World Journal of Clinical Cases

Submit a Manuscript: https://www.f6publishing.com

World J Clin Cases 2024 July 26; 12(21): 4609-4617

DOI: 10.12998/wjcc.v12.i21.4609

ISSN 2307-8960 (online)

ORIGINAL ARTICLE

Observational Study

Factors influencing further vertebral height loss following percutaneous vertebroplasty in osteoporotic vertebral compression fractures: A 1-year follow-up study

Zhong-Qiu Tang, Shao-Bo He, Dong-Yang Yu, Hai-Mao Luo, Xue-Hong Xing, Yong-Wen Zhou

Specialty type: Orthopedics

Provenance and peer review: Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's classification

Scientific Quality: Grade B

Novelty: Grade C

Creativity or Innovation: Grade B

Scientific Significance: Grade B

P-Reviewer: Nelson M, United States

Received: March 14, 2024

Revised: May 13, 2024

Accepted: June 5, 2024

Published online: July 26, 2024

Processing time: 108 Days and 23.3 Hours

Zhong-Qiu Tang, Shao-Bo He, Dong-Yang Yu, Hai-Mao Luo, Xue-Hong Xing, Department of Spinal Surgery, Affiliated Hospital of Panzhihua University, Panzhihua 617000, Sichuan Province, China

Yong-Wen Zhou, Department of Shoulder and Elbow Surgery, Affiliated Hospital of Panzhihua University, Panzhihua 617000, Sichuan Province, China

Corresponding author: Yong-Wen Zhou, MD, Professor, Department of Shoulder and Elbow Surgery, Affiliated Hospital of Panzhihua University, No. 27 Taoyuan Street, East District, Panzhihua 617000, Sichuan Province, China. andyzhouyongwen@163.com

Abstract

BACKGROUND

Osteoporotic vertebral compression fractures (OVCFs) contribute to back pain and functional limitations in older individuals, with percutaneous vertebroplasty (PVP) emerging as a minimally invasive treatment. However, further height loss post-PVP prompts investigation into contributing factors.

AIM

To investigate the factors associated with further height loss following PVP with cement augmentation in OVCF patients.

METHODS

A total of 200 OVCF patients who underwent successful PVP between January 2021 and December 2022 were included in this study. "Further height loss" during 1 year of follow-up in OVCF patients with bone edema was defined as a vertical height loss of ≥ 4 mm. The study population was divided into two groups for analysis: The "No Further Height Loss group (n = 179)" and the "Further Height Loss group (n = 21)."

RESULTS

In comparing two distinct groups of patients, significant differences existed in bone mineral density (BMD), vertebral compression degree, prevalence of intravertebral cleft (IVF), type of bone cement used, and cement distribution patterns. Results from binary univariate regression analysis revealed that lower BMD, the presence of IVF, cleft distribution of bone cement, and higher vertebral

compression degree were all significantly associated with further height loss. Notably, the use of mineralized collagen modified-poly(methyl methacrylate) bone cement was associated with a significant reduction in the risk of further height loss. In multivariate regression analysis, lower BMD and the presence of IVF remained significantly associated with further height loss.

CONCLUSION

Further height loss following PVP in OVCF patients is influenced by a complex interplay of factors, especially lower BMD and the presence of IVF. These findings underscore the importance of assessing and managing these factors when addressing height loss following PVP in OVCF patients.

Key Words: Percutaneous vertebroplasty; Osteoporotic vertebral compression fractures; Further height loss; Bone mineral density; Intravertebral cleft

Core Tip: This research represents a significant contribution to the field of spinal surgery and osteoporosis management. We believe that the findings from our study provide valuable insights into the factors influencing height loss in patients with osteoporotic vertebral compression fractures (OVCFs) following percutaneous vertebroplasty (PVP). Our study is based on a 1-year follow-up of 200 OVCF patients who underwent successful PVP between January 2021 and December 2022.

Citation: Tang ZQ, He SB, Yu DY, Luo HM, Xing XH, Zhou YW. Factors influencing further vertebral height loss following percutaneous vertebroplasty in osteoporotic vertebral compression fractures: A 1-year follow-up study. *World J Clin Cases* 2024; 12(21): 4609-4617

URL: https://www.wjgnet.com/2307-8960/full/v12/i21/4609.htm

DOI: https://dx.doi.org/10.12998/wjcc.v12.i21.4609

INTRODUCTION

The World Health Organization has defined osteoporosis as a systemic bone disorder characterized by a concurrent decrease in bone mass and structural deterioration of bone tissue[1]. This phenomenon results in augmented bone fragility and a heightened propensity for fractures[2]. Vertebral compression fractures are among the most common type of fracture in patients with osteoporosis[3]. Osteoporotic vertebral compression fractures (OVCFs) are a common cause of both acute and chronic back pain in older populations, although only about one-third of radiographic OVCF deformities present with acute pain[4]. Both symptomatic and asymptomatic osteoporotic vertebral fractures can lead to substantial spinal deformity, functional limitation, pulmonary compromise and decreased quality of life[5,6].

