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Original Article

Percutaneous vertebroplasty or kyphoplasty for osteoporotic vertebral compression fractures: a comparison among different elderly age groups

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Abstract: *Background:* Controversy remains regarding percutaneous vertebroplasty (PVP) and kyphoplasty (PKP) for osteoporotic vertebral compression fractures (OVCFs) and the effect of age on outcomes in elderly patients has rarely been investigated. *Aim:* To compare therapeutic effects between PVP and PKP for aged patients stratified by different ages. Methods: A Total of 387 patients between January 2010 and January 2014 were reviewed. They were divided into 3 groups according to age: 60-69 (A: PVP, n = 61; PKP, n = 58), 70-79 (B: PVP, n = 103; PKP, n = 105), and 80-91 (C: PVP, n = 31; PKP, n = 28). Outcomes included vertebral body height, kyphotic angle, visual analog scale (VAS), Oswestry disability index (ODI), and complications after 24 months of follow up. Results: Compared with preoperation, vertebral body height was significantly increase but kyphotic angles, VAS, and ODI were decreased postoperatively in the two groups. However, no differences were observed between PVP and PKP groups. Similarly, there were no significant differences in parameters among A, B and C groups, postoperatively, nor between PVP and PKP according to age classification. Cement leakage and adjacent vertebral fractures, respectively, occurred in 22 (11.28%) and 20 (10.42%) patients in PVP and PKP groups but was not significant among A, B and C in PVP and PKP groups as well as between PVP and PKP in groups A, B and C. *Conclusion:* Both PVP and PKP may be effective and safe for OVCFs, regardless of age.

Keywords: Kyphoplasty, vertebroplasty, osteoporotic vertebral fractures, aging, elderly patients

Introduction

Osteoporotic vertebral compression fractures (OVCFs) have become a major public health condition. With increasing aging of the population, an estimated 3 million new fractures are expected to occur annually in China by 2050 [1, 2]. Patients with OVCFs usually present with back pain, spinal deformity, and even reduced lung and digestive function, seriously affecting quality of life for patients [3] and imposing a substantial economic burden on families [1, 4]. Thus, investigation of effective, safe, and lower cost treatment strategies has always been an important issue.

Conservative treatments including bed rest, analgesic, bracing, and physical therapy are generally cost-effective for OVCFs but are not sufficient to resolve symptoms in some patients [5, 6]. Percutaneous vertebroplasty (PVP) and kyphoplasty (PKP) are widely used minimally invasive surgeries but they remain controversial [7]. Compared with PVP, PKP involves 2 times higher costs due to a longer operating time and an overnight hospital stay [6]. Also, it has been reported that there are no significant differences in correction of kyphotic deformity, restoration of vertebral body heights, and pain relief between PVP and PKP [8], suggesting that PVP may be the optimal management for OVCFs. However, Guo et al. performed a meta-analysis of 7 studies in 2013 and indicated that PKP is more effective for pain relief and restoring anterior vertebral body height, Oswestry Disability Index (ODI), and kyphotic angle [9]. Chang et al. [10] included 20 studies to evaluate the efficacy and safety of PVP and PKP in 2014, demonstrating that PKP group had higher anterior vertebral body height and lower Cobb angle than

Table 1. General characteristics of two groups

Characteristics	PVP group (n = 195)	PKP group (n = 192)	*P*-value
Age (year)	72.72 ± 9.72	73.01 ± 8.31	0. 527
60-69	61 (31.28)	59 (30.73)	0.913
70-79	103 (52.82)	105 (54.69)	
80-91	31 (19.50)	28 (14.58)	
Female (n, %)	127 (65.13)	129 (67.19)	0.747
Location of compression fracture			0. 701
T8	2 (1.03)	3 (1.56)	
T9	7 (3.59)	7 (3.65)	
T10	14 (7.18)	11 (5.73)	
T11	22 (11.28)	18 (9.38)	
T12	45 (23.08)	53 (27.60)	
L1	59 (30.26)	62 (32.29)	
L2	34 (17.44)	29 (15.10)	
L3	9 (4.62)	6 (3.13)	
L4	3 (1.54)	2 (1.04)	
L5		1 (0.52)	
BMD (t score)	-3.34 ± 0.72	-3.26 ± 1.57	0. 131
Follow up time	35.07 ± 6.50	34.12 ± 4.50	0.096

