PAIN MEDICINE CASE REPORTS

ISSN 2768-5152

Volume 10, Number 5, pp. 389-393

PERCUTANEOUS KYPHOPLASTY FOR ACUTE VERTEBRAL COMPRESSION FRACTURES: A SINGLE-CENTER CASE SERIES ANALYZING PAIN AND FUNCTIONAL OUTCOMES

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Background: Vertebral compression fractures (VCFs) are a common and debilitating complication of osteoporosis, causing severe pain and immobility in the elderly population. Percutaneous kyphoplasty (PKP) is a minimally invasive procedure used to stabilize these fractures and provide pain relief, but its efficacy remains a topic of debate.

Case Report: We conducted a retrospective case series, recording data from 54 sets of VCFs followed by PKP in 46 individuals, to evaluate changes in pain levels measured on a subjective Visual Analog Scale. Secondary outcomes included the presence of follow-up procedures and changes in analgesics used, emphasizing a focus on functional outcomes.

Conclusions: The average reduction in pain was 4.3/10 points ($P < 0.001$), further supported by a significant decline in analgesic strength used ($P = 0.014$). These findings support the role of PKP in addressing both pain and recovery from acute VCFs.

Key words: Percutaneous kyphoplasty, vertebral compression fracture, spinal fractures, pain, pain management, pain reduction, interventional pain management, opioid reduction, outpatient procedure, analgesic use

BACKGROUND

Vertebral compression fractures (VCFs) are classified as the fracture and subsequent collapse of a spinal column segment due to a compressive axial force (Fig. 1) (1-3). Under normal physiological conditions, these fractures are quite rare and require extensive amounts of pressure. However, in patients with a reduced bone mineral density (BMD), these injuries are the most common skeletal complication (4). A reduced BMD is a prevalent development in the elderly population, especially characteristic of postmenopausal women, and the hallmark feature of conditions like osteoporosis and osteopenia (5,6). Over 700,000 patients experience osteoporotic VCFs annually, and it is estimated that around 25% of postmenopausal women are affected by a compression fracture at least once in their lifetime (1,4). Further epidemiological trends suggest that VCFs are only increasing in prevalence, nearly doubling over the past 20 years (6). And, with the presence of an ever-growing elderly population, VCFs exemplify a growing burden in our aging society.

VCFs often result in severe acute back pain, reduced mobility, structural spinal deformities, and an overall decline in quality of life (1,2). As such, management is crucial for these patients, and several approaches can be taken. Available options include conservative care (i.e., bed rest, bracing, and physical therapy), analgesic pharmacotherapy (i.e., nonsteroidal anti-inflammatory drugs and opioids), and operative management (3).

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Disclaimer: There was no external funding in the preparation of this manuscript.
Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.
Patient consent for publication: The IRB determined this retrospective review of de-identified data to be exempt from review. Informed consent was not required.
This case report adheres to CARE Guidelines and the CARE Checklist has been provided to the journal editor.
Accepted: 2026-02-12, Published: 2026-07-31

Fig. 1. Sagittal T1-weighted magnetic resonance imaging showing a mild/moderate acute T9 VCF. MRI, magnetic resonance imaging; VCF, vertebral compression fracture.

Percutaneous kyphoplasty (PKP) is one example of a minimally invasive procedure that is widely used as a treatment modality for patients with VCFs (7-9). The procedure involves filling the collapsed vertebrae with bone cement to alleviate pain and provide stability to the affected segment, preventing further collapse and possible neurological sequelae (3,10).

Despite its widespread use in the outpatient pain management setting, the effectiveness of PKP remains a topic of debate, particularly concerning its impact on acute pain relief and functional outcomes (8,11,12). Understanding the clinical benefits and potential limitations of PKP is crucial to refining treatment strategies for patients with VCFs and ensuring optimal care in the outpatient setting (12). Our retrospective case series aims to investigate the efficacy of PKP on improving patient outcomes following VCFs, with an emphasis on changes in acute pain.

CASE PRESENTATION

Our study was formulated as a retrospective case series, with data being obtained via chart review from an electronic health record platform. Informed consent was not required as the study used deidentified data and was deemed exempt by the TouroNY Institutional Review Board (protocol #25390; verified as exempt under 45 CFR 46.101[b][4]). The population in question was a cohort of patients who underwent a PKP secondary to acute VCF between December 2020 and December 2024, in a pain management clinic in New York City. Exclusion criteria were set to limit population outliers and maintain a level of consistency in the reported data. Exclusion criteria were as follows:

1. Patients younger than 50 years of age.
2. Patients with chronic vertebral fractures (> 3 months old or reported as chronic on imaging based on bone marrow edema per the radiology report).
3. Patients who were missing key data in their health records (e.g., pre- and postoperative pain severity score using the Visual Analog Scale (VAS), lack of appropriate imaging, etc).
4. Patients who did not have a postoperative follow-up visit within 3 months of having the procedure.
5. Patients who had an aborted procedure secondary to complications, pathology, or pain intolerance.

