



Original Research Article

PERCUTANEOUS VERTEBROPLASTY FOR OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURES: PAIN, DISABILITY, AND RADIOGRAPHIC OUTCOMES IN A SINGLE-CENTRE PROSPECTIVE STUDY

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ABSTRACT

Background: Osteoporotic vertebral compression fractures (OVCFs) are a significant cause of pain, disability, and kyphotic deformity in older adults. Percutaneous vertebroplasty (PVP) is widely used, yet real-world data on pain, function, and simple radiographic outcomes from prospective cohorts remain valuable.

Materials and Methods: We conducted a prospective, single-centre observational study of consecutive adults with osteoporotic OVCFs treated with PVP at a tertiary hospital (September 2017–September 2019). Twenty patients (mean age 66.7 ± 10.99 years; 80% female) were enrolled—index levels clustered at T12–L1 (65%). Outcomes included pain (measured using the Visual Analogue Scale, VAS), disability (assessed using the Roland–Morris Disability Questionnaire, RMDQ), and radiographic measurements of the immediate upper and lower adjacent vertebral body heights. Assessments were performed preoperatively, immediately post-procedure, and at routine follow-up visits ($\approx$ approximately 6 months and at the last follow-up). Complications—including cement leakage and incident vertebral fractures—were recorded.

Results: Mean VAS decreased from 7.55 ± 1.05 preoperatively to 4.75 ± 0.94 post procedure, with further reductions to 3.05 ± 1.11 at mid-term and 2.47 ± 0.59 at last follow-up. Mean RMDQ improved from 16.5 ± 1.88 to 15.05 ± 1.96 post procedure, then to 8.3 ± 2.03 and 7.36 ± 1.03 at subsequent visits. Across the cohort, the mean heights of the upper and lower adjacent vertebrae remained unchanged over time; however, one patient showed a reduced height at a remote level following a fall. Procedure-related complications were uncommon. Two patients experienced minor cement leakage, which did not result in embolic or infectious complications. One patient (5%) developed a symptomatic new vertebral fracture at L4 following trauma, and another showed a slight increase in the kyphotic angle on follow-up imaging.

Conclusion: In this prospective cohort study, percutaneous vertebroplasty for osteoporotic vertebral compression fractures resulted in a prompt and sustained reduction in both pain and functional disability, while maintaining the height of adjacent vertebral bodies and demonstrating a low complication rate. Further large-scale controlled studies are needed to validate these outcomes.

Keywords: osteoporotic vertebral compression fracture; percutaneous vertebroplasty; pain; disability; Roland–Morris Disability Questionnaire; VAS; radiographic outcomes.

INTRODUCTION

Osteoporotic vertebral compression fractures (OVCFs) represent one of the most frequent fragility fractures in the elderly population. They are a leading cause of pain, loss of function, and increased healthcare use.^[1] Recent population-based data show that the absolute burden of OVCFs continues to rise with global aging. Estimates from the Global Burden of Disease reports and related systematic reviews suggest that approximately 1.4–1.5 million osteoporotic vertebral fractures occur worldwide each year, with significant regional variation and a steady increase in total numbers, despite slight declines in age-adjusted incidence.^[2] These fractures often affect frail, multimorbid individuals and serve as an early warning for future fractures, progressive disability, and increased mortality, emphasizing the importance of prompt and effective therapeutic intervention.

Initial management is typically conservative—analgesia, short-term activity modification, bracing, and early mobilization—together with osteoporosis therapy and falls prevention. Evidence-based guidelines from the North American Spine Society (NASS) emphasize a multimodal approach and note that many patients improve over weeks to months without procedures; nevertheless, a sizable subset experiences persistent or severe pain and functional limitation that impedes rehabilitation.^[3] Related reviews highlight ongoing debate about the magnitude and durability of benefit from bracing and other non-operative adjuncts, reinforcing the need for individualized pathways when pain remains refractory.

