The Role of Imaging Studies of Percutaneous Vertebroplasty in 63 Patients with Osteoporotic Compression Fracture: Preliminary Report

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To evaluate the role of imaging studies for percutaneous vertebroplasty to treat back pain associated with osteoporotic compression fractures for the vertebral bodies.

Sixty-three patients (51 women, 12 men; mean age, 70.6 y/o) suffering from back pain refractory to medical treatment received percutaneous injections of polymethylmethacrylate (PMMA) into 66 vertebrae (32 thoracic and 34 lumbar) under biplane fluoroscopic guidance. Plain radiograph, computed tomography, and/or magnetic resonance imaging were performed for pre-operation survey. During the procedure, intraosseous venography was performed before PMMA injection. After the procedure, plain radiograph and CT of each treated vertebral level were obtained immediately to evaluate the migration of PMMA. At follow-up 3 months after vertebroplasty, patients were asked to complete a questionnaire.

The procedures were technically successful in all patients. After treatment, fifty-four (86%) patients reported improvement in back pain from compression fractures. Fifty-four (86%) patients reported satisfaction with percutaneous vertebroplasty. The single serious adverse event involved clinically was suspected pulmonary embolism syndrome. The complication rate was 1.6 percent. In multiple compression fractures, pre-operative MRI evaluation is very helpful for determining appropriate treatment.

Percutaneous vertebroplasty is a minimally invasive procedure which can provide satisfactory symptomatic relief for patients with refractory back pain associated with osteoporotic compression fracture. All kinds of imaging studies play their own roles in the procedure.

Key words: Spine, Vertebroplasty; Spine, Fractures; MR imaging; Osteoporosis

A painful osteoporotic vertebral fracture can be a significant burden for patients and their families, impairing physical function and quality of life. Additionally, vertebral body compression fractures cause chronic pain, poor sleep, decreased mobility, depression, and loss of independence [1-3]. For initial treatment, narcotic analgesics and non-steroid inflammatory agents are administered during a short period of immobilization. The use of multiple medications, including narcotic analgesics at increasing dosages, often results in drug toxicity and dependence. Percutaneous vertebroplasty, introduced as a minimally invasive therapeutic alternative for the treatment of pain associated with compression fractures, involves injection of polymethylmethacrylate (PMMA) into a fractured vertebral body through one or two bone biopsy needles [4]. This procedure has been developed to help stabilize fractured vertebra and, more importantly, decrease pain and improve the function of individuals with osteoporotic compression fractures [5, 6]. Several prospective studies of percutaneous vertebroplasty with
long-term follow-up have been published previously [7, 8], but not in Taiwan. Pre-operation magnetic resonance imaging (MRI) and post-operation computed tomography (CT) were enrolled in the protocol. Under appropriate clinical symptoms and imaging evaluation, percutaneous vertebroplasty is recommended to be the treatment for back pain associated with vertebral body compression fractures safely and effectively.

MATERIALS AND METHODS

Patients
Between November 2001 and March 2003, sixty-three patients were consecutively enrolled in this study. The inclusion criteria were acute severe vertebral fracture pain with failure of medical treatment, osteoporosis, and acute fracture activity indicated by magnetic resonance imaging. Exclusion criteria were pathologic fracture due to myeloma/metastasis, osteomyelitis, major retroplacement of bony fragments into the spinal canal, and coagulopathy. Twelve men and 51 women with a mean age of 70.6 years (41-91 y) were treated with percutaneous vertebroplasty. A total of 66 vertebral bodies were infused with PMMA (thoracic vertebrae: T10 (2); T11 (7); T12 (23); lumbar vertebrae, L1 (19); L2 (4); L3 (6); L4 (4); L5, (1)). Failure of medical therapy was defined as (1) minimal or no pain relief after administration of analgesics or (2) adequate pain relief only after narcotic dosages inducing excessive and intolerable sedation, confusion, or constipation. All patients were clinically evaluated before the procedure. Complete blood count, laboratory studies (eg. bleeding time), and systemic disease screening (eg. diabetes mellitus, cardiovascular disease) were performed on all patients. Initial radiographic evaluation of the patients included plain radiograph, CT, and/or MRI. MRI of following features were included: 1) acute vertebral marrow edema with low signal intensity on T1-weighted images, high signal intensity on T2-weighted images and obvious enhancement after contrast medium injection; 2) osteonecrosis with air or fluid collection in vertebral bodies. MRI was also used to rule out other spinal diseases such as infectious or malignant lesions. If pathological fracture was suspected, vertebral body biopsy was performed before the procedure. In cases of multiple compression fractures, MRI helped to identify any ongoing vertebral abnormality.

