



Research Article

Practical evaluation of risk factors in patients with osteoporosis-induced thoracic and lumbar vertebral compression fractures requiring surgery

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ABSTRACT

This descriptive longitudinal study aims to assess the risk factors for severe thoracic and lumbar vertebral compression fractures before and after surgery, contributing to preventive knowledge enhancement in communities and effective treatment management. The study involved 34 patients diagnosed with thoracic and lumbar vertebral compression fractures requiring surgery with bio-cement-augmented pedicle screws between June 2021 and June 2022. Postoperative complications, notably adjacent segment injury, were monitored, and patients received osteoporosis management post-surgery.

The majority of patients were female (61.8 %), with an average age of 66.4 ± 9.2 years. Daily life accidents were the most common cause of injuries (88.2 %). Most patients underwent surgery more than 3 months after injury (58.8 %), with a notable percentage seeking examination and treatment post-injury. Osteoporosis prevalence was high among patients at the time of spinal injury, indicating a need for improved osteoporosis management strategies post-surgery. Various comorbidities were observed, with a portion of patients having pre-existing conditions like diabetes, hypertension, and kidney failure. Changes in bone mineral density correlated with age, highlighting the increased fracture risk seen in older individuals. Two patients required vertebral body reconstruction due to adjacent vertebra damage post-surgery. A significant proportion of patients received osteoporosis treatment after the surgical intervention.

Patients with lumbar-thoracic osteoporosis fractures need a comprehensive assessment of clinical and para-clinical factors to select appropriate and effective treatment methods. Postoperatively, these patients also require osteoporosis management, regular monitoring, and evaluations to reduce postoperative complications, including the risk of adjacent segment injury and other vertebral compression fractures.

Introduction

Osteoporotic vertebral compression fractures (VCFs) represent a significant health challenge, particularly among the elderly population. These fractures occur primarily due to the weakening of bones associated with osteoporosis, leading to an increased risk of fractures even from minimal trauma. In the United States alone, VCFs account for over 700,000 cases annually, making them the most common osteoporotic fractures. The prevalence of these fractures escalates with age, affecting nearly 50 % of individuals over 80 years old [1].

The consequences of VCFs extend beyond the immediate injury, contributing to chronic pain, reduced mobility, and a diminished quality of life. Patients with VCFs often experience complications such as kyphosis and increased risk of subsequent fractures, which further

exacerbate health issues and healthcare costs. The estimated direct annual healthcare expenditure for managing osteoporotic fractures, including VCFs, ranges from \$10 billion to \$15 billion in the U.S. [2,3].

Surgical interventions, such as percutaneous vertebroplasty and balloon kyphoplasty, have been developed to address the pain and instability associated with VCFs. These procedures aim to restore vertebral height and alleviate pain, yet their effectiveness remains debated. Recent studies suggest that while these surgical options can provide significant pain relief for some patients, they are generally recommended only after conservative treatments have failed to yield satisfactory results. Moreover, a substantial proportion of patients do not receive appropriate osteoporosis treatment following a fracture, highlighting a critical gap in post-fracture care [4–6].

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Patients and methods

A descriptive longitudinal study included 34 patients diagnosed with thoracic and lumbar vertebral compression fractures undergoing surgery with bio-cement-augmented pedicle screws from June 2021 to June 2022. The study obtained approval from Institutional Review Board of Hanoi Medical University, numbered 4561/QĐ-ĐHYHN. All patients provided informed consent.

Selection criteria

We include all patients who underwent surgery at our institution for thoracic and lumbar vertebral compression fractures. The inclusion criteria for surgery include:

- Patients with thoracic and lumbar vertebral compression fractures
- Bone density with T-score < -2.5 [7]
- Thoracic and lumbar vertebral compression fractures from T11 to L2 identified on X-ray, CT scans, and MRI
- For patients with new trauma (<3 months): unstable spine injury (according to Denis classification [7,8]), demonstrating neurological compression and TLIC score of 5 or above. For TLIC 4, surgery is indicated with spinal canal stenosis of 30 % or more, or vertebral body compression angle over 15° [9].
- For patients with injuries over 3 months: those with chronic, unresponsive pain and X-ray showing kyphotic deformity $> 20^\circ$, vertebral body compression $> 50\%$, and possible progressive neurological deficits (such as bilateral limb weakness, numbness, bladder voiding disorder).

Exclusion criteria

- Patients with severe systemic illnesses or contraindications
- Those non-compliant or lost to follow-up
- Allergic to bio-cement components or non-trauma-related spinal issues

Data collection

Patients underwent surgery with bio-cement-augmented pedicle screws. Study parametrizes were collected using predefined forms at various time points: preoperative, intraoperative, and postoperative follow-ups at 1 month and 6 months.

