



Original Article

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Difference in the Cobb Angle Between Standing and Supine Position as a Prognostic Factor After Vertebral Augmentation in Osteoporotic Vertebral Compression Fractures

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Objective: We retrospectively analyzed patients with osteoporotic vertebral compression fracture (OVCF) undergoing vertebral augmentation to compare the Cobb angle changes in the supine and standing positions and the clinical outcomes.

Methods: We retrospectively extracted the data of OVCF patients who underwent vertebral augmentation. Back pain was assessed using a visual analogue scale (VAS). Supine and standing radiographs were assessed before treatment to determine the Cobb angle and compression ratio. Receiver operating characteristic curve analysis was performed to determine the optimal cutoff to predict favorable outcomes after vertebral augmentation.

Results: A total of 249 patients were included. We observed a statistically significant increase in the VAS score change with increasing Cobb angle and compression ratio ($p < 0.001$), and multivariate logistic regression analysis showed that a difference in the Cobb angle (odds ratio [OR], 1.27) and compression ratio (OR, 1.12) were the independent risk factors for predicting short-term favorable outcomes after vertebral augmentation. In addition, we found that the difference in the Cobb angle (OR, 1.05) was the only factor for predicting midterm favorable outcomes after vertebral augmentation. The optimal cutoff value of the difference in the Cobb angle for predicting midterm favorable outcomes was 35.526°.

Conclusion: We found that the midterm clinical outcome after vertebral augmentation was better when there was a difference of approximately 35% or more in the Cobb angle between the standing and supine positions. Surgeons should pay attention to the difference in the Cobb angle depending on the posture when deciding to perform vertebral augmentation in patients with OVCFs.

Keywords: Osteoporotic vertebral compression fracture, Vertebral augmentation, Cobb angle, Compression ratio



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INTRODUCTION

The impact of osteoporosis has been increasingly recognized as the population ages. One of the main complications of osteoporosis is vertebral compression fractures.¹ Osteoporotic vertebral compression fractures (OVCFs) are a frequently encountered clinical problem and are becoming more important as the

median age of the population continues to increase.² Most OVCFs are managed with a period of absolute bed rest or activity modification, narcotic analgesics, and braces.³⁻⁵ However, approximately 150,000 vertebral compression fractures every year in the United States are refractory to these measures and require hospitalization, with prolonged periods of bed rest and narcotic analgesics.²

Currently, the main clinical diagnostic method for OVCFs is magnetic resonance imaging, and the proper determination of the fractured vertebra is the key to successful surgical treatment.⁶ Patients with symptomatic OVCFs typically present with severe back pain following a minor injury. Until now, there has been little correlation between the degree of collapse of the vertebral body and the level of pain.⁷ Some studies have reported that the changes in the supine lateral and standing lateral radiographs in thoracolumbar OVCFs^{8,9} correlate with back pain.¹⁰ Qian et al.¹¹ reported that improvement in symptoms after kyphoplasty is better in patients with wedge-shaped changes in the supine and standing positions. Based on a previous study, we hypothesized that the degree of difference in the Cobb angle according to the posture would affect the clinical outcomes after vertebral augmentation.

However, there are no reports on the relationship between the difference in the Cobb angle and clinical outcomes after vertebral augmentation. In this study, a retrospective analysis was performed in patients undergoing percutaneous vertebral augmentation to compare the Cobb angle changes in supine and standing positions and to illustrate their relevance to the short-term and midterm clinical outcomes after vertebral augmentation in patients with OVCFs.

MATERIALS AND METHODS

1. Study Design

We retrospectively extracted data of patients with thoracolumbar OVCF who underwent vertebral augmentation between January 1, 2010, and December 31, 2019.

We included patients with only 1-level of OVCF in the thoracolumbar vertebra between T11 and L2, a compression ratio of >30%, and a bone mineral density (BMD) of less than -2.5 who underwent vertebral augmentation.

The exclusion criteria included patients younger than 55 years of age, with spinal canal invasion by retropulsion of bony fragments, spinal infection, and chronic back pain prior to trauma, including a history of previous spinal decompression or fusion surgery. Patients with severe cardiopulmonary comorbidity, cognitive disorders, or cerebral disease who could not communicate independently were excluded. The exclusion criteria included neurologic deficits, pathologic fractures, and unstable vertebral fractures involving the middle or posterior column of the spine. Patients over 80 years of age were excluded because there were cases of early surgery without conservative treatment for 2 weeks.

This study was approved by the Institutional Review Board of the Nowon Eulji Medical Center (2021-09-009) using the tenets of the World Medical Association Declaration of Helsinki (2018). The requirement for informed consent was waived because of the retrospective nature of the study. All individual records were anonymized prior to analysis.

