Prospective Study

# Can Additional Facet Joint Block Improve the Clinical Outcome of Kyphoplasty for Acute Osteoporotic Vertebral Compression Fractures?

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**Background:** Percutaneous kyphoplasty (PKP) has been reported to provide a favorable analgesic effect for pain caused by osteoporotic vertebral compression fractures (OVCFs). However, a systematic review demonstrated that pain relief was only reported for approximately 86% of kyphoplasty treatments.

**Objectives:** To explore whether an additional facet joint block (FJB) can minimize pain and improve the clinical outcome of PKP in patients with acute OVCFs.

**Study Design:** Prospective study.

**Setting:** All data were from Honghui Hospital in Xi'an.

**Methods:** According to the inclusion and exclusion criteria, 194 patients were eventually included in our study; they were randomly divided into 2 groups of 97 patients each and treated with either PKP + FJB or PKP alone. Follow-up consultations were scheduled 1 day, 3 days, 1 week, 1 month, 3 months, and 1 year postoperatively; the demographic characteristics, related surgical information, and complications observed within both groups were recorded. The clinical evaluation parameters included the intraoperative satisfaction score, the Visual Analog Scale (VAS) score, and the Oswestry Disability Index (ODI).

**Results:** A total of 171 patients (61 men and 110 women; age range: 62–85 years) completed the full postoperative follow-up schedule, with 83 patients in the PKP + FJB group and 88 in the PKP group. No significant differences were observed in the genders, ages, preoperative bone mineral density, surgical levels, or volume of cement injected between the 2 groups ($P > 0.05$, respectively). The average duration of the surgeries in the PKP + FJB group was slightly longer than that in the PKP group (35.5 ± 4.8 min vs. 31.8 ± 4.3 min; $P = 0.038$), and in terms of the clinical outcomes, the average intraoperative satisfaction score was significantly higher in the PKP + FJB group (8.6 ± 1.1 vs. 6.3 ± 1.3; $P < 0.001$). Compared with the preoperative data, significant improvements in the VAS scores of back pain and ODI were observed at each follow-up interval ($P < 0.05$, respectively). These scores were significantly higher in the PKP + FJB group than in the PKP group; however, this was only observed within the first month after the procedure.

**Limitations:** A single-center noncontrol study.

**Conclusions:** The addition of an FJB (which in our study involved a unique combination of ropivacaine, prednisolone, and vitamin B12) improved the short-term clinical outcome of PKP for acute OVCFs. The local anti-inflammatory and analgesic effects on the facet joints resulted in higher intraoperative satisfaction and lower VAS and ODI scores for the first postoperative month when compared with the PKP group.

**Key words:** Osteoporotic vertebral compression fracture, pain, posterior elements, percutaneous kyphoplasty, facet joint block, medial branch

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Osteoporotic vertebral compression fractures (OVCFs) are the most common fractures associated with osteoporosis; over 700,000 new OVCFs are reported yearly in the United States (1). One of the most serious symptoms is severe back pain, lasting from weeks to months. OVCFs are commonly encountered in older patients, in which the resulting back pain can impair their functional abilities and lead to a significantly impaired quality of life (2,3). The goal of reducing back pain, stabilizing the vertebrae, and restoring spinal mobility may be achieved with conservative treatments, such as bed rest, analgesic medication, bracing, and nerve block, to an extent; however, long-term bed rest can lead to subsequent demineralization, aggravation of osteoporosis, bed sores, pneumonia, and deep vein thrombosis. Conservative treatment may be at risk of poor pain relief, vertebral collapse, and kyphosis formation.