Evaluation included:

- Osteoporosis was diagnosed according to The World Health Organization's criteria, based on the T-Score, a measure used in osteoporosis diagnosis, particularly in assessing bone density compared to a healthy young adult population. Osteoporosis is diagnosed when the T-Score is ≤ -2.5 .
- Assessing pain levels using the Visual Analog Scale (VAS) [10].
- Spinal cord injury categorized by the Frankel scale [11]. The Frankel score is a system used to classify spinal cord injury based on a scale that ranges from A to E, in which A is completely paralysis and E is normal. This scale helps determine the extent of impairment and is crucial in assessing the level of paralysis and functional independence in individuals with spinal cord injuries.

Adjacent segment injury was evaluated as a postoperative complication, by X-ray or CT scans and physical examinations.

Postoperative osteoporosis management: Patients received adequate treatment and were monitored by orthopedic physicians at 1 and 6 months. The treatment depended on the patient's choice, including intravenous Zoledronic acid 5 mg or oral Fosamax Plus. All patients are supplemented with daily Calcium and Vitamin D (1200 mg/day).

Data analysis method

The analysis utilized medical statistical algorithms and processed the results using SPSS 20.0. Descriptive statistics were employed, with frequency and percentage used to describe qualitative variables such as gender and age groups, while mean and standard deviation were used for quantitative variables.

For quantitative variables:

Non-parametric tests were employed:

- The Mann-Whitney test was used to compare differences between two independent groups
- The Kruskal-Wallis test was used to compare differences among three or more groups

The linear correlation between two quantitative variables was examined using regression analysis, with the correlation coefficient (r) calculated; values closer to 1 indicate a stronger correlation between the variables.

Statistical significance was determined at a p-value of less than 0.05, indicating a meaningful difference or relationship.

Results

From June 2021 to June 2022, we collected 34 patients diagnosed with thoracolumbar spine injuries with osteoporosis who underwent cement augmentation pedicle screws. None of them were lost to follow-up.

The prevalence of female patients is 61.8 %, with a female-to-male ratio of 1.62:1. The mean age of the patients was 66.4 ± 9.2 years. The age bracket with the largest patient representation falls within the 60–70 years category, constituting 44.1 % of the total. Among the 34 patients, 30 patients had injuries due to daily life accidents accounting for the highest proportion (88.2 %). Most patients had a time from injury to surgery of more than 3 months, accounting for 58.8 % (Table 1).

The rate of patients with newly discovered osteoporosis at the time of spinal injury is very high (79.4 %). Only 20.6 % of patients had osteoporosis detected before spinal injury. Of the 7 patients with pre-existing osteoporosis, only 2 patients had previously been treated for osteoporosis. However, only 1 patient was treated for osteoporosis according to the correct regimen: Taking Fosamax Plus weekly continuously and supplementing with Calcium. The remaining 1 patient received irregular

Table 1
Demography, medical history, and characteristics of patients.

Characteristics		Number of patients (n = 34)	Ratio %
Gender	Male	13	38.2
	Female	21	61.8
Ages	< 60	8	23.5
	60–70	15	44.1
	70–80	9	26.5
	> 80	2	5.9
	Mean \pm SD	66.4 ± 9.2	
	Min - Max	45 - 87	
Cause of injury	Labor accidents	1	2.9
	Daily life accidents	30	88.2
	Traffic accidents	3	8.9
Injury time before surgery	Under 3 months	14	41.2
	From 3 months or more	20	58.8
Pre-traumatic osteoporosis	Yes	7	20.6
	No	27	79.4
Previous treatment of osteoporosis	Regularly (n = 7)	1	14.3
	Not often (n = 7)	1	14.3
	No treatment (n = 7)	5	71.4
History of medication use	Corticosteroids (n = 34)	3	8.8

treatment (Table 1).

Of the patients in the study, 7 patients had other accompanying diseases, accounting for 20.6 %, mainly common diseases of the elderly. Among them, 2 patients have type II diabetes, 3 patients have hypertension, 1 patient has stage II kidney failure, and especially 1 patient has hyperparathyroidism. The proportions of patients with a history of vertebral collapse due to osteoporosis, corticosteroid use, and fractures of the lower end of the radius bone accounted for 11.8, 8.8, and 5.9 %, respectively.

The patients showed mainly moderate and mild neurological injuries: 14 patients were graded Frankel D (41.2 %), the majority of patients had Frankel E nerve damage, accounting for 47.0 %. There were 2 patients with bladder voiding disorder accounting for 5.9 %. Only 3 patients had pain relief when using painkillers, but the pain level was still severe according to VAS (Table 2).