Procedure
The vertebroplasty procedure was performed according to the technique described by Jensen et al [6]. The patients were placed in prone position on the examination table with bi-plane fluoroscopy. The procedure was performed under intravenous conscious sedation with 25mg Diazepam (Dupin; China Chemical and Pharmaceutical, Taiwan) and pain control with codeine (National Bureau of Controlled Drugs, Department of Health, Taiwan) in a dosage of 15-30 mg. If pain control could not be achieved with codeine, 25mg Meperidine (National Bureau of Controlled Drugs, Department of Health, Taiwan) was administered intravenously. We used 11-gauge bone marrow biopsy needle (Hakko Electric Machine Works Co., Nagano, Japan) to puncture the collapsed vertebral body through either one of the pedicles and advance the needle to the anterior third of the vertebral body under fluoroscopic guidance. Intraosseous venography using 0.5-2 mL Iohexol (Omipaque, Amersham Health, Cork, Ireland, USA) was performed via bone biopsy needle under direct bi-plane fluoroscopic visualization before injection of cement. We watched for the following features including opacification of bony trabeculae, the drainage veins, and the leakage of contrast medium into spinal canal and disc space. If venography showed only ipsilateral bony trabeculae opacification or direct and fast venous communication (Fig 1), the contralateral pedicle approach would be performed. Bone cement was prepared by mixing the copolymer
powder with sterile barium sulfate (9:1 by weight), followed by the addition of the monomer liquid for polymerization (OsteoBond; Zimmer, Warsaw, IN). We injected the cement into the vertebral body under direct fluoroscopic control and immediately terminated the procedure when one of the following signs was observed: 1) cement reaching the posterior fourth of the vertebral body; 2) cement migrating to drainage veins; or 3) significant leakage into the disc space.

After the procedure, plain radiographic and CT images of each treated vertebral level were assessed to ensure that no unexpected or undesirable migration of cement had occurred (Fig 3). Plain radiographs were obtained with the patient in the left lateral decubitus position. Postoperative spinal CT was performed within 1-2 hour after the procedure. The thickness of the slice was set at 3mm, the pitch was 1.0 and the reconstruction increment 1.0mm. All patients were observed in the supine position for 3 hours after the procedure.

The change in height of the treated vertebral body before and after treatment was recorded for comparison (Fig. 2). Percentage of the residual vertebral body height was calculated by the following formula: \( \frac{2RA}{(UP+LP)} \). (UP: posterior body height of upper vertebra; LP: posterior body height of lower vertebra; RA: Residual anterior body height of the compressed vertebra).

**Figure 2.** Percentage of the residual vertebral body height was calculated by the following formula: \( \frac{2RA}{(UP+LP)} \). (UP: posterior body height of upper vertebra; LP: posterior body height of lower vertebra; RA: Residual anterior body height of the compressed vertebra).

**Figure 3.** The cement leakage may invade any area through a cortical defect or communication vessels, including the spinal canal (A), the neural foramen (B), and the basivertebral vein (C).

