ORIGINAL ARTICLE

Physical Therapy Journal of Indonesia (*PTJI*) 2026, Volume 7, Number 1: 131-136
E-ISSN : 2722-6034 ; P-ISSN : 2722-0125

# Kyphoplasty for osteoporotic vertebral fractures: Epidemiology and clinical-radiological outcomes

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Received: 2025-09-29
Accepted: 2026-01-26
Published: 2026-04-22

## ABSTRACT

**Background:** Osteoporotic vertebral fractures (OVFs) are the most common complication of osteoporosis and a significant public health burden. Kyphoplasty is a minimally invasive surgical option that can restore vertebral body height and reduce deformity. This study aimed to describe the epidemiological characteristics, clinical profile, and radiological outcomes of OVFs patients treated with kyphoplasty at Hasan Sadikin General Hospital, Indonesia.

**Methods:** A retrospective observational study was conducted on patients with OVFs who underwent kyphoplasty between January 2020 and August 2025 at Hasan Sadikin General Hospital, Indonesia. Demographic data, fracture characteristics, and radiological parameters (Beck's index, local kyphotic angle) were collected. Continuous variables were reported as median and range; categorical variables as frequency and percentage.

**Results:** Twenty patients were included (15 females, 75%; 5 males, 25%), with a median age of 67 years (range: 46–87). Fractures involved the thoracic (45%), lumbar (35%), and thoracolumbar (20%) regions. Compression fractures were most common (45%), followed by burst (30%) and mixed patterns (25%). Single-level involvement occurred in 65% of patients. Postoperative radiographs demonstrated significant improvements: Beck's index increased from 58% preoperatively to 69% postoperatively (+19%), and local kyphotic angle improved from 14.9° to 10.3° (–28%).

**Conclusion:** Kyphoplasty was effective in restoring vertebral height and correcting kyphotic deformity in patients with OVFs. Older women were most commonly affected, reflecting the epidemiological burden of osteoporosis in Indonesia. These findings support kyphoplasty as a valuable treatment option in selected OVF patients.

**Keywords:** osteoporotic vertebral fracture, kyphoplasty, epidemiology, Beck's index, kyphotic angle, Indonesia.
**Cite This Article:** Hendra, Rahim, A.H., Ramdhan, A., Hadar, A.K., Junilla, R. 2026. Kyphoplasty for osteoporotic vertebral fractures: Epidemiology and clinical-radiological outcomes. *Physical Therapy Journal of Indonesia* 7(1): 131-136. DOI: 10.51559/ptji.v7i1.368

## INTRODUCTION

Osteoporotic vertebral fractures (OVFs) are the most frequent clinical manifestation of osteoporosis and remain a major global health problem. Worldwide, approximately 1.4 million new vertebral fractures occur annually, with a lifetime risk estimated at 15% in women and 8% in men.[1] As populations in Asia, including Indonesia, continue to age, the prevalence of osteoporosis is rising steadily, with reports indicating that 24–36% of women older than 50 years are affected.[2] National Indonesian data further estimate that osteoporosis affects 23–35% of women above 50 years, underscoring the increasing disease burden in the country.[3] OVFs also impose serious clinical consequences beyond pain and structural deformity. Vertebral fractures have been shown to raise mortality risk significantly, with several cohort studies reporting up to an eightfold increase compared with individuals without fractures.[4-6] Importantly, reviewer concerns highlight the need to address the functional implications of

OVFs. A collapsed vertebral body disrupts sagittal alignment, increases anterior spinal loading, and reduces the mechanical efficiency of the paraspinal and trunk extensor muscles. These alterations contribute to chronic back pain, impaired balance, reduced gait speed, postural instability, and limitations in daily activities such as bending, lifting, standing, or walking.[7-15] Literature on conservative OVF management consistently shows that kyphotic deformity and reduced trunk muscle strength are key contributors to long-term disability and functional decline.[16,17]

Conservative management—comprising analgesics, short-term bed rest, bracing, and anti-osteoporotic pharmacotherapy—remains the initial standard of care.[7] Nevertheless, vertebral augmentation procedures such as vertebroplasty and balloon kyphoplasty are now widely utilized for selected patients because they can relieve pain rapidly, restore lost vertebral height, and partially correct kyphotic deformity.[8] Randomized controlled trials have demonstrated that the radiological improvements achieved through kyphoplasty are associated with better functional outcomes, enhanced mobility, and improved quality of life compared with nonsurgical management.[10,11] Recent systematic reviews also confirm that kyphoplasty provides meaningful short- to intermediate-term benefits in pain and functional recovery. However, the degree of benefit may vary with the extent of kyphosis correction and adherence to postoperative rehabilitation principles.[12]

Given the rising prevalence of osteoporosis in Indonesia and the significant structural and functional impact of OVFs, there is a clear need to characterize treatment outcomes in local populations. Therefore, this study aimed to evaluate the epidemiology, fracture characteristics, and radiological outcomes, specifically vertebral height restoration and kyphotic angle correction, of patients with OVFs treated with kyphoplasty at Hasan Sadikin General Hospital, Bandung, Indonesia, between January 2020 and August 2025.

