

# Percutaneous Vertebroplasty Does Not Increase the Incidence of New Fractures in Adjacent and Nonadjacent Vertebral Bodies

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**Study Design:** This was a clinical retrospective study.

**Objectives:** This retrospective study aimed to investigate the incidence of new vertebral compression fractures (NVCFs) and analyze the risk factors that influence the secondary fractures in adjacent and nonadjacent levels after percutaneous vertebroplasty (PVP) and conservative treatment (CT).

**Summary of Background Data:** PVP is an effective procedure to alleviate the pain caused by osteoporotic vertebral compression fractures. NVCFs have been noted as a potential late sequela of the procedure. However, it remains unclear whether NVCFs are due to this augmentation or simply are the result of the natural progression of osteoporosis.

**Methods:** A total of 290 patients who had undergone PVP and 270 patients who had undergone CT during the last 4 years were examined. They were followed-up on a monthly basis by telephone for >2 years. They were divided into 2 groups: NVCFs and non-NVCFs. The groups were statistically compared in terms of age, sex, body mass index, initial fracture levels, bone mineral density (BMD) score of the spine, original fracture levels, and new fracture levels.

**Results:** After a mean follow-up of at least 24 months (range, 24–78 mo), 42 NVCFs occurred in 37 of 290 patients after PVP and 33 NVCFs in 30 of 270 patients after CT. Only BMD was significantly different between the groups. Lower BMD was a significant predictive factor for NVCFs.

**Conclusions:** PVP did not increase the incidence of NVCFs, especially those adjacent to the treated vertebrae, following augmentation with PVP compared with CT. The most important risk factor for NVCFs was osteoporosis.

**Key Words:** osteoporotic vertebral compression fracture, percutaneous vertebroplasty, adjacent-level fracture, bone mineral density, osteoporosis

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The continued aging of the population around the world has aroused concern with regard to osteoporosis and osteoporotic vertebral compression fractures (OVCFs). OVCFs constitute a major health problem that affects >1.4 million people each year worldwide.<sup>1</sup> Conservative treatment (CT), such as bed rest, opioid analgesia, muscle relaxants, bracing, external fixation, and a combination of these treatments, is routine. CT may not relieve pain, frequently leads to long-term bed rest, and may lead to pulmonary deterioration, bedsores, deep venous thrombosis, progressive kyphotic deformity, depression, bone demineralization, and an overall decrease in the quality of life.<sup>2</sup> Especially exacerbated bone demineralization inevitably increases the risk of bone fracture.

During the last few decades, percutaneous vertebroplasty (PVP) has been one of the minimally invasive procedures used in treating painful OVCFs. The technique of vertebroplasty was originally developed by Galibert and Deramond in 1984 and published in 1987.<sup>3</sup> It uses a percutaneous transpedicular approach to introduce polymethylmethacrylate (PMMA) cement into the vertebral body. A number of reviews<sup>1,4</sup> have recently shown PVP to be efficacious in providing rapid pain relief, reducing the need for pain medication, improving functional ability, and enhancing health-related quality of life for patients with OVCFs.

However, some perioperative and postoperative adverse events are associated with PVP, such as symptomatic cement leakage, pulmonary embolism, hematoma, spinal cord compression, radiculopathy, infection, and new vertebral compression fractures (NVCFs) at nontreated vertebra.<sup>5–10</sup> A possible increase in the risk of NVCFs at nontreated vertebra following augmentation is of concern, especially in osteoporotic patients.<sup>11</sup> Several studies<sup>11–13</sup> reported an increase in the incidence of NVCFs after bone cement augmentation compared with CT, especially adjacent vertebral compression fractures (VCFs). These studies presumed that PVP was associated with a higher incidence of NVCFs as a result of the augmented stiffness of the treated vertebra related to the amount of injected cement or due to cement leakage in the adjacent vertebral disk space. However, some scholars<sup>5,14,15</sup>

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believe that the development of NVCFs is a natural process associated with osteoporosis. No convincing evidence exists indicating that NVCFs are inevitable after augmentation than after CT, and it is still unclear whether new fractures are the consequence of augmentation or simply are the result of the natural progression of osteoporosis.<sup>16</sup> The objective of this study was to determine whether PVP increased new-level vertebral fractures and whether vertebral fractures more frequently occurred adjacent to the treated one. It also explored the dominant risk factors associated with new OVCFs.

