

# Could lateral decubitus position improve the cement distribution of unilateral percutaneous kyphoplasty in patients with osteoporotic vertebral compression fracture?

**Tao Wu**

Second Affiliated Hospital of Nanjing Medical University

**Hu Qin**

Second Affiliated Hospital of Nanjing Medical University

**Xiaohui Tang**

Second Affiliated Hospital of Nanjing Medical University

**Yunfeng Bai**

Second Affiliated Hospital of Nanjing Medical University

**Zhen Jin**

Second Affiliated Hospital of Nanjing Medical University

**Jun Liu** (✉ [13776698080@139.com](mailto:13776698080@139.com))

Second Affiliated Hospital of Nanjing Medical University

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## Research Article

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# Abstract

**Background:** To determine the influence of lateral decubitus position on cement distribution of unilateral percutaneous kyphoplasty (PKP) in patients with osteoporotic vertebral compression fracture (OVCF).

**Methods:** A retrospective review was performed on patients who underwent PKP for OVCF at the Spine Department of our hospital between January 2016 and January 2020. Unilateral PKP were performed by the same senior spinal surgeon team under local anesthesia. Patients were divided into two groups according to positions with injecting cement. Complete symptom and radiographic evaluation information were gathered from each patient since the initial presentation. Then, the radiographic and symptomatic indexes between two groups were compared.

**Results:** There were 190 patients included in this study. Ninety-four patients used to receive cement injection in lateral decubitus position while 96 patients were in prone position. A significantly longer surgical time ( $28.7 \pm 4.5$  min vs.  $26.8 \pm 4.3$  min) and more cement volume ( $6.14 \pm 0.66$  ml vs.  $5.69 \pm 0.69$  ml) were found in lateral decubitus group. And visual analogue scale (VAS) scores were significantly lower ( $p < 0.05$ ) in lateral decubitus group one week after surgery. Compared with prone group, lateral decubitus group showed a significantly higher proportion of grade III cement distribution (18.2% vs. 7.3%,  $p < 0.05$ ) and a significantly lower cement leakage rate (13.8% vs. 26%,  $p < 0.05$ ).

**Conclusion:** It is possible that lateral decubitus position can improve cement distribution, relieve acute pain more and decrease leakage incidence in OVCF patients with unilateral PKP, although it might be slightly time-consuming. It was recommended that position could be switched to lateral decubitus position during cement injection for unilateral PKP, especially when extraversion angle was small.

## Background

Osteoporosis is a severe medical condition that mainly affects older female population and is characterized by low bone mass density resulting in bone porosity and fragility [1, 2]. The prevalence of this disease increases with population aging, and it is becoming a worldwide challenge of elderly health [3]. The risk of fractures rises markedly as it gets worse [4]. Osteoporotic fractures are frequently identified in thoracic and lumbar spine even after a slight trauma, presenting with back megalgia, kyphosis, compromised mobility, as well as high mortality [2]. Conservative treatment, mainly consisting of bed resting, is usually used to deal with mild and moderate osteoporotic vertebral compression fracture (OVCF). Nonetheless, due to the seniority of osteoporotic patients, continuous resting on bed might lead to high risk of related complication, such as muscular atrophy, pulmonary and urinary infection as well as deep venous thrombosis [5-8]. Fixation surgery is indicated for OVCF patients with neurologic deficit or spinal instability. The conservative treatment is considered to be effective but have some shortcomings: Firstly, poor health conditions in OVCF patients that may raise the surgical risk. Secondly, low bone mass density is prone to result in instrument related complication, such as screw misplacement and pull-out. Therefore, a less invasive and more effective treatment is needed.

Percutaneous kyphoplasty (PKP) is a minimally invasive surgery for OVCF. It has been proved by many researchers[9-12] that this surgery can relieve pain symptom, reinstate the vertebral height and restore the spinal alignment immediately, which seal off the gap of the above-mentioned treatment. And several studies[13-15] further proved that unilateral PKP has similar effects on pain relief and vertebral height restoration as bilateral PKP, but with shorter surgical time and less blood loss which suggests that this surgery was better for OVCF patients. Nonetheless, it was commonly found in clinical practice that cement was prone to be distributed around injection point and unable to reach the contralateral side of vertebrae, resulting in a symmetrical stress distribution. Although it seemed to have no influence on the short-term therapeutic effect of PKP surgery, this phenomenon might lead to long-term complication, such as pain recurrence, vertebral collapse in contralateral side, as well as vertebral wedge deformity. For the purpose of improving cement distribution of unilateral PKP, our team changed patient's position to lateral decubitus position before cement injection to induce cement flow to the contralateral side with the help of gravity. Then, we assessed and compared effect of lateral decubitus position on cement distribution in unilateral PKP surgery.