Percutaneous kyphoplasty (PKP) involves the percutaneous placement of an inflatable balloon and the injection of polymethylmethacrylate (PMMA) cement into the fractured vertebra. This method cannot only effectively restore the height of the collapsed vertebral body and correct the kyphotic deformity, but also provides a favorable analgesic effect for pain caused by OVCFs. However, a systematic review demonstrated that pain relief was only reported for approximately 86% of kyphoplasty treatments (4). The phenomenon of residual back pain experienced after vertebroplasty was noted by several scholars; high-risk factors associated with poor back pain relief after vertebroplasty in patients with OVCFs included a low preoperative bone mineral density (BMD), lumbodorsal fascial injury, multiple segment fracture, an insufficient volume of injected cement, unsatisfactory cement distribution, and depression (5,6). Bogduk et al (7) observed that the posterior elements of the vertebral column must subluxate cephalad or caudad in response to deformity of a vertebral body based on the biomechanics model analysis; thus back pain cannot originate solely from the micromovement of the vertebral fracture and may also arise from the posterior elements, explaining why medial branch blocks can relieve pain in OVCFs. We consider that vertebral augmentation can potentially eliminate the vertebral microfractures, and that addition of a facet joint block (FJB) can relieve the pain arising from the posterior elements, resulting in a better clinical outcome. The aim of this study was to explore whether an additional FJB can minimize pain and improve the clinical outcome of PKP in patients with acute OVCFs.

## Methods

This prospective study was approved by the medical ethics committee of Xi'an Honghui Hospital in accordance with relevant guidelines and regulations; informed consent was obtained from all patients. Between January 2017 and January 2018, a total of 232 patients with thoracolumbar OVCFs were treated with PKP at Xi'an Honghui Hospital. Inclusion criteria were single-level fresh thoracolumbar OVCFs confirmed via x-ray and magnetic resonance imaging (MRI); severe back pain (Visual Analog Scale [VAS] scores were > 6) for 6 weeks or less; a T-value for BMD of –2.5 or less; the posterior wall of the vertebral body remaining intact without any neurologic deficit or compression in the spinal canal; and the patient willing to receive PKP treatment with or without an FJB. Exclusion criteria for patients included having received treatment via percutaneous vertebroplasty; older OVCFs with back pain lasting more than 6 weeks; severe cardiopulmonary comorbidity; coagulation abnormalities or suspected malignant disease; burst vertebral fracture with spinal canal stenosis and neurologic deficit; and spinal infection or skin disease. According to these criteria, 194 patients were eventually included in our study; they were randomly divided into 2 groups of 97 patients each and treated with either PKP + FJB or PKP alone.

### Surgical Technique

The patient was placed in the prone position, and PKP was performed via a bilateral transpedicular approach under local anesthesia. After positioning of the targeted vertebra and administration of local anesthesia, bilateral incisions of approximately 5 mm in length were made. All 194 patients underwent this procedure.

For the PKP + FJB group, FJBs was administered in the bilateral facet joints of the fractured vertebral body prior to the injection of bone cement. A mixture of prednisolone (125 mg: 5 mL), ropivacaine (3 mL: 37.5 mg), vitamin B12 (4 mL: 1 mg), and saline solution (0.9%, 4 mL) was utilized to perform the FJB. The classic medial branch block was targeted to the medial branch at the affected level. However, when OVCFs occur, the compression of the anterior middle column inevitably leads to an increase in the pressure applied to the structure of the posterior column, increasing the shear stress on the whole facet joints. Because the unilateral facet joint receives innervation from the medial branches of same level and level above, the medial and lateral margins of the facet joints should be included in the process of capsular admixture infiltration. In addition, degenerative

joint disease is quite common in elderly patients with OVCFs, which can lead to the lower back pain. Hence besides the classic medial branch block, the intraarticular injection and inferior articular process administration were also included in our FJB technique. A needle was first placed into the facet joint space under the oblique view of fluoroscopy (Fig. 1). The mixture (1 mL) was injected into the bilateral facet joint space. The needle was then slightly retrieved and placed on the surface of the facet joint capsule. The remaining mixture was divided into 2 parts for infiltration injections around the bilateral facet joint capsule with different segments attached (Fig. 2) to execute the effective nerve block of the medial branch of the spinal dorsal ramus.