2. Outcome Assessment

The clinical outcomes were measured using a visual analogue scale (VAS) score. The VAS score was measured before treatment and at 1 and 6 months after treatment. When assessing the VAS score, patients were asked to rate their pain on a scale from 0 to 10, with 0 representing no pain and 10 representing the worst pain. Therefore, patients were divided into a favorable outcome pain group (change in VAS score greater than 4) and an unfavorable outcome group (VAS score less than 4) for further analysis.

3. Imaging Assessment (Cobb Angle and Compression Ratio)

Supine and standing radiographs were assessed before treatment to determine the Cobb angle and compression ratio at the level of the fracture. The Cobb angle was measured as the angle between the superior endplate of the vertebral body above and the inferior endplate of the vertebral body below the fractured vertebral body (Fig. 1). From the lateral projection, the compression ratio (%) of the fractured vertebral body was calculated using the following equation: $\{1 - 2d/(c+e)\} \times 100$.

Differences in the Cobb angle and compression ratio from supine to standing position were reported using the following equation:

The difference in the Cobb angle (%) = $(\text{Cobb angle standing} - \text{Cobb angle supine}) / \text{Cobb angle standing} \times 100$, Difference in compression ratio (%) = $(\text{compression ratio standing} - \text{compression ratio supine}) / \text{compression ratio standing} \times 100$.

4. Surgical Procedures and Management

Patients were placed in a prone position on the operating table and received local or general anesthesia. Next, bone puncture trocars were placed bilaterally through the lateral margin of the pedicles at the fractured level and progressively passed through the pedicles into the vertebral body under C-arm guidance. An inflatable bone balloon was then used, and polymethylmethacrylate was carefully injected into the vertebral body. The injection was stopped if the cement reached the cortical edge of the vertebral body or leaked into extraosseous structures

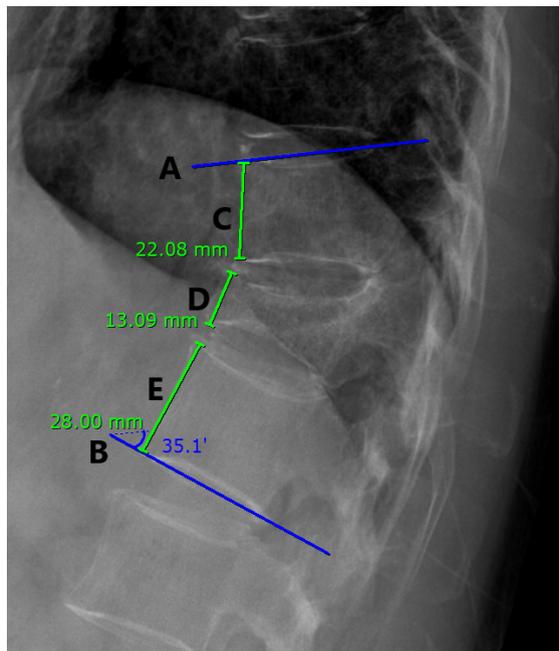


Fig. 1. Five lines (A–E) of the thoracolumbar vertebrae in x-ray radiographs were determined. The Cobb angle was measured using the angle between the superior endplate of the vertebral body above (line A) and the inferior endplate of the vertebral body below (line B) the fractured vertebral body. The length of the line (C, D, E) was used to calculate the compression ratio.

or veins. After the procedure, the patients were maintained in a prone position for 10–15 minutes. All patients were restricted to bed rest after the procedure and were encouraged to ambulate on the first day after augmentation. To assist ambulation, patients were required to wear a brace for at least 1 month.

5. Statistical Analysis

Continuous variables are expressed as mean \pm standard deviation or median with interquartile range. Discrete variables were expressed as counts and percentages. The chi-square test and Student t-test were used to assess the differences between the favorable and unfavorable outcome groups. We constructed scatterplots with regression lines to represent the associations between the differences in the Cobb angle and compression ratio with changes in VAS score. Box plots with dot plots were used to visualize the association between the Cobb angle and compression ratio with the changes in the VAS score. Receiver operating characteristic curve analysis was performed to identify the optimal cutoff values of the difference in the Cobb angle and compression ratio for predicting the short-term and mid-term favorable outcomes in patients receiving vertebral augmen-

Table 1. Demographic characteristics of the patients (n = 249)

Characteristic	Value
Age (yr)	69.3 \pm 5.6
Male sex	56 (22.5)
Body mass index (kg/m ²)	22.6 \pm 3.1
Bone mineral density	-3.1 \pm 0.5
Shape of fracture	
Wedge	141 (56.6)
Biconcave	67 (26.9)
Crush	41 (16.5)
VAS preoperation	7.4 \pm 1.3
VAS 1 month	2.9 \pm 1.2
Cobb angle at standing (°)	18.9 \pm 5.7
Cobb angle at supine (°)	11.4 \pm 3.7
Compression ratio at standing (%)	49.6 \pm 7.2
Compression ratio at supine (%)	37.7 \pm 5.6

