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ORIGINAL ARTICLE

Outcome of kyphoplasty for the management of osteoporotic vertebral compression fractures.

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ABSTRACT… Objective: To evaluate the clinical and radiological outcomes of percutaneous kyphoplasty in patients with osteoporotic vertebral compression fractures. **Study Design:** Prospective Cohort study. **Setting:** Department of Orthopedics, GTTH, Lahore, Pakistan. **Period:** 18th December 2025 to 30th Mar 2026. **Methods:** Patients who had undergone percutaneous kyphoplasty were selected. The clinical assessment at 12 weeks was made with respect to pain using the Visual Analog Scale (VAS), while the radiological assessment was done with respect to vertebral body height on lateral radiograph images. Data were analyzed using SPSS 27. **Results:** The mean age of patients was 65.8 ± 8.2 years (age range 46–83), with females being more common (73.3%). The highest number of cases involved L1 vertebrae (38.7%), and there was predominance of cases involving a single vertebra (60.0%). The mean VAS pain score was significantly reduced from 9.2 ± 0.7 to 1.8 ± 1.9 at 12 weeks ($p < 0.001$), resulting in a mean decrease of 7.4 points in pain intensity. Mean vertebral body height was improved from 2.78 ± 0.35 cm to 3.05 ± 0.32 cm ($p < 0.001$), which corresponds to an average increase of about 9.7% in height. **Conclusion:** There was an observed improvement in the degree of pain reduction and in the amount of increase in height of the affected vertebrae at 12 weeks in patients suffering from osteoporotic vertebral compression fractures, making it a reliable and safe form of treatment for OVCFs.

Key words: Minimally Invasive Spine Surgery, Osteoporotic Vertebral Compression Fracture, Osteoporosis, Percutaneous Kyphoplasty, Thoracolumbar Junction, Visual Analog Scale, Vertebral Body Height.

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INTRODUCTION

As the population ages and life expectancy continues to grow, the burden of osteoporotic vertebral compression fractures (OVCFs) as a population health issue will continue to increase due to the high prevalence of osteoporosis globally.[1,2] These fractures can lead to severe back pain, decreased mobility, spinal deformity, and reduced standard of living. For the treatment of VCFs, percutaneous kyphoplasty (PKP) has become a popular minimally invasive procedure, intended to release pain, restore vertebral height, and correct kyphosis through balloon inflation and cement augmentation.[3]

Recent studies confirm that PKP provides significant short-term improvements in pain (VAS scores), vertebral height, and Cobb angle alignment, often outperforming conservative treatments and conventional vertebroplasty.[4,5] A 2025 meta-analysis by Erşen et al. demonstrated that both unipedicular and bipedicular kyphoplasty significantly improved pain and function at 3-year follow-up, with minimal complication rates.[6] Similarly, robotic-assisted PKP has gained attention for improved precision and outcomes in elderly populations with severe OVCFs.[7]

However, the procedure is not without limitations. Cement leakage remains a concern, occurring in up to 20% of cases, although generally asymptomatic.[8] A 2025 study by Li et al. proposed a "warning line" based on intraoperative imaging to predict and minimize leakage risk during PKP.[9] Moreover, patient-specific factors, such as intravertebral clefts and endplate morphology, have been linked to variable outcomes, highlighting the need for improved patient stratification.[10]

As innovation in technique and instrumentation continues (e.g., use of expandable implants, robot navigation), evaluating the real-world clinical outcomes and safety of kyphoplasty remains a

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clinical priority. Comparative studies between conventional and modified or robot-assisted PKP suggest evolving trends in procedural efficacy, but larger multicenter trials are still warranted.[11]

Cai et al.[12] performed a similar study, and the findings indicate that the vertebral body height increased from 11.60±1.48 mm to 21.49±2.20 mm while the Cobb's angle decreased from 15.39±3.81° ° to 7.79±2.39°°.

This study aims to synthesize the latest evidence on clinical and radiological outcomes of percutaneous kyphoplasty in the management of OVCFs. It focuses on patient-reported outcomes (pain and function), radiographic correction (height, Cobb angle). By integrating recent innovations and evidence, this review seeks to support optimized, evidence-based use of kyphoplasty in osteoporotic spine care. So the study aimed to evaluate the outcomes of percutaneous kyphoplasty (PKP) in patients with osteoporotic vertebral compression fractures (OVCFs), clinically and radiologically.