All patients presented with thoracolumbar spine pain. The patient's average preoperative VAS score was 8.1 ± 1.0 points, with a range of 6–10 points. The majority of patients had VAS scores of 7–8 points (21/34 patients). There were 9/34 patients with VAS 9–10 points.

There is a statistically significant relationship between age and bone density of patients. The older patients, the lower their bone density ($r^2 = 0.700, p = 0.001$) (Fig. 1).

Among 34 patients, 1 patient experienced a surgical site infection, accounting for 2.9 %, and 2 patients developed urinary tract infections while indwelling a urinary catheter, representing 5.9 % (Table 3).

In our study, the VAS score decreased from 8.1 ± 1.0 before surgery to 1.2 ± 0.8 at one-month post-surgery and 1.1 ± 0.6 at six months post-surgery, showing a significant difference compared to pre-operation with $p < 0.001$. Therefore, at one-month post-surgery and at six months post-surgery, the pain level of the patients decreased significantly compared to before surgery, with a confidence level of over 99.9 %.

Among the 34 patients who had surgery, after 6 months, 2 patients had damage to the adjacent vertebrae and underwent vertebral body reconstruction with cement-augmented pedicle screws. 82.4 % of patients were treated for osteoporosis after surgery (Table 4).

Table 2
Injury characteristics.

Characteristics		Number of patients (n = 34)	Ratio %
History of vertebral compression fractures	Vertebral fractures (n = 34)	4	11.8
	Other fractures (n = 34)	2	5.9
Spinal cord Injury assessments	Frankel A	0	0
	Frankel B	0	0
	Frankel C	4	11.8
	Frankel D	14	41.2
	Frankel E	16	47.0
Bladder voiding disorder	Urinary retention	2	5.9
	Urinary incontinence	0	0
Responds to pain relief	Yes	3	8.8
	No	31	91.2
VAS pain level	No pain (0 points)	0	0
	Mild pain (1 - 2 points)	0	0
	Moderate pain (3 - 4 points)	0	0
	Severe pain (5 - 6 points)	4	11.8
	Very severe pain (7 - 8 points)	21	61.8
	Worst possible pain (9 - 10 points)	9	26.4
	Total	34	100
	Mean \pm SD (range)	8.1 ± 1.0 (6–10)	

Discussion

In our study, there were 34 patients with an average age of 66.4 ± 9.2 years old. The oldest patient is 87 years old and the youngest is 45 years old. The age group with the highest proportion is the group from 60 to under 70 years old, accounting for 44.1 %. Yamana and colleagues studied 34 patients with fractured vertebrae due to spinal trauma, with an average age of 77 (range 67–89) [12], similar to our study.

Osteoporosis is a typical disease in the elderly population, especially the 60–80-year-old group. Osteoporosis in the elderly appears in both men and women over the age of 70 and is the result of gradual bone loss over many years. According to Ledlie, the older the patient, the higher the rate of vertebral body rupture due to osteoporosis, with 40 % of patients are aged 80–85 [13].

In our study, the majority of patients were female, accounting for 61.8 % of the study population. This finding is consistent with epidemiological studies indicating that the rate of osteoporosis-related vertebral fractures is much higher in women compared to men. Globally, one in three women faces a risk of osteoporosis-induced vertebral compression fractures, while the risk ratio for men stands at one in five [4]. The high prevalence of osteoporosis in postmenopausal women is attributed to several factors, including sexual dysfunction, decreased parathyroid hormone (PTH) secretion, and increased urinary calcium excretion. Osteoporosis is particularly common in women aged 50–60 years who have undergone menopause or oophorectomy for approximately 5–15 years. In contrast, osteoporosis in men is more often associated with advanced age and an accompanying risk of spinal injury. A study by Kuru examining 105 patients admitted for osteoporosis-related vertebral compression fractures reported that about 89 % of them were postmenopausal women [4].

Among the patients studied, 3 patients used long-term corticosteroids to treat chronic lumbar spine pain, accounting for 8.8 %. According to Van Staa [14], there is a strong correlation between corticosteroid use, reduced bone density and the risk of vertebral fractures. A study by LeBlanc on patients requiring regular corticosteroid treatment also have shown that the rate of vertebral fracture due to osteoporosis in patients after starting corticosteroid use within the first 3 years is 4.4 per 100 people. The risk is highest during the first year of corticosteroid treatment and remains elevated during the first 3 years of starting treatment [15]. Harrop has shown that corticosteroids are a risk factor for vertebral fracture and new vertebral body collapse. The mechanism may be due to the use of corticosteroids, which limits bone formation, reduces calcium deposition inside the vertebral body, or is due to a decrease in the amount of bone-forming cells [16].