**Postprocedural follow-up**

At 3 months after vertebroplasty, patients were asked to describe their feeling of pain relief as significantly improved, moderately improved, unchanged, or worse than before the procedure. Patients were examined in clinic or contacted by phone quarterly thereafter for continuous data collection. The correlation between pre-operation imaging studies and post-operation pain relief were compared, and the following subtypes were classified. Type A: Patients’ acute compression fracture levels were indicated by radiographic evidence and MRI in the presentation of back pain, but at the same time, there were also another compression fractures with shape change of the vertebral body in radiograph without definite bone marrow edema or osteonecrosis in MRI. Type B: Patients’ compression fracture levels were indicated...
by MRI without definite shape change of the vertebral body in radiograph. Type C: Patients’ compression fracture levels were indicated by radiograph with shape change of the vertebral body without definite bone marrow edema or osteonecrosis in MRI.

Minor adverse events were defined as any unexpected or undesirable clinical events within the first 2 weeks after vertebroplasty not requiring surgical intervention. Serious adverse events were defined as any unexpected or undesirable clinical events after vertebroplasty requiring surgical intervention or resulting in death or significant disability.

**RESULTS**

Between December 2001 and March 2003, a total of 69 patients underwent percutaneous vertebroplasty for treatment of symptomatic compression injuries. During the follow-up period, 6 patients died of causes unrelated to vertebroplasty. Follow-up was conducted in 63 of 69 patients with a mean duration of 9.25 months (range, 3-16 months). The procedure was technically successful in all 66 treated vertebrae. A single puncture via right pedicle was the most commonly performed procedure (56 of 66 vertebrae). Four procedures were via left pedicle and 6 procedures were bilateral. Eighty-six percent (54 of 63) of the patients reported significant or mild improvement of their back pain. Six patients reported no change, and 3 patients reported their back pain had been worsened. Eighty-six percent (54 of 63) of the patients stated that they were satisfied with the procedure. After the procedure, increased vertebral body height was observed in treated vertebral bodies. The correlation between pre-operation imaging studies and post-operation pain relief is summarized in Table 1. The immediate increase in anterior residual height of the 66 treated vertebral bodies is shown in Table 2. There was one major adverse event. The patient sustained respiratory distress; plain radiograph revealed bilateral pulmonary infiltration on the day after operation. Pulmonary embolism syndrome was suspected. The patient was discharged 40 days later without sequelae. The mean number of post-vertebroplasty hospitalization days for the other 62 patients was 2.5 (2 to 17) days.

Post-operative CT was valuable. Unexpected cement migration to spinal canal via the needle tract (Fig. 3a), to the neural foramen (Fig. 3b), and to the basivertebral vein (Fig. 3c) can be detected earlier. Cement leaking from the vertebra adjacent to a nerve root may produce radicular pain. Serious complications, such as possible motor deficit (or bowel or bladder dysfunction) or paraplegia, may occur if large amount of cement leakage with subsequent spinal cord compression. When these migrations occurred, we notified referring physicians the possibilities of neurological complaints or deficits right away and careful neurological evaluation was performed till patients discharged. There was no permanent neurologic deficit in our patient population in the end of this study.

**DISCUSSION**

The risk of osteoporotic-related fracture increases with age in postmenopausal women [7]. For many patients, treatment with external bracing, analgesics, and bed rest may be sufficient for pain control. In some cases, however, these measures may be too conservative for controlling protracted pain [8]. Serious complications, such as urine retention, ileus, or spinal cord compression, are associated with protracted back pain and immobilization [9]. Long-term effects can include kyphosis, insomnia, and depression [9]. The actual cost and potential risk of morbidity and mortality may therefore be very high. Recent studies have demonstrated significant success using vertebroplasty to relieve pain resulting from osteoporotic vertebral compression fractures [6, 10, 11]. Significant pain relief is achieved in 75-90% of patients with benign fractures [6, 10, 11], and in 59-86% of patients with malignant vertebral compression fractures [12, 13]. Our 86 percent successful rate is consistent with previous reports.