Values are presented as mean \pm standard deviation or number (%). VAS, visual analogue scale.

tation for OVCFs. The differences in the Cobb angle and compression ratio with the maximum concurrent sensitivity and specificity were considered the optimal cutoff values. The odds ratios (ORs) with 95% confidence intervals (CIs) were estimated using the univariate and multivariate logistic regression to determine the independent predictive factors for favorable outcomes in patients receiving cement augmentation for OVCFs. Sex, age, body mass index, Cobb angle in the standing position, Cobb angle in the supine position, difference in the Cobb angle, compression ratio in the standing position, compression ratio in the supine position, difference in compression ratio, hypertension, and diabetes, were entered into the multivariable model. Statistical significance was set at $p < 0.05$. All statistical analyses were performed using the R software ver. 3.5.2. (<https://www.r-project.org/>; R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

1. Demographic Characteristics of the Patients

All the surgeries were completed in 249 patients. The male-to-female patient ratio was 56:193, and the mean age was 69.3 years. L1 was the most common level affected in 126 cases, followed by T12 in 77 cases, T11 in 25 cases, and L2 in 21 cases. The demographic characteristics of the patients are presented in Table 1.

2. Association Between the Cobb Angle and Compression Ratio With the VAS Score

Fig. 2 shows the significant positive correlations between the differences in the Cobb angle and the change in the VAS score. We observed a statistically significant increase in the VAS score change with an increase in the Cobb angle ($p < 0.001$) (Fig. 2A). In addition, we observed a statistically significant increase in the VAS score change with an increase in the compression ratio ($p < 0.001$) (Fig. 2B).

3. Differences in the Cobb Angle and Compression Ratio for Predicting the Short-term Favorable Outcomes After Vertebral Augmentation

A comparison of the short-term clinical outcomes in the patients is summarized in Table 2. There was no significant difference in the preoperative VAS score between the 2 groups (favorable outcome group 7.5 ± 1.2 versus unfavorable outcome group 7.4 ± 1.4). The Cobb angle and compression ratio when standing and differences in the Cobb angle and compression

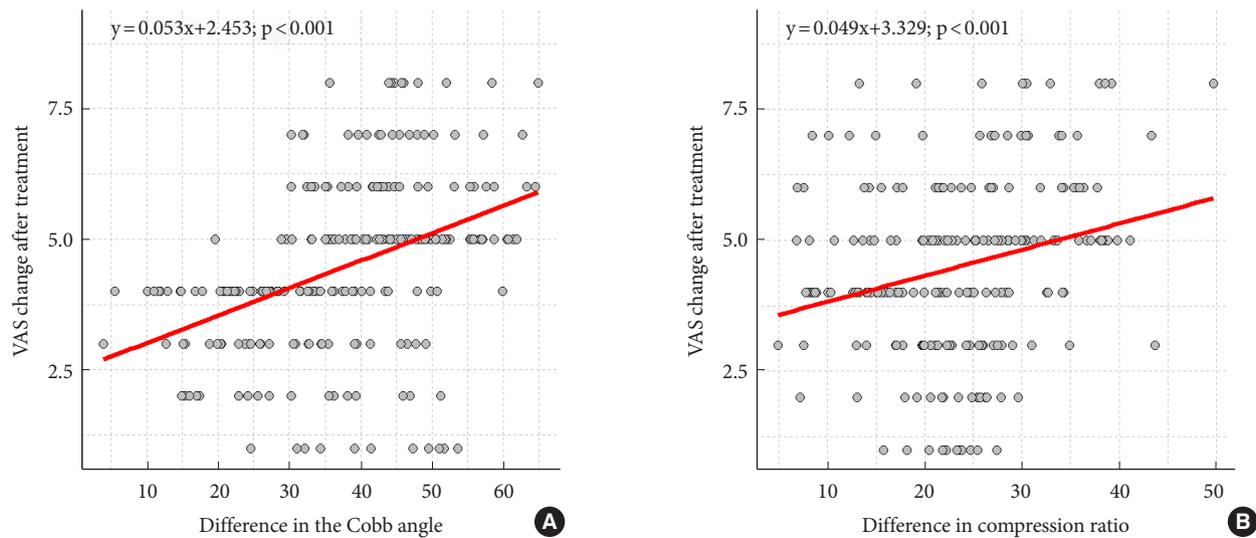


Fig. 2. A scatter plot with the linear regression line. Linear regression line showing the association between the difference in the Cobb angle and visual analogue scale (VAS) score after treatment (A) and difference in the compression ratio and VAS score after treatment (B).

