

RESULTS OF CEMENT-AUGMENTED PEDICLE SCREW SURGERY IN THE TREATMENT OF THORACIC AND LUMBAR SPINE COLLAPSE IN SEVERE OSTEOPOROSIS PATIENTS

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Objective: This 2023 study aimed to assess pain relief, functional recovery, and kyphosis correction following pedicle screw surgery with cement augmentation in severe osteoporosis patients with vertebral collapse. *Methods:* Seventy-one patients underwent surgery and were evaluated for postoperative pain reduction (VAS score), functional improvement (ODI score), vertebral kyphosis angle, pre- and postoperative spinal curvature angles, and complications. *Results:* The study included 71 participants (13 males, 58 females; mean age 67.6±6.7 years). Trauma sources included falls (47.9%), heavy lifting (17%), and unclear mechanisms (35.2%). Mean hospital stay was 12±6.5 days. Preoperative, postoperative, and 1/6-month VAS scores were 8.7, 2.2, 1.5, 0.9 respectively ($p<0.001$). ODI scores were 77.6, 52.8, 43.0, 37.9 respectively ($p<0.001$). Kyphotic angle (vertebral body) decreased from preop 12.9° to postop 9.9°, 1/6 months 10.1° ($p<0.001$); at surgical site, preop 15.4° to 1/6 months 11.9° ($p<0.001$). Cement leakage occurred in 36.6% of cases, mostly asymptomatic, with distribution in the disc space (2.8%), blood vessels (8.5%), around vertebral body (12.7%), spinal canal (14.1%), and lungs (2.8%). *Conclusion:* Pedicle screw fixation with enhanced cement augmentation effectively manages severe osteoporotic vertebral compression fractures, providing significant pain relief, improved postoperative function, and spinal alignment. Symptomatic cement leakage is rare.

Keywords: Cement-augmented pedicle screw, thoracic and lumbar spine collapse, severe osteoporosis.

I. INTRODUCTION

As the population ages, susceptibility to osteoporosis-related vertebral fractures rises, leading to increased spinal deformities and prolonged back pain episodes.¹ Conservative treatments for stable vertebral compression fractures include bed rest, back brace use, pain relief medication, and anti-resorptive therapies, particularly in cases without neurological compromise.² Surgery is indicated

for collapsed or unstable vertebral bodies or nerve compression. Pedicle screw fixation is commonly employed for stabilizing spinal fractures due to its simplicity and fast recovery. Nonetheless, screw loosening or pullout in osteoporotic spines poses a challenge. Strategies like cortical screw fixation, larger diameter screws, or hollow screws with cement injection are utilized to mitigate these concerns.³

The technique of using hollow screws with cement injection to treat vertebral compression fractures with bone loss involves inserting a hollow screw through the pedicle while simultaneously injecting a specific amount of cement under fluoroscopic guidance into

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the vertebral body to securely stabilize the screw head.⁴ This method is easily applicable and significantly alleviates patient pain while minimizing complications such as screw loosening and cement extravasation, which occur infrequently and typically remain asymptomatic.⁵

II. PATIENTS AND METHODS

1. Research subjects

Inclusion criteria: Patients diagnosed with osteoporosis and collapsed thoracic (T6-T12) and lumbar vertebrae causing instability or nerve compression requiring surgery; treated with pedicle screw fixation combined with augmented cement with or without nerve decompression; patients' consent to participate in the study. Exclusion criteria: Patients with severe internal medicine disorders, hematological disorders; unable to be followed up or insufficient post-operative follow-up time.

2. Study design

Prospective, non-controlled clinical descriptive trial. Surgical procedure: Prone position, endotracheal anesthesia, expose collapsed vertebra, insert screws, fill with cement, place stabilization rod, decompress if needed, achieve hemostasis, close wound. Cement leakage is assessed directly during surgery through fluoroscopic imaging. We compared the level of pain reduction, functional recovery, and improvement in spinal curvature angle before and after surgery. The optimal screw position is assessed to be 80-90% of the anterior-posterior length of the vertebral body; good cement distribution is defined as even distribution on both sides around the screw within the vertebral body.

3. Study period and location

The study was conducted from January to December 2023 at Trà Vinh Provincial General Hospital.

4. Sampling method and sample size

We selected our sample using a convenient sampling method, including all patients who met the sample selection criteria during the study period. The sample size in the study was 71 cases (calculated using a formula).