## METHODS

This study employed a retrospective observational design and was conducted at Dr. Hasan Sadikin General Hospital, Bandung, Indonesia, a tertiary referral center specializing in spine and orthopedic services. Medical records of all patients diagnosed with osteoporotic vertebral fractures (OVFs) who underwent balloon kyphoplasty between January 2020 and August 2025 were systematically reviewed. This design allowed the evaluation of real-world clinical and radiological outcomes without introducing additional interventions.

Eligible participants were adults with clinically and radiologically confirmed OVFs who received kyphoplasty during the study period and had complete preoperative and immediate postoperative lateral spine radiographs. Patients were excluded if their records lacked essential clinical information, if radiological images were incomplete or unavailable for measurement, or if they were lost to follow-up immediately after surgery such that postoperative imaging could not be obtained. When multiple fractures were present, only the vertebral levels treated with kyphoplasty were considered for analysis.

Data extraction was performed using a predefined template to ensure consistency across cases. Demographic variables included age and sex. Fracture characteristics comprised the anatomical level of the fracture, classification of fracture morphology, and the number of vertebral levels treated. Radiological parameters were obtained from standardized lateral spine radiographs, focusing on Beck's index, calculated as the anterior-to-posterior vertebral height ratio, and the local kyphotic angle measured at the fractured segment. Both parameters were recorded preoperatively and within 48 hours postoperatively to minimize variability related to patient positioning or early postoperative swelling.

To reduce measurement bias, radiological assessments were carried out independently by two trained observers: a spine fellow and a radiology resident. Both assessors were blinded to clinical information, operative notes, and each other's measurements. All radiographs were reviewed on the hospital's digital imaging system under identical viewing conditions. Discrepancies greater than 5% in Beck's index or 3 degrees in local kyphotic angle were re-evaluated jointly, and a consensus value was determined in consultation with an attending spine consultant. This blinding and reconciliation process was implemented to improve objectivity and enhance the reliability of radiological measurements.

Postoperative physiotherapy practices during the study period were also examined. While no formal standardized physiotherapy protocol specific to kyphoplasty existed at the institution, patients generally received uniform postoperative recommendations from the spine service. These consisted of early ambulation within 24–48 hours, instruction on avoiding excessive trunk flexion, guidance on safe movement patterns during daily activities, and initiation of gentle trunk-extensor activation exercises as tolerated. Patients were also advised regarding fall prevention strategies and osteoporosis-related lifestyle modifications. However, because physiotherapy details were not consistently documented in medical records, adherence and specific progression of exercises could not be quantified and were therefore not included as outcome variables.

All data were tabulated and analyzed using SPSS statistical software. Continuous variables were summarized as medians with ranges due to non-normal distribution, and categorical variables were presented as frequencies and percentages. Given the descriptive nature of the study, no inferential statistical testing was performed. Radiological improvement was evaluated descriptively by comparing preoperative and postoperative measurements of vertebral height restoration and kyphotic angle correction.

## RESULTS

A total of 20 patients who met the eligibility criteria were included in the analysis. The demographic and fracture characteristics of the study population are summarized in **Table 1.** The cohort

**Table 1. Demographic characteristics of 20 patients with osteoporotic vertebral fractures**

| Characteristic | N (%) or median (range) |
|---|---|
| Sex | |
| Female | 15 (75.0) |
| Male | 5 (25.0) |
| Age, years | 67 (46–87) |
| Fracture segment | |
| Thoracic | 9 (45.0) |
| Lumbar | 7 (35.0) |
| Thoracolumbar | 4 (20.0) |
| Fracture type | |
| Compression | 9 (45.0) |
| Burst | 6 (30.0) |
| Mixed | 5 (25.0) |
| Number of levels | |
| One level | 13 (65.0) |
| Two levels | 6 (30.0) |
| Three levels | 1 (5.0) |

N, number of participants

consisted predominantly of females, with 15 women (75%) and 5 men (25%), reflecting the well-documented higher prevalence of osteoporosis among postmenopausal women. The median age was 67 years (range 46–87), indicating that OVFs in this population primarily affected older adults.