## METHODS

### Inclusion and Exclusion Criteria

The computerized database was examined to identify all patients diagnosed with OVCFs in the hospital from September 2012 to February 2016. The inclusion criteria were as follows: (1) age more than 60 years; (2) first single-level OVCF; (3) back pain related to the location of the OVCF on magnetic resonance imaging (MRI) radiographs; (4) presence of an apparent bone edema in the fractured vertebra on T2-weighted MRI; (5) bilateral pedicle intact without fracture; (6) bone mineral density (BMD)  $<-2.5$ ; and (7) complete monthly telephone follow-up record for at least 24 months. The exclusion criteria were as follows: (1) patients with VCF due to causes other than osteoporosis; (2) patients with spinal cord compression; (3) patients with neurologic deficits; (4) patients with incurable bleeding disorders; (5) patients with severe comorbidity of heart, liver, kidney, or lung intolerance to surgery; (6) patients with contraindication for MRI; (7) patients with follow-up time  $<24$  months, (8) patients with communication barriers, and (9) patients who failed to go to the hospital for physical and imaging examinations when the pain aggravated. All the investigations were approved by the ethics committee of the hospital.

### Groups and Clinical Investigations

Patients who met the criteria were retrospectively reviewed for the study. The patients were divided into 2 groups according to the type of management: (1) operated group that underwent PVP; and (2) nonoperated group that underwent CT. Clinical data, such as age, sex, body mass index (BMI), and BMD score of the spine, initial fracture levels, new fracture interval, and new fracture levels, were reviewed. Among these patients, the patients suffering from NVCFs after PVP and CT were selected and assigned to the NVCF group; the rest of the patients were assigned to the non-NVCF group. The same clinical data, such as age, sex, BMI, and BMD score of the spine and initial fracture levels, were analyzed and compared. Among these NVCF patients, the patients suffering from adjacent NVCFs after PVP and CT were selected and assigned to the adjacent NVCF group, and the rest were assigned to the remote NVCF group. The same clinical data were analyzed and compared.

At baseline, radiography and MRI of the spine were performed. The MRI features were indicative of an acute fracture activity; low signal intensity on T1-weighted MRI

images, high signal intensity on T2-weighted MRI images, and high signal intensity on T2-weighted MRI images with fat suppression within the vertebral body indicating active edema and inflammation.

### Treatments

PVP was performed under biplane fluoroscopy with the unilateral transpedicular injection of bone cement (PMMA). The patient was allowed to move wearing the brace 6 after PVP. Conservative therapy consisted of oral analgesics, bed rest, physiotherapy, and thoracolumbar brace. Patients who underwent 4 weeks of CT were allowed to exercise if they tolerated pain. Patients in both treatment groups received bisphosphonates, calcium supplementation, and vitamin D. Symptomatic NVCFs were treated according to the originally allocated treatment strategy.

PVP procedure was as follows. Local anesthesia (2% lidocaine and 1% ropivacaine, 1:1) was administered. The patients were positioned prone on a radiolucent table. The orientation of the puncture was located in the anterior three-fourths of the vertebral body under the guidance of G-arm x-ray machine. Subsequently, 3–5 mL of PMMA (Osteopal V; Heraeus Medical, Germany) was injected until the adequate filling of the vertebral body under lateral fluoroscopic guidance.

### Follow-up Protocol and NVCF Inclusion Criteria

A monthly telephone follow-up was conducted for each patient. The 24th month was selected as the end of follow-up. If the patient had a sudden increase in back pain, he or she was asked to go back to the hospital for medical and MRI examinations to determine whether an NVCF existed. The inclusion criteria for NVCFs were as follows: (1) relapse of pain after initial PVP, after an obvious pain-free interval; and (2) evidence of NVCFs in new levels on MRI. In this study, only the symptomatic NVCFs were recorded and analyzed.