The following PKP procedures were performed on the patients from both groups, and were similar to procedures reported by Garfin et al (8). Needle puncture, working cannula establishment, balloon inflation, and bone cement filling were sequentially completed under the guidance of fluoroscopy by a single senior spine surgeon within our spinal surgery department. PMMA (Via Andrea Doria, CEMEX, Verona, Italy) cement (4–6 mL) was injected into the fractured vertebra under continuous biplanar fluoroscopic monitoring.Filling was terminated when satisfactory cement distribution had been achieved (when cement had spread from the superior to the inferior end plate, and bridged bilateral pedicle), or if there was any cement extravasation into the spinal canal, intraspinal venous system, or adjacent intervertebral disc.

## Postoperative Management and Follow-Up

Six hours after the operation, out-of-bed activity was allowed without requiring a spinal brace. All patients received supplemental calcium (1,000 mg/day), vitamin D (2,000 IU/day), and antiosteoporosis therapy. Follow-up consultations were scheduled 1 day, 3 days, 1 week, 1 month, 3 months, and 1 year postoperatively; the demographic characteristics, related surgical information, and complications observed within both groups were recorded. An intraoperative satisfaction score between 0 and 10 was introduced to evaluate surgical tolerance and the effect of the intraoperative local anesthesia. Postoperative clinical outcomes included a VAS score between 0 and 10 representing the severity of the back pain (with 0 representing no