METHODS

This prospective cohort study was conducted in the Department of Orthopedics at Ghurki Trust Teaching Hospital, Lahore, over a period from December 18, 2025, to 30th Mar, 2026, after obtaining ethical approval from the Institutional Review Board (Ref. No.2025/06/R-35) Dated:30-06-25. A total sample size of 75patients was calculated based on previously published data (Cai et al.), considered verteberal body height after treatment as 21.49±2.20 mm with 95% confidence level and 5% absolute precision.[12] Non-probability consecutive sampling was employed.

Patients aged 50 years and above, diagnosed with one or more recent osteoporotic vertebral compression fractures (OVCFs) confirmed on MRI or CT scan, were included in the study. Only those patients with persistent pain (VAS ≥5) not responding to conservative treatment for at least two weeks and having radiological evidence of vertebral collapse ≥20% were enrolled. Patients with pathological fractures due to malignancy or infection, neurological deficits requiring decompression, prior spinal instrumentation at the same vertebral level, coagulopathy, or severe cardiorespiratory comorbidities precluding surgery, and those lost to follow-up were excluded.

Written informed consent was obtained from all subjects, as well as demographic information like age, sex, and body mass index (BMI). Clinical assessment was performed preoperatively, together with imaging studies like plain X-rays, MRI, and CT scan to measure the vertebral heights, posterior wall thickness, and bone marrow edema. If the MRI was contraindicated, then a bone scan was done to establish the age and symptom levels of the fracture.

All patients were subjected to PKP surgery either under general anesthesia or under spinal anesthesia. The procedure was done using a radiolucent table, where the patient was placed in the prone position. With the help of fluoroscopy, either a transpedicular or an unipedicular approach was used in order to reach the vertebra that had been affected by the compression. Next, the balloon tamp was inserted into the vertebral body to inflate it. Once the cavitation was done, the balloon was then deflated and removed, after which PMMA cement was injected into the bone using fluoroscopy. The procedure was immediately halted if cement leakage was observed or if it approached the posterior vertebral wall.

The clinical results were measured by the use of the Visual Analog Scale (VAS) with a scale of 0 to 10, where 0 means no pain, while 10 represents the worst possible pain. The radiologic outcome assessment involved the measurement of the height of the vertebral bodies by lateral radiograph. The vertebral height restoration was measured by comparison of the postoperative anterior and middle vertebral heights of the fracture vertebra to those of the adjacent vertebrae. These parameters were assessed preoperatively and at 12 weeks postoperatively.

All data were recorded by the principal investigator using a structured pro forma. Statistical analysis was performed using SPSS version 27. Quantitative variables such as age, BMI, VAS score, vertebral height, and Cobb angle were expressed as mean ± standard deviation, while qualitative variables

such as gender and affected vertebral level were presented as frequencies and percentages. Stratification was performed for potential effect modifiers, including age, gender, BMI, and vertebral level. Post-stratification, the Student's t-test was applied, and a p-value of ≤0.05 was considered statistically significant.

RESULTS

The average age of the study group was 65.8 ± 8.2 years (range: 46–83 years), which is typical for older people who get osteoporotic vertebral compression fractures (OVCFs). A notable female predominance was recorded, with 73.3% (n = 55) females, corresponding to the recognized higher incidence of osteoporosis in women, with a mean BMI of 27.9±6.5. The L1 vertebra (38.7%) was the most common level involved, followed by L2–L4 (32.0%) and the thoracic spine D7–D12 (29.3%). This shows how weak the thoracolumbar junction is. Sixty percent of the cases had single-level fractures, while forty percent had multi-level involvement. This means that most cases had localized vertebral collapse instead of diffuse spinal involvement.

Patients exhibited significant baseline pain, with an average VAS score of 9.2 ± 0.7. After 12 weeks, this number dropped significantly to 1.8 ± 1.9 ($p < 0.001$), which is a mean drop of 7.4 points. This big drop shows not only statistical significance but also a clear clinical improvement, since a drop of this size is bigger than the smallest clinically important difference for VAS.