Nonsurgical treatment methods for OVCFs encompass a range of conservative approaches including bed rest, calcium and vitamin D supplementation, physical therapy, analgesic medications, hormone replacement therapy, and the use of orthopedic supports[7-9]. However, these conventional strategies often fail to effectively alleviate the pain linked with vertebral compression fractures, while subjecting patients to extended bed rest, thereby elevating the susceptibility to complications such as aspiration pneumonia, urinary tract infections, and pressure sores[10]. Percutaneous vertebroplasty (PVP) has emerged as a minimally invasive alternative, which involves percutaneous puncture guided by imaging, utilizing a posterior approach along the pedicle direction to introduce specific material into the affected vertebral body [11]. The first PVP by Galibert *et al*[12] used to treat a painful cervical haemangioma in a 54-year-old woman, which was performed by a French team in 1984 and reported in the literature in 1987, leading to immediate and lasting pain relief, with positive outcomes during follow-up. Subsequent applications of this technique include its utilization by Kaemmerlen *et al*[13] in treating vertebral metastatic tumors and by Lapras *et al*[14] for addressing vertebral osteoporosis.

Presently, PVP is widely employed across fields encompassing vertebral tumors, multiple myeloma, vertebral collapse [11,15]. Furthermore, PVP has become a primary minimally invasive treatment strategy for OVCFs, providing rapid pain relief and essential support to the fractured vertebrae[16]. However, further height loss during the follow-up of treated baseline OVCFs has been observed in 8%[17] and 12%[18] of patients after PVP.

The purpose of this study was to investigate the factors associated with further height loss following PVP with cement augmentation in OVCF patients and to enhance our understanding of the outcomes and variables affecting this procedure.

MATERIALS AND METHODS

Study population

A total of 200 patients with OVCFs, who underwent first-time PVP with successful completion of the procedure between January 2021 and December 2022 at our institution, were included in this analysis. Inclusion criteria for this study were individuals with a T-score of less than -2.5 in lumbar spine bone mineral density (BMD) assessments, confirming osteoporosis[19], and the detection of vertebral compression fractures on spine radiographs, characterized by a minimum loss of 15% of vertebral height[18]. Additionally, participants were required to have experienced back pain lasting less than 6 wk, present with a single vertebral body fracture indicative of osteoporosis, and exhibit evidence of bone edema in current Short Tau Inversion Recovery magnetic resonance imaging (MRI). Exclusion criteria were individuals with multiple vertebral body fractures, fractures attributed to underlying skeletal pathologies, concurrent limb fractures, hypersensitivity to bone cement, severe cardiopulmonary comorbidities, intractable coagulopathy, infection, suspicion of an alternative underlying malignancy, radicular syndrome, myelum compression syndrome, contraindications for MRI imaging, or neurological deficits. Patient records, clinical data, and imaging reports were reviewed to gather relevant information. At baseline, radiography and MRI of the spine were performed independently by two radiologists at baseline and follow-up imaging. Our follow-up time was 1 year for every included patient. This study was approved by the Ethics Committee of our hospital. Informed consent was not obtained due to the retrospective nature of the analysis.

Procedures

Patients fasted for 6 h pre-surgery. Using a C-arm fluoroscopy machine, the fractured vertebra location was precisely marked. The surgical area was disinfected with iodine and then deiodinated with alcohol. Local anesthesia with 1% lidocaine was administered at the puncture point, targeting the facet joint area. A small incision allowed for bone puncture needle insertion. Guided by C-arm fluoroscopy, the needle was accurately positioned at the upper outer edge of the lamina, aligned with the vertebral pedicle projection. The needle angle was adjusted for entry into the vertebral body through the pedicle. Lateral fluoroscopy ensured that the needle tip did not breach the pedicle's inner edge. The needle was advanced until being positioned 3 mm from the posterior edge of the vertebral body. After removing the needle core, a guide wire was inserted, replaced by the working cannula, and the guide wire was withdrawn. A bone drill expanded the hole into the anterior one-third of the vertebral body. Bone cement, either poly(methyl methacrylate) (PMMA) or mineralized collagen (MC)-modified PMMA, was meticulously injected directly through the puncture needle. MC-modified PMMA bone cement (Mendec Spine; Tecres S.P.A., Verona, Italy) consisted of 22.6 g conventional bone cement, 3.4 g MC (Beijing Allgens Medical Science and Technology Co., Ltd., Beijing, China), and 10 mL MMA monomer liquid, which were thoroughly mixed to achieve the required viscosity. Post-injection, the puncture needle was carefully retracted, concurrently sealing the inner lumen with a stylus to prevent cement leakage. Bilateral pedicle puncture injections of bone cement were performed. Patients remained nil by mouth for 4 h post-surgery, received antibiotics twice daily for 2 consecutive days, and were prescribed bisphosphonates, calcium, and vitamin D. On the second day after the procedure, as pain relief improved, a gradual reintroduction of weight-bearing activities commenced.

Definitions

Vertebral fractures can be classified into three morphological types: wedge, biconcave, and crush fractures[20]. Classification criteria for the cement distribution pattern were as follows: cleft type and trabecular type[21]. Cement leakage and filling were evaluated using X-ray and computed tomography on postoperative day 1. The height of the fractured vertebral body was measured at its anterior, middle, and posterior thirds, and the smallest of these measurements was divided by the height of the anterior cortex of the nearest normal vertebral body to determine the percentage of height loss, namely vertebral compression degree[22,23]. "Further height loss" during the 1 year follow-up of OVCFs with bone edema was defined as height loss of ≥ 4 mm in vertical dimension[17,18].