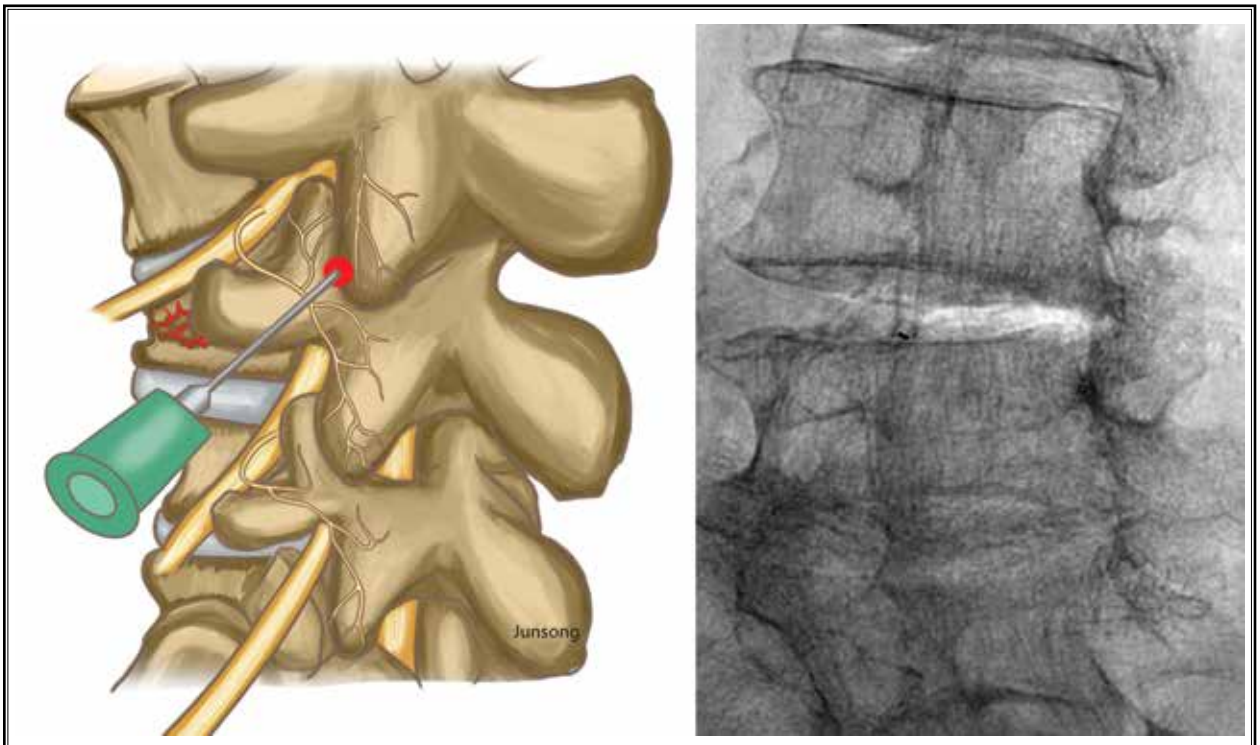


Fig. 1. *The schematic picture shows a needle placed within the facet joint space (panel left, red spot), which was confirmed by an oblique fluoroscopic view (panel right).*

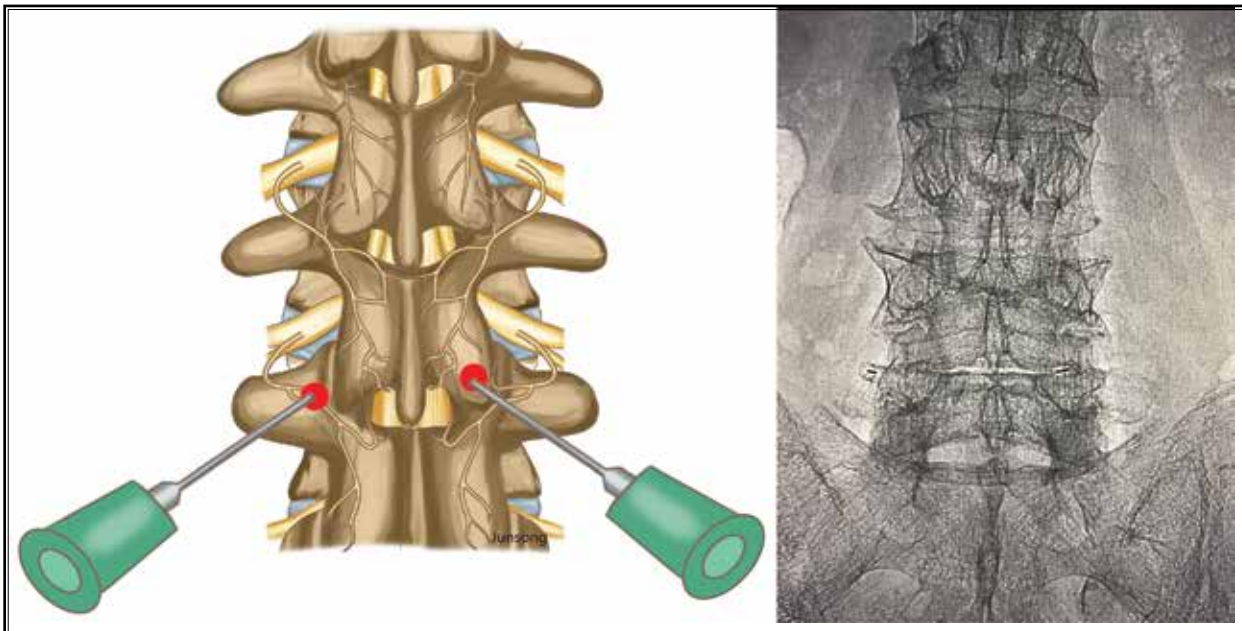

Fig. 2. *The schematic picture shows the needle slightly retracted from its intraarticular location and placed onto the surface of the facet joint capsule. Because the unilateral facet joint receives innervation from the medial branch of same level and level above, the medial and lateral margins of the facet joints should be included (panel left, red spots) in the process of capsular admixture infiltration under fluoroscopic guidance (panel right).*

pain and 10 representing the highest degree of pain), as well as the Oswestry Disability Index (ODI). To accurately reflect the intensity of back pain and level of dysfunction. These evaluations were performed without the use of analgesics. Plain film thoracolumbar x-rays were recommended at the 1- and 12-month follow-up consultations; if new OVCFs were suspected, they could be confirmed via MRI, including T1-weighted, T2-weighted, and short time inversion recovery sequences.