Regarding fracture distribution, the thoracic spine was the most frequently involved region, accounting for 9 cases (45%), followed by the lumbar spine with 7 cases (35%). Four patients (20%) had fractures at the thoracolumbar junction, an area known to be biomechanically vulnerable due to its transition between thoracic rigidity and lumbar mobility. Compression fractures were the most common morphological type (45%), whereas burst fractures occurred in 30% of cases and mixed fracture patterns in 25%. Most patients (65%) presented with a single-level vertebral fracture, while 30% had two affected levels, and only one patient (5%) exhibited three-level involvement. These data illustrate a typical OVF distribution pattern observed in aging populations, with higher susceptibility in regions subjected to axial loading and repetitive stress.

Radiological outcomes before and after kyphoplasty are presented in **Table 2.** There was a notable improvement in vertebral height restoration following the procedure. The median Beck's index increased from 58% in the preoperative assessment to 69% postoperatively, representing a 19% relative improvement. This finding demonstrates that kyphoplasty effectively re-expanded the anterior vertebral body, reducing the degree of wedge deformity. Similarly, the local kyphotic angle showed a measurable correction; it improved from a preoperative mean of 14.9° to 10.3° postoperatively, corresponding to a 28% reduction. Correction of kyphotic angulation is clinically relevant because it decreases anterior column loading, improves sagittal alignment, and may contribute to reduced pain and functional impairment.

These radiological changes are visually illustrated in **Figure 1**, which depicts representative preoperative and postoperative lateral radiographs of treated vertebrae. The images highlight the restoration of vertebral height and reduction of kyphotic deformity following balloon inflation and cement augmentation. In the postoperative image, the improvement in anterior vertebral height is clearly evident, with better vertebral body symmetry and more normalized sagittal contour. The reduction in local kyphotic angle reflects successful internal fracture reduction and stabilization. Together, these imaging findings align with previously published evidence demonstrating the structural benefits of kyphoplasty in osteoporotic fractures.

**Table 2. Radiological parameters before and after kyphoplasty**

| Measurements | Pre-operative | Post-operative | Change (%) |
|---|---|---|---|
| Beck's Index (%) | 58.0 | 69.0 | +19 |
| Local Kyphotic Angle (°) | 14.9 | 10.3 | –28 |

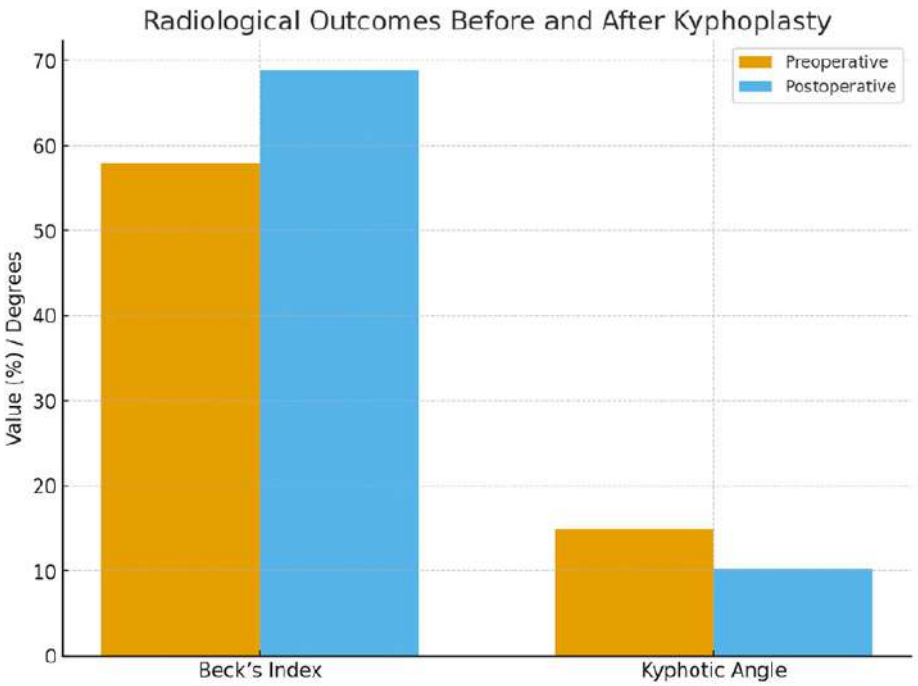


**Figure 1.** Radiological outcomes before and after kyphoplasty, showing improvement in vertebral height (Beck's index) and reduction in local kyphotic angle.