5. Main study variables

We assessed the level of pain reduction using the VAS (Visual Analog Scale) scoring, evaluated functional recovery based on the ODI (Oswestry Disability Index) index, and measured spinal curvature using Cobb angle on postoperative computed tomography scans.

6. Ethical issue

The research was approved by the Ethics Committee of Hanoi Medical University (No. 795/GCN-HDDNCYSH-ĐHYHN dated May 16, 2023). All patients were clearly explained and their confidentiality was maintained.

III. RESULTS

We studied 71 cases of collapsed thoracic and lumbar vertebral bodies due to osteoporotic instability or nerve compression surgically treated by cement-augmented pedicle screw surgery in 2023.

Clinical findings: 100% of patients presented with back pain, 45.1% had radicular pain, 18.3% bilateral leg hypoesthesia, 1.4% complete sensory loss; 93% adopted pain-alleviating postures, 5.6% partial paralysis, 1.4% complete paralysis of both legs; 5.6% reduced tendon reflexes; 26.8% muscle atrophy pre-surgery.

Table 1. Patient characteristics and descriptive data

Baseline characteristics	n = 71
Observation period (mean, SD) (month)	09 ± 1.5 (7 - 12)
Age (mean, SD) (year)	67.6 ± 6.7 (47 - 83)
Gender (male, female, m/fm)	13, 58, 1/4.5
BMI (kg/m ²) (min-max)	22.5 ± 2.8 (17.5 - 33.3)
Profession	54.9% housewives, 11.3% farmers, 7% retirees, 26.8% elderly and frail.
Traumatic circumstances	47.9% falls, 35.2% unclear, 17% incorrect posture
The risk factors for osteoporosis	postmenopausal status (78.9%), prolonged corticosteroid use (70.4%), BMI <19 (14.1%), diabetes (12.7%), smoking (16.9%), and alcohol abuse (1.4%)
The average T-score	-3.2 (-2.5 → -5.3)
Mean hospital stay (mean, SD) (days)	12 ± 6.5 (7-39)

Radiographic findings: Classification of vertebral injuries (OF2 5.6%, OF3 45.1%, OF 4 43.7%, OF5 5.6%); Vertebral compression fractures (64.8% single-level, 23.9% two-level, 8.5% three-level, 2.8% >three-level); 97.2%

had vertebral body fractures; 4.2% had pedicle fractures; 16.9% had posterior wall fractures; 8.5% had vertebral dislocations; 40.8% had bone fragments causing spinal canal compression.

Table 2. Pre- and Postoperative Results

n = 71	Pre-operation	Post-operation	After 1 months	After 6 months	p
VAS (mm)	8.7	2.2	1.5	0.9	0.0001
ODI (%)	77.6	52.8	43	35.1	0.0001
Local kyphotic angle (°)	15.4	11.9	11.9	11.9	0.001
Kyphotic angle (°)	12.9	9.9	10.1	10.1	0.001
ASIA	A(1), C (1), D(10), E(59)	A(1), D(2), E(68)	A(1), E(70)	A(1), E(70)	

Post-operative results: The total number of screws used was 398 screws, among which 12 screws were not cemented, and 5 screws were misplaced. 71.8% of cases involved spinal fusion accompanied by nerve decompression. The amount of cement injected per screw was

1.7 ml (0.5-4ml). The average surgical time was 109 minutes (60-210 minutes). The average blood loss was 241 ml (50-1500ml).

Complications: Cement leakage accounted for 36.6%, however, it does not cause clinical symptoms. Specifically, 2.8% leaked into the

disc space, 8.5% leaked into the blood vessels surrounding the vertebral body, 12.7% leaked around the vertebral body, 2.8% leaked into the lungs, and 14.1% leaked into the spinal canal. Nerve root injury accounted for 2.8%.

Treatment of postoperative osteoporosis was 88.7%, with 29.6% utilizing Alendronate 70mg, 19.7% utilizing Risedronate 35mg, and 39.4% utilizing Zoledronic acid 4mg/100ml.

IV. DISCUSSION

The method of pedicle screw fixation with cement augmentation used in the treatment of vertebral compression fractures is still under investigation. However, currently, this method offers several advantages to avoid serious cement leakage complications as well as screw pullout in patients with severe osteoporosis⁴.