### Statistical Analysis

Data were analyzed using SPSS 22.0 software (IBM Corporation, Armonk, NY) and have been presented as mean ± standard deviation. Independent sample t-tests, as well as $\chi^2$ tests, were used to compare the differences between the 2 groups; $P < 0.05$ was defined as statistically significant.

## Results

Successful surgical treatment was achieved within both groups; no patient required conversion to an open procedure. A total of 171 patients (61 men and 110 women; age range: 62–85 years) completed the full postoperative follow-up schedule, with 83 patients in the PKP + FJB group and 88 in the PKP group. The demographic characteristics and surgical information of patients within both groups are summarized in Table 1. No significant differences were observed in the genders, ages, preoperative BMDs, surgical levels, or volume of cement injected between the 2 groups ($P > 0.05$, respectively). Catastrophic complications, such as intraspinal cement leakage, pulmonary embolism, and cardiovascular or cerebrovascular accidents, did not occur, although 9 patients developed a secondary OVCF after the initial surgery (4 patients belonged to the PKP + FJB group and 5 patients belonged to the PKP group). The average duration of the surgeries in the PKP + FJB group was slightly longer than that in the PKP group (35.5 ± 4.8 min vs. 31.8 ± 4.3 min; $P = 0.038$), and in terms of the clinical outcomes, the average intraoperative satisfaction score was significantly higher in the PKP + FJB group (8.6 ± 1.1 vs. 6.3 ± 1.3; $P < 0.001$). Compared with the preoperative data, significant improvements in the VAS scores of back pain and ODI were observed at each follow-up interval ($P < 0.05$, respectively). These scores were significantly higher in the PKP + FJB group than in the PKP group; however, this was only observed within the first month after the procedure (Tables 2 and 3; Figs. 3 and 4).

Table 1. *Summary of demographic characteristics and surgical related information of both groups.*

| | PKP + FJB Group | PKP Group | *P* Value |
|---|---|---|---|
| Female gender (%) | 54 (65.1) | 56 (63.6) | 0.846 |
| Mean age (yrs) ( x ± s ) | 65.3 ± 4.6 | 66.8 ± 4.3 | 0.721 |
| Preoperative BMD | –2.8 ± 0.3 | –2.9 ± 0.3 | 0.931 |
| The volume of cement injection | 5.5 ± 0.3 | 5.4 ± 0.5 | 0.952 |
| Surgical levels | | | 0.589 |
| T1-4 | 5 | 3 | |
| T5-9 | 19 | 21 | |
| T10-L2 | 51 | 53 | |
| L3-L5 | 8 | 11 | |

Table 2. *Changes of pre- and postoperative VAS scores for back pain (x±s).*

| Group | Preoperative | 1 Day Postoperative | 1 Week Postoperative | 1 Month Postoperative | 3 Months Postoperative | 12 Months Postoperative |
|---|---|---|---|---|---|---|
| PKP + FJB group | 7.5 ± 0.3 | 1.8 ± 0.3 | 1.6 ± 0.4 | 1.5 ± 0.2 | 1.4 ± 0.2 | 1.3 ± 0.3 |
| PKP group | 7.3 ± 0.4 | 3.3 ± 0.4 | 2.8 ± 0.4 | 2.4 ± 0.7 | 1.7 ± 0.5 | 1.5 ± 0.3 |

Table 3. *Changes of pre- and postoperative ODI for back pain (%, x±s).*

| Group | Preoperative | 1 Day Postoperative | 1 Week Postoperative | 1 Month Postoperative | 3 Months Postoperative | 12 Months Postoperative |
|---|---|---|---|---|---|---|
| PKP + FJB group | 75.0 ± 2.9 | 24.8 ± 3.0 | 20.4 ± 2.8 | 18.5 ± 3.5 | 16.2 ± 2.0 | 15.8 ± 2.1 |
| PKP group | 74.6 ± 2.8 | 37.3 ± 3.2 | 39.5 ± 2.6 | 25.9 ± 2.9 | 19.8 ± 1.7 | 16.2 ± 1.9 |