## DISCUSSION

This study highlights the epidemiology and outcomes of OVFs treated with kyphoplasty at Hasan Sadikin General Hospital. Consistent with global and regional literature, most patients were elderly women, reflecting the higher prevalence of osteoporosis in postmenopausal females.[2,9]

Thoracic and lumbar segments were most frequently involved, aligning with biomechanical vulnerability at the thoracolumbar junction.

Radiologically, kyphoplasty significantly improved vertebral body height (Beck's index: +19%) and reduced local kyphotic deformity (–28%). These outcomes are comparable to previous studies, which reported that kyphoplasty improves pain, restores vertebral height, and enhances patient autonomy.[7,8]

In our study, the primary outcomes were radiological parameters, Beck's index, and local kyphotic angle, rather than explicit rehabilitation or functional metrics. This focus provides a detailed picture of structural correction but does not directly quantify pain relief, disability, or health-related quality of life. When our findings are interpreted alongside studies that included functional outcomes and rehabilitation elements, they appear broadly concordant. Randomized and

prospective trials of balloon kyphoplasty have consistently shown that radiographic restoration of vertebral height and reduction in segmental kyphosis are accompanied by clinically meaningful improvements in pain scores, disability indices, and quality of life compared with non-surgical management. Boonen et al. reported that kyphoplasty produced rapid pain reduction and improved Roland–Morris Disability Questionnaire and SF-36 scores versus conservative treatment in patients with acute vertebral compression fractures.[10] Similarly, Van Meirhaeghe et al. demonstrated that kyphotic angle correction after kyphoplasty was associated with superior long-term quality of life and pain relief over 24 months compared with non-surgical care.[11]

More recently, a 2025 systematic review and meta-analysis by Encalada et al. showed that balloon kyphoplasty provides superior pain reduction compared with conservative treatment from 1 to 12 months and improves disability at 1 and 3 months, although disability differences attenuate at later time points.[12] These studies typically integrate kyphoplasty into a broader care pathway that includes analgesia, osteoporosis therapy, and at least basic physiotherapy or early mobilization. For example, Kasperk et al. followed kyphoplasty patients for three years. They reported sustained improvements in pain and mobility scores. Still, all participants received standard pharmacologic anti-osteoporosis treatment, pain medication, and physiotherapy, making it difficult to disentangle the isolated effect of surgery from that of rehabilitation.[13] Likewise, Grafe et al. showed that mobility improvements after kyphoplasty were maintained up to three years, again in the context of structured pharmacologic management and physiotherapy.[14]

Compared with these studies, our cohort demonstrates radiological improvements of a similar magnitude in Beck's index and local kyphotic angle, suggesting that the structural prerequisite for functional recovery has been achieved. Prior evidence indicates that better vertebral height restoration and kyphosis correction correlate with less chronic pain and improved function.[15] However, because we did not prospectively record standardized rehabilitation metrics such as the Oswestry Disability Index, Barthel Index, or time to independent ambulation, our interpretation must remain cautious. Our results support the notion that kyphoplasty in our setting achieves radiographic outcomes comparable to those in centers where detailed rehabilitation programs and functional follow-up are routinely reported. Still, we cannot empirically confirm that the same degree of functional recovery occurred.

From a biomechanical and clinical standpoint, we consider postoperative physiotherapy an essential adjunct to kyphoplasty in maintaining vertebral height correction and optimizing long-term outcomes.[16] Kyphoplasty restores vertebral body height and reduces local kyphosis by internal fracture reduction and cement augmentation; the durability of this correction depends not only on cement properties and bone quality, but also on how the spine is loaded during daily activities.[17] Postoperative physiotherapy can modulate these loads by improving trunk muscle strength, posture, and movement patterns, thereby reducing recurrent flexion moments across the treated segment and limiting progressive deformity.[18] Conservative management literature for osteoporotic vertebral fractures emphasizes that analgesia, osteoporosis medication, bracing, and individualized physiotherapy are central to restoring function and minimizing chronic pain.[19] Even in the era of vertebral augmentation, expert reviews highlight that orthoses and physiotherapy remain important components of care to reduce hyperkyphosis, improve mobility, and potentially reduce future fracture risk.[20]