Percutaneous vertebroplasty (PVP) was introduced to stabilize painful OVCFs by injecting polymethyl methacrylate into the fractured vertebral body to reduce micromotion and nociception and enable earlier mobilization.^[4] Over the past two decades, PVP and balloon kyphoplasty (BKP) have been widely adopted. Meta-analyses and guidelines concur that, in appropriately selected patients with acute symptomatic OVCFs, vertebral augmentation provides rapid pain relief and functional improvement compared with conservative care. At the same time, BKP tends to yield greater height restoration.^[5]

Notwithstanding this broad consensus, two persistent controversies frame current research. First, the size of PVP's effect relative to placebo in unselected acute fractures remains a matter of dispute. The sham-controlled VERTOS IV randomized trial found no significant advantage of PVP over a sham procedure across patient-reported outcomes, fuelling calls for tighter indications.^[6] In contrast, the VAPOUR trial demonstrated that vertebroplasty provided significant and rapid pain relief in patients who had severe, MRI-confirmed edematous fractures treated soon after symptom onset.^[7] Subsequent focused reviews have supported these findings, suggesting that early

intervention in well-selected patients with intensely painful fractures can be highly effective. This emphasis on patient selection and the timing of treatment is echoed in current clinical guidelines, which recommend vertebral augmentation for acute OVCFs when disabling pain persists despite adequate conservative management.^[8]

Secondly, the safety profile and long-term structural outcomes of vertebral augmentation continue to receive considerable attention. Although cement leakage is frequently observed on imaging and is often clinically inconsequential, specific leakage patterns—particularly intradiscal extension—have been linked to an increased risk of adjacent or subsequent vertebral fractures in observational studies.^[9] The relationship between vertebral augmentation and the incidence of new fractures remains inconsistent across pooled analyses. Depending on study design and patient characteristics, augmentation has been reported to confer higher, similar, or even lower fracture risks compared with conservative management. Notably, a 2023 meta-analysis identified a higher risk of new fractures following augmentation. In contrast, a subsequent RCT-based meta-analysis in 2025 observed a lower incidence of adjacent-level fractures relative to non-operative care.^[10] Contemporary meta-analyses also refine procedural risk factors for cement leakage (e.g., cortical defects, intravertebral vacuum clefts) and highlight modifiable contributors to post-procedure refracture risk, informing technical choices and secondary prevention.^[11]

Radiographically, BKP more reliably restores vertebral height and segmental alignment than PVP; however, guideline panels and comparative reviews emphasize that the degree of height restoration does not consistently translate into superior pain relief or functional outcomes. Both PVP and BKP can achieve comparable clinical improvement when patients are appropriately selected.^[12] While the literature has expanded, two gaps persist in day to day practice: (i) prospective, single centre data sets that track both patient reported outcomes (pain and disability) and simple, reproducible radiographic indices after PVP are relatively limited compared with retrospective series or mixed technique meta analyses; and (ii) the relationship between early, procedure level variables (cement volume/distribution, leakage pattern) and subsequent clinical and structural outcomes remains incompletely resolved in routine care settings. Addressing these evidence gaps is essential for centers where PVP is a principal augmentation technique and where pragmatic, low-cost radiographic measures (e.g., adjacent vertebral body heights) are routinely available alongside validated instruments, such as the visual analogue scale (VAS) and the Roland-Morris Disability Questionnaire (RMDQ). The present single-centre prospective study was designed against this backdrop.

This study prospectively evaluates patients with painful osteoporotic vertebral compression fractures

undergoing percutaneous vertebroplasty at a tertiary centre, with four a priori objectives: (1) to quantify change in pain (VAS) after PVP; (2) to quantify change in disability (RMDQ) after PVP; (3) to describe radiographic outcomes—including vertebral alignment and adjacent vertebral height measurements—over follow up; and (4) to document early and late complications (e.g., cement leakage) and incident vertebral fractures. By reporting pain, disability, and radiographic trajectories in a uniform cohort, we aim to provide practice-proximal evidence to inform the selection, counselling, and follow-up of patients considered for vertebroplasty.

MATERIALS AND METHODS

Study design and setting: This was a prospective, single-centre observational cohort conducted at the Department of Orthopaedics, Bharati Vidyapeeth Medical College and Hospital, Pune, India. Consecutive patients with painful osteoporotic vertebral compression fractures (OVCFs) who underwent percutaneous vertebroplasty (PVP) during the accrual window were enrolled and followed according to a predefined protocol and case report proforma.