Data analysis

Descriptive statistics will be used to summarize patient demographics and baseline characteristics. Continuous variables were presented as means ± standard deviations. Categorical variables are presented as frequencies and percentages. Univariate logistic regression analyses were performed to identify potential risk factors associated with further vertebral height loss in patients who underwent PVP with cement augmentation. The results of the binary multivariate regression analysis were based on an approach that considered variables with a significance level of $P < 0.10$ from the above univariate analysis, allowing us to explore potential associations with further height loss.

RESULTS

Patient characteristics of OVCF patients who underwent PVP with cement augmentation

The study involved a cohort of 200 patients who completed a 1-year follow-up with spine X-ray assessments. Among these patients, 75% were female. These individuals exhibited diverse demographic and clinical characteristics, including an average age of 68.69 years and a mean BMI of 21.13 kg/m^2. Their BMD T-scores ranged from -4.00 to -2.60. The duration of back pain before the procedure varied from 2 d to 42 d, and vertebral compression degrees spanned from 10.00% to 60.00%. The surgical procedures lasted from 45.00 min to 65.00 min. All patients had a visual analog scale (VAS) score[24] of ≥ 5 or an Oswestry disability index (ODI) score[25] of ≥ 30. IVF was detected in 8.5% (17 of 200) of cases

on MRI. Regarding vertebral levels, 33% (66 patients) of the fractures were located in the lumbar (L) or thoracic (T) region, with the remaining 67% (134 patients) in the thoracolumbar region. Regarding vertebral fracture morphology, 49% had wedge-shaped fractures, while 51% had biconcave-shaped fractures. Concerning bone cement usage, the mean volume of injected cement per vertebral body was 5.12 mL, with a range of 1 mL to 9 mL. Among the patients, 117 cases received MC-PMMA, while the remaining 83 cases received PMMA.

Comparison of patient characteristics between two distinct groups of OVCF patients who underwent PVP with cement augmentation

A comparative analysis was conducted on two distinct groups of patients with OVCF who underwent PVP with cement augmentation (Table 1): Those experiencing "No Further Height Loss (n = 179)" and those exhibiting "Further Height Loss (n = 21)." The groups demonstrated similar age distributions (P = 0.871) and BMI values (P = 0.783). However, a significant difference was observed in BMD (T-score), with the Further Height Loss group (median: -3.8, interquartile range [IQR]: -3.95 to -3.7) showing markedly lower values compared to the No Further Height Loss group (median: -3.2, IQR: -3.5 to -2.8; P < 0.001). Several factors, including the duration of back pain before the procedure, operation time, preoperative and postoperative VAS and ODI score, did not exhibit significant differences between the two groups (all P > 0.05). Notably, the Further Height Loss group had a higher vertebral compression degree (39% *vs* 26%; P < 0.001) and a significantly higher prevalence of IVF (71.4% *vs* 1.1%; P < 0.001). Moreover, differences in the type of bone cement used were evident, with a significant lower proportion of the Further Height Loss group receiving MC-PMMA compared to the No Further Height Loss group (63.7% *vs* 14.3%; P < 0.001). Additionally, there were significant variations in bone cement distribution patterns, with the majority of the Further Height Loss group exhibiting cleft distribution compared to the trabecular distribution seen in the No Further Height Loss group (P < 0.001). Additionally, no differences were observed in the morphology of vertebral fractures, vertebral level, bone cement volume, and the presence of cement leakage (all P > 0.05). The length of hospital stay was similar between the groups, with a median of 8 d (P = 0.544).

Table 1 Comparison of patient characteristics between two distinct groups of patients with osteoporotic vertebral compression fracture who underwent percutaneous vertebroplasty with cement augmentation

Characteristics	No Further Height Loss, n = 179	Further Height Loss, n = 21	P value
Age in years	68.72 ± 7.93	68.43 ± 6.67	0.871
Sex			0.110
Male	48 (26.8%)	2 (9.5%)	
Female	131 (73.2%)	19 (90.5%)	
BMI in kg/m^2	21.14 ± 1.61	21.04 ± 1.63	0.783
BMD by T-score	-3.2 (-3.5 to -2.8)	-3.8 (-3.95 to -3.7)	< 0.001
Back pain before procedure in d	20.59 ± 7.06	19.9 ± 6.83	0.776
Vertebral compression degree	26% (16%-37%)	39% (32.5%-42.5%)	< 0.001
Operation time in minutes	54.72 ± 5.95	54.29 ± 5.62	0.750
Preoperative VAS	7.47 ± 1.79	7.19 ± 1.5	0.092
Postoperative VAS	4.45 ± 2.01	4.05 ± 1.88	0.062
Preoperative ODI	40.84 ± 6.12	39.86 ± 5.77	0.154
Postoperative ODI	20.59 ± 7.06	19.9 ± 6.83	0.135
Presence of intravertebral cleft on MRI			< 0.001
Yes	2 (1.1)	15 (71.4)	
No	177 (98.9)	6 (28.6)	
Morphology			1.000
Wedge	88 (49.2)	10 (47.6)	
Biconcave	91 (50.8)	11 (52.4)	
Vertebral level			0.126
Lumbar (L) or Thoracic (T)	63 (35.2)	3 (14.3)	
Thoracolumbar (TL)	116 (64.8)	18 (85.7)	
Bone cement			< 0.001

MC-PMMA	114 (63.7)	3 (14.3)	
PMMA	65 (36.3)	18 (85.7)	
Bone cement volume in mL	5.03 ± 2.34	5.82 ± 2.49	0.151
Bone cement distribution			< 0.001
Trabecular	119 (66.5)	2 (9.5)	
Cleft	60 (33.5)	19 (90.5)	
Filling from Inferior to Superior Endplate			0.211
Yes	35 (71.4)	2 (9.5)	
No	144 (28.6)	19 (90.5)	
Bone cement leakage			0.194
Yes	135 (75.4)	13 (61.9)	
No	44 (24.6)	8 (38.1)	
Length of hospital stay in days	8 (6-9)	8 (7-9)	0.544

Data are *n* (%). BMD: Bone mineral density; IVF: Intravertebral cleft; MC-PMMA: Mineralized collagen modified-poly(methyl methacrylate); ODI: Oswestry disability index; VAS: Visual analog scale.

