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# Investigation of Possible Reasons of Failed Treatment of Conservative Thoracolumbar Osteoporotic Vertebral Fractures

Mustafa Abdullah OZDEMIR[1], Serkan BAYRAM[2], Sahin KARALAR[2], Murat KORKMAZ[2], Iljhan SULEJMANI[2], Sevan SIVACIOGLU[3], Turgut AKGUL[2]

[1]Kahramanmaras Sutcu Imam University, Faculty of Medicine, Department of Orthopaedics and Traumatology, Kahramanmaras, Turkey
[2]Istanbul Faculty of Medicine, Istanbul University, Department of Orthopaedics and Traumatology, Istanbul, Turkey
[3]Acibadem University, Faculty of Medicine, Department of Orthopaedics and Traumatology, Istanbul, Turkey

**Corresponding author:** Serkan BAYRAM ✉ dr.serkanbayram89@gmail.com

## ABSTRACT

**AIM:** To investigate the possible reasons of failed conservative treatment of osteoporotic thoracolumbar vertebral compression fractures (VCFs). Sagittal balance impairment may weaken union by increasing the load on the fracture line. Most osteoporotic vertebral fractures occur in the thoracolumbar and mid-thoracic regions.

**MATERIAL and METHODS:** We investigated the records of patients aged >60 years who underwent treatment for osteoporotic thoracolumbar VCFs between 2012 and 2020. The patients were divided into two groups: those who required surgical treatment due to the failure of conservative treatment and those who were successfully treated with conservative treatment. All the patients underwent lateral radiography and computer tomography of the whole spine at their initial and final visit. The radiographic parameters of spine and presence of sarcopenia, age, and gender were compared between the groups.

**RESULTS:** Of the study subjects, the mean age of 13 females and 7 males in whom conservative treatment was successful was 67.4 years and the mean follow-up period was 23.5 months, while in 18 females and 5 males who underwent surgical treatment due to the failure of conservative treatment, the mean age was 68.7 years and the mean follow-up period was 22.1 months. No significant differences between the groups regarding age and gender were observed. However, significant differences were observed between the groups regarding the presence of sarcopenia and thoracic kyphosis, thoracolumbar kyphosis and distance from the center of the fractured vertebra to the plumb line (DSVA).

**CONCLUSION:** Sarcopenia and DSVA were significantly higher in the surgical treatment group. Receiver operating characteristic analysis demonstrated that the sensitivity and specificity of DSVA for identifying high-risk patients for failed conservative treatment of osteoporotic thoracolumbar VCFs were 100% and 95%, respectively, with an optimum diagnostic cutoff value of 6.5 mm.

**KEYWORDS:** Thoracolumbar region, Osteoporotic vertebral fractures, Sarcopenia, Radiological parameters

**ABBREVIATIONS: CT:** Computed tomography, **PI:** Pelvic incidence, **PT:** Pelvic tilt, **SS:** Sacral slop, **LL:** Lumbar lordosis, **TLK:** Thoracolumbar kyphosis, **TK:** Thoracic kyphosis, **T1SPI:** T1 spinopelvic inclination, **T9SPI:** T9 spinopelvic inclination, **TPA:** T1 pelvic angle, **DSVA:** Distance from the center of the fractured vertebra to the plumb line, **VAS:** Visual analog scale

Mustafa Abdullah OZDEMIR : 0000-0002-8281-3528
Serkan BAYRAM : 0000-0001-7651-1200
Sahin KARALAR : 0000-0002-4386-9107
Murat KORKMAZ : 0000-0003-2809-6721
Iljhan SULEJMANI : 0000-0002-0715-5772
Sevan SIVACIOGLU : 0000-0002-3969-0315
Turgut AKGUL : 0000-0002-0704-3797

## INTRODUCTION

As the average age of the population increases, the proportion of the elderly population and the incidence of osteoporosis increase accordingly (2). Osteoporosis is characterized by the weakening of the bone structure and an increased risk of fractures (3). The estimated lifetime risk of osteoporosis-related fractures after the age of 50 years is 40% for females and 13% for males (11). Most osteoporotic vertebral fractures occur during daily activities and do not result in significant trauma. Although pain occurs in the affected areas for a short time period, the pain often resolves within 2–3 weeks.