Study period: Patients were recruited and treated between September 2017 and September 2019, and prospective clinical and radiographic follow-up was recorded at routine postoperative visits.

Participants and eligibility criteria: All adults with radiographically confirmed osteoporotic OVCFs selected for vertebroplasty at the tertiary centre were eligible. Typical indications included persistent or severe pain attributable to the index fracture and failure of initial conservative measures, consistent with institutional practice. Patients with neurological deficit, systemic infection, spinal infection, pregnancy, or unstable fractures were not enrolled.

Case ascertainment and baseline assessment: Potentially eligible patients were screened in the orthopaedic outpatient clinics and inpatient wards. After obtaining written informed consent, baseline demographics, comorbidities, fracture level, and osteoporosis history were recorded on a structured pro forma (Annexure I of the dissertation). Pain intensity was captured on a 0–10 cm Visual Analogue Scale (VAS), and functional disability was measured with the 24-item Roland–Morris Disability Questionnaire (RMDQ), both at baseline and follow-up time points.

Imaging protocol and radiographic measurements: Standard anteroposterior and lateral radiographs of the thoracic and lumbar spine were obtained preoperatively and at each follow-up visit, with baseline and follow-up films reviewed side by side to detect changes. The primary radiographic metric was vertebral body height of the immediate upper and lower adjacent levels to the treated vertebra, measured on lateral radiographs and recorded in centimetres. Segmental alignment,

including kyphotic contour, was noted on follow-up imaging, as relevant, in the clinical record.

Vertebroplasty technique: All procedures were performed under sterile conditions in the operating theatre, using fluoroscopic guidance in accordance with standard institutional technique. Polymethyl methacrylate (PMMA) cement was injected into the fractured vertebral body under continuous imaging until satisfactory fill was achieved while avoiding extravasation. The volume of cement used per level was recorded in the operative notes and the master chart. When multiple levels were treated in the same sitting, the clinically dominant, symptomatic level was considered the index level for level-wise summaries; pain and disability outcomes were analysed at the patient level.

Post-procedural care and follow-up schedule: post-procedure observation, analgesia, and mobilisation followed institutional routines. Patients were reviewed clinically and radiographically immediately after the procedure and at routine follow-up visits corresponding to approximately six months and one year in the archival dataset. VAS and RMDQ were re-administered at each visit, and repeat radiographs were obtained to reassess adjacent level heights and overall alignment. The working article draws on these same scheduled assessments.

Outcomes: The prespecified clinical outcomes were change in pain intensity (VAS) and disability (RMDQ) from baseline to each follow-up. The prespecified radiographic outcome was the maintenance of vertebral body height at the immediately adjacent upper and lower levels to the treated vertebra. Safety outcomes included peri-procedural and post-procedural complications, such as cement leakage identified on fluoroscopy or postoperative radiographs, pulmonary or venous embolic events, wound infections, and incident symptomatic vertebral fractures at adjacent or remote levels recorded during follow-up.

Definitions and event ascertainment: Cement leakage was defined as any visible extravasation of cement beyond the vertebral body seen intra operatively or on immediate postoperative radiographs, including epidural, paravertebral, or intradiscal spread when present. New vertebral fractures were considered incident if they occurred after the index procedure and were confirmed clinically and radiographically at follow-up visits.

Data management and statistical analysis: All variables were entered into a prespecified master chart. Continuous data, including VAS, RMDQ, and vertebral height measurements, were analysed as means with standard deviations. Within-patient change over time was assessed with parametric tests when distributions were approximately normal; categorical outcomes were summarised as counts and proportions. The dissertation protocol notes use of SPSS (version 22) for all analyses, with two-sided tests and a conventional alpha set at 0.05. The present article follows the same analysis plan.

Ethics: The study protocol received approval from the Institutional Ethics Committee at Bharati Vidyapeeth Medical College. All participants provided written informed consent. This article uses the same prospectively collected dataset and preserves participant confidentiality.