PVP in the long-term but no difference in visual analogue scale (VAS) scores, ODI scores, and Cobb angle in the short-term. Liang et al. [11] updated the number of literatures to 32 in 2015 and proved that PKP may result in better pain relief, improvements in Oswestry dysfunction, and anterior and middle height and kyphotic angle but with higher incidence of fracture. These findings imply there are different conclusions when samples are different. Further study with expanded sample size may be necessary to obtain more accurate conclusions.

In addition, age has been proven to be an independent risk factor for postoperative outcomes and complications for these two surgeries. For example, multivariate analysis performed by Martinez-Ferrer et al. [12] showed that age > 80 years (RR = 3.20, 95% CI = 1.70-6.03) was a risk factor for development of new vertebral fractures following PVP. Takahara et al. suggested that age > 85 years conferred an elevated risk of adjacent vertebral collapse after PVP [13]. Shen et al. demonstrated that age was negatively associated with kyphotic angle reduction (b = -0.226; p = 0.009) by PKP [14]. These indicate differences between PVP and PKP in different studies which may also be attributed to different ages. Specific strategies should be performed to minimize complications and improve radiographic outcomes in elderly patients. However, direct investigation of the effect of age on outcomes in elderly patients has been rarely conducted.

The goal of this study was to retrospectively compare therapeutic effects between PVP and PKP for aged patients stratified by different ages.

Materials and methods

Patients

A retrospective review of patients that were diagnosed with VCFs by MRI and that underwent PKP or PVP treatment in our hospital, between January 2010 and January 2014, was carried out. Eligible patients met the following inclusion criteria: (1) Age older than 60 years; (2) Had primary osteoporosis identified by dual-energy x-ray absor-ptiometry before operation; (3) Had symptoms (back pain and restricted motion) for more than four weeks with no evidence of nerve damage; (4) Being refractory to conservative therapies such as bed rest, analgesics, and anti-osteoporosis medication; and (5) With a minimum of 24 months of clinical follow up. Patients were excluded due to the following reasons: (1) With secondary osteoporosis due to endocrine disorders and inflammatory diseases; (2) With non-osteoporotic VCFs secondary to other factors, such as spinal tumors; (3) Had a history of spinal surgery (PKP or PVP); and (4) With a follow up shorter than 2 years.

Informed consent was obtained from all individual participants prior to surgery. Due to the retrospective nature of our study, formal consent was not further required. This study was approved by the Institutional Review Board of Beijing Shijitan Hospital.

Surgical procedure

Surgery was performed under local anesthesia with fluoroscopic guidance. Dolantin was administered 30 minutes before the procedure to relieve pain. PVP and PKP was performed after postural reduction of the compressed vertebr-