All patients must have undergone a successful PKP (single level or series) using the proper procedural methods with a Stryker Kyphoplasty Kit (Stryker, Kalamazoo, MI) (Fig. 2). Patients with multilevel vertebral fractures had their series of consecutive procedures combined and evaluated as a single data set. Their VAS scores were obtained from the follow-up visit after completion of the entire procedural series. After finishing the chart review, a total of 76 procedures on 53 patients were initially identified. After further application of exclusion criteria, a final 66 PKPs were recorded and compiled into 54 sets of procedures on 46 unique patients. For each entry, appropriate data was extracted (Table 1) and used for statistical analysis.

A combination of descriptive and correlational analyses was completed, assessing for demographics, a significance in pain reduction, and the presence of changes in functional outcomes in patients postoperatively.

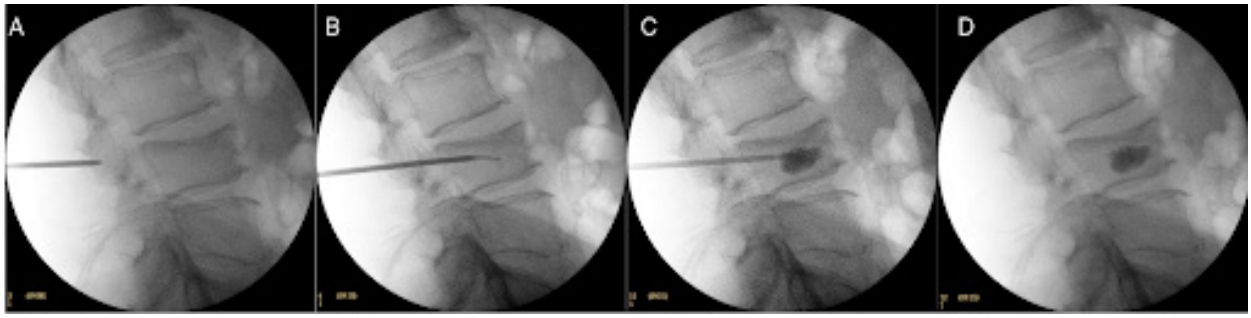

Fig. 2. Progression of an L4 vertebral kyphoplasty as seen on sagittal view with fluoroscope.

Table 1. Study variables recorded and their description.

Category	Variable	Definition/Description
Demographics	Age	Age at the Time of Procedure (y)
	Gender	Man /Woman
	BMI	Weight/height squared (kg/m²)
Independent	Spinal level of vertebral fracture	Thoracic vs lumbar level of vertebrae
	Fracture severity (13)	Radiologist-reported % vertebral height loss: mild (< 20% to 25%), moderate (25% to 40%), severe (> 40%)
	Lumbar spine DEXA T-score (14)	Average T-score value (osteoporosis/osteopenia assessment)
Dependent	Pain severity (VAS) (15, 16)	Pre- and postprocedural VAS (0 = no pain, 10 = worst pain imaginable)
	Analgesic strength used (WHO scale) (17)	Pre- and postprocedural: 0 = none, 1 = nonopioid, 2 = weak opioid, 3 = strong opioid
	Supplemental procedure at follow-up visit	Presence of an interventional procedure (e.g., epidural steroid injection, medial branch block, trigger point injection) in the same region on follow-up visit

Abbreviations: BMI, body mass index; DEXA, dual-energy x-ray absorptiometry; VAS, Visual Analog Scale; WHO, World Health Organization.

Patient Characteristics

The mean age of the patients at the time of the procedure was 74.85 ± 8.07 years, with 33/46 (71.7%) of them being women and 13/46 (28.3%) being men. Average body mass index (BMI) was recorded at 27.04 ± 4.56 (kg/m2). Only 25/46 of the patients had a reported dual-energy x-ray absorptiometry (DEXA) T-score on file, with the average being -2.06 ± 1.3. Of the vertebral fractures, 40/66 (60.6%) were in the lumbar region, and 26/66 (39.4%) were in the thoracic region, with the densest concentration seen around the thoracolumbar junction. Furthermore, 62 of the 66 fractures had a radiological description of the severity, with 31 (50%) classified as mild, 6 (9.7%) as mild-moderate, 15 (24.2%) as moderate, 1 (1.6%) as moderate-severe, and 9 (14.5%) as severe. The group recorded an average time to follow-up visit of 16.78 days (minimum = 3 days; maximum = 63 days).