Results of binary univariate regression analysis

The results of the binary univariate regression analysis, as presented in Table 2, reveal significant associations with further height loss among OVCF patients undergoing PVP with cement augmentation. Lower BMD (T-score) exhibits a robust negative association, significantly increasing the risk of further height loss [odds ratio (OR) = 0.003, 95% confidence interval (CI): 0.000-0.030; $P < 0.001$]. Conversely, the presence of an IVF (OR = 221.250, 95%CI: 41.035-1192.920; $P < 0.001$) and cleft distribution of bone cement (OR = 18.842, 95%CI: 4.248-83.578; $P < 0.001$) demonstrate substantial positive associations, significantly elevating the risk. A higher vertebral compression degree is also linked to an increased risk of further height loss (OR = 1.048, 95%CI: 1.014-1.082; $P = 0.005$). Although the impact of vertebral level on further height loss is borderline significant (OR = 3.259, 95%CI: 0.924-11.490; $P = 0.066$), it may still exert a moderate effect. Additionally, the use of MC-PMMA bone cement significantly decreases the risk (OR = 0.095, 95%CI: 0.027-0.335; $P < 0.001$). Notably, other variables, including age, sex, BMI, operation time, preoperative and postoperative VAS and ODI scores, back pain before the procedure, morphology of vertebral fractures, bone cement volume, filling from inferior to superior endplate, bone cement leakage, and length of hospital stay, do not exhibit significant associations with further height loss (all $P > 0.05$).

Results of the binary multivariate regression analysis

As demonstrated in Table 3, lower BMD (T-score) was significantly associated with a higher risk of further height loss, with an OR of 0.036 (95%CI: 0.001-0.996; $P = 0.045$). The presence of an IVF showed a highly significant association with further height loss, with an OR of 163.189 (95%CI: 9.493-2805.209; $P < 0.001$). By contrast, vertebral compression degree, vertebral level (thoracolumbar *vs* lumbar and thoracic) and the type of bone cement used (MC-PMMA *vs* PMMA) did not exhibit significant associations with further height loss. The type of bone cement distribution (cleft *vs* trabecular) demonstrated a borderline significant association (OR: 11.852, 95%CI: 0.739-190.132; $P = 0.081$), indicating a potential moderate impact.

DISCUSSION

Further height loss following PVP with cement augmentation is a complex and multifactorial process, encompassing intrinsic vertebral factors and surgical-related factors. PVP offers immediate pain relief and stabilization of the fractured vertebral body through minimally invasive PMMA bone cement injection, widely employed in OVCF treatment[26]. In our study, we observed significant differences in the choice of bone cement, with a notably lower proportion of patients in the Further Height Loss group receiving MC-PMMA compared to those in the No Further Height Loss group (63.7% *vs* 14.3%). Our analysis demonstrated that MC-PMMA bone cement significantly reduced the risk of further height loss (OR = 0.095, 95%CI: 0.027-0.335), as shown in the results of binary univariate regression analysis. This benefit may be attributed to MC-PMMA's capacity to provide ample mechanical support for vertebral height restoration while simultaneously reducing stress on the vertebral body's endplate. This creates a durable and stable structure within the vertebral body over an extended period[27]. Liebschner *et al*[28] reported that vertebral body strength recovery was closely related to bone cement distribution. In our study, we observed significant variations in bone cement distribution patterns, with the Further Height Loss group predominantly showing cleft distribution, in contrast to the trabecular distribution in the No Further Height Loss group. Consistently, a previous study found that trabecular-type distribution (vertebrae with

Table 2 Results of the binary univariate regression analysis revealed significant associations with further height loss among osteoporotic vertebral compression fracture patients undergoing percutaneous vertebroplasty with cement augmentation