The height of the vertebral body improved significantly, going from 2.78 ± 0.35 cm before surgery to 3.05 ± 0.32 cm after surgery ($p < 0.001$). This is an average gain of 0.27 cm, or about 9.7% of the original vertebral height. Post-stratification analysis demonstrated that the clinical and radiological benefits of percutaneous kyphoplasty (PKP) were consistent and highly significant across all subgroups, including age, gender, and vertebral region ($p < .001$ for all comparisons).

Patients aged ≤65 years showed a marked reduction in VAS score from 9.1 ± 0.8 to 1.6 ± 1.7, while those aged >65 years improved from 9.3 ± 0.6 to 2.0 ± 2.1 (both $p < .001$). Similarly, vertebral body height increased from 2.81 ± 0.33 cm to 3.09 ± 0.30 cm in the younger group and from 2.75 ± 0.36 cm to 3.01 ± 0.33 cm in the older group ($p < .001$).

Both male and female patients experienced comparable and significant improvements. VAS scores decreased from 9.2 ± 0.7 to 1.9 ± 2.0 in males and from 9.2 ± 0.7 to 1.7 ± 1.8 in females ($p < .001$). Vertebral body height improved from 2.80 ± 0.32 cm to 3.07 ± 0.29 cm in males and from 2.77 ± 0.36 cm to 3.03 ± 0.33 cm in females ($p < .001$).

Stratification by vertebral region demonstrated significant improvements in both thoracic (D7–D12) and lumbar (L1–L4) fractures. VAS scores declined from 9.3 ± 0.6 to 2.1 ± 2.1 in the thoracic group and from 9.1 ± 0.7 to 1.6 ± 1.7 in the lumbar group ($p < .001$).

Vertebral body height increased from 2.73 ± 0.35 cm to 2.99 ± 0.32 cm in thoracic fractures and from 2.82 ± 0.34 cm to 3.10 ± 0.31 cm in lumbar fractures ($p < .001$). While lumbar vertebrae demonstrated slightly greater height restoration, likely due to anatomical and biomechanical factors, both regions showed clinically meaningful improvement.

DISCUSSION

The present prospective cohort of 75 OVCF patients treated with PKP showed marked shortterm clinical and radiological improvement at 12 weeks, broadly aligning with contemporary evidence on vertebral augmentation.

The mean reduction in VAS pain score of 7.4 points observed in our study is comparable to outcomes reported in the existing literature. Cai et al. reported significant postoperative pain relief following PKP in a propensity-score matched cohort of patients with OVCFs, confirming that both PKP and percutaneous vertebroplasty (PVP) achieve meaningful analgesia, with PKP demonstrating superior vertebral height restoration. 12 Our VAS reduction of 7.4 points exceeds the commonly accepted minimal clinically important difference of 2–3 points on a 10-point scale, underscoring the clinical significance of our findings.

TABLE-I

Baseline characteristics, clinical and radiological outcomes of the study cohort (n =75)

Variable	Category	Pre-operative (Mean ± SD / n, %)	Post-operative (12 Weeks) (Mean ± SD / n, %)	P-Value
Age (years)	Mean ± SD	65.8 ± 8.2		
	Range	46–83 years		
Gender	Female	55 (73.3%)		
	Male	20 (26.7%)		
BMI (kg/m²)	Mean ± SD		27.9±6.5	
Affected Vertebral Level	L1	29 (38.7%)		
	L2–L4	24 (32.0%)		
	Thoracic (D7–D12)	22 (29.3%)		
Number of Levels	Single level	45 (60.00%)		
	Multi-level	30 (40.00%)		
VAS Score	Mean ± SD	9.2 ± 0.7	1.8 ± 1.9	<.001*
Vertebral Body Height (cm)	Mean ± SD	2.78 ± 0.35	3.05 ± 0.32	<.001*

* Statistically significant ($p \leq 0.05$)

TABLE-II

Stratification analysis of VAS score and vertebral body height by age, gender, and vertebral region (n = 75)