More recently, ERAS-based protocols for patients undergoing percutaneous kyphoplasty have integrated early mobilization, breathing exercises, and functional training as core elements. Fan et al. showed that an ERAS program after kyphoplasty significantly reduced postoperative pain, shortened hospital stay, and improved ODI and Barthel Index scores up to one year compared with conventional care.[21] Although vertebral height maintenance was not the primary endpoint, better early mobilization and functional recovery may indirectly help sustain alignment by decreasing prolonged bed rest, deconditioning, and compensatory postures that increase segmental loading.[22] In parallel, risk-factor analyses for new vertebral compression fractures after kyphoplasty have highlighted low bone mineral density, suboptimal osteoporosis treatment, and sagittal imbalance as contributors to subsequent fractures, underscoring that surgery alone is insufficient without comprehensive post-fracture management.[23]

In our setting, postoperative physiotherapy has not yet been standardized into a protocol tailored explicitly for kyphoplasty patients, and this is a limitation we acknowledge. Based on the evidence above, a structured program should minimally include: early supervised mobilization, trunk and back-extensor strengthening, postural retraining aimed at reducing thoracolumbar flexion, gait and balance training to prevent falls, and education on spine-sparing techniques. These interventions should be combined with optimized anti-osteoporotic therapy and, where appropriate, bracing in the early postoperative period. Looking forward, we consider the development and implementation of a dedicated postoperative physiotherapy pathway, potentially aligned with ERAS concepts, an essential next step to ensure that the vertebral height correction achieved by kyphoplasty in our patients is maintained over time and translated into durable functional benefits.

This study has several important limitations that should be acknowledged. First, its retrospective design inherently restricts the ability to control for confounding variables, relies on the accuracy of existing medical records, and prevents assessment of temporal changes beyond what was documented. Second, the study was conducted at a single tertiary referral center, which may limit generalizability, as patient characteristics, referral patterns, and clinical practices may differ across institutions. Third, the sample size was relatively small, reducing the ability to explore subgroup analyses or detect more nuanced patterns in radiological outcomes. Fourth, postoperative physiotherapy adherence and functional recovery metrics were not

consistently documented in the medical records, preventing the evaluation of how structural correction translated into pain reduction, mobility improvement, or quality-of-life outcomes. Finally, only immediate postoperative radiographs were analyzed; the absence of long-term imaging follow-up limits conclusions regarding the durability of vertebral height restoration and kyphotic correction over time.

## CONCLUSION

Kyphoplasty demonstrated meaningful radiological improvements in patients with osteoporotic vertebral fractures, as evidenced by substantial restoration of vertebral body height and reduction of local kyphotic deformity. Although functional outcomes such as pain reduction, mobility enhancement, and quality-of-life measures were not directly assessed in this retrospective study, the structural corrections observed are clinically relevant. Restoration of vertebral height and improved sagittal alignment may reduce mechanical strain on the spine, facilitate better posture, and support more efficient load distribution during daily activities. These radiological gains are consistent with mechanisms known to contribute to pain relief and improved mobility following vertebral augmentation. The findings therefore suggest that kyphoplasty not only stabilizes the fractured vertebra but also provides a biomechanical foundation that may allow patients to benefit from postoperative rehabilitation, regain functional capacity, and potentially reduce the long-term consequences of vertebral deformity. Future prospective studies incorporating standardized measures of pain, gait, muscle function, and physiotherapy outcomes are warranted to more clearly delineate the patient-centered benefits that may accompany the radiological success achieved in this cohort.

## CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to the subject matter or materials discussed in this manuscript. All authors have read and approved the final version of the manuscript, and no financial or personal relationships have influenced the research process or its outcomes.

## ETHICS CONSIDERATIONS

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of Dr. Hasan Sadikin General Hospital, Bandung, Indonesia, prior to data collection with number LB.02.01/X.7.4/515/2025. As this study employed a retrospective design using anonymized medical records, individual informed consent was waived by the ethics committee. All patient data were kept confidential and used solely for research purposes.

## FUNDING

The authors received no external funding for the design, execution, analysis, or publication of this study. Institutional resources from the Department of Orthopaedic and Traumatology, Dr. Hasan Sadikin General Hospital, Bandung, Indonesia, supported all research activities.

## AUTHOR CONTRIBUTIONS

H. conceived the study, collected the clinical and radiological data, performed preliminary analysis, and drafted the initial manuscript. AHR provided overall supervision, contributed to clinical interpretation, and critically revised the manuscript for important intellectual content. AR assisted in methodological development, radiological assessment, and refinement of the manuscript. AKH contributed to the verification of data accuracy, the interpretation of orthopedic findings, and the critical review of the manuscript. RJ supported data extraction, literature review, and preparation of tables and figures. All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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