4. loss of integrity of the vertebral frame or vertebral body collapse or pincer-type fracture
 OF 5. injuries with distraction or rotation

Note. Reprinted from “Classification of Osteoporotic Thoracolumbar Spine Fractures: Recommendations of the Spine Section of the German Society for Orthopaedics and Trauma (DGOU)”, by Schnake KJ, Blattert TR, Hahn P, et al., 2018, *Global Spine J*, 8(2 Suppl), p.46S-49S. Copyright 2018 by SAGE Publications

-2.5 and -3.0. The groups were compared using the Student t-test and Mann-Whitney test. To assess the correlation between patients' OF classification and outcomes, categorical variables were analyzed with the chi-square and Fisher exact tests, and continuous variables were compared using the Kruskal-Wallis test with Bonferroni post-hoc tests. Statistical calculations were performed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA).

RESULTS

From January 2009 to May 2017, there were 148 patients who were over 50 years old and diagnosed with burst fractures; among them, 138 patients had thoracolumbar (T11-L2) fractures. Sixty-six patients were treated with surgery, and seven patients underwent vertebroplasty or kyphoplasty. Among the 65 remaining patients with non-operative fractures, nine and then four patients were excluded due to the unavailability of bone densitometry data and follow-up loss, respectively.

Fifty-two patients were included in the analysis. The demographic data of the included patients are presented in Table 1. Patients' mean age was 69.54 years, and ages ranged from 50 to 89 years. There were 11 male and 41 female patients. The most frequent location of fracture was L1 (46.2%), followed by T12 (32.7%). The most frequently observed mechanism of traumatic injury was slip downs (57.7%), followed by car crashes (21.2%) (Table 1). Seven patients (13.5%) had no definite trauma. The patients' Frankel grades were above D; 90% of them had a grade of E. The average visual analog scale (VAS) scores were 4.44 at baseline and 2.26 in the final assessment. The average T-score was -3.37, and scores ranged from -5.8 to -1.5. According to the OF classification system²¹⁾, there was no patient with OF1 or OF2, and only 2 patients were classified as OF5 in our series (Fig. 2A-2C). The most frequent type was OF4 (55.8%), followed by OF3 (40.4%) (Table 1).

Simple linear regression analysis (Table 2) revealed significant negative correlations between the T-score and age ($p=$

0.001). For radiologic parameters, the Cobb and wedge angles at baseline showed a negative correlation with the T-score ($p < 0.001$). However, the final Cobb angle was not significantly correlated with the T-score. The anterior and posterior vertebral heights showed a positive correlation with the T-score at baseline and final assessments ($p < 0.001$), while the compression rate showed a negative correlation ($p < 0.001$). The difference in compression rate between the baseline and final assessments also showed a negative correlation with the T-score ($p = 0.018$). Conversely, the VAS score showed a negative correlation with the T-score at baseline ($p = 0.044$), while the final VAS score did not reach significant correlation. In summary, regression analysis showed that patients who had a lower BMD showed a more painful and more compressed vertebra at baseline and that they more often developed a delayed vertebral collapse than those with a higher BMD.

For the comparative study, we divided the groups according to 2 different cut-off values of the T-score (T-2.5 and T-3.0). As shown in Table 3, the group with a lower T-score

showed worse overall radiologic parameters than the group with a higher T-score. When the patient groups were divided according to a cut-off value of T-3.0, a more prominent difference was observed. Specifically, the final compression rate reached a significant difference only in the comparison between T-scores ≤ -3.0 and > -3.0 ($p < 0.001$). However, the initial and final VAS scores were not different between the groups in both the T-2.5 and T-3.0 comparisons. Although not shown in the tables, the location of the fracture was not different between the groups.

In Table 4, we compared the OF3, OF4, and OF5 groups. Because there were only 2 patients in the OF5 group, there was only a statistically significant difference between the OF3 and OF4 groups according to the Bonferroni post-hoc test.