The importance of osteoporotic vertebral fractures is increasing and it is accepted as a significant health problem. Managing these fractures can be complicated due to the additional complications associated with aging, multiple drug use, poor functional capacity, and other comorbidities. Most osteoporotic vertebral fractures are conservatively treated with bed rest, analgesia, and osteoporosis treatment, with which most of the fractures functionally heal almost completely (14). However, in some patients, fracture healing is impaired by nonunion, endplate collapse, spinal deformity, and spinal cord narrowing. Although these complications are mostly uncommon, they can result in prolonged back pain, deterioration in the performance of daily activities, chronic pain, depression, sleep disturbance, and decreased self-esteem (5). In cases where conservative treatment fails, percutaneous cement strengthening techniques are used (e.g., kyphoplasty and vertebroplasty). The use of spinal instrumentation/implants is required for unstable fractures and in patients with neurological deficits and vertebral deformities.

One of the main objectives of osteoporotic vertebral fracture treatment is enabling union. Impairment in sagittal balance may weaken union by increasing the load on the fracture line (9). Most osteoporotic vertebral fractures occur in the thoracolumbar and midthoracic regions (16). The thoracolumbar region carries the dynamic load along the entire spine and is at the highest risk for kyphotic deformity and nonunion.

This study investigated the possible reasons for failed conservative treatment of osteoporotic thoracolumbar vertebral fractures.

## MATERIAL and METHODS

### Study Design

The study retrospectively reviewed the patients who were followed up with the diagnosis of osteoporotic vertebral fracture in the Department of Orthopedics and Traumatology of the Faculty of Medicine at Istanbul University between 2012 and 2020. The institutional review boards approval was obtained by our Institute of Orthopedics and Traumatology. The study was explained to the patients in detail and written informed consent was obtained from all the patients prior to their participation in the study.

*Inclusion criteria:* Patients with osteoporotic vertebral fractures at the thoracolumbar level, with a follow-up period of at least 1 year and available clinical and radiological data were included in the study.

*Exclusion criteria:* Patients with high-energy traumas, treated with only vertebroplasty or kyphoplasty without instrumentation, history of malignancies, and patients with unfollowed were excluded from the study.

Patients diagnosed with thoracolumbar vertebral fractures and followed up conservatively were routinely treated with a thoracolumbar brace. They were allowed to walk using a walker while wearing a corset. Pain-relief medications such as nonsteroidal anti-inflammatory drugs and acetaminophen were provided to the patients for use as needed. A lower extremity exercise program was also conducted with the help of a physiotherapist. The patients were examined on the 2$^{nd}$, 4$^{th}$, and 6$^{th}$ weeks of their outpatient follow-up. Use of the corset was terminated at the 6$^{th}$-week follow-up and these patients were re-examined at the 12$^{th}$ week. The success of the conservative treatment was evaluated by considering absence of neurological symptoms and pain relief in addition to fracture union. Surgical treatment was indicated for patients whose pain did not resolve after at least 3 months of conservative treatment and who experienced difficulty in walking.

Accordingly, the patients were divided into two groups: those who required surgical treatment due to the failure of conservative treatment (surgically treated group) and those who were successfully treated with conservative treatment (conservatively treated group).

The patients with failed conservative treatment consequently underwent posterior approach and pedicle screw instrumentation. A posterior longitudinal incision was made three levels above and below the fracture and long level fixation was performed at two or three levels above and below the fracture level.

### Radiological Evaluation

We examined the computed tomography (CT) and lateral radiograph of the spine at the C7 vertebra and both hips. The CT images for all the patients were underwent in the standard position at the time of admission and after the surgical treatment in the tomography unit of our hospital. The radiographs of the patients were used to measure pelvic incidence (PI), pelvic tilt (PT), sacral slop (SS), lumbar lordosis (LL), thoracolumbar kyphosis (TLK), thoracic kyphosis (TK), T1 spinopelvic inclination (T1SPI), T9 spinopelvic inclination (T9SPI), T1 pelvic angle (TPA), and the distance from the center of the fractured vertebra to the plumb line (DSVA).