The site of fracture was classified as thoracic (between T5 and T10), thoracolumbar (T11–L2), and lumbar (below L3) regions. The BMD of the spine was measured for all patients who developed initial VCFs using dual-energy x-ray absorptionmetry technique (Hologic QDR 2000; Hologic Inc., MA). The osteoporosis was defined as T-score  $\leq -2.5$ .

### Statistical Analysis

Patient characteristics were summarized using descriptive statistics, which were expressed as the mean  $\pm$  SD for continuous variables and percentages for categorical variables. Differences between groups were assessed using the *t* test for continuous variables and the  $\chi^2$  test for categorical variables. A *P*-value  $<0.05$  indicated a statistically significant difference. A statistical analysis was performed with the Predictive Analytics Software Statistics 23.0 program (SPSS Inc., IL).

## RESULTS

Among 712 patients who were screened between September 2012 and February 2016, 565 patients met the inclusion criteria. Among 565 eligible patients, 283 were

**TABLE 1.** The Clinical Characteristics of the Study Populations

Parameters [n(%)]	PVP Group	CT Group	t/ $\chi^2$	P
No. patients	290	270		
Age (mean $\pm$ SD)	64.20 $\pm$ 12.2	64.19 $\pm$ 12.2	0.01	0.99
Female	196 (67)	176 (65)	0.36	0.55
Mean BMI (kg/m <sup>2</sup> )	23.3 $\pm$ 2.4	23.5 $\pm$ 2.2	1.03	0.31
Mean BMD (T-score)	-3.6 $\pm$ 0.78	-3.7 $\pm$ 0.63	1.66	0.10
Original fracture site (vertebrae)				
Thoracic spine	93 (32)	81 (30)	0.28	0.56
Thoracolumbar spine	174 (60)	165 (61)	0.07	0.79
Lumbar spine	23 (8)	24 (9)	0.17	0.68

CT indicates conservative treatment; BMD, bone mineral density; BMI, body mass index; PVP, percutaneous vertebroplasty.

assigned to the PVP group and 282 to the CT group, according to the type of initial management. Ten patients assigned to the CT group with ongoing invalidating pain requested and underwent PVP during the follow-up. Five patients who died due to other causes failed to complete a 2-year follow-up: 3 patients in the PVP group and 2 patients in the CT group. Finally, 290 patients in the PVP group and 270 patients in the CT group completed at least 24 months of follow-up. The baseline characteristics of these 2 groups are shown in Table 1. All patients underwent a monthly telephone follow-up for at least 24 months (range, 24–78 mo).

Up to the 24th month of follow-up, 42 new fractures were observed in 37 of 290 patients treated with PVP and 33 new vertebral fractures were apparent in 30 of 270 patients treated with CT. The incidence of NVCFs in the PVP group was slightly higher than that in the CT group, 13% versus 11% concerning patient proportion and 14% versus 12% with regard to new fracture number. This difference in incidence (patient proportion) was not significant ( $P=0.55$ ). In the PVP group, 14 new fractures were identified in vertebrae adjacent to treated vertebrae, and 23 new fractures were detected in vertebrae not adjacent to treated vertebrae. The number of new fractures that occurred in vertebrae adjacent to treated vertebrae was significantly less than the number of new fractures in vertebrae not adjacent to treated vertebrae. In the CT group, 12 new fractures in vertebrae adjacent to treated vertebrae and 18 new fractures in vertebrae not adjacent to treated vertebrae were apparent. Both groups indicate a higher incidence of non-adjacent recompression. The PVP and CT groups did not differ significantly in age, sex distribution, location of original fracture segments, and incidence of new OVCFs (including adjacent and nonadjacent OVCFs). The incidence of new VCFs is shown in Table 2.

**TABLE 2.** The Incidence of New VCFs

Incidence of New Fractures [n (%)]	PVP Group	CT Group	$\chi^2$	P
Total	37 (13)	30 (11)	0.36	0.55
Adjacent	14 (38)	12 (40)	0.03	0.86
Distant	23 (62)	18 (60)	0.03	0.86

CT indicates conservative treatment; PVP, percutaneous vertebroplasty; VCF, vertebral compression fractures.