Our study also showed that 4 patients had a history of vertebral collapse due to osteoporosis, accounting for 11.8 %, and 2 patients with fractures of the lower end of the radius, accounting for 5.9 %. In Kuru's study, there were 105 patients with vertebral body subsidence due to osteoporosis, 34 patients (accounting for 32.7 %) had a history of fracture after a fall or after a very mild injury [4]. This makes us more vigilant in cases of multiple fractures, especially in the elderly and premenopausal women, who need to screen and detect osteoporosis.

The patient's average preoperative VAS score was 8.1 ± 1.0 points significantly reduced to 1.1 ± 0.6 after six months of surgery. Preoperative osteoporosis patients with thoracolumbar spine injuries often have very high VAS scores. These patients often have unbearable back pain and are unresponsive to medical treatment before considering surgery. Therefore, VAS before and after surgery will have a statistically significant difference. Studies also show that patients with vague or no back pain have little or no difference in pain after surgery. Thus, using the VAS scale to quantify the patient's pain level, makes surgical indications accurate and effective.

After six months, 2 patients had damage to the adjacent vertebrae and underwent vertebral body reconstruction with non-balloon cement-augmented pedicle screws, slightly lower than other studies. Mo [17] and colleagues studied 34 patients with 7 adjacent vertebrae damaged after