PI is the angle between the perpendicular line drawn at the sacral-end upper-plate midpoint and the line connecting the axis of the femoral head to this midpoint. PT is the line connecting the vertical line drawn from the femoral head axis and the sacral-end upper-plate midpoint from the femoral head axis. SS is the angle between the line drawn from the last upper sacral plate and the horizontal line drawn from the midpoint of the last upper sacral plate. LL is the Cobb angle between the L1 and S1 vertebrae upper endplates. TLK is the

Cobb angle between the T10 vertebra upper endplate and L2 vertebra lower endplate. TK is the Cobb angle between the T4 vertebra upper endplate and T12 vertebra lower endplate. T1SPI is the angle between the line drawn from the center of the T1 vertebra to the femoral head axis and vertical plumb line. T9SPI is the angle between the line drawn from the center of the T9 vertebra to the femoral head axis and vertical plumb line. TPA is the angle between the line drawn from the femoral head axis to the center of the T1 vertebra and the line drawn from the femoral head axis to the sacral-end upper plate. DSVA is the distance of the C7 plumb line from the center of the fractured vertebra. The farthest distance was measured in patients with multiple fractures. Sagittal balance (SB) is the distance from the vertical descending line at the center of the C7 vertebra to the posterior upper-plate posterosuperior corner of the S1 vertebral body. The distance of this line from the S1 vertebral body to the final upper-plate posterosuperior corner, 2.5 cm anteriorly and posteriorly, is considered a neutral SB. The distance of >2.5 cm anteriorly and posteriorly was considered positive and negative SB, respectively.

Fracture union was defined as the absence of movement in the fracture line on the radiographs captured during extension and flexion at 12$^{th}$ week visit control.

The psoas muscle was used to evaluate sarcopenia in the patients (4). Psoas lumbar vertebral index (PLVI) is a valid and easy measurement tool that has previously been reported in the literature. In the axial CT of the patients, the mean cross-sectional areas of the right and left psoas muscles at the L4 vertebra level and the ratio of the L4 vertebral body at the L4 pedicles level were calculated. L4 vertebral index values were determined, and the patients were divided into high and low categories according to their relationship with the cohort median.

### Functional Evaluation

The visual analog scale (VAS) was used to measure the clinical outcomes of the surgical group.

### Statistically Analyses

For the statistical analysis, SPSS software (Version 24.0; SPSS Inc., Chicago, IL, USA) was used. Descriptive statistical methods (mean, standard deviation, median, minimum, and maximum) were used to evaluate the study data. Normal distribution was tested by Shapiro–Wilk test. The patients were initially stratified into high versus low PLVI groups with a median value of 0.720 to identify baseline characteristic differences. The high PLVI cohort was defined as ≥0.720 and low PLVI cohort was defined as <0.720. Student's t-test was used for the comparison of the quantitative data of the two groups that were normally distribution, and Mann–Whitney U test was used for the comparison of the data of the two groups that were not normally distribution. A paired samples t-test was used for the analysis of normally distributed dependent variables. Pearson chi-square test, Fisher Freeman Halton Exact test, and Fisher's Exact test were used to compare the qualitative data. P values <0.05 were considered as statistically significant. Receiver operator characteristics curve (ROC) analysis was performed to obtain the optimal values for the radiological parameters.

## RESULTS

Forty-three patients (21 females and 12 males) who met the criteria were included in the study. The mean age of the patients was 68.1 ± 7.4 (range, 60–86) years, mean time to surgery was 22.05 ± 12.42 (range, 10–52) weeks, and mean follow-up period was 22 ± 10 (range, 12–52) months after surgery (Table I).

In 20 patients, the 6-week thoracolumbar brace and medical treatments were successful, and these patients were able to return to their daily activities. Surgical intervention was performed in 23 patients with unresolved pain after at least 3 months of follow-up, gait disturbances, and nonunion (as observed on the radiographs).