General findings

In our study, the average follow-up duration paralleled that of Kashii's investigation,⁵ averaging 75.2 years (range 55-88), with a male-to-female ratio of 1/6.25. Injury mechanisms were often mild or ambiguous, mirroring Kashii's findings of 62.5% and 36.5% rates respectively. Most cases exhibited osteoporosis risk factors, chiefly prolonged corticosteroid usage, which disrupts bone cell composition, impacting osteoclast and osteoblast absorption, proliferation, and lifespan. Consequently, bone formation is impaired, resorption is heightened, and microarchitecture is compromised⁶.

Postoperative pain relief

Preoperative back pain in patients can be severe, hindering mobility and sitting ability. However, post-surgery, there is a notable reduction in back pain upon discharge, with residual discomfort being minor. Patients exhibit improved mobility, capable of independent movement and sitting. This outcome aligns with Dai's research,⁴ showing a decrease in Visual

Analog Scale (VAS) scores from 7.46 pre-surgery to 1.83 post-surgery ($p=0.284$). This improvement is sustained and progresses over 1 and 6 months of follow-up. Surgical intervention is often necessary for vertebral collapse from osteoporosis, addressing instability or nerve compression. Screw fixation, with or without decompression, enhances spinal resilience, thus diminishing patient discomfort. Additionally, heat generated during cement curing aids in pain relief by targeting vertebrae pain receptors, facilitating rapid postoperative recovery.⁷

To enhance postoperative pain management, patients should receive adjunct analgesic therapy for 4-6 weeks, alongside supportive bracing and osteoporosis treatment. Postoperative patients are recommended bisphosphonates for pain relief, bone density enhancement, and adjacent vertebral fracture prevention. In our study, nearly 70% used weekly Alendronate 70mg or Risedronate 35mg, while a minority chose annual Zoledronic acid infusion (4mg/100ml).⁸

Functional recovery outcomes

Preoperative ODI scores were subpar, but improved post-surgery, reaching good levels at one and six months after discharge. Patients with vertebral collapse from osteoporosis-related instability often experience limited mobility due to pain. Spinal stabilization surgery using cement augmentation reduces postoperative pain, facilitating easier mobility alongside physical therapy.⁵ Among patients, 9 cases with incomplete lower limb paralysis (ASIA D) were observed; by discharge, 3 had recovered, with most showing motor improvement after a month. One case with preoperative complete paralysis (ASIA A) still lacked motor function after six months. Mild to moderate nerve compression cases, especially promptly decompressed, may recover post-surgery, but complete paralysis

poses challenges for recovery.

Results of imaging

The mean recovery angle for vertebral body kyphosis is 3.3° , and for spinal kyphosis, it's 4.9° , with minimal changes observed over a 6-month follow-up period. Screw fixation with cement augmentation aids in stabilizing the collapsed spine segment, particularly with long construct stiffening to partially correct kyphosis by securing screws at three points⁸. Among 398 screws studied, 12 lacked cement augmentation due to firm engagement in the vertebral body, impeding cement injection into the screw shaft. Cement volume per screw varies based on cement extravasation extent or visualization into surrounding vascular channels.

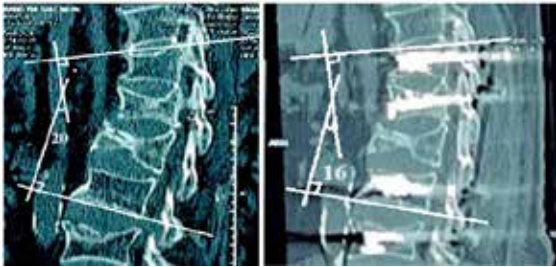


Figure 1. Spinal deformity correction on computed tomography scan; preoperative (left); postoperative (right)

Complications of cement leakage

In osteoporotic patients, the porous bone structure of the vertebral body, coupled with fractures along the vertebral body walls and within the intravascular venous system, contributes to a relatively high incidence of cement leakage⁹. Our study found that leakage primarily occurred around the vertebral body, followed by entry into the spinal canal via the venous system and into the disc space. However, precise control of cement injection using C-arm fluoroscopy minimized significant leakage. Clinical symptoms were generally absent, with only one case of postoperative foot drop, which

resolved after 2 months of treatment. Two cases experienced postoperative dyspnea, attributed to pulmonary cement embolism detected via computed tomography. Both patients fully recovered within 3 days following corticosteroid therapy and respiratory support.