Table 1. Patient demographics and overall clinical outcomes

	Patients with burst fractures (n=52)
Mean age (years, range)	69.54 (50-89)
Female sex, n (%)	41 (78.8%)
Bone mineral density (T-score, range)	-3.37 (-5.8 - -1.5)
Location of the burst fracture, n (%)	
T11	2 (3.9%)
T12	17 (32.7%)
L1	24 (46.2%)
L2	9 (17.3%)
Mechanism of traumatic injury, n (%)	
Slip down	30 (57.7%)
Car crash	11 (21.2%)
Fall down	4 (7.7%)
Unknown	7 (13.5%)
OF classification	
OF 3	21 (40.4%)
OF 4	29 (55.8%)
OF 5	2 (3.8%)
Frankel grade, n (%)	
-E	47 (90.4%)
-D	5 (9.6%)
Visual analog scale score (mean)	
Initial	4.44
Final	2.26

Table 2. Simple linear regression analysis of the bone mineral density (T-score)

Independent variables	B	95% CI		p-value
		Lower	Upper	
Age	-0.048	-0.076	-0.019	0.001*
Cobb angle, mean (°)				
Initial	-0.067	-0.097	-0.037	<0.001*
Final	-0.030	-0.066	0.006	0.099
Difference	0.010	-0.055	0.075	0.756
Wedge angle, mean (°)				
Initial	-0.095	-0.125	-0.065	<0.001*
Final	-0.067	-0.105	-0.028	<0.001*
Difference	0.015	-0.044	0.073	0.613
Anterior height, mean (mm)				
Initial	0.111	0.079	0.142	<0.001*
Final	0.087	0.043	0.131	<0.001*
Difference	0.029	-0.091	0.148	0.631
Posterior height, mean (mm)				
Initial	0.110	0.049	0.172	0.001*
Final	0.141	0.072	0.211	<0.001*
Difference	0.024	-0.156	0.203	0.788
Compression rate, mean (%)				
Initial	-0.032	-0.044	-0.021	<0.001*
Final	-0.032	-0.046	-0.017	<0.001*
Difference	-0.031	-0.057	-0.006	0.018*
Canal encroachment (%)	-0.022	-0.043	0.000	0.051
Visual analog scale score				
Initial	-0.185	-0.364	-0.005	0.044*
Final	0.012	-0.215	0.239	0.916

B, the unstandardised regression coefficient; CI, Confidence interval

*Indicates significant difference with $p < 0.05$

The mean age in the OF4 group was higher than that in the OF3 group (73.03 and 65.01 years, respectively, $p=0.021$), and the BMD was lower ($p=0.004$). The mean BMD in the OF4 group was -3.79, which was lower than -2.85 in the OF3 group, and the ratio of severe osteoporotic patient with

$T \leq -3.0$ in the OF4 group was 82.8%. The initial and final compression rates were also significantly greater in the OF4 group than in the OF3 group ($p=0.007$ versus $p<0.001$). The initial wedge angle, but not the final wedge angle, was greater in the OF4 group ($p=0.006$). However, there was no difference

Table 3. Comparative analysis between the groups based on the bone mineral density