Thorough evaluations of both symptoms and imaging studies were essential to the success of the procedure. In type C (Table 1), the condition of three patients worsened after the procedure. MR imaging of the treated vertebral bodies in these three cases

| Table 1. Correlation between pre-operation imaging study and post-operation pain relief. |
|-----------------|-----------------|-----------------|-----------------|
| coherence        | Patients Improve | No change | Worse |
| MRI consistent with Radiograph | 32 | 29 | 3 |
| MRI inconsistent with Radiograph | 17 | 9 | 1 |
| Type A           | 10 | 4 | 3 |
| Type B           | 4 | 3 | 3 |
| Type C           | 3 | 3 | 3 |

Type A: Patients’ acute compression fracture levels were indicated by radiographic evidence and MRI in the presentation of back pain, but at the same time, there were also another compression fractures with vertebral body shape change in radiograph without definite bone marrow edema or osteonecrosis in MRI.

Type B: Patients’ compression fracture levels were indicated by MRI without definite vertebral body shape change in radiograph.

Type C: Patients’ compression fracture levels were indicated by radiograph with vertebral body shape change without definite bone marrow edema or osteonecrosis in MRI.
indicated the fractures were healed and maybe in more chronic status. Many patients with osteoporosis have multiple compression deformities of the vertebral bodies, not all of which require treatment with percutaneous vertebroplasty. Previous studies have stressed the importance of physical examination findings in selecting appropriate patients, whereby lack of focal tenderness over the vertebral fracture site has been used as a reason to exclude patients from vertebroplasty [14], but none have offered evidence to support this assumption. However, Gaughen [15] noted that pain on palpation over the fractured vertebra was by itself not a sufficient indication that a patient would benefit from percutaneous vertebroplasty. All potentially relevant factors, such as MR evidence of edema, should be carefully weighed considerably in the decision to treat a patient.

In our initial study, we noted that although we correlated clinical symptoms with plain radiographs revealing shape change of the vertebral body in serial tests and carefully identified the target painful lesions, 3 patients reported increased back pain. On the other hand, we found that type B patients (Table 1) whose plain radiographs with no significant shape change of the vertebral bodies did reveal significant signal intensity change on T2W imaging and on post-contrast imaging of MRI study, indicating acute inflammatory phase. Nearly all these cases had satisfactory treatment results. In a review of the role of MRI in patient selection for vertebroplasty, Do [16] noted that many patients had multiple vertebral compression fractures and that MRI might be useful in pinpointing more acute lesions. MRI helped not only to differentiate benign compression fractures from malignant and infectious lesions, but also to identify other neurological defects, such as herniated disc or causes of radiculopathy. It should be emphasized that MRI, if available, is the most important test in pre-operation evaluation. MRI may reveal that a chronic compression fracture has not improved or even worsened after vertebroplasty, more cases are needed for further evaluation [17].

In our series of studies, we also observed the additional effect of restoration of the heights of the treated vertebral bodies (Fig 2). Teng et al [18] stated that the anterior vertebral height significantly increased by 16.7% after vertebroplasty, much more than the posterior vertebral height did and

<table>
<thead>
<tr>
<th>Increase in vertebral body height</th>
<th>No. of treated vertebral bodies (%)</th>
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<tr>
<td>Less than 10%</td>
<td>43 (65)</td>
</tr>
<tr>
<td>Between 11 and 20%</td>
<td>14 (21)</td>
</tr>
<tr>
<td>Between 21 and 30%</td>
<td>5 (8)</td>
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<tr>
<td>More than 31%</td>
<td>4 (6)</td>
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<tr>
<td>Total</td>
<td>66 (100)</td>
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**Table 2. Immediate kyphoplasty effect of the 66 treated vertebral bodies**