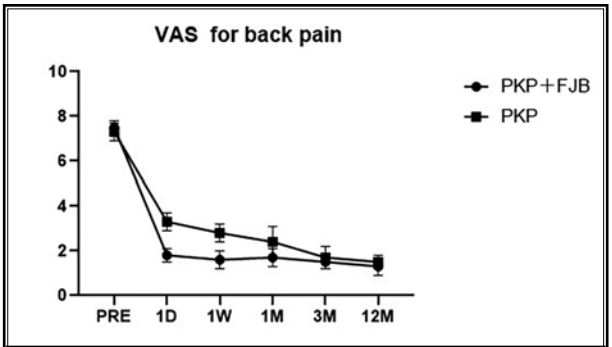


Fig. 3. *Changes of pre- and postoperative VAS scores of back pain.*

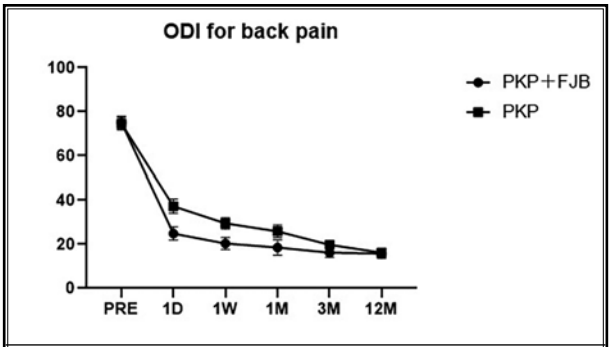


Fig. 4. *Changes of pre- and postoperative ODI scores of back pain.*

## Discussion

In our case series, although the operation time of PKP + FJB group was longer than that of the PKP group, the VAS scores for back pain and the ODI were significantly improved after the surgery in both groups ($P < 0.05$, respectively). Besides the better intraoperative satisfaction score, the VAS scores for back pain and the ODI in the PKP + FJB group were significantly lower than those in the PKP group at each follow-up interval of the first month postoperatively.

Although some patients with OVCFs respond to conservative treatment, chronic pain and delayed kyphotic deformity may eventually lead to sleep loss, depression, decreased appetite, and impaired pulmonary function. As the mobility of the patient is affected by the degree of pain experienced, a decline in their quality of life is observed, resulting in a significant increase in morbidity (9-13). PKP was introduced as a minimally

invasive technique in 1998 to help stabilize the fractured vertebra, control back pain, improve the physical function of individuals, and promote rapid recovery after surgery (10,14). The process of PKP involves utilizing an inflatable balloon to reduce the collapsed vertebra before injection of the PMMA cement. This technique produced advantages in the form of realigning the spine, decreasing the risk of cement leakage, and providing back pain relief. The mechanisms underlying back pain relief following PKP remain multifactorial, but may include the direct neurotoxic effects of the PMMA, heat-induced neurolysis during cement polymerization, elimination of vertebral microfractures, and restoration of vertebral body height (15).