	Classified by T-score of -2.5			Classified by T-score of -3.0		
	$T \leq -2.5$ (n=41)	$T > -2.5$ (n=11)	p-value	$T \leq -3.0$ (n=32)	$T > -3.0$ (n=20)	p-value
Mean age (years, range)	70.98 (50-89)	64.18 (53-89)	0.012*	72.25 (51-86)	65.20 (50-89)	0.002*
Female sex, n (%)	33 (80.5%)	8 (72.7%)	0.681	28 (87.5%)	13 (65.0%)	0.081
Mechanism of traumatic injury, n (%)			0.290			0.064
Slip down	24 (58.5%)	6 (54.5%)		18 (56.3%)	12 (60.0%)	
Car crash	7 (17.1%)	4 (36.4%)		6 (18.8%)	5 (25.0%)	
Fall down	3 (7.3%)	1 (9.0%)		1 (3.1%)	3 (15.0%)	
Unknown	7 (17.1%)	0 (0.0%)		7 (21.9%)	0 (0.0%)	
OF classification			0.196			0.001*
OF 3	15 (36.6%)	6 (54.5%)		7 (21.9%)	14 (70.0%)	
OF 4	25 (61.0%)	4 (36.4%)		24 (75.0%)	5 (25.0%)	
OF 5	1 (2.4%)	1 (9.1%)		1 (3.1%)	1 (5.0%)	
Cobb angle, mean (°)						
Initial	17.97	9.86	0.004*	19.16	11.61	0.001*
Final	17.96	13.13	0.331	19.46	13.43	0.053
Difference	1.88	2.87	0.587	2.14	2.16	0.990
Wedge angle, mean (°)						
Initial	17.87	9.09	<0.001*	19.11	11.05	<0.001*
Final	19.49	13.68	0.024*	20.62	14.81	0.011*
Difference	1.99	4.11	0.502	1.72	3.54	0.314
Anterior height, mean (mm)						
Initial	14.31	20.25	0.008*	12.53	20.43	<0.001*
Final	13.17	17.12	0.080	11.35	17.64	0.001*
Difference	-3.70	-3.30	0.697	-3.79	-3.35	0.629
Posterior height, mean (mm)						
Initial	27.66	29.89	0.053	26.58	30.62	<0.001*
Final	26.73	30.55	0.005*	25.71	30.18	<0.001*
Difference	-1.97	-0.77	0.027*	-1.68	-1.62	0.807
Compression rate, mean (%)						
Initial	48.30	32.36	0.032*	52.81	32.31	<0.001*
Final	54.34	41.96	0.075	60.19	40.06	<0.001*
Difference	14.54	9.60	0.284	16.45	9.38	0.074
Canal encroachment (%)	30.94	26.36	0.337	33.16	25.62	0.058
Visual analog scale score						
Initial	4.89	3.38	0.060	5.14	3.69	0.071
Final	2.26	1.80	0.909	2.21	2.10	0.617

*Indicates significant difference with $p<0.05$

rence between the groups in terms of the initial and final VAS scores or Frankel grades.

DISCUSSION

In our retrospective review, we identified some common

features of non-operative osteoporotic burst fractures that differed from those of non-osteoporotic burst fractures. Aged patients with a low BMD have a fragile vertebra; thus, a minor trauma could lead to burst fractures in the vertebral column due to their poor bone quality despite a lack of injury to relatively stronger structures of the posterior column, such

Table 4. Comparative analysis between the groups based on the OF classification

	OF3 (n=21)	OF4 (n=29)	OF5 (n=2)	p-value
Mean age (years, range)	65.01 (50-89)	73.03 (59-89)	66.50 (58-75)	0.021 ⁺
Female sex, n (%)	13 (61.9%)	26 (89.7%)	2 (100.0%)	0.074
Location of the burst fracture, n (%)				0.166
T11	0 (0.0%)	2 (6.9%)	0 (0.0%)	
T12	4 (19.0%)	12 (41.4%)	1 (50.0%)	
L1	13 (61.9%)	11 (37.9%)	0 (0.0%)	
L2	4 (19.0%)	4 (13.8%)	1 (50.0%)	
Bone mineral density (T-score, range)	-2.85 (-5.1 to -1.5)	-3.79 (-5.8 to -1.6)	-2.95 (-4.5 to -1.5)	0.004 ⁺
T ≤ -3.0	7 (33.3%)	24 (82.8%)	1 (50.0%)	0.001 [*]
Mechanism of traumatic injury, n (%)				0.101
Slip down	13 (61.9%)	16 (55.2%)	1 (50.0%)	
Car crash	5 (23.8%)	5 (17.2%)	1 (50.0%)	
Fall down	3 (14.3%)	1 (3.4%)	0 (0.0%)	
Unknown	0 (0.0%)	7 (24.1%)	0 (0.0%)	
Cobb angle, mean (°)				
Initial	14.27	17.58	17.85	0.556
Final	14.56	19.07	16.02	0.438
Difference	1.06	3.23	-1.82	0.256
Wedge angle, mean (°)				
Initial	12.69	18.46	15.40	0.006 ⁺
Final	15.52	20.57	14.65	0.080
Difference	2.80	2.55	-0.75	0.406
Anterior height, mean (mm)				
Initial	19.80	12.49	15.75	0.000 ⁺
Final	18.16	10.32	15.65	0.001 ⁺
Difference	-3.36	-4.57	-0.10	0.101
Posterior height, mean (mm)				
Initial	30.52	26.44	27.50	0.001 ⁺
Final	23.20	17.51	26.65	0.000 ⁺
Difference	-1.34	-1.13	-0.85	0.601
Compression rate, mean (%)				
Initial	35.04	51.90	47.63	0.007 ⁺
Final	28.43	42.98	47.92	0.000 ⁺
Difference	6.24	11.99	0.29	0.026
Visual analog scale score (mean)				
Initial	4.38	4.50	5.00	0.796
Final	2.50	1.93	3.00	0.234
Frankel grade, n (%)				0.506
-E	20 (95.2%)	25 (86.2%)	2 (100.0%)	
-D	1 (4.8%)	4 (13.8%)	0 (0.0%)	