RESULTS

Cohort and baseline characteristics: Twenty consecutive adults with osteoporotic vertebral compression fractures (OVCFs) underwent percutaneous vertebroplasty (PVP) and were followed prospectively. The mean age was 66.7 ± 10.9 years, and 16 of the 20 participants were women.

Hypertension, diabetes, and hyperlipidemia were common co morbidities. Index fracture levels clustered at the thoracolumbar junction, with L1 and T12 accounting for the majority of cases.

Clinical outcomes: Pain and disability improved rapidly after PVP and continued to improve at routine follow-up. Mean VAS decreased from 7.55 ± 1.05 preoperatively to 4.75 ± 0.94 immediately post-procedure, 3.05 ± 1.11 at mid-term, and 2.47 ± 0.59 at the last visit. Mean RMDQ improved from 16.5 ± 1.88 to 15.05 ± 1.96 post procedure, 8.3 ± 2.03 at mid-term, and 7.36 ± 1.03 at the previous visit. As detailed in the source tables, two individuals showed transient score increases during follow-up, including one patient who sustained a remote L4 fracture after a fall.

Table 1: Baseline characteristics (n = 20)

Characteristic	Value
Age, years	66.7 ± 10.99
Age groups, n	51–60: 9; 61–70: 4; 71–80: 5; ≥ 81 : 2
Sex, n (%)	Female: 16 (80); Male: 4 (20)
Co-morbidities, n (%)	Hypertension: 10 (50); Diabetes mellitus: 9 (45); Hyperlipidemia: 6 (30); Tuberculosis/Renal disease/Hypothyroidism: 0
Additions, n (%)	Smoking: 5 (25); Alcohol use: 5 (25)

Table 2: Distribution of index vertebral level (n = 20)

Level	n (%)
T11	1 (5)
T12	6 (30)
L1	7 (35)
L2	2 (10)
L3	3 (15)
L4	1 (5)

Table 3A: Pain intensity (VAS 0–10), mean $\pm$ SD

Timepoint	VAS
Pre-operative	7.55 ± 1.05
Immediate post-operative	4.75 ± 0.94
Mid-term follow-up	3.05 ± 1.11
Last follow-up	2.47 ± 0.59

Table 3 B. Disability (RMDQ 0–24), mean $\pm$ SD

Timepoint	RMDQ
Pre-operative	16.5 ± 1.88
Immediate post-operative	15.05 ± 1.96
Mid-term follow-up	8.3 ± 2.03
Last follow-up	7.36 ± 1.03

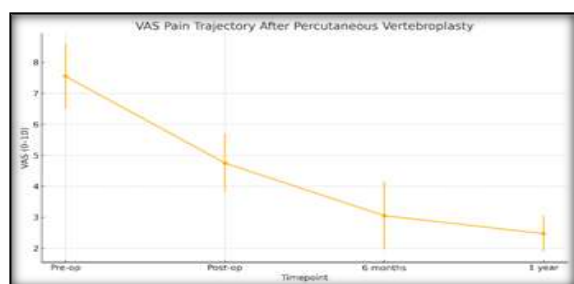


Figure 1. VAS pain trajectory with SD error bars.

Radiographic outcomes: Adjacent-level vertebral body heights remained stable on serial lateral radiographs across all scheduled visits; there was no systematic loss of height at the vertebrae immediately above or below the treated level. One patient—who

reported a fall—showed reduced L4 height and parallel worsening of pain scores at mid-term follow-up.

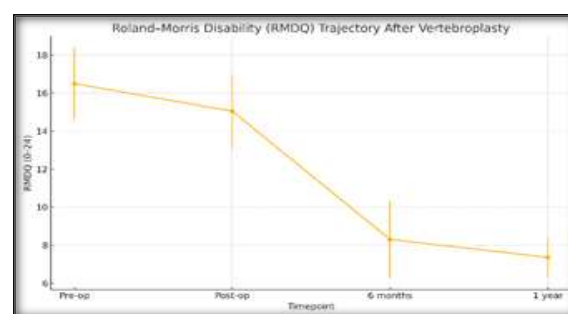


Figure 2. Roland-Morris Disability (RMDQ) trajectory with SD error bars.