In the 20 patients (13 females and 7 males) who were successfully treated with conservative treatment, the mean age was 67.4 years and mean follow-up period was 23.5 ± 6.1 (range, 14–36) months. Ten patients who were conservatively followed up had fractures at the T12 level, four had fractures at the T11–T12 level, and six had fractures at the L1 level.

The measurements of SB, DSVA, TLK, TK, T9SPI, TPA, and T1SPI showed significant differences between the two groups. However, no significant differences were observed in other sagittal parameters (Table II).

Among the conservatively treated group, 16 had neutral SB and 4 had positive SB. Sagittal imbalance was present in all the patients who required surgical treatment. Positive SB was noted in 18 patients and negative SB in 4. Neutral SB was achieved in 11 patients postoperatively.

The mean age of the 23 patients (18 females and 5 males) who underwent surgical treatment due to the failure of conservative treatment was 68.7 years and the mean follow-up period was 22.1 ± 10 (range, 12–35) months. Twelve patients had fractures

**Table I:** Demographic Data of All Patients

| | Conservative Group (n=20) | | Surgical Group (n=23) | | |
|---|---|---|---|---|---|
| | Mean ± SD | Min – Max | Mean ± SD | Min – Max | p |
| Age, years | 67.4 ± 7.5 | 60 – 85 | 68.8 ± 7.4 | 60 – 86 | 0.538 |
| Gender, F/M | 14/6 | | 19/4 | | 0.329 |
| Follow-up, months | 23.5 ± 6 | 12 – 36 | 22 ± 10 | 12 – 52 | 0.636 |

at the T12 level, nine had fractures at the T11–T12 level, and two had fractures at the L1 level. Posterior instrumentation was performed in all the patients. In addition, a cage was placed between the vertebral bodies due to vertebral collapse in four patients. By performing revision surgery, longer-level fusion was performed in 10 patients who had previously underwent short-level fusion due to adjacent segment degeneration and implant failure. Three of the patients who underwent revision surgery also had Parkinson's disease. Clinical improvement concerning preoperative walking difficulties was achieved in all the patients. The pain of the patients during the postoperative period was significantly reduced compared with that during the preoperative period. The mean VAS scores significantly decreased from 7.78 ± 0.48 (6–9) to 2.32 ± 0.55 (0–3) in the final visit. The TLK and DSVA were significantly improved, however, the other parameters did not change (Table III) (Figure 1, 2).

ROC analysis demonstrated that the sensitivity and specificity of the DSVA for identifying high-risk patients for failed conservative treatment of osteoporotic thoracolumbar vertebral fractures were 100% and 95%, respectively, with an optimum diagnostic cutoff value of 6.5 mm (area under the ROC curve 0.999 95% confidence interval : 0.994–1.00) (Figure 3).

**Table II:** Comparison of Radiological Parameters Between Both Groups

| | Conservative Group (n=20) | | Surgical Group (n=23) | | |
|---|---|---|---|---|---|
| | **Mean ± SD** | **Min – Max** | **Mean ± SD** | **Min – Max** | **p** |
| Pelvic Incidence (°) | 51.3 ± 9.1 | 37 – 66 | 50.9 ± 7.8 | 35 – 63 | 0.884 |
| Pelvic Tilt (°) | 15.4 ± 7.9 | 1 – 32 | 19.2 ± 12.3 | 1 – 41 | 0.067 |
| Sacral Slope (°) | 36.2 ± 3.7 | 30 – 42 | 30.7 ± 8.6 | 17 – 47 | 0.059 |
| Lumbar Lordosis (°) | 43.2 ± 8 | 34 – 62 | 45.8 ± 19 | 5 – 70 | 0.656 |
| Thoracolumbar kyphosis (°) | 22.7 ± 7 | 8 – 32 | 41.1 ± 20 | 4 – 80 | **0.026*** |
| Thoracic kyphosis (°) | 29 ± 7.3 | 18 – 45 | 40.8 ± 20 | 4 – 85 | **0.001**** |
| T1 spinopelvic inclination (°) | 3.1 ± 2.4 | 1 – 12 | 5.62 ± 4 | 0 – 14 | **0.034*** |
| T9 spinopelvic inclination (°) | 5.7 ± 3 | 1 – 15 | 13.5 ± 7 | 0 – 25 | **0.001**** |
| T1 pelvic angle (°) | 9.8 ± 6.5 | 4 – 32 | 18,9 ± 15 | 8 – 54 | **0.023*** |
| DSVA (cm) | 4.01 ± 1.5 | 2 – 7 | 11.04 ± 3.2 | 7 – 18 | **0.001**** |
| Sarcopenia (n) | 0 | | 20 | | **0.001**** |