**TABLE 3.** The Clinical Characteristics of the NVCF Group and Non-NVCF Group

Parameters [n (%)]	NVCFs	Non-NVCFs	t/ $\chi^2$	P
No. patients	67	493		
Age (mean $\pm$ SD)	63.10 $\pm$ 11.4	64.21 $\pm$ 12.0	0.71	0.48
Female	45 (67)	327 (66)	0.02	0.56
Mean BMI (kg/m <sup>2</sup> )	22.8 $\pm$ 2.6	23.6 $\pm$ 2.1	2.84	1.65
Mean BMD (T-score)	-4.4 $\pm$ 0.68	-3.0 $\pm$ 0.64	16.67	<0.01#
Original fracture site (vertebrae)				
Thoracic spine	21 (31)	153 (31)	0.003	0.96
Thoracolumbar spine	43 (64)	296 (60)	0.42	0.52
Lumbar spine	3 (5)	44 (9)	1.52	0.22

BMD indicates bone mineral density; BMI, body mass index; NVCF, new vertebral compression fracture.

#Statistically significant difference ( $P < 0.01$ ).

BMD was significantly lower in the NVCF group than in the non-NVCF group, reaching the statistical significance. The risk of NVCF increased with the increase in BMD ( $P < 0.01$ ). No statistically significant differences were observed in age, sex distribution, and location of original fracture segments. The baseline characteristics of the 2 groups are shown in Table 3. Further, no statistically significant difference was found in age, sex distribution, location of original fracture segments, and BMD between groups with adjacent NVCFs and nonadjacent NVCFs. The baseline characteristics of these 2 groups (adjacent NVCFs group and nonadjacent NVCFs group) are shown in Table 4.

The distribution of new VCFs was as follows: in the PVP group, thoracic spine (27%), thoracolumbar spine (62%), and lumbar spine (11%); in the CT group, thoracic spine (33%), thoracolumbar spine (60%), and lumbar spine (7%). More NVCFs occurred in the thoracolumbar levels in both the groups. Compared with initial fracture levels, new fracture levels did not show statistically significant differences. The distribution of initial VCFs and new VCFs was similar between the 2 groups (PVP and CT groups).

## DISCUSSION

PVP has become widely accepted as a safe and effective minimally invasive procedure for treating painful VCFs

**TABLE 4.** The Clinical Characteristics of the Adjacent NVCF Group and Distant NVCF Group

Parameters [n (%)]	Adjacent NVCFs	Distant NVCFs	t/ $\chi^2$	P
No patients	30 (45)	37 (55)		
Age (mean $\pm$ SD)	63.22 $\pm$ 12.0	63.20 $\pm$ 12.2	0.01	0.99
Female	18 (69)	27 (66)	1.26	0.26
Mean BMI (kg/m <sup>2</sup> )	23.0 $\pm$ 2.4	23.8 $\pm$ 2.3	1.39	0.17
Mean BMD (T-score)	-4.4 $\pm$ 0.68	-4.4 $\pm$ 0.72	0.00	1.00
Original fracture site (vertebrae)				
Thoracic spine	8 (27)	13 (35)	0.55	0.46
Thoracolumbar spine	21 (70)	22 (60)	0.80	0.37
Lumbar spine	1 (3)	2 (5)	0.00	1.00*

\*Continuous calibration  $\chi^2$  test.

BMD indicates bone mineral density; BMI, body mass index; NVCF, new vertebral compression fracture.

refractory to medical therapy since the first case of successful vertebral augmentation by intravertebral injection of PMMA in patients with vertebral hemangiomas was described by Galibert et al.<sup>3</sup> Using PVP treatment, the pain of patients can be rapidly relieved, the quality of life greatly improves, and patients start moving again sooner. Generally, the short-term effects of PVP treatment are satisfactory. However, complications with regard to new-level fractures have been reported in many retrospective studies,<sup>11,17–19</sup> increasing the concern whether augmentation increases the incidence of new compression fractures, especially in adjacent vertebrae. Uppin et al<sup>11</sup> carried out a study of 177 patients with OVCFs and reported that the incidence of NVCFs within the subsequent year of fracture was 12.4%. Two-thirds (67%) of these new fractures occurred in vertebrae adjacent to those previously treated. Lin et al's<sup>6</sup> study reached a similar conclusion. Komemushi et al<sup>20</sup> identified 59 new fractures in 30 the 83 patients and 41 new fractures in vertebrae adjacent to treated vertebrae. New fractures occurred in vertebrae adjacent to treated vertebrae significantly more frequently than in vertebrae not adjacent to treated vertebrae. Mudano et al<sup>21</sup> found that treated patients had a significantly greater risk of secondary VCFs within 90 days of the procedure [adjusted odds ratio, 6.8; 95% confidence interval (CI), 1.7–26.9] and within 360 days (adjusted odds ratio, 2.9; 95% CI, 1.1–7.9).