Pain Outcomes

The mean preoperative VAS score was 9.74 ± 0.71, and the mean postoperative VAS score was 5.48 ± 3.03, yielding a mean change of -4.26 points (Wilcoxon signed rank test, $P = 4.80\times10^{-10}$; Cohen's $d_x = -1.48$). A clinically meaningful improvement of ≥ 2 VAS points was observed in 81.5% (44/54) of the sample population, and 64.8% (35/54) had over a 30% reduction in VAS rating. Furthermore, a significant decline in the strength of analgesics used was noted on follow-up visits, with a mean reduction of 0.48 on the World Health Organization analgesic ladder (Wilcoxon signed rank test, $P = 0.014$). Change in analgesic strength used was noted to improve in 37.0% (20/54), worsen in 7.4% (4/54), and remain the same in 55.6% (30/54) of the sample. This step down in analgesic strength correlated with a greater reduction in pain based on VAS (Spearman, $\rho = 0.42$, $P = 0.0015$). Additional procedures were documented at follow-up in 53.7% (29/54) of cases, with

patients who required a follow-up procedure exhibiting smaller reductions in pain from the PKP compared to those not requiring a procedure on the follow-up visit (Pearson correlation: r = -0.62, $P < 0.001$). Pain reduction and outcomes did not differ by vertebral region (thoracic spine vs lumbar spine, $P = 0.242$).

Predictors

Evaluation of demographic data yielded minimal significance in relation to outcome measures. On univariate regression, age was weakly negatively correlated with a change in VAS score, but was ultimately deemed not significant (R = -0.206, $R^2 = 0.043$, $P = 0.135$). When applying similar methods of examining the relationship between demographic data (age, gender, BMI, fracture severity, and DEXA T-score) and pain outcomes (ΔVAS, Δanalgesic strength, and presence of supplementary procedure), none of the parameters revealed a significant result ($P > 0.05$).

DISCUSSION

As medicine within the United States develops and the average life span extends, the incidence of age-related pathologies continues to increase, as demonstrated by the expansion in prevalence and impact of conditions, such as VCFs. These injuries cause severe pain and ultimately burden the elderly population, limiting their ability to participate in routine activities (4,6). Despite a small sample, our cohort reflected the typical U.S. population with VCFs, consisting predominantly of women with a mean age in the mid-70s and reduced BMD (18,19). Further, the vertebral segment at which the VCF and subsequent PKP occurred was normally distributed, densely focused around the thoracolumbar junction (T11-L2). This is consistent with the typical course of injury, as the transition point from thoracic vertebrae to lumbar vertebrae carries the highest compressive loads, making them most prone to compressive fractures (20).

We found that PKP resulted in a significant improvement in pain, with a mean VAS reduction of 4.26 ($P = 4.80\times10\text{-}10$) points and a clinically meaningful improvement in over 80% of cases on the follow-up visit. These findings are consistent with current literature, which also demonstrates that kyphoplasty provides rapid and clinically meaningful reductions in pain and improvements in function. Adjacent studies (11,15,21-23) found a similar trend in changes in VAS following PKP, showing major improvement in symptomatology as compared to conservative care.

In addition to pain, the results demonstrate an overall decrease in analgesic requirement following the procedure, with a large portion of patients transitioning away from opioid-based regimens to nonopioid analgesics or discontinuing pharmacologic pain management altogether ($P = 0.014$). Unsurprisingly, this trend was shown to be statistically significant when correlated to changes in VAS reported ($P = 0.0015$). These findings relay an important societal benefit of PKP—the potential to reduce reliance on analgesic medications in patients with VCFs.

Severe pain following VCF creates the potential for prolonged opioid use, which carries well-documented risks of dependence, adverse events, and further contribution to the ongoing opioid epidemic in the United States (1,3,4,24). Considering that elderly patients with osteoporosis are particularly vulnerable to both fracture-related morbidity and pharmacological complications, such as gastrointestinal dysmotility and cognitive deficits, effective interventions that provide durable pain relief without escalating pharmacotherapy are especially valuable (1). By ameliorating pain and mitigating the risks associated with long-term analgesic and opioid use, PKP addresses both individual patient outcomes and broader public health concerns.

Our study is limited by its retrospective design, small sample size, and reliance on physician documentation of subjective outcomes, such as VAS scores and analgesic use, which may introduce reporting and selection bias (16). These factors restrict generalizability and reduce power to detect subgroup differences.

CONCLUSIONS

The results showed that PKP provided substantial acute pain relief in an outpatient cohort, while also demonstrating the potential to mitigate opioid use in a vulnerable population. Improvements in VAS correlated with a reduction in strength of analgesics used and a lower chance for an additional intervention at the follow-up visit, reinforcing its clinical relevance in acute pain relief. Given the increasing prevalence of VCFs in the aging population, interventions, such as PKP, may play an important role in improving patient outcomes and addressing broader public health challenges. Although our study adds to the growing body of evidence supporting PKP, larger prospective studies with more objective pain quantifications are warranted to confirm these benefits and identify predictors of optimal response.

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