Table 2. Comparisons of patients' variables according to the short-term clinical outcomes

Variable	Favorable outcome (n = 128)	Unfavorable outcome (n = 121)	p-value
Age (yr)	68.8 ± 5.2	69.9 ± 5.9	0.127
Male sex	34 (26.6)	22 (18.2)	0.152
Body mass index (kg/m ²)	22.5 ± 3.1	22.8 ± 3.1	0.521
Bone mineral density	-3.1 ± 0.5	-3.1 ± 0.5	0.389
VAS preoperation	7.5 ± 1.2	7.4 ± 1.4	0.286
VAS 1 month	1.8 ± 1.1	4.2 ± 1.3	<0.001*
Cobb angle - standing (°)	20.3 ± 6.1	17.5 ± 4.8	0.001*
Cobb angle - supine (°)	11.1 ± 4.0	11.8 ± 3.3	0.107
Difference in Cobb angle (%)	45.7 ± 9.1	31.7 ± 11.2	<0.001*
Compression ratio - standing (%)	51.1 ± 6.0	48.1 ± 7.9	0.001*
Compression ratio - supine (%)	37.5 ± 4.9	38.0 ± 6.2	0.442
Difference in compression ratio (%)	26.3 ± 8.4	20.6 ± 7.0	<0.001*

Values are presented as mean ± standard deviation or number (%).

VAS, visual analogue scale.

* $p < 0.05$, statistically significant differences.

ratio were higher in the favorable outcome group than in the unfavorable outcome group. Multivariate logistic regression analysis was performed to detect the factors associated with the favorable outcomes after surgery. As shown in Table 3, the differences in the Cobb angle (OR, 1.27; 95% CI, 1.16–1.40; $p < 0.001$) and compression ratio (OR, 1.12; 95% CI, 1.06–1.17; $p < 0.001$) were identified as the independent factors for predicting the short-term favorable outcomes after vertebral augmentation.

We observed a significant positive correlation between the differences in the Cobb angle and compression ratio with the change in VAS score (Fig. 2). The optimal cutoff values of the differences in the Cobb angle and compression ratio for predicting the short-term favorable outcomes after vertebral augmentation were 40.254 (area under the curve [AUC], 0.848; sensitivity, 74.2%; specificity, 82.6%; $p < 0.001$) and 26.493 (AUC, 0.703; sensitivity, 54.7%; specificity, 82.6%; $p < 0.001$), respectively (Fig.

Table 3. Multivariate logistic regression analysis for predicting the short-term favorable outcomes after vertebral augmentation based on various predictive factors

Variable	OR	95% CI	p-value
Age	0.95	0.89-1.02	0.149
Sex	2.27	0.95-5.42	0.065
Bone mineral density	0.48	0.22-1.04	0.063
Difference in Cobb angle	1.27	1.16-1.40	<0.001
Difference in compression ratio	1.12	1.06-1.17	<0.001

OR, odds ratio; CI, confidence interval.

3). When comparing the differences in the Cobb angle and compression ratio, the difference in the Cobb angle had a higher AUC for predicting the short-term favorable outcomes after vertebral augmentation.

4. Differences in the Cobb Angle and Compression Ratio for Predicting the Midterm Favorable Outcomes After Vertebral Augmentation

Of the 249 patients, 126 were followed up for more than 6 months. These patients were analyzed for the midterm clinical outcome after vertebral augmentation. A comparison of the midterm clinical outcomes in the patients is summarized in Table 4. The differences in the Cobb angle and compression ratio at supine were higher in the midterm favorable outcome group than in the unfavorable outcome group. Multivariate logistic regression analysis was performed to detect the factors associated with the favorable outcomes after surgery. As shown in Table 5, the difference in the Cobb angle (OR, 1.05; 95% CI, 1.02–1.09; $p < 0.001$) was found to be the only factor for predicting the midterm favorable outcomes after vertebral augmentation. In the favorable outcome group, hammer fracture occurred in 10.3% (7 of 68) of the patients, and in the unfavorable outcome group, hammer fracture occurred in 24.1% (14 of 58). There was no statistically significant difference between these results.