^{*}Indicates a significant difference with p<0.05

⁺Indicates a significant difference between OF3 and OF4 after Bonferroni correction with p<0.017 (0.05/3)

as the pedicles, facets, and ligamentous complex. In the current study, although there were burst fractures, the most common trauma mechanism was slip downs (57.7%); 13.5% did not show a definite trauma (Table 1). Therefore, if patients with osteoporosis develop back pain after a minor trauma, meticulous physical examination and radiography are necessary.

In the current study, we analyzed the BMD using the T-score obtained with DXA. However, DXA has many limitations, such as its ability to obtain only two-dimensional images rather than volumetric density¹⁾. Considering the cost-effectiveness and relatively smaller radiation in DXA than in quantitative computed tomography, DXA is still the diagnostic tool of choice for osteoporosis. In South Korea, osteoporosis drugs can be reimbursed from the National Health Insurance Service only in patients who have a T-score of ≤ -2.5 . Therefore, BMD has been widely measured in postmenopausal women and patients who are suspected to have compression fractures. A reduced BMD significantly increases the relative risk of fracture and require treatment^{1,9,10,16)}. However, the diagnostic cut-off value of T-2.5 is an arbitrary threshold suggested by the World Health Organization²⁷⁾. In fact, BMD is a continuous variable; thus, it should not be overlooked that there are many patients from both ends of the spectrum.

As shown in Table 2, a linear correlation was found between the radiologic parameters of delayed vertebral collapse. On the final radiographs, a lower T-score was found, which indicated a higher compression rate. Further, the comparative study showed that severe osteoporosis with a value below T-3.0 had a more prominent difference in radiologic parameters (Table 3). This finding raises a question on whether instrumentation is needed for patients with low T-scores. The problem is that an extremely low BMD has a high risk of instrumentation failure⁴⁾. In the current study, the final pain score was not related to BMD and the incidence of segmental kyphosis was lower than expected (most patients showed similar initial and final Cobb angles) despite the vertebral collapse. We suggest that conservative treatment is still favorable for patients who have an extremely low BMD. Lim et al. suggested the pathomechanism of delayed vertebral collapse after trauma in patients with osteoporosis as a mechanical damage to the blood vessel of the vertebral body¹³⁾. Additionally, we hypothesize that a lower BMD in the osteoporotic vertebral column would yield a weak structural endurance; If a crack occurs after minor trauma, the vertebral column can no longer bear the weight of the upper vertebrae, and this could result in a delayed collapse.

Most patients were compatible with the recommendation of the TLICS^{25,26)}. According to the TLICS, most patients had 2 points, with the exception of 6 patients (3 patients had 5 points, and the other 3 patients had 4 points). One of the patients who had 5 points was recommended to undergo surgery; however, she refused. Two of the patients who had 5 points could not undergo surgery because of the very high risk of general anesthesia. However, among the patients conservatively treated despite a TLICS of 4 or 5 points, none required delayed surgery for instability. Wood et al. reported that there was no benefit from operative therapy for stable thoracolumbar burst fractures without neurologic deficits and that the long-term outcome of their operative treatment was worse in their randomized clinical trial^{29,30)}. We believe that patients with osteoporotic burst fractures with low TLICS are the best candidates for conservative treatment. Even in patients with higher TLICS, conservative treatment could still be feasible if the risk of surgery is high, and the long-term outcome could be better than expected.