Unfortunately, much of the recent studies compared original and new fractures mainly in the operative group.<sup>11</sup> Limited data exist with respect to the recompression incidence of PVP versus CT. In the present comparative study, all baseline data were not statistically significantly different in the PVP and CT groups. Moreover, the risk of new fractures was 15% and 18%, respectively, which was also not statistically significant. This result revealed that PVP did not increase the incidence of NVCFs, including those adjacent to the treated vertebrae.

Many investigators attempted to explore this issue through biomechanical studies to determine the risk factors for newly developed vertebral fractures.<sup>22,23</sup> Some experimental biomechanical studies showed that PVP increased stiffness and strength.<sup>17,24–28</sup> The augmented vertebrae alter the biomechanics of load transfer to the adjacent vertebrae due to the increased stiffness.<sup>29</sup> This change increases the stress of other vertebrae, especially adjacent vertebrae, making them more prone to fracture.<sup>17</sup> Most of them<sup>17,26,27,29–32</sup> concluded that new fractures might be the consequence of an adjacent rigid reinforcement. In addition, the vertebrae treated with cement produced increased loading in adjacent vertebrae, inducing subsequent fractures.<sup>26,27,33</sup> The increased mechanical pressure, especially pertinent for patients who increased their daily physical activities as their back pain decreased after augmentation, also placed additional stress on the vertebrae.<sup>34</sup> Therefore, more and more clinicians believe that the stiffening of the treated vertebra might put adjacent vertebrae at a higher risk of subsequent fracture or degenerative change.

However, the findings of Villarraga et al<sup>35</sup> suggest that changes in stresses and strains in levels adjacent to

the treated level are minimal. They are less than the injury tolerance limits of cancellous and cortical bones. Berlemann et al<sup>29</sup> found that the failure strength of functional spine units treated using PVP in one vertebral body was lower than that of untreated controls. In addition, a 3-dimensional, nonlinear finite element model by Rohlmann et al<sup>36</sup> showed that the augmentation of vertebral bodies with bone cement had a much smaller effect on intradiscal pressure and endplate stress in the non-fractured vertebrae. They suggested that vertebral body fractures in adjacent vertebrae after PVP were not induced by increased stiffness of the treated vertebra.

Recently, a large number of clinical studies<sup>15,37,38</sup> have found that PVP does not increase the risk of untreated vertebral bodies, especially adjacent vertebral body fractures. Klazen et al<sup>15</sup> found that the incidence of new VCFs was not different after PVP compared with CT after a mean follow-up of 11.4 months. A meta-analysis did not support the hypothesis that PVP contributes to an increased risk of subsequent vertebral fracture, neither adjacent nor total vertebral fracture.<sup>38</sup> They found a similar incidence of vertebral fracture in the PVP and CT groups (hazard ratio, 0.60; 95% CI, 0.29–1.26;  $P=0.18$ ). Vertebroplasty was associated with a slightly increased but nonsignificant risk of vertebral fracture (hazard ratio, 1.14; 95% CI, 0.65–2.00;  $P=0.65$ ). Another meta-analysis<sup>39</sup> evaluated 12 studies encompassing 1328 patients in total, including 768 who underwent an operation with PMMA and 560 who received nonoperative treatments. For new-level vertebral fractures, the meta-analysis found no significant difference between the 2 methods, including total new fractures ( $P=0.55$ ) and adjacent fractures ( $P=0.5$ ). The analysis did not reveal any evidence of an increased risk of fracture of vertebral bodies, especially those adjacent to the treated vertebrae. Zhou et al's<sup>40</sup> meta-analysis obtained similar conclusions. These meta-analyses<sup>38–40</sup> further confirmed the main conclusion of the present study that PVP did not significantly increase the incidence of new vertebral fractures compared with CTs.