***DSVA:*** *Distance from the center of the fractured vertebra to the plumb line,* ***cm:*** *centimeter. *p< 0.05 and **p<0.001*

**Table III:** Comparison of Preoperative and Postoperative Radiological Parameters of Surgical Group

| | Preoperative | | Postoperative | | |
|---|---|---|---|---|---|
| | **Mean ± SD** | **Min – Max** | **Mean ± SD** | **Min – Max** | **p** |
| Pelvic Incidence (°) | 50.9 ± 7.8 | 35 – 63 | 50.6 ± 7 | 32 – 64 | 0.669 |
| Pelvic Tilt (°) | 19.2 ± 12.3 | 1 – 41 | 19 ± 6..6 | 5 – 29 | 0.992 |
| Sacral Slope (°) | 30.7 ± 8.6 | 17 – 47 | 31.8 ± 5 | 20 – 41 | 0.568 |
| Lumbar lordosis (°) | 45.8 ± 19 | 5 – 70 | 49.4 ± 7 | 37 – 63 | 0.445 |
| Thoracolumbar kyphosis (°) | 41.1 ± 20 | 4 – 80 | 22.6 ± 12 | 1 – 39 | **0.001*** |
| Thoracic kyphosis (°) | 40.8 ± 20 | 4 – 85 | 39.3 ± 8 | 21 – 52 | 0.775 |
| T1 spinopelvic inclination (°) | 5.62 ± 4 | 0 – 14 | 5.2 ± 3 | 0 – 12 | 0.712 |
| T9 spinopelvic inclination (°) | 13.5 ± 7 | 0 – 25 | 12 ± 4.5 | 3 – 20 | 0.502 |
| T1 pelvic angle (°) | 18,9 ± 15 | 8 – 54 | 15 ± 6 | 6 – 33 | 0.208 |
| DSVA (cm) | 11.04 ± 3.2 | 7 – 18 | 6.4 ± 2 | 3 – 11 | **0.001*** |

***DSVA:*** *Distance from the center of the fractured vertebra to the plumb line,* ***SD:*** *Standard deviation,* ***Min:*** *Minimum,* ***Max:*** *Maximum;* ***cm:*** *centimeter. *p< 0.05 and **p<0.001.*

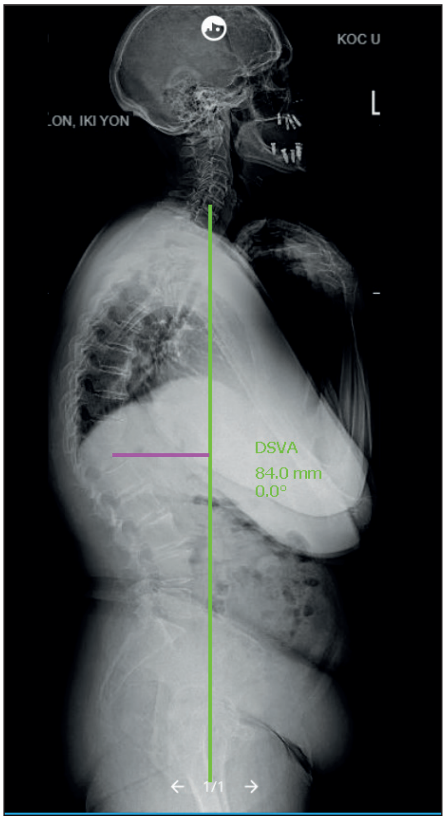


**Figure 1:** The preoperative distance from the center of the fractured vertebra to the plumb line was more than 65 mm in the patients with failed conservative management who were consequently treated with posterior instrumentation.