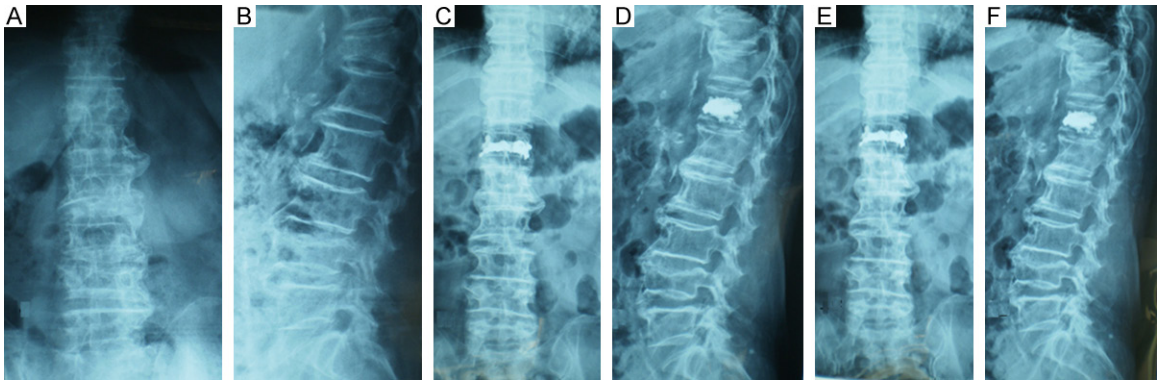

Figure 1. Radiological studies of a 78-year-old female with a T12 compression fracture treated by PVP. A, B: Preoperative plain radiographs x-ray showing T12 compression fracture. C, D: Immediate PVP postoperative plain x-ray radiographs showing kyphotic angle and height of compressed vertebral body. E, F: 24 months follow up after PVP, without the loss of kyphotic angle and vertebral body height. PVP, percutaneous vertebroplasty; PKP, percutaneous kyphoplasty.

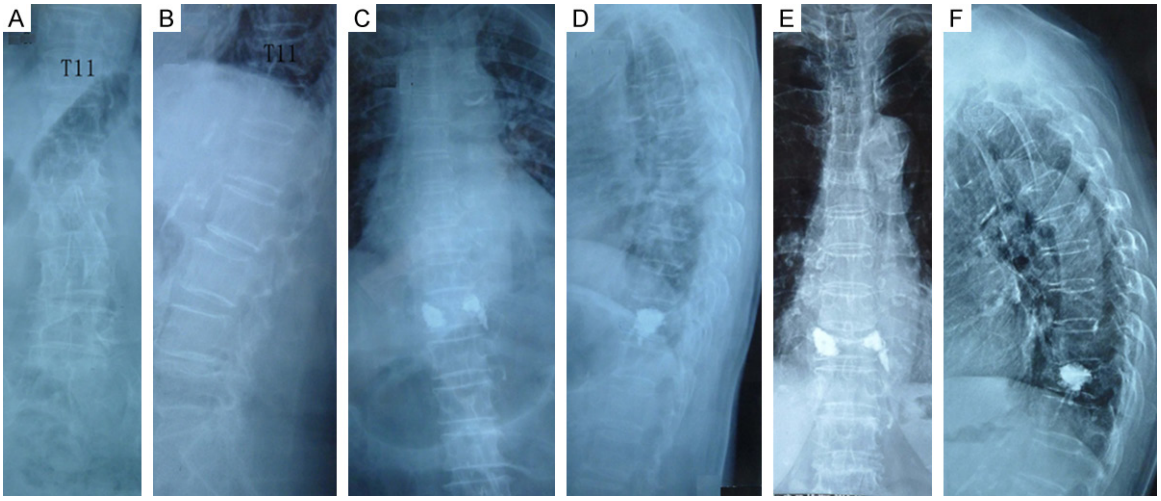

Figure 2. Radiological studies of an 84-year-old Female with a T11 compression fracture treated by PKP. A, B: Preoperative plain radiographs x-ray showing T11 compression fracture. C, D: Immediate PKP postoperative plain x-ray radiographs showing kyphotic angle and height of compressed vertebral body. E, F: 24 months follow up after PKP, without the loss of kyphotic angle and vertebral body height. PVP, percutaneous vertebroplasty; PKP, percutaneous kyphoplasty.

al body [15]. An 11- to 13-gauge needle was inserted percutaneously from bipedicular vertebral pedicles into one-third of fractured vertebral body through a transpedicular approach and then an optimal amount of polymethylmethacrylate (PMMA) bone cement was injected for PVP [8]. In the PKP procedure, inflatable balloons were placed through a working cannula to elevate the fractured vertebral body into the desired height before bone cement perfusion [8, 16]. When bone cement filled the cavity, needle and cannula were removed. Patients received oral antibiotics every 8 hours for 24 hours. All patients were permitted an out-of-bed activity wearing a waist belt beginning the second day after surgery.