## 1. Materials And Methods

### 1.1 Subjects

Under the approval of the University Ethics Committee, a retrospective review was performed on patients who underwent PKP for OVCF at the Spine Department of second affiliated Hospital of Nanjing medical University between January 2016 and January 2020. Subjects was selected who met the inclusion criteria as follow: (1) Age >65 years old; (2) Fresh vertebral compression fracture was identified in thoracic and lumbar spine by MRI and visual analogue scale (VAS) score was more than 6; (3) The diagnosis of osteoporosis was confirmed by Dual-emission X-ray Absorptiometry (DXA) and t-value was less than -2.5; (4) PKP was performed unilaterally for OVCF under local anesthesia;(5) The whole clinical and radiographic records were completed. Patients with other pathologic fractures or the broken posterior wall of vertebral body were excluded from this study.

### 1.2 Surgical Procedures

All surgeries were performed by the same senior spinal surgeon team under local anesthesia, and each procedure was monitored by C arm fluoroscopy (GE company from USA, oec 9800series). Patient was placed in prone position, and his or her abdomen was kept suspended with the help of bolsters. The projection of target pedicle was marked on the skin, and a gentle force was exerted at the marked area to make target vertebrae overextend and indirectly reduced. Trocar and cannula systems (KMC; KINETIC MEDICAL Co. LTD, Shanghai, China) were used in this study. Trocar was punctured at the lateral margin of pedicle and then was stuck through pedicle into vertebral body with 20° or so extraversion angle and the sagittal direction paralleled to the upper endplate. The trocar was replaced by cannula with the guidance of pin. The kyphoplasty balloon was inserted into the anterior part of the vertebral body through the cannula. Contrast agent was propelled meticulously into balloon to restore vertebral height gradually.

Then patient's position was switched carefully to lateral decubitus position, which can make injected side superior. Polymethyl-methacrylate was injected steadily into the vertebrae after the balloon withdrawal. The injection would be terminated if the cement area was no longer enlarged, or cement leaked from vertebral body. In control groups, cement was injected unilaterally in prone position, and other procedures were as same as the above.

### 1.3 Symptom and Radiographic Evaluation

All symptoms and radiographic evaluations were gathered from each patient at the initial presentation and at every follow-up. The radiographic parameters, consisting of vertebral kyphotic angle and vertebral height, were evaluated on anteroposterior and lateral X-ray.

Vertebral kyphotic angle was measured using Cobb's method from the upper endplate of fractured vertebrae to its lower endplate. Positive values were used to denote kyphosis, whereas negative values were used to indicate lordosis. The vertebral height was measured at bilateral pedicles. And cement distribution was classified into 3 grades: grade I, in which cement only distributed in the injected side of vertebrae. Grade II, in which cement crossed the vertebral midline but did not reach inner margin of contralateral pedicle. Grade III, in which cement crossed inner margin of contralateral pedicle. VAS scores and Oswestry disability index (ODI) scores were used to assess the symptom severity.

### 1.4 Data Analysis

All data were analyzed by SPSS (IBM SPSS 26.0, IBM Corp., Armonk, NY). Descriptive statistics, independent-sample t test, pair-sample t test and chi-square test were performed accordingly. Independent-sample t test and pair-sample t test were used to evaluate the surgical outcome in different position, whereas chi-square test was conducted to determine the influence of lateral decubitus position on the cement distribution in unilateral PKP. For all analyses, statistical significance was set at  $P < 0.05$ .

## 2. Results

There were 190 qualified patients included in this study. The mean follow-up time was 2.4 years, ranged from 1 year to 3.5 years. Table 1 showed that 94 patients received cement injection in lateral decubitus position while 96 patients were in prone position. There were 27 male patients (28.7%) in lateral decubitus group and 19 male patients (19.8%) in prone group. There was no significant difference among bone mineral density (BMD), age and gender between two groups. However, a significantly longer surgical time ( $28.7 \pm 4.5$  min vs.  $26.8 \pm 4.3$  min) and more cement volume ( $6.14 \pm 0.66$  ml vs.  $5.69 \pm 0.69$  ml) was found in lateral decubitus group.

From the first week after surgery to the end of observation, PKP surgery showed significantly higher scores in both groups (Figure 1 and Figure 2). Besides, VAS scores were found to be significantly lower ( $p < 0.05$ ) in lateral decubitus group than values in prone group one week postoperatively. Figure 3 illustrated that vertebral height gained significant restoration ( $p < 0.05$ ) in both sides of both groups one week later,

and then suffered a significant loss ( $p < 0.05$ ) at last follow-up. It was worthy to note that there was significant difference in term of vertebral height at contralateral side between two groups at last trial of observation. No significant difference was found between two group at other stages. Figure 4 showed that vertebral kyphosis angle in both groups decreased significantly ( $p < 0.05$ ) after PKP surgery but increased significantly ( $p < 0.05$ ) until last follow-up. No significant difference ( $p > 0.05$ ) of kyphosis angle was observed between two groups at any stages.