The optimal cutoff values of the difference in the Cobb angle for predicting the midterm favorable outcomes after vertebral augmentation were 35.526° (AUC, 0.676; sensitivity, 77.9%;

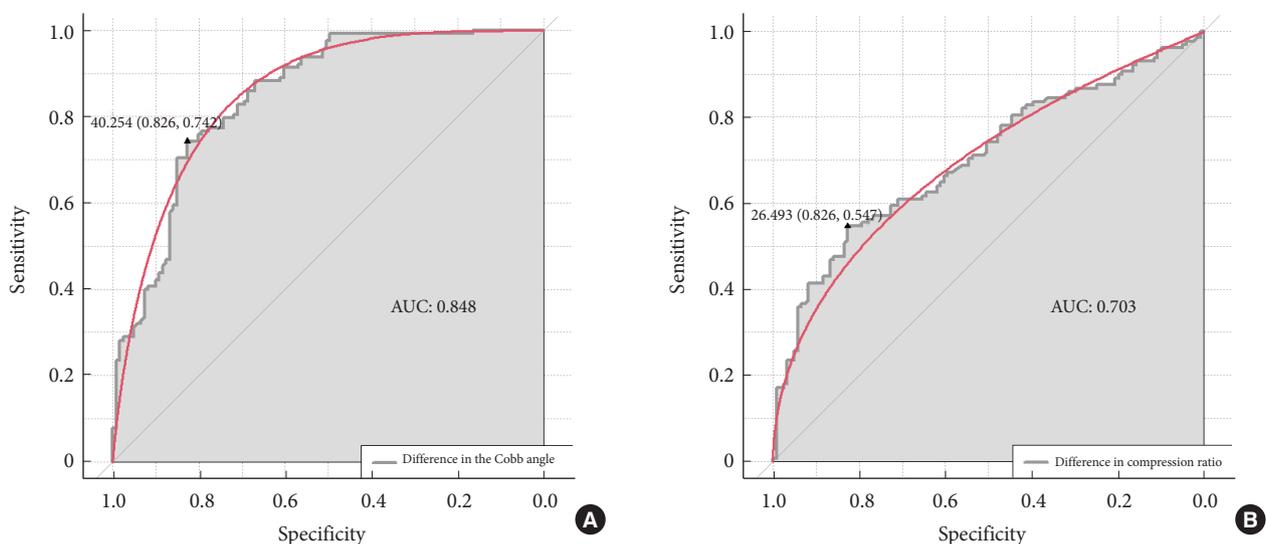


Fig. 3. Receiver operating characteristic (ROC) curve to identify the optimal cutoff values of the differences in the Cobb angle (A) and compression ratio (B) for the prediction of the short-term favorable outcomes after vertebral augmentation. AUC, area under the curve.

Table 4. A comparison of the patients' variables according to the midterm clinical outcomes

Variable	Favorable outcome (n=68)	Unfavorable outcome (n=58)	p-value
Age (yr)	69.1 ± 5.8	70.3 ± 6.1	0.257
Male sex	22 (32.4)	10 (17.2)	0.082
Body mass index (kg/m ²)	22.7 ± 3.3	22.9 ± 2.8	0.792
Bone mineral density	-3.1 ± 0.5	-3.2 ± 0.5	0.256
Cobb angle at standing (°)	20.7 ± 5.7	18.6 ± 5.0	0.030*
Cobb angle at supine (°)	11.8 ± 3.8	11.9 ± 3.5	0.846
Difference in Cobb angle (%)	42.9 ± 11.3	35.1 ± 12.4	<0.001*
Compression ratio at standing (%)	50.6 ± 5.3	52.7 ± 4.8	0.021*
Compression ratio at supine (%)	37.3 ± 3.5	40.8 ± 4.4	<0.001*
Difference in compression ratio (%)	25.6 ± 8.8	22.4 ± 6.7	0.021*
Hammer fracture	7 (10.3)	14 (24.1)	0.066

Values are presented as mean ± standard deviation or number (%).

*p < 0.05, statistically significant differences.

Table 5. Multivariate logistic regression analysis for predicting the midterm favorable outcomes after cement augmentation based on various predictive factors

Variable	OR	95% CI	p-value
Age	0.94	0.88–1.02	0.099
Sex	2.41	0.91–6.40	0.078
Bone mineral density	0.38	0.23–1.05	0.081
Difference of Cobb angle	1.05	1.02–1.09	<0.001
Difference of compression ratio	0.63	0.37–1.07	0.087

OR, odds ratio; CI, confidence interval.

specificity, 53.4%; p < 0.001). The optimal cutoff value of the difference in compression ratio for predicting the midterm favorable outcomes after vertebral augmentation was 26.583 (AUC, 0.629; sensitivity, 54.4%; specificity, 72.4%; p < 0.001) (Fig. 4).