In a systematic review of 69 clinical studies, the rate of bone cement leakage during PKP was reported as 9%. In that review, approximately 86% of patients reported postoperative relief of back pain. This suggested that nearly 14% of patients still experienced significant postoperative back pain. The origin of the pain in patients with acute OVCFs was traditionally attributed to the vertebral body; however, results of our analyses lead us to question whether these attributions were correct. Some scholars believed that the pain originated from the posterior soft tissue and posterior elements, such as the paraspinal muscles, tendons, and sympathetic nerves, or even secondary to a radiculopathy from foraminal stenosis after the collapse of the intervertebral space, from facet hypertrophy, or from extraforaminal disc herniations (16-19). Although any of these can cause postoperative back pain, facet joints should not be overlooked as a cause of secondary back pain. Microscopically, facet joint capsules have been shown to have an abundant nerve supply and are richly imbued with receptors sensitive to physical stretching and chemical inflammation (20,21). Several mechanisms are considered to modulate the chronic back pain associated with facet joints, including stretching of the joint capsule, entrapment of the synovial membranes into the facet joint space, and a local inflammatory response (22-25). The injection of local anesthetics, with or without steroids, is often used to block the innervating nerve branches. This technique has been widely utilized for the treatment of chronic low back pain in degenerative lumbar diseases, even acute or old OVCFs (26-28). Thoracic OVCFs are characterized by the collapse of vertebra and increased kyphosis. The facet joint is the main force-bearing structure of the posterior vertebral column; when OVCFs occur, the compression of the anterior middle column inevitably leads to an increase in the pressure applied to the structure of the posterior column. A cadaveric study confirmed that induced anterior thoracic compression fractures lead to increased thoracic kyphosis, increasing the shear stress on the facet joints (29). Bogduk et al (7) presented a biomechanical model to prove that the posterior elements of the thoracolumbar spine must subluxate cephalad or caudad in response to segmental kyphosis, thus increasing strain on the facet joints. The pain induced by thoracolumbar OVCFs in 6 cases of a reviewed study was only relieved after medial branch blocks, implying that the posterior elements could be a cause of the pain (7). Mitra et al (30) also presented 2 patients with OVCFs who were treated with intraarticular facet blocks; a dramatic reduction in pain was achieved. Intraarticular facet blocks were thus considered a potential alternative to vertebroplasty. Additionally, Lehman et al (31) noted that facet joint signal changes on MRI were more common in facet joints associated with acute/subacute OVCFs than those in facet joints associated with a normal vertebral body or chronic OVCFs. These studies confirm that the facet joints play an important role in fracture pain, and that FJB with local administration of anti-inflammatory and/or analgesic agents has a positive effect regarding pain relief.

In our case series, no significant differences were observed in the baseline of demographic information, preoperative BMDs, surgical levels, volume of cement injected, or complications encountered between the PKP + FJB and PKP groups. However, patients in the PKP + FJB group reported better scores regarding intraoperative satisfaction and improvement of back pain immediately post operation. At the 1-month follow-up, reported back pain (VAS) and functional scores (ODI) were better than those in the PKP group. This confirmed that the addition of an FJB can improve the clinical outcome of PKP for acute OVCFs. We believe that in analyzing the causes of back pain after OVCFs, the entire spine should be considered, including the vertebral body and facet joints. Although the cement injected into the vertebral body can stabilize the vertebral micromovements and fill the gap between microfractures, it only eliminates one source of pain. The improvement in vertebral body height by reducing the kyphosis is beneficial for reducing the risk of bone cement leakage and correcting the abnormal mechanical state after vertebral collapse. A subsequent additional FJB can have a local anti-inflammatory and analgesic effect, eliminating pain originating from the posterior facet joint.

Unlike the previous studies (7,27,28,30,32), we performed the FJB prior to performing the PKP because the results of the FJB could be affected by the local

anesthesia used around the puncture point during PKP surgery. We first introduced the scale of intraoperative satisfaction scores to evaluate the degree of intraoperative pain and satisfaction. Because of the need for local anesthesia around the puncture point during PKP surgery, we believe that local anesthesia can be modified by the FJB. Anatomically, the facet joint is innervated by the medial branch of the spinal dorsal ramus at the same level and from a cephalad branch. Infiltration around the capsule as we have suggested, will block the pain from both medial branch divisions. Intraarticular injection is also beneficial for improving pain from inside the joint space, often caused by conditions such as synovial membrane entrapment or facet joint arthritis. The modified "anesthetic" technique can achieve an ideal analgesic effect during surgery and further improve the intraoperative satisfaction of patients. This explains why the intraoperative satisfaction scores of the PKP + FJB group were higher than those of the PKP group.