Outcome assessment

Outcome assessment was performed before operation, one day after operation, and at the last follow up following PVP and PKP. Anterior- and middle-column heights of the vertebral body as well as kyphotic angle were measured on a standing lateral radiograph. Cement leakage was detected by fluoroscopic image during the operation. In addition, pain was assessed with a VAS score ranging from 0 (no pain) to

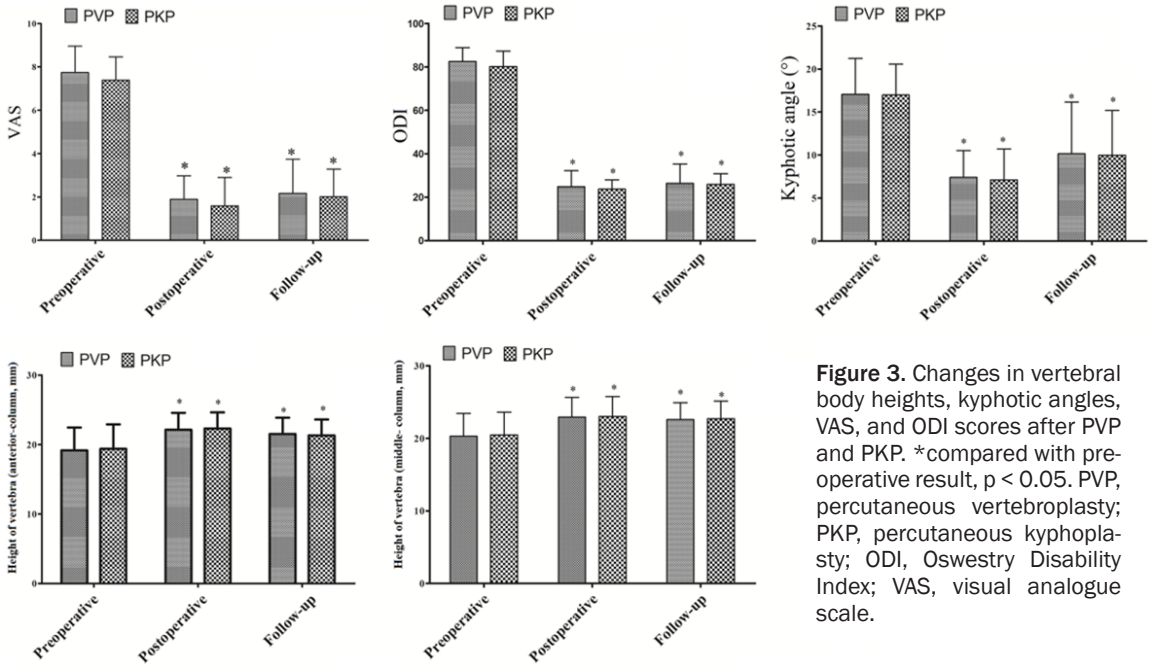

Figure 3. Changes in vertebral body heights, kyphotic angles, VAS, and ODI scores after PVP and PKP. *compared with preoperative result, $p < 0.05$. PVP, percutaneous vertebroplasty; PKP, percutaneous kyphoplasty; ODI, Oswestry Disability Index; VAS, visual analogue scale.

Table 2. Complications after surgery

	PVP			PKP		
	A (n = 61)	B (n = 103)	C (n = 31)	A (n = 59)	B (n = 105)	C (n = 28)
Asymptomatic leakage of cement						
Into the paravertebral vein	3 (4.92)	5 (4.85)	1 (3.23)	2 (3.39)	4 (3.81)	1 (3.57)
Into the intervertebral disc	1 (1.64)	3 (2.91)	2 (6.45)	1 (1.69)	2 (7.14)	1 (3.57)
Into the paravertebral tissues	1 (1.64)	2 (1.94)	1 (3.23)	1 (1.69)	3 (2.86)	1 (3.57)
Adjacent vertebral fracture occurred	0 (0)	2 (1.94)	1 (3.23)	0 (0)	2 (1.90)	2 (7.14)

10 (worst possible pain) [17]. Health-related quality of life was estimated by ODI [18], one of the most widely used questionnaires to measure "back-specific function", and scored from 0 to 100 according to the sum of a 10 item scale with six response categories each (each item scores from 0 to 5). Other potential complications and adverse events were also recorded.