5. Differences in the Cobb Angle and Compression Ratio According to Shape of Fracture

The most common fracture shape was the wedge shape (56.6%). The biconcave and crush shapes were 26.9% and 16.5%, respec-

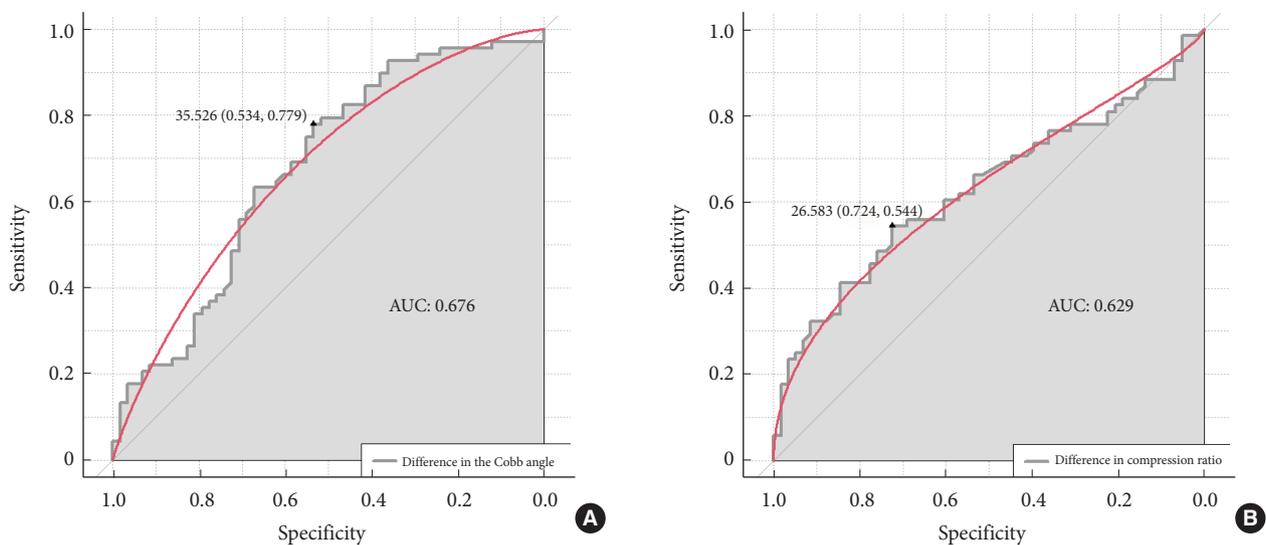


Fig. 4. Receiver operating characteristic (ROC) curve to identify the optimal cutoff values of the differences in the Cobb angle (A) and compression ratio (B) for the prediction of the midterm favorable outcomes after vertebral augmentation. AUC, area under the curve.

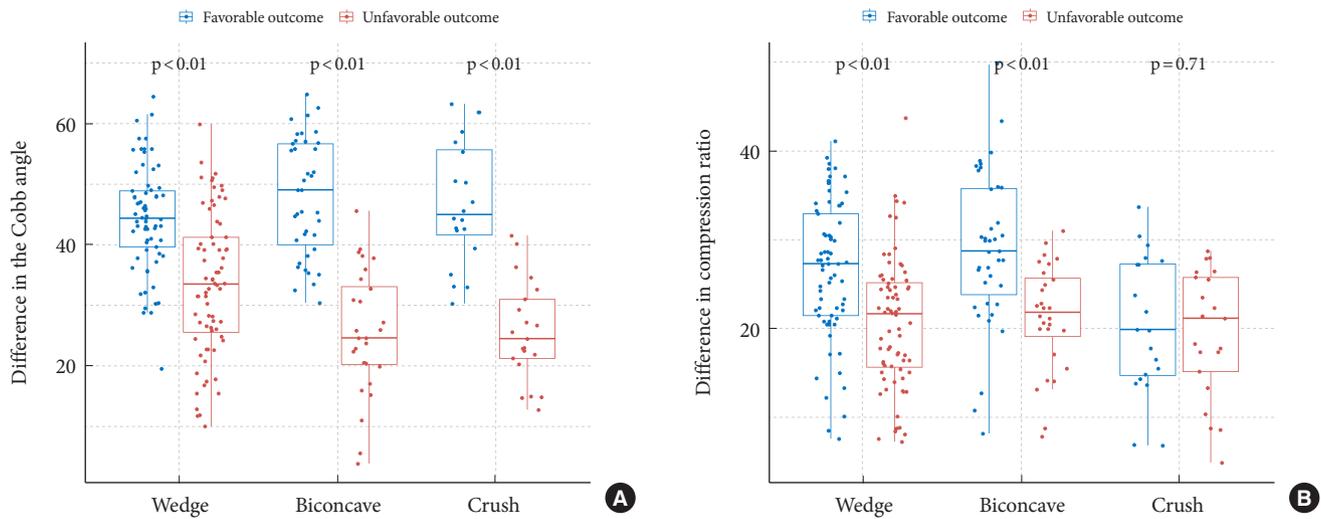


Fig. 5. Boxplots with dot plots of the differences in the Cobb angle (A) and compression ratio (B) classified according to the shape of the fracture.

tively. There was no significant difference in the Cobb angle or compression ratio according to the shape of the fracture. In the classification according to fracture shape, we found that the change in VAS score was significantly different from the differences in the Cobb angle and compression ratio (Fig. 5).