Outcome Variable	Stratification Variable	Category	Pre-op (Mean ± SD)	Post-op (Mean ± SD)	P-Value
VAS Score	Age	≤65 years	9.1 ± 0.8	1.6 ± 1.7	<.001
		>65 years	9.3 ± 0.6	2.0 ± 2.1	<.001
	Gender	Male	9.2 ± 0.7	1.9 ± 2.0	<.001
		Female	9.2 ± 0.7	1.7 ± 1.8	<.001
	Vertebral Region	Thoracic (D7–D12)	9.3 ± 0.6	2.1 ± 2.1	<.001
		Lumbar (L1–L4)	9.1 ± 0.7	1.6 ± 1.7	<.001
Vertebral Body Height (cm)	Age	≤65 years	2.81 ± 0.33	3.09 ± 0.30	<.001
		>65 years	2.75 ± 0.36	3.01 ± 0.33	<.001
	Gender	Male	2.80 ± 0.32	3.07 ± 0.29	<.001
		Female	2.77 ± 0.36	3.03 ± 0.33	<.001
	Vertebral Region	Thoracic (D7–D12)	2.73 ± 0.35	2.99 ± 0.32	<.001
		Lumbar (L1–L4)	2.82 ± 0.34	3.10 ± 0.31	<.001

* Statistically significant ($p \leq 0.05$); Student's t-test applied within each stratum. VAS = Visual Analog Scale.

Similarly, Ege et al. (2025), in a 3-year single-institute follow-up comparing unipedicular and bipedicular balloon kyphoplasty, documented significant improvements in VAS scores across both approaches, with no clinically meaningful difference between the two techniques at final follow-up.6 Our cohort's pain relief trajectory at 12 weeks aligns well with the early postoperative improvements reported in these studies.[6]

A systematic review by Aduri et al. (2025) comparing unipedicular versus bipedicular approaches in both vertebroplasty and kyphoplasty found that both techniques produced significant and comparable

pain relief, suggesting that the procedural approach may be tailored to patient anatomy without compromising analgesic outcomes.[8] This is especially important for our study because we used both transpedicular and unipedicular approaches based on the clinical situation, and our combined results still showed a strong reduction in pain. Moreover, Tao et al. (2025), in a systematic review and pilot meta-analysis comparing modified and conventional PKP, demonstrated that both variants significantly alleviate postoperative pain, thereby affirming the applicability of PKP-related analgesia across technique modifications.[1]

The average increase of 0.27 cm in vertebral body height (9.7% restoration) seen in our series is in line with what has been reported in the literature. However, comparisons must account for differences in measurement methodologies. Cai et al. reported a markedly larger increase in vertebral body height from 11.60 ± 1.48 mm to 21.49 ± 2.20 mm in their PKP cohort, which likely reflects different inclusion criteria, fracture severity, and measurement units (mm vs. cm).[12] Nevertheless, the directional improvement and statistical significance are concordant with our findings. In a broader context, Tao et al. (2025) demonstrated that modified PKP techniques, including the use of expandable implants, achieved greater height restoration compared to conventional PKP, suggesting that our modest 9.7% gain may represent the lower bound of the achievable range with standard balloon kyphoplasty.[1]

Another study showed that regional kyphosis improved from 12.1° to 7.4° with a significantly mean reduction of 4.3° (p<10-3). Beck's index went up from 0.66 to 0.8 post-operatively (p<0.05). The improvement of kyphosis on the level of the fractured vertebra (angular gain) was more important for the group treated with Kyphoplasty (8.45° vs 5.5, p=0.01).[13] Another study showed significant improvement in pain, disability, and quality of life across all groups. The vertebroplasty group demonstrated the greatest improvement, with a VAS score from 7.6 to 0.43 (p<0.001).[14]

Meta-analyses consistently show that kyphoplasty achieves greater anterior/middle height restoration and kyphotic angle correction than vertebroplasty, with pooled anterior height increases of about 3–4 mm (≈19%) and kyphosis correction of ≈3–12° depending on baseline deformity.[15-22] The magnitude of height gain in the current series thus falls within the lower to mid range of previously reported PKP corrections, which is expected given moderate baseline collapse.

Recent work also suggests that higher vertebral height restoration rates (>80%) are associated with better longterm pain and function, with strong negative correlations between restoration rate and VAS(r ≈ −0.60 to −0.70).[19] The present study did not stratify by restoration rate but demonstrates that even partial height recovery is accompanied by substantial symptomatic benefit.