Statistical analysis

All data are expressed as n (%) or mean ± standard deviation (SD) and analyzed using SPSS 18.0 statistical software (SPSS Inc., Chicago, IL, USA). Continuous variables between PVP and PKP groups, including preoperative and postoperative within the same group or different age groups, were compared using Student's t-test and categorical variables were compared using Chi-square test (or Fisher's test). A value of $p < 0.05$ was considered to indicate a significant difference.

Results

A total of 387 patients with OVCFs were enrolled in this study, with 195 undergoing PVP (68 men and 127 women with an average age of 72.72 ± 9.72 years; 90 thoracic and 105 lumbar involved; mean T score, -3.34 ± 0.72) and 192 undergoing PKP (63 men and 129 women with an average age of 73.01 ± 8.31 years; 92 thoracic and 100 lumbar involved; mean T score, -3.26 ± 1.57) treatment. Statistical analysis indicated there were no significant differences in age, sex, location of osteoporotic VCFs, BMD score, and follow up time between PVP and PKP groups ($p < 0.05$, **Table 1**), indicating comparability of these two groups.

To compare therapeutic effects between PVP and PKP, vertebral body heights, kyphotic angles, VAS, and ODI scores were collected. Compared with preoperative results, vertebral body heights were significantly increased but kyphotic angles (**Figures 1** and **2**), VAS, and ODI

scores were significantly decreased, postoperatively, and at the last follow up in the two groups. However, no obvious differences were observed between PVP and PKP groups, suggesting similar therapeutic effects of these two procedures (**Figure 3**). This conclusion was also demonstrated in respect to complications. No major peri-operative complications such as compression of the spinal cord, pulmonary embolism, or infection were recorded. Asymptomatic leakage of cement into the paravertebral vein, however, occurred in 9 (4.62%) and 7 (3.65%) patients. Leakage into the intervertebral disc in 6 (3.08%) and 4 (2.08%) patients occurred. Leakage into the paravertebral in 4 (2.05%) and 5 (2.60%) patients of PVP and PKP groups occurred, respectively. In addition, adjacent vertebral fracture was present in 3 (1.54%) patients of PVP group and 4 (2.08%) patients of PKP group (**Table 2**). These findings led to a complication rate of 11.28% and 10.42%, which was not statistically significant ($p = 0.871$).

Previous studies have suggested age may be an important factor influencing therapeutic effects [19, 20]. Therefore, investigation of age differences may be beneficial in providing a basis for decision-making of surgery. In this study, patients were further divided into 60-69 years (A group), 70-79 years (B group), and 80-91 years (C group) and compared. Within PVP group, 61 (31.28%) were between 60 and 69 years, 103 (52.82%) were between 70 and 79 years, and 31 (2%) were between 80 and 91 while 59 (30.73%) were between 60 and 69 years, 105 (54.69%) were between 70 and 79 years, and 28 (14.58%) were between 80 and 91 in PKP group, which was not statistically significant ($p = 0.913$, **Table 1**). Results indicated no significant differences in vertebral body heights, kyphotic angles, VAS pain, and ODI scores among A, B and C groups after surgery, nor between PVP and PKP groups according to age classification (**Figure 4**). Similarly, complication rates were not different between A and B (PVP, 8.20% *vs.* 11.65%, $p = 0.607$; PKP, 6.78% *vs.* 10.48%, $p = 0.516$), A and C (8.20% *vs.* 16.13%, $p = 0.276$; PKP, 6.78% *vs.* 17.86%, $p = 0.140$), or B and C (PVP, 11.65% *vs.* 16.13%, $p = 0.542$; PKP, 10.48% *vs.* 17.86%, $p = 0.328$) in PVP and PKP groups (**Table 2**). There were also no differences between PVP and PKP in group A (8.20% *vs.* 6.78%, $p = 1.00$), group B (11.65% *vs.* 10.48%, $p = 0.828$), and group C (16.13% *vs.* 17.86%, $p = 1.00$) (**Table 2**). These findings illustrate that both of PVP and PKP may be appropriate for OVCFs, regardless of age.