DISCUSSION

We found that the differences in the Cobb angle and compression ratio between the standing and supine positions were related to the short-term clinical outcome after vertebral augmentation. The optimal cutoff values of the differences in the Cobb angle and compression ratio for predicting the short-term favorable outcomes were 40.254° (AUC, 0.848) and 26.493° (AUC, 0.703), respectively. In addition, the optimal cutoff values of the differences in the Cobb angle and compression ratio for predicting the midterm favorable outcomes were 35.526° (AUC, 0.676) and 26.583° (AUC, 0.629), respectively. The difference in the Cobb angle was found to be the only factor for predicting the midterm favorable outcomes after vertebral augmentation. To the best of our knowledge, this study is the first study to suggest that the difference in the Cobb angle between the standing and supine positions is related to the clinical outcomes after vertebral augmentation in patients with OVCF.

Several treatments have been used to manage OVCFs. Typical treatments include conservative treatment, minimally invasive surgery (vertebral augmentation), and open surgery with spinal fusion. In many studies, cement augmentation was appropriate for treating OVCFs because it reduced pain and re-

stored ambulation with minor complications in comparison to conservative treatment.¹²⁻¹⁴ Vertebral augmentation provides significant, immediate, and sustained pain relief in patients with back pain from OVCFs. It rapidly improves physical function and the quality of life in patients with OVCFs. However, vertebral augmentation has adverse effects. Adjacent segment fractures and cement leakage have been reported.^{15,16} The effectiveness of vertebral augmentation compared with conservative treatment is controversial.

Increase in the loading forces on the vertebral body and posterior tension forces increase pain after OVCFs.¹⁷ A previous study reported that the degree of collapse of the vertebral body and the intensity of back pain are partially related.⁷ The extent of radiologic collapse had no bearing on the length of hospital stay. However, in previous studies, measurements were only based on supine radiographs. The patients with compression fractures complained of more pain in the standing position than in the supine position. Based on this observation, we postulated that standing radiographs may provide some information about instability at the fracture level.

Qian et al.¹¹ reported that improvement in symptoms after kyphoplasty is better in patients with wedge-shaped changes in the supine and standing positions. There are 3 types of osteoporotic fractures: wedge-shaped, crush, or biconcave fractures.¹⁸ In that study, only wedge-shaped compression fractures were analyzed. However, the wedge shape ratio cannot be measured in the biconcave compression fractures. Therefore, the Cobb angle and compression ratio, which can be measured even in the biconcave or crush shape fracture, were analyzed in this study.

Patients with symptomatic OVCFs typically present with severe back pain following a minor injury. Fracture site instability is thought to be the main cause of back pain in patients with OVCF.¹⁹ Therefore, areas with severe instability should be targeted for vertebral augmentation. Pain relief can be expected when the instability is resolved by injecting cement into the fracture site. We observed a significant correlation between the differences in the Cobb angle and compression ratio with the short-term and midterm clinical outcomes after vertebral augmentation. Differences in the Cobb angle and change in compression ratio were identified as the independent factors for predicting short-term favorable outcomes after vertebral augmentation. In addition, difference in the Cobb angle was found to be the only factor for predicting the midterm favorable outcomes after vertebral augmentation. The results of our study showed that the more severe the instability, the better the postoperative outcome after vertebral augmentation. Based on the results of our study, it can be inferred that the pain after OVCFs is caused by instability in the fractured vertebrae. Instability at the fractured vertebrae is thought to be the main cause of back pain in patients with OVCF. Therefore, areas with severe instability should be targeted for vertebral augmentation. Pain relief can be expected when the instability is resolved by cement augmentation at the fracture site.

To measure the compression ratio, a total of the 3 heights of the fractured vertebral body and the adjacent 2 should be measured. On the other hand, to measure the Cobb angle, the angle between the superior endplate of the vertebral body above and the inferior endplate of the vertebral body below the fractured vertebral body should be measured. In addition, when measuring the compression ratio, an error may occur depending on which point is measured because it is measured from the fractured vertebral body. However, when measuring the Cobb angle, the normal vertebral bodies above and below the fractured vertebra are used, and the possibility of such an error is relatively small. When measuring the angles and heights, there is a possibility of interobserver error. However, if the number of measured values can be reduced, this error will reduce. It is easier to measure the Cobb angle than the compression ratio, with a reduced possibility of error.