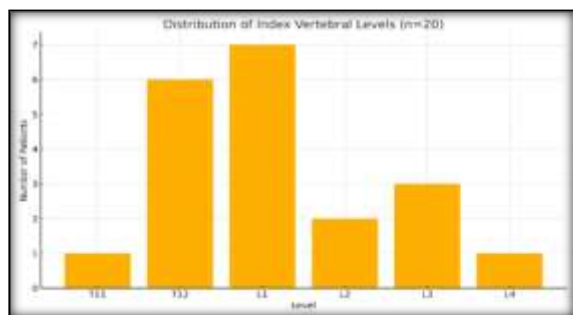


Figure 3. Distribution of index vertebral levels.

Procedural characteristics and safety: Cement volumes recorded in the master chart ranged from 2.0 to 3.5 ml per treated level, with most procedures in the 2.5–3.0 ml range. Procedure-related events were infrequent. There were two cases of radiographic cement leakage without clinical sequelae, no infections, and no cement embolization. One patient (5%) developed a symptomatic new vertebral fracture at a remote level (L4) after a fall; another patient demonstrated an increased kyphotic angle on follow-up imaging.

Table 4. Adjacent vertebral body heights by level: pre-operative vs last follow-up

Level	Upper height pre-op (cm)	Upper height last (cm)	Lower height pre-op (cm)	Lower height last (cm)
T11	2.12	2.12	1.94	1.94
T12	2.28	2.28	2.37	2.37
L1	2.35	2.35	2.27	2.27
L2	2.54	2.54	2.70	2.70
L3	2.77	2.77	2.57	2.57
L4	2.80	2.80	2.75	2.75

Table 5: Adverse events and sequelae (n = 20)

Event	n (%)	Notes
Cement leakage	2 (10)	Radiographic: no embolic or infectious sequelae
Cement embolization	0 (0)	None observed
Infection	0 (0)	None observed
New vertebral fracture	1 (5)	Remote L4 fracture after fall; associated VAS/RMDQ increase
Kyphotic angle increase	1 (5)	Seen on the last follow-up imaging

DISCUSSION

In this single-centre prospective cohort of 20 adults with osteoporotic vertebral compression fractures treated by percutaneous vertebroplasty (PVP), pain and disability improved promptly after the procedure and continued to improve at routine follow-up. Mean VAS decreased from 7.55 pre operatively to 4.75 immediately postoperatively and to 2.47 at the last visit, while mean RMDQ fell from 16.5 to 15.05 and then to 7.36. Adjacent level vertebral body heights were preserved across time points, and procedure-related events were infrequent: two radiographic leakages without sequelae, one remote new fracture after a fall, and no embolic or infectious complications. These results replicate the source dataset's Observations and Results tables and figures, as well as the current manuscript's Results section, confirming rapid clinical benefit with stable, simple radiographic indices under uniform technique. The magnitude and trajectory of pain and disability relief are consistent with contemporary evidence that, in appropriately selected patients, vertebral augmentation accelerates symptom improvement compared with conservative care. Recent randomized and meta-analytic syntheses report clinically meaningful early gains with vertebroplasty in phenotypes chosen, particularly when treatment is delivered for severe, MRI oedematous fractures or persistent/chronic symptomatic fractures managed against active controls.^[13] In contrast, the sham-controlled VERTOS IV trial, which included a broader population of patients with acute OVCFs, failed to demonstrate a significant advantage of

vertebroplasty over a simulated procedure, emphasizing the crucial roles of timing, imaging selection, and patient eligibility. Our cohort, drawn from real-world clinical practice where intervention was reserved for severe or persistent pain, corresponds more closely to studies that reported positive outcomes—likely accounting for the similarity of results. Regarding structural parameters, guideline committees have noted that balloon kyphoplasty more effectively restores vertebral height and segmental alignment than percutaneous vertebroplasty. However, this radiographic improvement does not consistently yield superior reductions in pain or disability, as both techniques appear to offer comparable clinical benefits when applied to patients who are appropriately selected. Our finding of preserved adjacent level heights with low leakage and few structural sequelae sits within the heterogeneous literature on safety: pooled analyses differ on whether augmentation increases, decreases, or does not change the risk of new or adjacent fractures compared with conservative management, reflecting design and case mix differences.^[14,15] Previous observational and meta-analytic studies have associated intradiscal cement leakage and low bone mineral density with an increased risk of refracture. In our series, two cases of cement leakage were identified, both of which were clinically silent. Because the leakage pattern was not systematically documented, our data do not allow firm conclusions about this potential mechanism.