Table 2 demonstrated that there was a significant difference in cement distribution and cement leakage between lateral decubitus group and prone group. Compared with prone group, the proportion of grade III cement distribution was significantly higher (18.2% vs. 7.3%,  $p < 0.05$ ). Also, a significantly lower cement leakage rate (13.8% vs. 26%,  $p < 0.05$ ) was found in lateral decubitus group.

### 3. Discussion

Main targets of treatment for OVCF comprised sufficient relief of pain symptom, adequate restoration of spine alignment, rapid recovery of self-care ability, and necessary precautions against future fractures[10]. Risk and complication of treatment also needs to be taken into consideration. PKP was a premium choice for OVCF, which could achieve most of the above-mentioned targets with low risk and rare complications. Unilateral and bilateral PKP, as main approaches of this surgery, has been both proved to have an obviously positive effect on OVCF, while unilateral approach seemed to be easy to operate. Recent comparative studies [14, 15] found that unilateral PKP are safe and effective for OVCF patients as bilateral PKP, but need less radiation dose, less operation time and fewer cement volume. And several meta-analyses [16-18] proposed the similar viewpoints and suggested that unilateral PKP appeared to be superior to bilateral PKP in the treatment of OVCFs. Hence, unilateral PKP might be recommended to treat OVCF due to these advantages. However, several drawbacks reported in some studies provoked concerns about complications of unilateral PKP. Cement leakage was found frequently during the process of unilateral PKP, especially when cement was bilaterally distributed [19]. In order to make cement flow to contralateral side, more cement and faster injected velocity were needed during unilateral cement injection, resulting in not only greater cement distribution but also more risk of cement leakage. Adjacent segment re-fracture was considered as another drawback of unilateral PKP[13].It was attributed mainly to asymmetrical vertebral stress due to eccentric cement distribution[20, 21].To solute this drawbacks, unilateral transverse process-pedicle approach was proposed, but it was not widely accepted due to its harsh puncture requirement. Therefore, our team tried to find a simple way to improve cement distribution in patients with unilateral PKP. Based on the effects of gravity on liquid cement, patients' positions were switched to lateral decubitus position before cement injection and cement was injected at superior side in OVCF patients with unilateral PKP in recent years. Then a comparative study was performed to determine the effect of position on cement distribution in patients with unilateral PKP.

The results of our study showed that obvious improvement of symptomatic and radiographic indexes could be noted immediately after surgery in both group, and further improvement can also be observed afterwards. It implied that cement injection in lateral decubitus position had quite limited negative

influence on surgical outcome of unilateral PKP. In our study, more cement volume and better cement distribution were noted in lateral decubitus group, supporting that gravity could induce liquid cement flow down toward contra lateral side in lateral decubitus position. Additionally, less pressure was needed during cement injection, which explains less leakage incidence was found among lateral decubitus subjects. Furthermore, we also found that patients in lateral decubitus group could gain better relief in pain symptoms in a short time. It might be attributed to more cement volume and better distribution in lateral decubitus group, restoring the stability of fractured vertebrae better immediately after surgery. And significant difference of vertebral height in contralateral side at last follow-up implied that better cement distribution could avoid the vertebral collapse after surgery due to better vertebral stability. No significant difference of adjacent segment re-fracture incidence was observed between two groups in our study, although a significantly better cement distribution was identified in lateral decubitus group. This finding seemed to be in consistent with empirical studies. It might be explained by smaller sample size, shorter follow-up time and better BMD in our study.

The potential limitation of the present study was the retrospective nature, such as the varied follow-up duration. And the cement distribution classification was subjectively defined according to our experience due to the lack of objective definition in the literature. Despite these limitations, we believe that the present results can reflect the influence of lateral decubitus position on cement distribution of unilateral PKP. Further investigation should be done in this field in future.

## **4. Conclusion**

Lateral decubitus position seemed to improve cement distribution, have better effects on pain relief and decrease leakage incidence in OVCF patients with unilateral PKP. Although it seemed to take more time, it was suggested that position could be switched to lateral decubitus position during cement injection for unilateral PKP, especially when extraversion angle of trocar was small.

## **Declarations**

Ethics approval and consent to participate: Institutional review board of Nanjing Medical University approved the respective study protocol. And all methods were performed in accordance with the relevant guidelines and regulations.