Discussion

Our present study suggests that PVP and PKP may be similarly effective and safe for OVCFs, with no significant difference in restoration of anterior and middle vertebral body height, kyphotic angle, improvement in ODI, and VAS scores. Postoperative complications and in long-term follow up seemed to be in line with the studies of Jung-Tung et al. [8] and Tang et al. [6]. The mechanism responsible for rapid pain regression and function improvement after PVP and PKP may be mainly attributed to mechanical stabilization of microfractural fragments of the vertebral body through a hardening process of the bony cavity by PMMA bone cement and neurotoxicity of the cement monomer to intraosseous pain receptors, rendering peripheral nerve endings insensitive [21]. Furthermore, other procedures including local anesthesia (not general anesthesia), preoperative use of analgesic (50 mg dolantin), additional oxygen delivered during the procedure via an oxygen mask, and bilateral transpedicular access for PMMA injection [22] were also applied in this study to reduce patient pain and decrease complications. As expected, no major peri-operative complications (such as compression of the spinal cord, pulmonary embolism, or infection) were recorded and fewer cement leakages (9.74%, PVP; 8.33%, PKP) (approximately 14%) [8] and adjacent vertebral fractures (1.54%, PVP; 2.08%, PKP) than reported in the literature (2-50%) [23] were observed.

In addition, age has been proven to be an independent risk factor for post-operative outcomes and complications for these two surgeries. This may be caused by the fact that aging leads to a reduction in BMD, an indicator for trabecular bone strength. When the strength of trabecular bone is less than working stresses experienced within the vertebral body during loading, compressive fractures are triggered. As expected, BMD gradually declined with increase in age in our current study and there was a statistical significance between all groups ($p < 0.05$, **Figure 5**). Also, several studies demonstrated that a lower BMD was associated with poor outcomes. For example, Xie et al. [20] found that one of the main factors