![Figure 4](image-url) This 76 year old woman underwent percutaneous vertebroplasty for L1 compression fracture. Plain radiographs before (A) and after (B) the procedure reveal significant increase in anterior vertebral body height. MRI examination before vertebroplasty of this patient reveal fluid collections within the area of the vacuum cleft (arrowhead) and trabecular injury which appear hypointense on T1-weighted images (C) and hyperintense on T2-weighted sequences (D), indicating focal bone ischemia associated with nonhealing vertebral collapse.
stressed that both kyphoplasty and vertebroplasty may result in similar gain in the vertebral height at the anterior border and the center. In a prospective registry study, Garfin [19] reported that kyphoplasty performed within 3 months of fracture increased the height of the fractured vertebra, and improved kyphosis by over 50%. One such paper presented by Dudeney [20] reported a 34% recovery of lost height in the treatment of multiple myeloma. Although the purpose of vertebroplasty is mainly to relieve refractory pain, a mild kyphoplasty effect is also achieved. In our study (Table 3), we also noted that the effect of anterior body height increment were more significant in those vertebrae of which imaging study revealed intervertebral cleft in plain radiograph, osteonecrosis in MRI and contrast medium collection in a cavity in venography. These potential spaces in the vertebral bodies give an opportunity to open the anterior border for correction of the wedge angle during vertebroplasty as kyphoplasty acts [18].

After percutaneous vertebroplasty, complications are rare. The complication rate in osteoporotic fractures is 1-3% and as high as 10% in treatment of metastatic lesions [10, 21, 22]. The risks and complications of vertebroplasty, including bleeding, infection, pain, cement leakage, nerve root compression, paralysis, and pulmonary embolization have been reported previously. Complications usually result from injection of cement. The best method of safely injecting cement without unexpected or undesired migration has been the subject of much discussion. We believe that careful patient selection is essential to the success of percutaneous vertebroplasty and the injection under fluoroscopy must be extremely precise in order to avoid not only the spinal canal and existing nerve roots, but also the center of the posterior portion of the vertebral body due to the danger of entering a large channel of the basivertebral plexus. Clear views of the anatomy and cement deposition are very important for this procedure, especially in patients with severe scoliosis. Imaging of thoracic and lumbar vertebrae may be hampered by air in the lung and bowel gas. In our study, no obvious neurologic side effects have occurred during follow-up. In the most extensive previous study of osteoporotic fracture, the rate of radiculopathy was 4%, and the rate of cord compression was less than 0.5% [23]. In our study, we scheduled CT survey immediately after each procedure and remained in contact with the referring physician to ensure that cement did not migrate into the neural foramen and epidural space. Immediate post-operation examination for undesired cement migration, especially in cases of neurologic complication, is as important as safe cement injection because early detection may allow the clinical physician to take action before the migration becomes irreversible.

**CONCLUSIONS**

Imaging studies play an important role in percutaneous vertebroplasty. With appropriate pre-procedure image evaluation, high-quality-image guide during the procedure and early post-operation image survey, percutaneous vertebroplasty is an effective procedure for the treatment of pain and disability associated with osteoporotic compression fractures.

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REFERENCES


影像檢查在經皮穿刺脊椎整形術治療63位壓迫性骨折病人的角色：初步結果報告

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探討影像檢查在經皮穿刺脊椎整形術治療因骨質疏鬆性脊椎壓迫性骨折併發的背痛所扮演的角色。

共63位病人（12位男性51位女性；66個椎體）因為脊椎壓迫性骨折所引起的疼痛無法以藥物獲得緩解而接受經皮穿刺脊椎整形術治療。手術前，病人會接受X光片、電腦斷層或磁振造影的檢查，以確定病灶所在的位置。病人以靜脈注射鎮定劑後利用雙方位的透視X光機施行手術。在注射人工骨泥前（PMMA），都先施行椎體內靜脈攝影。術後病人立即接受電腦斷層檢查以評估人工骨泥注射的情形。3個月後再以問卷的方式評估病人疼痛改善的結果。

經過16個月的追蹤，86%的病人疼痛獲得的改善，86%的病人覺得滿意。臨床上，有一位病人術後發生疑似肺栓塞的症狀。總體的併發症為1.6%。結果顯示，術前磁振造影檢查對於術前病人的評估及計畫具有非常重要的角色。

在熟手與好的透視機導引下，經皮穿刺脊椎整形術對於壓迫性骨折所引起的疼痛是一種微侵入性且有效的治療。而各項影像檢查間是相輔相成的，且都有其重要性。

關鍵詞：脊椎整形術，壓迫性骨折，磁振造影，骨質疏鬆