Parameter	B	SE	Wals	*P* value	OR (95%CI)
Age in years	-0.005	0.030	0.027	0.871	0.995 (0.939-1.055)
Sex as male *vs* female	-1.247	0.762	2.677	0.102	0.287 (0.064-1.28)
BMI in kg/m^2	-0.040	0.144	0.077	0.782	0.961 (0.724-1.275)
BMD by T score	-5.925	1.239	22.886	< 0.001	0.003 (0.000-0.030)
Presence of intravertebral cleft as yes *vs* no	5.399	0.860	39.449	< 0.001	221.25 (41.035-1192.92)
Operation time in minutes	-0.013	0.039	0.102	0.749	0.987 (0.914-1.067)
Preoperative VAS	-0.100	0.138	0.526	0.468	0.905 (0.690-1.186)
Postoperative VAS	-0.068	0.124	0.295	0.587	0.935 (0.732-1.193)
Preoperative ODI	0.029	0.038	0.564	0.453	1.029 (0.955-1.110)
Postoperative ODI	0.033	0.033	0.973	0.324	1.033 (0.968-1.103)
Back pain before procedure in days	0.005	0.018	0.082	0.775	1.005 (0.970-1.042)
Vertebral compression degree	0.046	0.016	8.060	0.005	1.048 (1.014-1.082)
Morphology as biconcave *vs* wedge	0.062	0.462	0.018	0.894	1.064 (0.430-2.630)
Vertebral level as thoracolumbar *vs* lumbar and thoracic	1.181	0.643	3.376	0.066	3.259 (0.924-11.490)
Bone cement volume in mL	0.147	0.103	2.036	0.154	1.158 (0.947-1.418)
Bone cement distribution as cleft *vs* trabecular	2.936	0.760	14.922	< 0.001	18.842 (4.248-83.578)
Filling from inferior to superior endplate as no *vs* yes	0.837	0.767	1.191	0.275	2.309 (0.514-10.381)
Bone cement as MC-PMMA *vs* PMMA	2.354	0.643	13.411	< 0.001	0.095 (0.027-0.335)
Bone cement leakage as yes *vs* no	-0.636	0.482	1.741	0.187	0.530 (0.206-1.361)
Length of hospital stay in days	0.087	0.134	0.418	0.518	1.090 (0.839-1.418)

BMD: Bone mineral density; CI: Confidence interval; IVF: Intravertebral cleft; MC-PMMA: Mineralized collagen modified-poly(methyl methacrylate); ODI: Oswestry disability index; OR: Odds ratio; VAS: Visual analog scale.

sponge-like cement filling) better maintained vertebral body height, corrected local kyphosis, reduced the risk of vertebral body recompression, long-term pain, and restored functions when compared to cleft-type distribution (vertebrae with compact and solid cement filling)[26]. Moreover, we observed higher vertebral compression degree is also linked to an increased risk of further height loss.

Bone density (usually measured by T-scores) is a vital indicator of bone mass and is indicative of the degree of bone density loss in osteoporotic patients, reflecting the increased risk of vertebral fractures resulting from reduced bone volume and altered bone quality due to the imbalance between bone resorption and formation[29]. Lower bone density indicates a sparser trabecular bone structure, which in turn elevates bone fragility, making patients more prone to OVCFs [30]. Consequently, even when vertebral augmentation is performed, postoperative height loss remains a notable concern. Research, such as the study conducted by Hey *et al*[31], has confirmed that patients with lower BMD T-scores have a higher likelihood of experiencing long-term vertebral height loss following surgery. Rho *et al*[32] conducted a retrospective analysis of 147 patients with osteoporotic vertebral fractures who underwent PVP or kyphoplasty treatment. Among these patients, 27 individuals (18.4%) experienced recurrent fractures or height loss. Statistical analysis revealed that BMD and the leakage of bone cement into the intervertebral disc were the primary risk factors. Moreover, lower BMD WAS associated with the recollapse of cemented vertebrae in patients with thoracolumbar OVCF following PVP [33]. Our study results also indicated a significant distinction in BMD (T-score), with the Further Height Loss group showing markedly lower values compared to the No Further Height Loss group. Lower BMD (T-score) exhibits a robust negative association, significantly increasing the risk of further height loss in the binary regression analysis. Therefore, it can be inferred that the degree of osteoporosis is one of the important factors influencing postoperative vertebral height loss, emphasizing the necessity for proper and long-term anti-osteoporosis treatment following PVP.

In 1895, Kümmell first discovered and reported a distinctive medical condition, primarily affecting middle-aged and elderly patients. This condition typically manifests in the thoracolumbar spine following minor trauma, characterized by persistent and progressively worsening lower back pain accompanied by an exacerbation of spinal kyphotic deformity [34]. Radiologically, Kümmell disease is identified by the presence of IVF or the vacuum phenomenon within vertebral

Table 3 Results of the binary multivariate regression analysis revealed significant associations with further height loss among osteoporotic vertebral compression fracture patients undergoing percutaneous vertebroplasty with cement augmentation

Parameter	B	SE	Wals	*P* value	OR (95%CI)
BMD by T score	-3.326	1.695	3.850	0.046	0.036 (0.001-0.996)
Presence of intravertebral cleft as yes *vs* no	5.095	1.451	12.326	< 0.001	163.189 (9.493-2805.209)
Vertebral compression degree	0.006	0.041	0.021	0.885	1.006 (0.928-1.090)
Vertebral level as thoracolumbar *vs* lumbar and thoracic	0.151	1.018	0.022	0.882	1.163 (0.158-8.552)
Bone cement distribution as cleft *vs* trabecular	2.472	1.416	3.049	0.081	11.852 (0.739-190.132)
Bone cement as MC-PMMA *vs* PMMA	-1.834	1.501	1.493	0.222	0.16 (0.008-3.026)

BMD: Bone mineral density; CI: Confidence interval; MC-PMMA: Mineralized collagen modified-poly (methyl methacrylate); OR: Odds ratio.

bodies, serving as a hallmark of this condition[35]. During PVP procedures, due to relatively lower intracavity pressure, bone cement primarily fills the cavity rather than diffusing into the trabecular interstices[36]. As a result, the bone cement forms clumps within the vertebral body, further increasing local strength. Even with minor external forces, microfractures can occur within the vertebral body, resulting in a loss of vertebral height. Chen *et al*[37] conducted a retrospective analysis of 1800 patients treated with vertebral augmentation for OVCF and found that 90% of cases with preoperative IVF experienced postoperative vertebral height loss. Therefore, IVF were considered a significant influencing factor in post-augmentation height loss. In our study, the group experiencing further height loss had a significantly higher prevalence of IVF. The presence of an IVF showed a highly significant association with further height loss in both binary univariate regression analysis (OR = 221.250) and binary multivariate regression analysis (OR = 163.189), underscoring the importance of IVF as a contributing factor to postoperative vertebral height loss.