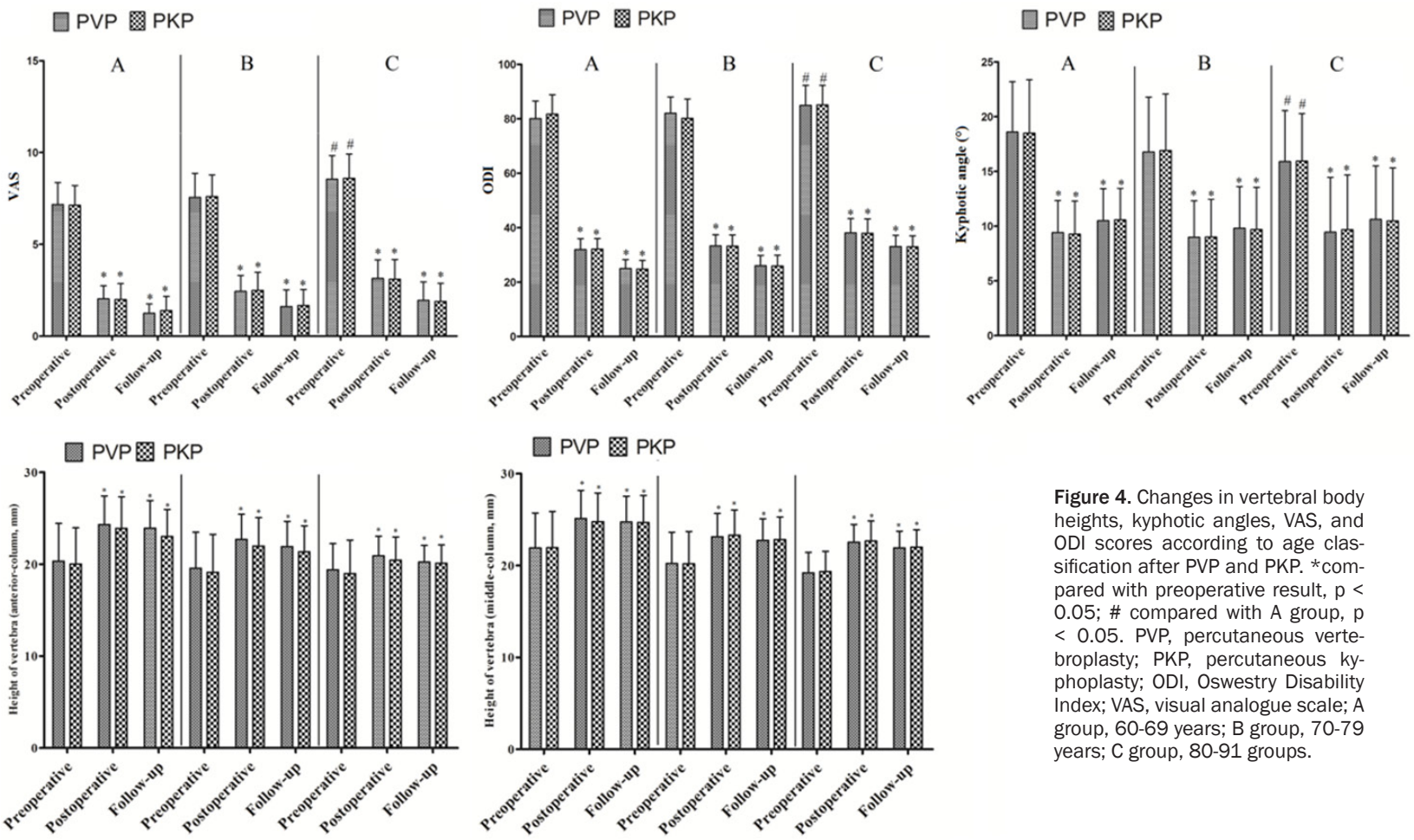

Figure 4. Changes in vertebral body heights, kyphotic angles, VAS, and ODI scores according to age classification after PVP and PKP. *compared with preoperative result, $p < 0.05$; # compared with A group, $p < 0.05$. PVP, percutaneous vertebroplasty; PKP, percutaneous kyphoplasty; ODI, Oswestry Disability Index; VAS, visual analogue scale; A group, 60-69 years; B group, 70-79 years; C group, 80-91 groups.

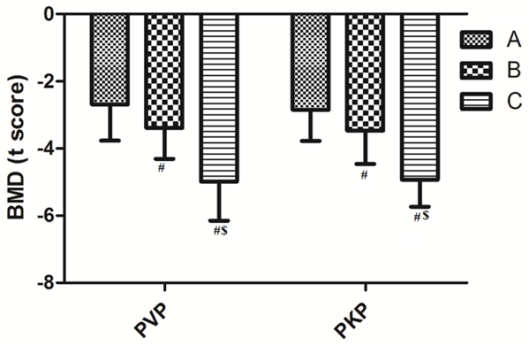

Figure 5. BMD changes according to age classification. #compared with A group (60-69 years), $p < 0.05$; $, compared with B group (70-79 years), $p < 0.05$. BMD, bone mineral density; A group, 60-69 years; B group, 70-79 years; C group, 80-91 groups.

influencing bone cement leakage was bone density, with standardized partial regression coefficients of -0.085. Lu et al. [24] showed that only T-score of bone mineral density was significantly associated with subsequent vertebral compression fractures ($p < 0.0001$; odds ratio = 0.27; 95% confidence interval, 0.15-0.49) after multivariate analyses. Gao et al. identified that presence of low bone mineral density (BMD) was one of three strong predictors for cement leakage ($p = 0.002$) after PKP [25]. However, in contrast, there were no differences in all outcome parameters among different ages. This may be ascribed to two reasons: (1) Small sample size in our study; (2) Age and BMD may be not crucial factors for therapeutic outcomes, as reported by other studies [26, 27]. Thus, further studies are needed to confirm the role of age in PVP and PKP therapy.

There are several limitations to our study. First, it was retrospective in nature which led to patients not randomized to receive PVP and PKP. Second, our study was performed in a single center and thus sample size was relatively small. This may result in under- or over-estimation of complication rate and reduction effect. Therefore, further clinical investigation with a large sample size and randomized control remains necessary to obtain a more precise efficacy evaluation.

Both PVP and PKP may be effective and safe for OVCFs, regardless of age. Considering the higher cost of the PKP procedure, PVP over PKP should be recommended for treatment of OVCFs.

Disclosure of conflict of interest

None.

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