Another study highlighted that intravertebral cleft types significantly influence PKP outcomes, with cleft-associated fractures sometimes exhibiting superior height restoration due to the void available for cement expansion.[4] The exclusion of pathological fractures and neurologically compromised patients in our study may have limited the heterogeneity of our results, but also minimized confounding. Researchers further emphasized that endplate osteoporosis, assessed on CT and MRI, is a critical predictor of adjacent vertebral fractures after PKP, a complication not directly measured in our study due to the 12-week follow-up window.[2]

The results obtained through our stratified analysis indicate that patients both ≤65 years and >65 years showed significant changes in terms of VAS scores and vertebral height ($p < 0.001$ in all cases), with somewhat greater improvements in the younger group. The same was found by Liu et al. (2025) when comparing robotically and fluoroscopically assisted kyphoplasty in the treatment of severe osteoporotic vertebrae fractures among elderly patients, confirming the efficiency and effectiveness of PKP in the most vulnerable patient groups.[5] Recent study reported no differences between robot-assisted unilateral and bilateral PKP surgery in an elderly population, further supporting the opinion that aging should not serve as a reason to avoid PKP.[7]

Stratification according to gender did not yield any

disparate results between males and females, even though the female preponderance of 73.3% was anticipated for osteoporotic cases. Such results are similar to those by a few authors in 2025, [8]which have shown through an extensive meta-analysis that there are no differences in terms of gender regarding the effect of either kyphoplasty or vertebroplasty techniques.[8] Concerning the location of the vertebrae, the current study shows statistically significant results both for thoracic (D7-D12) and lumbar (L1-L4) vertebral fractures. The lumbar vertebral fractures showed slightly better restoration of height (0.28 cm compared to 0.26 cm in the former case). This is because the lumbar vertebrae possess greater trabecular bone mass and load-bearing capabilities. This is consistent with observations made by researchers

In our case series, we stopped the procedure right away if cement leakage was observed through fluoroscopy; no clinical episodes of cement leakage occurred for any participants in the study. This method corresponds with the safety strategy advocated, which recommended a "warning line" system using images obtained during surgery to minimize the risk of cement leakage during the course of PKP and showed an obvious decrease in the frequency of cement leakage with the application of such a system.[9] Additionally, neurological complications caused by cement leakage, although uncommon, occur in about 0.6% to 1% of percutaneous vertebral augmentation procedures.[10] The complication rate among our patients was very low and comparable to another study that found minimal complications after 3 years following unipedicular and bipedicular kyphoplasty.[6]

The current group managed their pain in the short run effectively with no serious complications related to neurology, in line with RCT and meta-analytic evidence showing kyphoplasty to be a safe procedure with minimal risk of cement extravasation or adjacent fractures.[14-20]

A few limitations of this study should be highlighted. Firstly, the time frame of 12 weeks postoperatively was sufficient to evaluate the results of surgery, but not enough to draw any conclusions concerning the longevity of the procedure, especially regarding pain reduction and vertebral body height conservation. According to researchers, a nomogram prediction model was used to assess the likelihood of re-fractures following PKP surgery; local fat parameters were identified as important predictors of re-fractures in patients with osteoporosis, and this aspect was ignored by our study.[11] Secondly, we did not provide measurements of Cobb angle correction, which is an important indicator of kyphotic deformity, which is a common outcome measured in many contemporary studies, such as those conducted.[1,12] Thirdly, we do not have a control group. Future studies from our center should incorporate longer follow-up (≥1 year), Cobb angle measurement, adjacent vertebral fracture surveillance, and patient-reported functional outcome measures such as the Oswestry Disability Index (ODI) to provide a more comprehensive efficacy profile of PKP in our regional population.

CONCLUSION

Percutaneous kyphoplasty is a safe and effective way to treat osteoporotic vertebral compression fractures with very little damage to the body. It provides quick and significant pain relief, as well as a small but important increase in the height of the vertebral body at short-term follow-up. The procedure yielded uniform results across various age groups, genders, and vertebral levels, demonstrating its extensive applicability in osteoporotic patients. The method also showed a good safety record, with no major problems seen during the study period. Nevertheless, extended follow-up and more extensive comparative studies are necessary to validate the persistence of outcomes and evaluate long-term complications, including adjacent-level fractures.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Fahad Khan Jadoon:** Conception of idea.
2	**Umair Ahmad:** Critical review.
3	**Zain Naseer:** Literautre review.
4	**Umar Faraz:** Data collection.
5	**Sabahullah:** Data entry.
6	**Atiq Uz Zaman:** Critical revisions.
7	**Sadaf Saddiq:** Data analysis.