CONCLUSION

The occurrence of further height loss following PVP with cement augmentation in OVCF patients is a multifaceted process influenced by several factors. Lower BMD, the presence of IVF, and higher vertebral compression degrees were all associated with an increased risk of further height loss. Additionally, the type of bone cement used and its distribution pattern played a role, with MC-PMMA cement potentially offering a protective effect. However, it is important to note that in the multivariate analysis, certain factors, such as vertebral compression degrees, as well as bone cement type and distribution, did not exhibit significant associations, possibly due to sample size limitations or unaccounted-for variables. Overall, these findings highlight the importance of considering multiple factors in the assessment and management of height loss following PVP in OVCF patients.

FOOTNOTES

Author contributions: Tang ZQ contributed to the study conceptualization, study design, data collection and analysis, manuscript writing, and review; He SB, Yu DY, Luo HM, and Xing XH contributed to data collection, statistical analysis, manuscript writing, and review; Zhou YW contributed to the study conceptualization, study design, supervision of the research, manuscript writing, and review; All authors have read and approved the final manuscript.

Supported by the 2022 Panzhihua City Science and Technology Guidance Plan Project, No. 2022ZD-S-35.

Institutional review board statement: This study has been approved by the Ethics Committee of the Affiliated Hospital of Panzhihua University.

Informed consent statement: Informed consent was not obtained due to the retrospective nature of the analysis.

Conflict-of-interest statement: The authors have no conflicts of interest to declare.

Data sharing statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

STROBE statement: The authors have read the STROBE statement, and the manuscript was prepared and revised according to the STROBE statement.

Country of origin: China

ORCID number: Yong-Wen Zhou 0009-0008-8657-9661.