For patients with thoracolumbar OVCFs, the collapse of the vertebral body itself can lead to vertebrogenic back pain and acute trauma. The secondary kyphotic deformity can also induce the local biomechanical changes in bilateral facet joints, leading to aggravation of the original back pain. The operative technique will have an impact on the postoperative efficacy. Li et al (33) enrolled 157 patients with thoracolumbar OVCFs undergoing bilateral PKP. The incidence of facet joint violation resulting from puncture trocars was observed to be as high as 15.9% (25/157) during postoperative computed tomography. They reported that facet joint violation could impact the clinical outcomes after PKP in OVCFs, primarily within the first 1-month follow-up period, and could affect the patient's long-term surgical satisfaction (56.0% vs. 78.8%, at 1-year follow-up) (33). An additional FJB can impose a local anti-inflammatory and analgesic effect, eliminating pain caused by iatrogenic facet joint injury. Notably, FJB can only accelerate the patient's pain improvement and functional recovery.

Any residual back pain because of the paraspinal muscles, tendons, and even the facet joints may gradually be relieved by conservative physical therapy. If needed, physical therapy could benefit the facet joints in the long term because the effect of the local anti-inflammatory and analgesic drugs administered during the FJB were found to be temporary, explaining why the back pain and functional disability score in the PKP + FJB group were significantly lower than those in the PKP group only within the first 1 month of follow-up. Long-term clinical results were found to be comparable between the 2 groups.

A major limitation of this study is its single-center design. Also, because FJB alone primarily relieves pain arising from the facet joint, we were skeptical of its value in the treatment of OVCFs. Im et al (34) observed that after FJB prior to PVP, overall approximately half of the patients still experienced pain. Thus we did not create a comparison group where FJB alone was performed. Although Xiang et al (35) reported ultrasound-guided FJB relieved relief residual pain after PKP, we modified the block technique of FJB and the composition of drugs. The composition of drugs that we used for the FJB is still controversial. We introduced a mixture of prednisolone, ropivacaine, and vitamin B12. Although ropivacaine is an amide local anesthetic with long-term effects, vitamin B12 has neurotrophic properties and is beneficial for reducing the inflammatory response and abnormal discharge of the damaged nerve (31,36). The corticosteroid additionally contributes to the blocking of inflammatory responses and abnormal neural discharge. Previous studies have shown that the combination of prednisolone, ropivacaine, and vitamin B12 can induce a synergistic effect, promoting the release and absorption of the drugs, prolonging their pharmacologic activity after lumbar decompression surgery (37). Further studies regarding the efficacy and safety of this mixture still need to be performed. Although the puncture site we chose was as lateral as possible to help prevent the occurrence of facet joint violation, breach of the facet joint was difficult to identify fluoroscopically. The puncture needle we chose was very small, which should have produced a lesser impact on the facet joints. In addition, for elderly patients, who already have degenerative facet joint diseases, the control of intrajoint inflammatory response by means of intrajoint injection is theoretically effective. However, whether there is permanent damage to the facet joints, capsule, and cartilage, or chronic facet problems secondary to degeneration, will require further long-term studies.

## Conclusions

The addition of an FJB (which in our study involved a unique combination of ropivacaine, prednisolone, and vitamin B12) improved the short-term clinical outcome of PKP for acute OVCFs. The local anti-inflammatory and analgesic effects on the facet joints resulted in higher intraoperative satisfaction and lower VAS

and ODI scores for the first postoperative month when compared with the PKP group.

## Authors' Contributions

Ding-Jun Hao and Yuan-Ting Zhao conceived the study design. Peng Zou, Peng Liu, Han-Lin Gong, Tuan-Jiang Liu, Xiang-Fu Wang, Jian-Min Wei, Bo Zhang, Qing-Da Li, and Lei Chu supervised the data collection and literature review. Jun-Song Yang drafted the manuscript. Ding-Jun Hao and Yuan-Ting Zhao are responsible for this article.

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