In this study, the overall rate of new fractures in the PVP group was slightly higher than that in the CT group, but the difference was not statistically significant, whether adjacent vertebral bodies or distal vertebral bodies. The increased incidence of new fractures and earlier new fracture occurrence in PVP might be associated with increased activity and earlier ambulation in patients with postoperative pain relief. Several recently published studies<sup>38,41,42</sup> yielded similar results and opinions. Probably biomechanical research can explain why PVP does not increase the risk of vertebral fractures. A recent biomechanical analysis<sup>32</sup> indicated that the procedure might instead restore normal load bearing in the spine. Vertebral fractures decrease spinal segment stiffness and decompress the intravertebral disk. These effects combined with kyphotic changes, transferred the load to the posterior spinal elements to the point that, in elderly spines, 90% of the load is shifted to the neural arch. Using cadaveric spinal motion segments similar to the FSUs described earlier but with intact spinal ligaments, the vertebroplasty restored

segment stiffness and intradiscal pressure to prefracture levels; the result was a more normal pattern of load bearing in the spine.

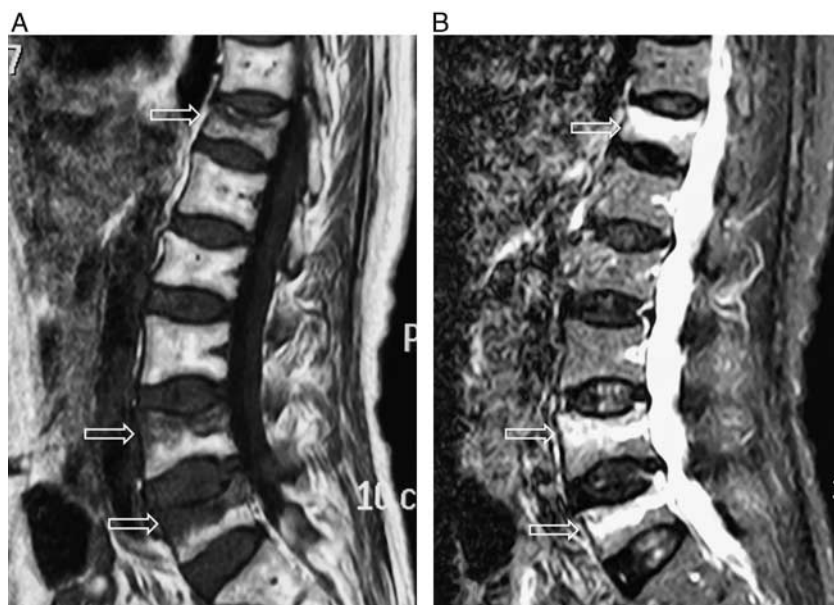
Lower baseline BMD was considered one of the most important risk factors for new fractures.<sup>43,44</sup> Several studies have suggested that BMD is associated with an increased rate of adjacent-level fractures. Of all the factors examined in the present study, only BMD was shown to increase the risk of new vertebral fractures. Average BMD was  $-4.4$  in the fracture group (67 patients) and  $-3.0$  in the fracture-free group (493 patients), and the baseline BMD was the only risk factor for the occurrence of NVCFs. No significant difference was observed in BMD between adjacent NVCF and remote NVCF groups.

A series of recently published studies provided similar conclusions.<sup>11,43</sup> Uppin et al<sup>11</sup> also mentioned that as osteoporosis worsened, patients were more likely to develop new

fractures in adjacent vertebrae. Osteoporosis contributes to progressive bone resorption and, finally, bone strength compromise and microarchitectural deterioration. Yoo et al<sup>45</sup> concluded that low BMD caused degenerative changes in vertebrae and that low BMD could result in not only VCF but also new vertebral fractures in adjacent vertebrae. In the present study, 8 patients who had  $\geq 2$  new fractures had an average BMD of  $-5.60$  (such as Figs. 1, 2), suggesting a clear inverse correlation between BMD and the likelihood of a vertebral fracture in adjacent vertebrae. In the present study, the incidence of new fractures in both PVP and CT groups was lower compared with most other reports. It was postulated that adequate antiosteoporosis medication and careful protection through external bracing within the first 2 months after surgery are critical for preventing subsequent vertebral fracture. Standardized antiosteoporosis treatment is essential to prevent vertebral body refracture. Unfortunately,