S-Editor: Liu JH
L-Editor: Filipodia
P-Editor: Zhao S

REFERENCES

1 **Yuan W**, Song C. Crosstalk between bone and other organs. *Med Rev (2021)* 2022; **2**: 331-348 [PMID: 37724328 DOI: 10.1515/mr-2022-0018]
2 **de Wit M**, Cooper C, Tugwell P, Bere N, Kirwan J, Conaghan PG, Roberts C, Aujoulat I, Al-Daghri N, Araujo de Carvalho I, Barker M, Bedlington N, Brandi ML, Bruyère O, Burlet N, Halbout P, Hiligsmann M, Jiwa F, Kanis JA, Laslop A, Lawrence W, Pinto D, Prieto Yerro C, Rabenda V, Rizzoli R, Scholte-Voshaar M, Vlaskovska M, Reginster JY. Practical guidance for engaging patients in health research, treatment guidelines and regulatory processes: results of an expert group meeting organized by the World Health Organization (WHO) and the European Society for Clinical and Economic Aspects of Osteoporosis, Osteoarthritis and Musculoskeletal Diseases (ESCEO). *Aging Clin Exp Res* 2019; **31**: 905-915 [PMID: 30993659 DOI: 10.1007/s40520-019-01193-8]
3 **Ström O**, Borgström F, Kanis JA, Compston J, Cooper C, McCloskey EV, Jönsson B. Osteoporosis: burden, health care provision and opportunities in the EU: a report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). *Arch Osteoporos* 2011; **6**: 59-155 [PMID: 22886101 DOI: 10.1007/s11657-011-0060-1]
4 **Buchbinder R**, Johnston RV, Rischin KJ, Homik J, Jones CA, Golmohammadi K, Kallmes DF. Percutaneous vertebroplasty for osteoporotic vertebral compression fracture. *Cochrane Database Syst Rev* 2018; **4**: CD006349 [PMID: 29618171 DOI: 10.1002/14651858.CD006349.pub3]
5 **Lau E**, Ong K, Kurtz S, Schmier J, Edidin A. Mortality following the diagnosis of a vertebral compression fracture in the Medicare population. *J Bone Joint Surg Am* 2008; **90**: 1479-1486 [PMID: 18594096 DOI: 10.2106/JBJS.G.00675]
6 **Luxue Q**, Changqing G, Ruili Z, Tong W, Junmei W, Yan G, Wei Z, Tingyao HU, Xilin C, Qian Z, Dian Z, Yue XU. Acupotomy inhibits aberrant formation of subchondral bone through regulating osteoprotegerin/receptor activator of nuclear factor-κB ligand pathway in rabbits with knee osteoarthritis induced by modified Videman method. *J Tradit Chin Med* 2022; **42**: 389-399 [PMID: 35610008 DOI: 10.19852/j.cnki.jtcm.2022.03.006]
7 **Kutsal FY**, Ergin Ergani GO. Vertebral compression fractures: Still an unpredictable aspect of osteoporosis. *Turk J Med Sci* 2021; **51**: 393-399 [PMID: 32967415 DOI: 10.3906/sag-2005-315]
8 **Phillips FM**, Pfeifer BA, Lieberman IH, Kerr EJ 3rd, Choi IS, Pazianos AG. Minimally invasive treatments of osteoporotic vertebral compression fractures: vertebroplasty and kyphoplasty. *Instr Course Lect* 2003; **52**: 559-567 [PMID: 12690882]
9 **Nannan X**, Liyang J, Qiyan LI. Potential of natural medicines for treatment of osteoporosis: a narrative review. *J Tradit Chin Med* 2023; **43**: 198-204 [PMID: 36640013 DOI: 10.19852/j.cnki.jtcm.20221108.003]
10 **McCarthy J**, Davis A. Diagnosis and Management of Vertebral Compression Fractures. *Am Fam Physician* 2016; **94**: 44-50 [PMID: 27386723]
11 **Noguchi T**, Yamashita K, Kamei R, Maehara J. Current status and challenges of percutaneous vertebroplasty (PVP). *Jpn J Radiol* 2023; **41**: 1-13 [PMID: 35943687 DOI: 10.1007/s11604-022-01322-w]
12 **Galibert P**, Deramond H, Rosat P, Le Gars D. [Preliminary note on the treatment of vertebral angioma by percutaneous acrylic vertebroplasty]. *Neurochirurgie* 1987; **33**: 166-168 [PMID: 3600949]
13 **Kaemmerlen P**, Thiesse P, Bouvard H, Biron P, Mornex F, Jonas P. [Percutaneous vertebroplasty in the treatment of metastases. Technic and results]. *J Radiol* 1989; **70**: 557-562 [PMID: 2593110]
14 **Lapras C**, Mottolese C, Deruty R, Lapras C Jr, Remond J, Duquesnel J. [Percutaneous injection of methyl-metacrylate in osteoporosis and severe vertebral osteolysis (Galibert's technic)]. *Ann Chir* 1989; **43**: 371-376 [PMID: 2757346]
15 **Filippiadis DK**, Marcia S, Masala S, Deschamps F, Kelekis A. Percutaneous Vertebroplasty and Kyphoplasty: Current Status, New Developments and Old Controversies. *Cardiovasc Intervent Radiol* 2017; **40**: 1815-1823 [PMID: 28856402 DOI: 10.1007/s00270-017-1779-x]
16 **Litin Y**, Rastogi S, Agarwal A, Misra S, Agrawal P, Malviya D. A Prospective Evaluation of Percutaneous Vertebroplasty in Osteoporotic Vertebral Compression Fracture Patients. *Cureus* 2023; **15**: e40255 [PMID: 37440815 DOI: 10.7759/cureus.40255]
17 **Firanescu CE**, de Vries J, Lodder P, Schoemaker MC, Smeets AJ, Donga E, Juttmann JR, Klazen CAH, Elgersma OEH, Jansen FH, van der Horst I, Blonk M, Venmans A, Lohle PNM. Percutaneous Vertebroplasty is no Risk Factor for New Vertebral Fractures and Protects Against Further Height Loss (VERTOS IV). *Cardiovasc Intervent Radiol* 2019; **42**: 991-1000 [PMID: 30941490 DOI: 10.1007/s00270-019-02205-w]
18 **Klazen CA**, Venmans A, de Vries J, van Rooij WJ, Jansen FH, Blonk MC, Lohle PN, Juttmann JR, Buskens E, van Everdingen KJ, Muller A, Fransen H, Elgersma OE, Mali WP, Verhaar HJ. Percutaneous vertebroplasty is not a risk factor for new osteoporotic compression fractures: results from VERTOS II. *AJNR Am J Neuroradiol* 2010; **31**: 1447-1450 [PMID: 20651016 DOI: 10.3174/ajnr.A2148]
19 **Tan L**, Wen B, Guo Z, Chen Z. The effect of bone cement distribution on the outcome of percutaneous Vertebroplasty: a case cohort study. *BMC Musculoskelet Disord* 2020; **21**: 541 [PMID: 32791975 DOI: 10.1186/s12891-020-03568-9]
20 **Melton LJ 3rd**, Lane AW, Cooper C, Eastell R, O'Fallon WM, Riggs BL. Prevalence and incidence of vertebral deformities. *Osteoporos Int* 1993; **3**: 113-119 [PMID: 8481586 DOI: 10.1007/bf01623271]
21 **Tanigawa N**, Komemushi A, Kariya S, Kojima H, Shomura Y, Omura N, Sawada S. Relationship between cement distribution pattern and new compression fracture after percutaneous vertebroplasty. *AJR Am J Roentgenol* 2007; **189**: W348-W352 [PMID: 18029848 DOI: 10.2214/ajr.07.2186]

22 **Genant HK**, Wu CY, van Kuijk C, Nevitt MC. Vertebral fracture assessment using a semiquantitative technique. *J Bone Miner Res* 1993; **8**: 1137-1148 [PMID: 8237484 DOI: 10.1002/jbmr.5650080915]

23 **Clark W**, Bird P, Gonski P, Diamond TH, Smerdely P, McNeil HP, Schlaphoff G, Bryant C, Barnes E, Gebski V. Safety and efficacy of vertebroplasty for acute painful osteoporotic fractures (VAPOUR): a multicentre, randomised, double-blind, placebo-controlled trial. *Lancet* 2016; **388**: 1408-1416 [PMID: 27544377 DOI: 10.1016/S0140-6736(16)31341-1]