The study's strengths lie in its prospective design and the use of standardized, validated patient-reported

outcome measures (VAS and RMDQ) collected at predefined intervals. Radiographic assessment employed simple, reproducible metrics of adjacent vertebral height, and all procedures were performed using a uniform technique within a single center, reducing operator-related variability and supporting internal consistency. Event detection was integrated with clinical evaluations and imaging at each follow-up visit, while procedural details, such as cement volume, were systematically recorded in a master chart, ensuring the accurate interpretation of outcomes. Nonetheless, several limitations warrant consideration: the small sample size and the absence of a concurrent non-operative or sham control group limit external generalizability. Patient selection reflected real-world clinical decision-making rather than strict trial-based imaging or timing criteria. Leakage morphology was not consistently subclassified—for example, distinguishing intradiscal from epidural extension—and bone health was not reassessed longitudinally with repeat densitometry. Consequently, the study lacked sufficient power to identify rare adverse events or to precisely estimate fracture risk across subgroups. Some residual confounding from variations in osteoporosis severity and fall risk is also likely.

CONCLUSION

In this prospective, real-world cohort, percutaneous vertebroplasty for painful osteoporotic vertebral compression fractures resulted in prompt and sustained reductions in pain and disability, with preservation of adjacent-level vertebral heights and a low incidence of complications. These findings align with current guideline recommendations that support vertebral augmentation in carefully selected patients who continue to experience severe symptoms despite adequate conservative management. They also emphasize the importance of meticulous procedural technique to minimize the risk of cement leakage and the necessity of comprehensive secondary prevention for osteoporosis. Further large-scale, controlled, and ideally multicentre studies—particularly within Indian clinical settings—are needed to refine patient selection criteria and better define long-term structural outcomes relative to standardized comparators.