Osteoporosis is one of the main factors that increase kyphosis after compression fracture. Bones with low quality cannot resist the vertebra's loads, leading to a loss in the vertebral body height.²⁰ Therefore, the height of the vertebral body may decrease more in the standing position, where the load on the spine increases, than in the supine position, where the load is less. Based on this, it can be expected that the more severe the osteoporosis,

the greater the difference in the Cobb angle between the standing and supine positions. However, in our study, there was no significant correlation between the BMD and difference in the Cobb angle between the standing and supine positions. This result is probably because only patients with osteoporosis with an average BMD of -3.1 were included in this study. To elucidate the relationship between the BMD and difference in the Cobb angle between the standing and supine positions, a larger study including patients with osteopenia with BMD greater than -2.5 should be conducted in the future.

Many studies have proposed a high recurrent compression fracture rate after augmentation procedure, possibly related to an increase in the stiffness of the treated vertebra known as the "Hammer effect."^{21,22} Kim et al.²³ found an increased risk of recurrent fracture of the adjacent level with increased height restoration after vertebroplasty. According to previous studies, the risk of recurrent fracture occurrence appears to be greater in kyphoplasty (45%–75%)^{24,25} than in vertebroplasty (0%–16%).^{23,26} In our study, 16.7% (21 of 126) of the recurrent fractures occurred after kyphoplasty. It is thought that the lower incidence of recurrent fractures in our study compared to that of previous studies was due to the short observation period of 6 months. Because there is a possibility of hammer fracture after augmentation, surgeons must carefully consider the difference in the Cobb angle between the standing and supine positions when deciding whether to operate.

In Korea, the national health insurance service system allows kyphoplasty when there is OVCF with a compression ratio of > 30% and noncontrolled pain despite medical treatment and bed rest for more than 3 weeks. We found that the changes in the Cobb angle and compression ratio between the standing and supine positions were significantly related to the clinical outcomes after surgery. Based on these results, it is necessary to consider the differences according to the posture, and not based on the simple compression ratio, before determining the management of OVCF.

Surgical treatment should be considered in cases of nonunion or osteonecrosis, and spinal cord compression after conservative treatment has failed. To date, various surgical procedures have been reported, including vertebroplasty or kyphoplasty, spinal fusion,^{27,28} vertebroplasty with posterior spinal fusion,²⁹ and posterior spinal shortening.³⁰ Surgical treatment of OVCF has been challenging for surgeons, because there are potential risks of instrumentation failure, including screw loosening, pseudarthrosis, and postoperative infection due to bone fragility in elderly patients with several comorbidities. OVCFs can be man-

aged with cement augmentation which is a less invasive procedure than spinal fusion. However, the most appropriate method should be selected based on the patient's condition and understanding of each surgical method.

Our study has some limitations. First, it was a retrospective study and included a relatively small number of patients with a relatively short follow-up period. Since our study was retrospective, it was more likely to be affected by various types of bias compared to a randomized controlled study. Second, only patients who underwent cement augmentation were included. The decision of vertebral augmentation was made only by the surgeon, which might have introduced a selection bias. A study on the difference in the Cobb angle and the degree of pain according to the posture is needed even in patients who have not undergone surgery. Third, although the Cobb angle and the degree of compression ratio after cement augmentation may be related to the clinical outcomes, the analysis of the postoperative Cobb angle and compression ratio was omitted in this study. Fourth, patients over 80 years of age were excluded. A recent study has shown that cement augmentation is a safe treatment for OVCFs in very elderly patients.³¹ Studies involving patients over 80 years of age should be conducted in the future. Fifth, since the spine has a normal physiological curvature, there is a difference in the Cobb angle for each segment. Therefore, it is necessary to analyze the difference in the Cobb angle between the standing and supine positions mentioned in this study for each segment. Therefore, a larger, randomized controlled case study with a long-term follow-up is required in the future. Despite these limitations, our study is the first to suggest that the difference in the Cobb angle between the standing and supine positions is related to the clinical outcomes after vertebral augmentation in patients with OVCF.

CONCLUSION

We found that the differences in the Cobb angle and compression ratio between the standing and supine positions were related to the short-term and midterm clinical outcomes after vertebral augmentation in patients with OVCFs. Furthermore, the difference in the Cobb angle was found to be the only factor for predicting the midterm favorable outcomes after vertebral augmentation. The optimal cutoff values of the difference in the Cobb angle for predicting the midterm favorable outcomes was 35.526°. The outcome was better when there was a difference of approximately 35% or more in the Cobb angle between the standing and supine positions. To the best of our knowl-

edge, this study is the first to suggest that the difference in the Cobb angle between the standing and supine positions is related to the clinical outcomes after vertebral augmentation in patients with OVCF. Surgeons should pay attention to the difference in the Cobb angle depending on the posture when deciding to perform vertebral augmentation in patients with OVCFs.

NOTES

Conflict of Interest: The authors have nothing to disclose.

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