24 **Chiarotto A**, Maxwell LJ, Ostelo RW, Boers M, Tugwell P, Terwee CB. Measurement Properties of Visual Analogue Scale, Numeric Rating Scale, and Pain Severity Subscale of the Brief Pain Inventory in Patients With Low Back Pain: A Systematic Review. *J Pain* 2019; **20**: 245-263 [PMID: 30099210 DOI: 10.1016/j.jpain.2018.07.009]

25 **Tonosu J**, Takeshita K, Hara N, Matsudaira K, Kato S, Masuda K, Chikuda H. The normative score and the cut-off value of the Oswestry Disability Index (ODI). *Eur Spine J* 2012; **21**: 1596-1602 [PMID: 22298236 DOI: 10.1007/s00586-012-2173-7]

26 **Li Q**, Long X, Wang Y, Guan T, Fang X, Guo D, Lv J, Hu X, Jiang X, Cai L. Clinical observation of two bone cement distribution modes after percutaneous vertebroplasty for osteoporotic vertebral compression fractures. *BMC Musculoskelet Disord* 2021; **22**: 577 [PMID: 34167517 DOI: 10.1186/s12891-021-04480-6]

27 **Zhu J**, Zhang K, Luo K, Qiu Z, Yang S, Cui F, Weng X, Jiang G. Mineralized Collagen Modified Polymethyl Methacrylate Bone Cement for Osteoporotic Compression Vertebral Fracture at 1-Year Follow-up. *Spine (Phila Pa 1976)* 2019; **44**: 827-838 [PMID: 30601358 DOI: 10.1097/BRS.0000000000002971]

28 **Liebschner MA**, Rosenberg WS, Keaveny TM. Effects of bone cement volume and distribution on vertebral stiffness after vertebroplasty. *Spine (Phila Pa 1976)* 2001; **26**: 1547-1554 [PMID: 11462084 DOI: 10.1097/00007632-200107150-00009]

29 **Benedetti MG**, Furlini G, Zati A, Letizia Mauro G. The Effectiveness of Physical Exercise on Bone Density in Osteoporotic Patients. *Biomed Res Int* 2018; **2018**: 4840531 [PMID: 30671455 DOI: 10.1155/2018/4840531]

30 **Qi H**, Qi J, Gao J, Sun J, Wang G. The Impact of Bone Mineral Density on Bone Metabolism and the Fracture Healing Process in Elderly Chinese Patients With Osteoporotic Vertebral Compression Fractures. *J Clin Densitom* 2021; **24**: 135-145 [PMID: 33323310 DOI: 10.1016/j.jocd.2020.11.003]

31 **Hey HW**, Tan JH, Tan CS, Tan HM, Lau PH, Hee HT. Subsequent Vertebral Fractures Post Cement Augmentation of the Thoracolumbar Spine: Does it Correlate With Level-specific Bone Mineral Density Scores? *Spine (Phila Pa 1976)* 2015; **40**: 1903-1909 [PMID: 26208228 DOI: 10.1097/BRS.0000000000001066]

32 **Rho YJ**, Choe WJ, Chun YI. Risk factors predicting the new symptomatic vertebral compression fractures after percutaneous vertebroplasty or kyphoplasty. *Eur Spine J* 2012; **21**: 905-911 [PMID: 22160212 DOI: 10.1007/s00586-011-2099-5]

33 **Kim WJ**, Ma SB, Shin HM, Song DG, Lee JW, Chang SH, Park KY, Choy WS, Oh TH. Correlation of Sagittal Imbalance and Recollapse after Percutaneous Vertebroplasty for Thoracolumbar Osteoporotic Vertebral Compression Fracture: A Multivariate Study of Risk Factors. *Asian Spine J* 2022; **16**: 231-240 [PMID: 34407571 DOI: 10.31616/asj.2021.0062]

34 **Cho Y**. Posterior Vertebrectomy and Circumferential Fusion for the Treatment of Advanced Thoracolumbar Kümmell Disease with Neurologic Deficit. *Asian Spine J* 2017; **11**: 634-640 [PMID: 28874983 DOI: 10.4184/asj.2017.11.4.634]

35 **McKiernan F**, Faciszewski T. Intravertebral clefts in osteoporotic vertebral compression fractures. *Arthritis Rheum* 2003; **48**: 1414-1419 [PMID: 12746915 DOI: 10.1002/art.10984]

36 **Nieuwenhuijse MJ**, van Rijswijk CS, van Erkel AR, Dijkstra SP. The intravertebral cleft in painful long-standing osteoporotic vertebral compression fractures treated with percutaneous vertebroplasty: diagnostic assessment and clinical significance. *Spine (Phila Pa 1976)* 2012; **37**: 974-981 [PMID: 22020580 DOI: 10.1097/BRS.0b013e318238bf22]

37 **Chen LH**, Hsieh MK, Liao JC, Lai PL, Niu CC, Fu TS, Tsai TT, Chen WJ. Repeated percutaneous vertebroplasty for refracture of cemented vertebrae. *Arch Orthop Trauma Surg* 2011; **131**: 927-933 [PMID: 21191607 DOI: 10.1007/s00402-010-1236-7]

Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: office@baishideng.com
Help Desk: https://www.f6publishing.com/helpdesk
https://www.wjgnet.com