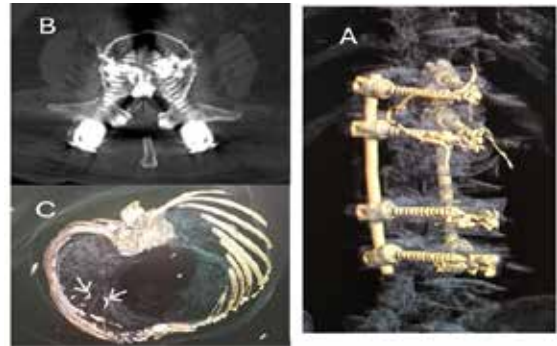


Figure 2. Cement leakage; A: Leakage into the blood vessels around the vertebral body (white arrow); B: Leakage into the spinal canal (black arrow); C: Leakage into the pulmonary blood vessels (white arrow)

V. CONCLUSION

The pedicle screw fixation method with cement augmentation is effective for treating conditions such as thoracic and lumbar vertebral collapse, unstable or nerve compression in patients with severe osteoporosis. Postoperative pain reduction is significant, with patients experiencing minimal or no pain after six months, compared to preoperative levels where mobility was severely limited. Functional recovery post-surgery is notable, particularly in daily activities such as mobility and light personal tasks. Postoperative spinal deformity correction or stabilization prevents further progression during follow-up. The most common complication is cement leakage into the spinal canal, surrounding vertebral bodies, or blood vessels, although it typically does not manifest severe clinical symptoms. Recommendations:

Osteoporosis is the leading cause of vertebral compression fractures, so early screening and treatment of osteoporosis are very important in management.

REFERENCES

1. Moser M, Jost J, Nevzati E. Kyphoplasty versus percutaneous posterior instrumentation for osteoporotic vertebral fractures with posterior wall injury: a propensity score matched cohort study. *J Spine Surg Hong Kong*. 2021; 7(1):68-82. doi:10.21037/jss-20-625.
2. Xu Z, Hao D, Dong L, Yan L, He B. Surgical options for symptomatic old osteoporotic vertebral compression fractures: a retrospective study of 238 cases. *BMC Surg*. 2021; 21(1): 22. doi:10.1186/s12893-020-01013-1.
3. Liu D, Sheng J, Wu HH, et al. Biomechanical study of injectable hollow pedicle screws for PMMA augmentation in severely osteoporotic lumbar vertebrae: effect of PMMA distribution and volume on screw stability. *J Neurosurg Spine*. 2018; 29(6): 639-646. doi:10.3171/2018.4.SPINE171225
4. Dai F, Liu Y, Zhang F, et al. Surgical treatment of the osteoporotic spine with bone cement-injectable cannulated pedicle screw fixation: technical description and preliminary application in 43 patients. *Clinics*. 2015; 70(2): 114-119. doi:10.6061/clinics/2015(02)08.
5. Kashii M, Yamazaki R, Yamashita T, et al. Surgical treatment for osteoporotic vertebral collapse with neurological deficits: Retrospective comparative study of three procedures-anterior surgery versus posterior spinal shorting osteotomy versus posterior spinal fusion using vertebroplasty. *Eur Spine J*. 2013; 22(7): 1633-1642. doi:10.1007/s00586-013-2759.
6. Adami G, Saag KG. Glucocorticoid-induced osteoporosis update. *Curr Opin Rheumatol*. 2019; 31(4): 388-393. doi:10.1097/BOR.0000000000000608.
7. Chiras J, Depriester C, Weill A, Sola-Martinez MT, Deramond H. [Percutaneous vertebral surgery. Technics and indications]. *J Neuroradiol J Neuroradiol*. 1997; 24:45-59.
8. Ilias I, Milionis C, Zoumakis E. An Overview of Glucocorticoid-Induced Osteoporosis. In: Feingold KR, Anawalt B, Blackman MR, et al., eds. *Endotext*. MDText.com, Inc.; 2000. Accessed July 28, 2023. <http://www.ncbi.nlm.nih.gov/books/NBK278968/>.
9. Donnally III CJ, DiPompeo CM, Varacallo M. Vertebral Compression Fractures. In: *StatPearls*. StatPearls Publishing. 2024. Accessed June 1, 2024. <http://www.ncbi.nlm.nih.gov/books/NBK448171/>.