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REFERENCES

1. Son, H., Park, S., Kim, J., & Park, J. (2023). Mortality risk after the first occurrence of osteoporotic vertebral compression fractures in the general population: A nationwide cohort study. *PLOS ONE*, 18. <https://doi.org/10.1371/journal.pone.0291561>.
2. Lan, Y., Chen, S., Lan, G., Li, C., & Wei, J. (2025). Global, regional, and national burden of vertebral column fracture, 1990–2021: analysis of data from the global burden of disease study 2021. *Frontiers in Public Health*, 13. <https://doi.org/10.3389/fpubh.2025.1573888>.
3. Jang, H., Kim, E., Lee, J., Choi, S., Kim, H., Cha, J., & Shin, B. (2022). Management of Osteoporotic Vertebral Fracture: Review Update 2022. *Asian Spine Journal*, 16, 934 - 946. <https://doi.org/10.31616/asj.2022.0441>.
4. Tang, L., Zhang, H., Yang, Y., & Huang, H. (2025). Hidden blood loss of percutaneous vertebroplasty for osteoporotic vertebral compression fractures. *Joint Diseases and Related Surgery*, 36, 240 - 247. <https://doi.org/10.52312/jdrs.2025.2201>.
5. Liu, D., Wen, T., Li, X., Xie, Z., Wei, M., Wang, Y., Tang, H., & Jia, Z. (2024). Percutaneous Vertebroplasty Versus Balloon Kyphoplasty in the Treatment of Osteoporotic Vertebral Compression Fractures: Evaluating the Overlapping Meta-analyses. *Pain physician*, 27 4, E383-E394. <https://doi.org/10.36076/ppj.2024.7.e383>.
6. Firanescu, C., De Vries, J., Lodder, P., Venmans, A., Schoemaker, M., Smeets, A., Donga, E., Juttmann, J., Klazen, C., Elgersma, O., Jansen, F., Tielbeek, A., Boukrab, I., Schonenberg, K., Van Rooij, W., Hirsch, J., & Lohle, P. (2018). Vertebroplasty versus sham procedure for painful acute osteoporotic vertebral compression fractures (VERTOS IV): randomised sham controlled clinical trial. *The BMJ*, 361. <https://doi.org/10.1136/bmj.k1551>.
7. Clark W, Bird P, Gonski P, Diamond TH, Smerdely P, McNeil HP, Schlaphoff G, Bryant C, Barnes E, Gebiski V. Safety and efficacy of vertebroplasty for acute painful osteoporotic fractures (VAPOUR): a multicentre, randomized, double-blind, placebo-controlled trial. *Lancet*. 2016;388(10052):1408-1416.
8. North American Spine Society (NASS). Diagnosis and Treatment of Adults with Osteoporotic Vertebral Compression Fractures. Evidence-Based Clinical Guideline. 2020
9. Hang T, Wang Y, Zhang P, Xue F, Zhang D, Jiang B. What are the risk factors for adjacent vertebral fracture after vertebral augmentation? A meta-analysis of published studies. *Global Spine J*. 2022;12(1):130-141. (Epub 2020 Dec 4.)
10. Qiu, Z., Wang, P., Chao, Y., & Yu, Y. (2023). The risk of new vertebral fracture after percutaneous vertebral augmentation in patients suffering from single-level osteoporotic vertebral compression fractures: A meta-analysis and systematic review. *Medicine*, 102. <https://doi.org/10.1097/MD.00000000000035749>.
11. Tang, J., Wang, S., Wang, J., Wang, X., Li, T., Cheng, L., Hu, J., & Xie, W. (2024). Risk factors for secondary vertebral compression fracture after percutaneous vertebral augmentation: a single-centre retrospective study. *Journal of orthopaedic surgery and research*, 19 1, 797. <https://doi.org/10.1186/s13018-024-05290-x>.
12. Onggo, J., Maingard, J., Nambiar, M., Buckland, A., Chandra, R., & Hirsch, J. (2021). Role of vertebroplasty and balloon kyphoplasty in pathological fracture in myeloma: a narrative review. *European Spine Journal*, 30, 2825 - 2838. <https://doi.org/10.1007/s00586-021-06955-5>.
13. Clark, W., Bird, P., Gonski, P., Gonski, P., Diamond, T., Diamond, T., Smerdely, P., Smerdely, P., McNeil, H., Schlaphoff, G., Schlaphoff, G., Bryant, C., Barnes, E., & Gebiski, V. (2016). Safety and efficacy of vertebroplasty for acute painful osteoporotic fractures (VAPOUR): a multicentre, randomised, double-blind, placebo-controlled trial. *The Lancet*, 388, 1408-1416. [https://doi.org/10.1016/S0140-6736\(16\)31341-1](https://doi.org/10.1016/S0140-6736(16)31341-1).
14. Essibayi, M. A., Mortezaei, A., Azzam, A. Y., Bangash, A. H., Eraghi, M. M., Fluss, R., Brook, A., Altschul, D. J., Yassari, R., Chandra, R. V., Cancelliere, N. M., Mendes Pereira, V., Jennings, J. W., Gilligan, C. J., Bono, C. M., Hirsch, J. A., & Dmytriw, A. A. (2024). Risk of adjacent level fracture after percutaneous vertebroplasty and kyphoplasty versus natural history for the management of osteoporotic vertebral compression fractures: A network meta-analysis of

- randomized controlled trials. *European Radiology*, 34(11), 7185–7196.
15. Láinez Ramos-Bossini, A. J., Jiménez Gutiérrez, P. M., Moraleda Cabrera, B., Bueno Caravaca, L., González Díez, M., & Ruiz Santiago, F. (2024). Risk of new vertebral

compression fractures and serious adverse effects after vertebroplasty: A systematic, critical review and meta-analysis of randomized controlled trials. *Quantitative Imaging in Medicine and Surgery*, 14(11), 7848–7861.