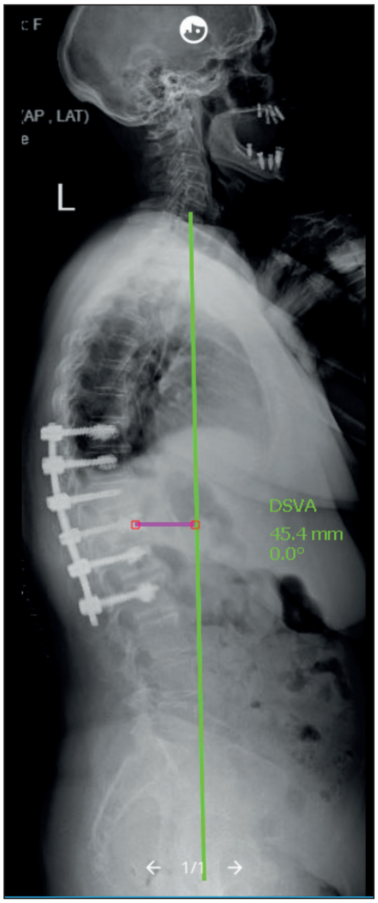


**Figure 2:** Postoperative lateral spinal radiographs; sagittal balance showed improvement after surgery.

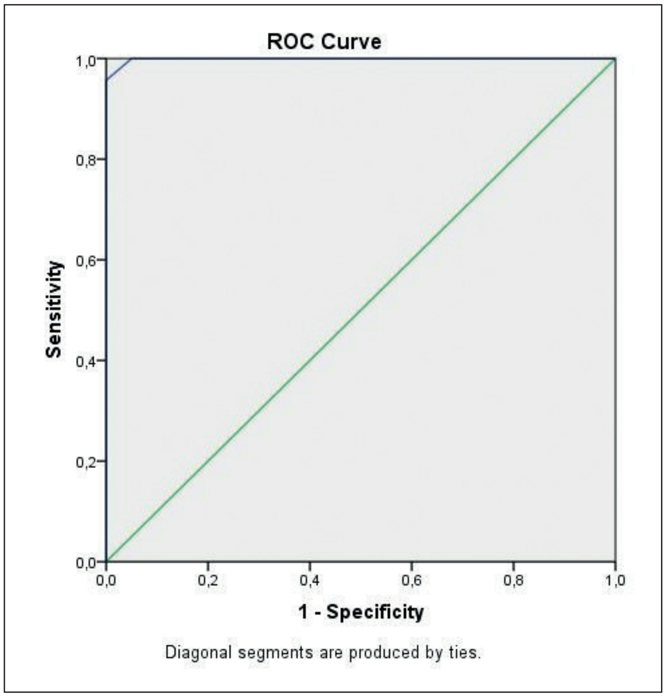


**Figure 3:** Receiver operating characteristic analysis of distance from the center of the fractured vertebra to the plumb line.

## DISCUSSION

Although numerous studies in the existing literature report on osteoporotic vertebral fractures, there is no consensus on the criteria to be used for surgical treatment. Lee et al. stated that osteoporotic fractures cannot be prevented, and the important issue in such cases is to minimize potential complications (12). Predicting the complications that may be caused by conservative treatment and deciding which surgical treatment interventions should be performed in patients constitute the main aspects of the treatment approach for osteoporotic vertebral fractures. Our study is important in terms of demonstrating the risk factors of unsuccessful conservative treatment for osteoporotic fractures in the thoracolumbar region.

Most osteoporotic fractures occur in the thoracolumbar region. The thoracolumbar region is the area that carries the greatest dynamic load in the entire spine, making it prone to fracture nonunion (8). A systematic study examining the reasons for the failure of conservative treatment reported that fractures in the thoracolumbar region have a high risk of developing both pseudoarthrosis and kyphotic deformity (14). Because of the difference in their biomechanical properties, the treatment approaches utilized for fractures in the thoracolumbar transition region should be different from those utilized for fractures in other parts of the spine. For this reason, only fractures in the thoracolumbar region were included in our study.