Informed Consent to participate and publish: This was a retrospective study. All patients were told that their clinical data might be used for medical research and published in an online open-access publication. Informed consent for both study participation and publication of identifying information/images in an online open-access publication was obtained for each patient before surgery. No information or images that could lead to identification of a study participant was contained in this manuscript.

Availability of data and materials: The datasets generated or analysed during the current study are not publicly available due there were other research plan in future but are available from the corresponding

author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: The first 2 authors contributed equally to this work. WT, and QH wrote the main manuscript text; TX provided radiographic measurement; BY prepared figures; JZ performed a statistical analysis; LJ was the Corresponding author providing the idea and protocol. All authors reviewed the manuscript.

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## Tables

Table 1 The general characteristics of OVCF patients by different types of PKP.

	Lateral decubitus group	Prone group	p-value
Patients NO.	94	96	
Gender	Male 27♀Female 67	Male 19♀Female77	0.15
Age/yrs	74.4±8.2	76.9±8.0	0.06
Bone mineral density	-3.31±0.53	-3.28±0.41	0.60
Surgical Time/min	28.7±4.5	26.8±4.3	<0.01
Cement volume/ml	6.14±0.66	5.69±0.69	<0.01
Adjacent segment re-fracture	7	9	0.63

Table 2 The Cement distribution in two group of UPKP patients

	Lateral decubitus group	Prone group	p value
Cement distribution			
Grade I	53(56.3%)	69(71.9%)	0.037
Grade II	24(25.5%)	20(20.8%)	
Grade III	17(18.2%)	7(7.3%)	
Cement leakage			
YES	13(13.8%)	25(26%)	0.035
NO	81(86.2%)	71(74%)	

## Figures

### Figure 1

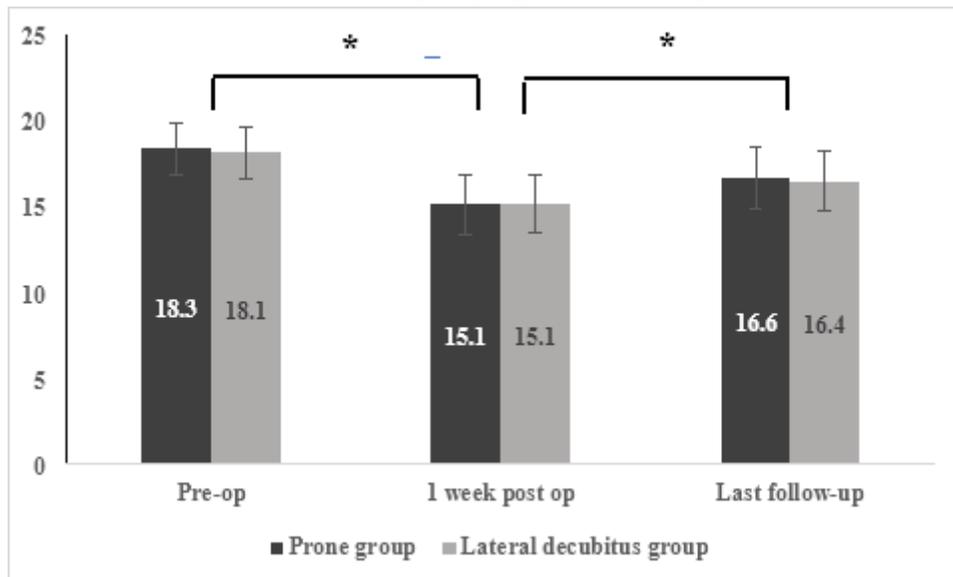
The change of VAS scores in two groups of patients. Obvious improvement could be observed in both groups at each stage and significant lower VAS score was noted in lateral decubitus group one week postoperatively. “\*” denoted there was significant difference when compared with preview value(p value<0.05);”#” denoted there was significant difference between different groups(p value<0.05).

### Figure 2

The change of ODI scores in two groups. Obvious improvement could be observed in both groups at each stage. “\*” denoted there was significant difference (p value<0.05).

**Figure 3**

The change of vertebral height in both side of two groups. Significant restoration in vertebral height was found 1 week postoperatively. And at last follow-up, significant collapses were noted in both sides of two groups, but more collapse was found in contralateral side in prone group. “\*” denoted there was significant difference when compared with preview value (p value<0.05); “#” denoted there was significant difference between different groups (p value<0.05).



**Figure 4**

Time course of vertebral Cobb angle in two groups. Significant decrement was noted in both groups one week postoperatively, whereas significant increment was found at last follow-up. “\*” denoted there was significant difference when compared with preview value (p value<0.05).