**FIGURE 1.** A 64-year-old woman with severe osteoporosis (bone mineral density,  $T=5.8$ ) presented with back pain. A and B, An acute fracture was observed in T11 (arrow). C and D, T11 vertebroplasty was performed. E and F, Only 2 weeks later, 2 new body fractures were found in T10 and T12 (arrows).



**FIGURE 2.** A 73-year-old woman with severe osteoporosis (bone mineral density,  $T=5.6$ ) presented with back pain. L5 compression fracture was treated conservatively. A and B, Only 3 weeks later, 2 new body fractures were found in L4 and T12 (arrows).

the present study did not record the patient's BMD data when new vertebral fractures occurred.

BMD, not PVP, is the risk factor for new fracture, but the available literature reports that more new fractures occur in adjacent segments, which needs investigation. A confirmed conclusion is that the thoracolumbar level is the most prone to OVCFs. This is determined by its special structural and mechanical conduction. Moreover, the thoracolumbar (T-L) junction has a higher dynamic motility. The outcome of the present study was consistent with the previously published evidence-based literature. The initial fracture level of the T-L junction was greater than that of the thoracic and lumbar regions. Moreover, the new fracture more frequently occurs at the thoracolumbar level in both the PVP and CT groups, whether the primary fracture occurred in the thoracolumbar region. Therefore, of fractures adjacent to the original fracture segment are highly probable, misleading the researchers to believe that PVP is a risk factor for adjacent vertebral fractures, NVCF occurrence was higher in an adjacent location due to high dynamic motility in the T-L junction. These results suggested the importance of wearing a back brace to reduce motion and requirement of careful physical activity in daily life.

### CONCLUSIONS

This study revealed that PVP did not increase the incidence of NVCFs, especially those adjacent to the treated vertebrae, following augmentation with PVP compared with CT. The most important risk factor for NVCFs was osteoporosis, and the development of NVCFs was a natural process associated with osteoporosis. This viewpoint is similar to that described in a randomized controlled trial in 2009 by Rousing et al<sup>46</sup> antiosteoporosis after vertebral fractures is crucial to prevent other vertebral refractures. Notwithstanding

the imperfect understanding of how vertebroplasty affects the risk of future fractures, 2 issues are particularly important to patient care. First, the potential risk for new fracture should be discussed before vertebroplasty with all patients. When PVP is performed in patients with severe osteoporosis, the risk of refracture must be carefully assessed. Second, all osteopenic patients with spontaneous spinal fracture are at a high risk of new fracture, with or without vertebroplasty. These patients should receive optimal medical management of their osteopenia or osteoporosis.

### Limitations

This study had several limitations. First, the study only included symptomatic new fractures and did not have a systematic radiologic follow-up for all eligible patients; consequently, asymptomatic vertebral fractures were not detected. However, previous literature demonstrated that almost two-thirds of vertebral fractures are symptomatic.<sup>47</sup> Second, only the unipedicular injection of cement was performed in this study, although bipedicular injection procedures are also used in clinical practice. The study did not involve PKP, another minimally invasive technique, but a meta-analysis<sup>48</sup> showed that PKP and PVP were both safe and effective surgical procedures in treating OVCF, with no significant difference in the incidence of new adjacent-level VCFs. Third, this study intended to only fill the fracture fissure rather than augment the entire vertebral body; also, less cement was injected. Thus, the change in the strength of the entire fractured vertebral body is less and the probability of leakage within the disk is smaller. Vertebral enhancement and intradiscal leakage are considered as risk factors for adjacent vertebral fractures. Fourth, this study had all the inherent limitations of a retrospective study. This, however, does not diminish the importance of the results of the present study in terms of advancing the understanding of the effects of PVP on OVCFs.

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