The objective of conservative treatment of an osteoporotic vertebral fracture is to relieve the patient's pain, provide early mobilization, and prevent new fractures. A meta-analysis by Gua et al. compared the efficacy and safety of conservative and surgical treatments for osteoporotic vertebral fractures and demonstrated that surgical treatment was more effective in reducing pain; however, no significant differences in the quality of life of patients in the medium and long terms between the two treatment approaches was observed (7). In fact, treatment success depends on several factors. Our study results indicate SB, DSVA, TLK, TK, T9SPI, T1SPI, and sarcopenia as risk factors for unsuccessful conservative treatment.

One of the main purposes of treatment of osteoporotic vertebral fracture is to provide union and relief pain. Sagittal imbalance may impair union by increasing the load on the fracture line. In a study investigating the effects of SB disorder on fracture union in patients with osteoporotic vertebrae, the effect of the distance from the C7 plumb line to the fracture union site on the fracture union was investigated (9). This study showed that this distance was significantly greater among patients with osteoporotic vertebral fractures who developed vertebral collapse than in patients without collapse (15). Yet another study reported that a distance of >5 cm of the C7 plumb line from the center of the fractured vertebra is a risk factor for nonunion (9). In our study, this distance was 4.01 cm in the conservatively treated group and 11.02 cm in the surgically treated group. Sagittal imbalance was present in all the patients who required surgical treatment. TLK was significantly higher in the surgically treated group than in the conservatively treated group.

Fractures may not heal completely in approximately 15%–35% of conservatively treated patients (16). Percutaneous vertebral cementing techniques can be performed in patients with severe pain who do not respond to conservative treatment. Previous studies have indicated that patients undergoing vertebroplasty have better clinical and radiological outcomes compared to those treated conservatively (13,19). Although percutaneous interventions contribute to pain relief and correct local kyphosis at the fracture line, their effects on SB are limited. Kanayama et al. reported on the results of a mean 36-month follow-up of 56 patients diagnosed with osteoporotic vertebral fractures and treated with kyphoplasty. The results showed that although the pain of the patients decreased with kyphoplasty, there was no improvement in their global sagittal alignment (10). Percutaneous interventions were not preferred owing to their limited effects on SB correction in patients undergoing surgical treatment.

Sarcopenia is a syndrome characterized by a decrease in muscle volume and mass. Bone and muscle tissue are closely related owing to their chemical and metabolic properties. The strongest mechanical forces on bones are generated by muscle contractions (18). Therefore, any decrease in muscle strength and function increases the risk of osteoporosis. A study reported sarcopenia to be a determinant of mortality in patients with osteoporotic vertebral fractures (1). In our study, 10 patients from the sarcopenic group underwent revision surgery. Spinal instrumentation techniques should be applied in geriatric patients with spinal instability, vertebral column collapse, neurological deficits, kyphotic deformities, and pseudoarthrosis. In patients with osteoporosis, adequate fixation may not be achieved in the pedicle screws due to the loss of bone structure. One of the most practical ways to increase pedicle screw stability is by using pedicle screws along with polymethyl methacrylate (6,17). In this study, cemented screws were used in 11 patients in whom insufficient screw stability was observed during surgery.

## CONCLUSION

Because of the difference in their biomechanical properties, the treatment approaches utilized for fractures in the thoracolumbar transition region should be performed more carefully and with close follow-ups. In this study, we investigated the factors that influence the failure of conservative treatment of osteoporotic thoracolumbar vertebral fractures. Sarcopenia and the DSVA were significantly higher in the surgically treated group who underwent operation following the failure of the conservative method. ROC analysis demonstrated that the sensitivity and specificity of the DSVA for identifying patients at a high risk of failed conservative treatment of osteoporotic thoracolumbar vertebral fractures were 100% and 95%, respectively, with an optimum diagnostic cutoff value of 6.5 mm.

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**AUTHORSHIP CONTRIBUTION**

Study conception and design: MAO, SB
Data collection: MAO, SK
Analysis and interpretation of results: MK, IS
Draft manuscript preparation: SB, MK, TA
Critical revision of the article: SS and TA
All authors (MAO, SB, SK, MK, IS, SS, TA) reviewed the results and approved the final version of the manuscript.

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