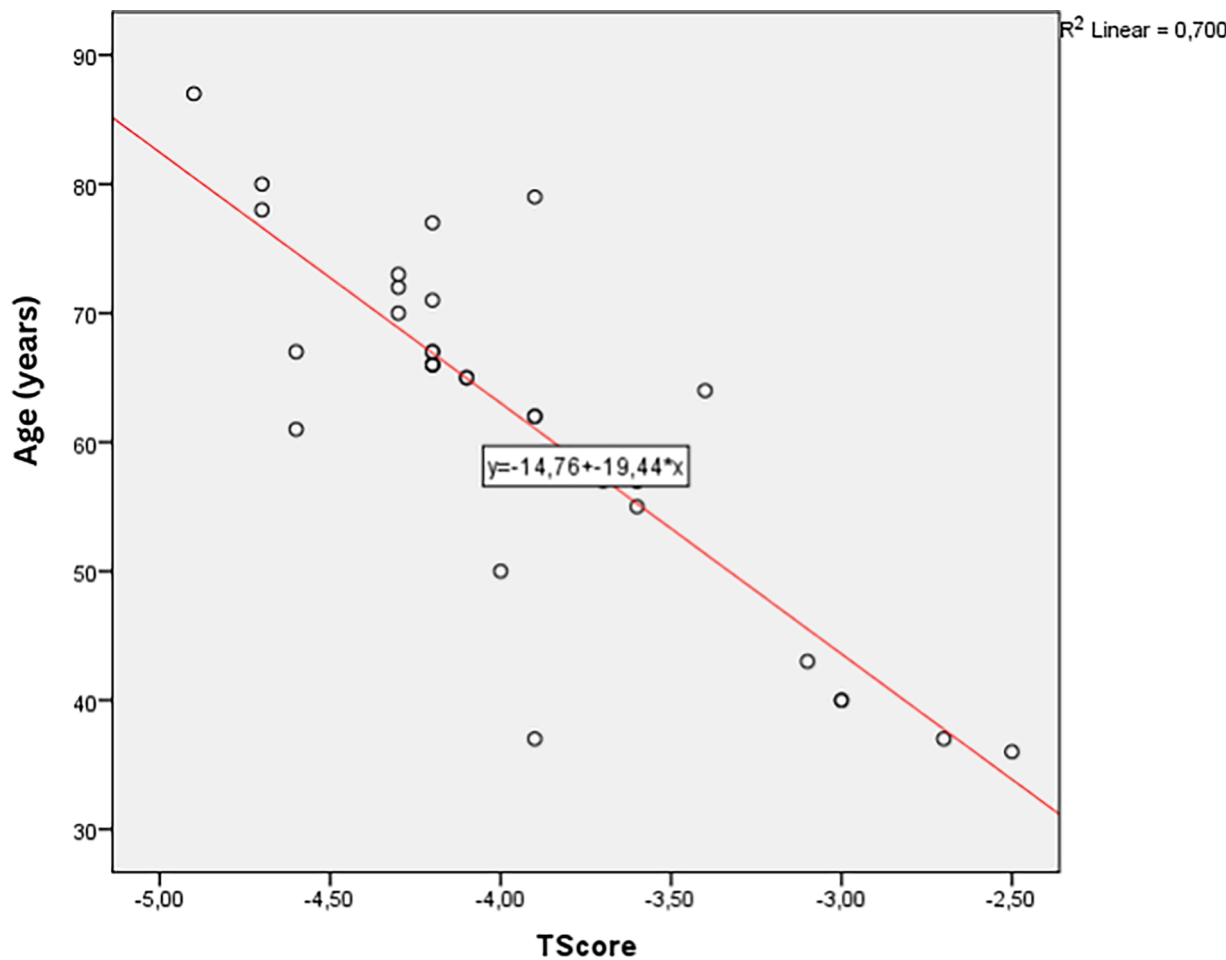


Fig. 1. Correlation between bone density (T-score) and age (n = 34).

Table 3
Post-surgical complications.

Postoperative complications	Number of patients (n = 34)	Ratio%
Mortality	0	0
Postoperative bleeding	0	0
Surgical site infection	1	2,9
Urinary tract infection	2	5,9
Pressure ulcer	0	0
Pneumonia	0	0
Cerebrospinal fluid leak	0	0

Table 4
Assessment for postoperative osteoporosis treatment.

Characteristics	Number (n = 34)	Ratio (%)
New injured vertebra		
After 1 month	0	0
After 6 months	2	5,9
Postoperative osteoporosis treatment		
Yes	28	82,4
No	6	17,6
VAS score	Mean ± SD	p
Before surgery (1)	8,1 ± 1,0	
1 month after surgery (3)	1,2 ± 0,8	p (1,2) < 0,001
6 months after surgery (3)	1,1 ± 0,6	p (1,3) < 0,001

surgery. In the study of Tandon [18] and colleagues, 2 adjacent vertebrae were damaged in 20 patients. A study by Schwarz [19] and colleagues on 87 patients had up to 19 adjacent vertebrae damaged among

14 patients, with 17 adjacent vertebrae above the fusion segment and only 2 vertebrae below. Most adjacent vertebrae are damaged in the first 12 months, with an average duration of 8.5 months (1–18 months). Adjacent vertebrae are subjected to greater pressure when the vertebrae next to them are reinforced with biological cement, while the patient's osteoporotic condition remains, so they easily collapse.

In Schwaz's study, patients with adjacent vertebral lesions had a T-Score of −3.76 compared to −3.06 in patients without adjacent vertebral lesions. The author's study also showed a trend of adjacent vertebral injury related to age, number of spinal fusion segments and T-Score [19]. Therefore, the treatment of osteoporosis after surgery is extremely important. According to Govindarajan, using bisphosphonate after surgery significantly reduces post-operative vertebral collapse and significantly reduces the VAS index. The benefits of bisphosphonate help accelerate bone healing when immobilizing the spine in the first 6 months after surgery in patients with vertebral fractures due to osteoporosis, reducing pain and reducing the risk of other vertebral fractures post-surgery [1]. Of the 34 patients in our study, 82.4 % were treated for osteoporosis after surgery. We achieved such a high rate because after surgery we explained to all patients the importance of postoperative osteoporosis treatment and continued effective anti-osteoporosis treatment.

The methodological approach of this study presents both strengths and limitations that are critical to consider when interpreting the findings. One of the primary strengths is the focused examination of risk factors associated with osteoporosis-induced thoracic and lumbar vertebral compression fractures, which addresses a significant clinical issue. The longitudinal design allows for the assessment of patients over time, providing insights into both preoperative and postoperative

factors that influence treatment outcomes. However, the study is limited by its small sample size of 34 patients, which restricts the generalizability of the results. This small cohort may not adequately represent the broader population of patients with similar conditions, potentially leading to selection bias. Additionally, the lack of a control group limits the ability to draw definitive conclusions regarding the effectiveness of the interventions. The reliance on historical data for some variables may introduce recall bias, and the absence of long-term follow-up limits the assessment of sustained outcomes. Overall, while the study contributes valuable information to the field, the identified limitations necessitate cautious interpretation of the results and highlight the need for further research with larger, more diverse populations to validate these findings.

Conclusions

In summary, effective management strategies, including prompt surgical intervention and ongoing osteoporosis treatment, are essential to enhance the quality of life for patients with osteoporosis-induced vertebral compression fractures. Future research should focus on developing standardized protocols for managing osteoporosis in surgical patients to improve outcomes and reduce healthcare costs.

CRediT authorship contribution statement

Hung Manh Do: Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Ha Thi-Ngoc Doan:** Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Conceptualization. **Son Ngoc Dinh:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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