Because the TLICS was devised in consideration of non-osteoporotic fractures, many authors have suggested new classification systems suitable for osteoporotic patients including the OF classification^{19,21)}. In the current study, we found that the OF classification is very easy to apply, and it provides several useful pieces of information. Schnake et al. suggested that patients with OF score of 4 or higher are indications for surgery whereas those with OF score of 2 or less are indications for conservative treatment²¹⁾. We found that the OF4 type suggests severe osteoporosis and implies delayed vertebral collapse. If the initial MRI findings of the burst fracture indicate the OF4 type, confirmation and treatment of osteoporosis, and more careful radiographic follow-up are required. On the other hand, we found that the proportion of osteoporotic burst fracture patients with OF4 was higher than expected in this retrospective study. Considering our successfully treated non-operative cases, the OF4 classification does not seem to warrant the need for surgery.

Vertebroplasty and kyphoplasty are known to be effective for early pain relief in patients with compression fractures^{5,7)}. In our department, we rarely perform vertebroplasty or kyphoplasty. Although they were not included in this study, we performed kyphoplasty in only 7 patients who presented with refractory back pain during the last 10 years. Therefore, the final vertebral height in the current study decreased considerably (because we did not perform procedures to augment the vertebral height). Several researchers have reported new

fractures in the adjacent vertebra after vertebroplasty or kyphoplasty^{12,23}. Kim et al. reported that greater restoration is related to the development of new fractures because of the increase in soft tissue tension¹². Conversely, Lin et al. suggested that leakage of cement into the disc space causes new adjacent vertebral fractures¹⁴. In cases of burst fracture, the risk of cement leak would be higher²⁰. For non-operative cases, we routinely used only medications and bracing. In patients with back pain that makes walking intolerable after 1 week, we performed nerve blocks. In our experience, some patients showed dramatic relief of severe axial pain with gray ramus communicans nerve blocks, although the result was not included in the current study because of the small number of patients.

The current study was a retrospective study; thus, several limitations exist. One of the limitations is the heterogeneity of treatment for osteoporosis. Among the 52 patients in our study, only 12 were already taking medications for osteoporosis. Nine patients were taking a bisphosphonate, and the 3 remaining were taking selective estrogen receptor modulators (SERMs). Medication for osteoporosis was initiated in all patients who were diagnosed with osteoporotic burst fractures. The first choice of drug was one of the bisphosphonates, and some female patients who were contraindicated for bisphosphonates received SERMs. Parathyroid hormone (PTH) is being used for patients with severe osteoporosis^{15,18,24}; some physicians have reported improved outcomes of conservative treatments with the use of PTH after fracture¹⁸. We also frequently prescribe PTH for osteoporotic burst fractures. BMD has a favorable specificity but a low sensitivity; considering that many risk factors influence the development of osteoporotic fractures, it is difficult to predict the fracture risk and prognosis using BMD alone¹¹. However, we found that a low BMD is related to radiologically worse outcomes. Considering the advancement in the therapies for osteoporosis and minimally invasive surgical techniques for the thoracolumbar spine³, further comparative prospective and randomized trials are needed to shed more light on this important and ever-growing topic of treatment for osteoporotic burst fractures.

CONCLUSIONS

Radiologically, BMD of patients is related to the compression rate and delayed vertebral collapse. We found that the proportions of osteoporotic patients with thoracolumbar fracture with OF4 was higher than expected. The OF4 type has

a high probability of vertebral collapse with severe osteoporosis, but in many cases, it is associated with a clinically benign course and can be properly treated conservatively. Patients with a higher OF score based on initial MRI scans require confirmation of BMD, and patients with a lower BMD require more careful radiographic follow-up with treatment of osteoporosis.

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