

# The Relationship between the Compression Grade of Vertebrae and Outcome after Percutaneous Vertebroplasty in Patients with Osteoporotic Vertebral Compression Fractures

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**Objective :** The aim of this study is to assess the immediate and long-term efficacy of percutaneous vertebroplasty for treating painful vertebral osteoporotic fractures.

**Methods :** A retrospective review of 149 patients who had undergone 167 vertebroplasty procedures for osteoporotic fractures was performed. Clinical, radiologic, and procedural data were analyzed as parameters of prognostic significance, including age, sex, bone marrow density score, symptom duration, bone cement filling grade, number of fractured vertebrae, compression grade of vertebrae, leakage of bone cement, volume of bone cement injected and complications.

**Results :** In 158 of the 167 procedures assessed, immediate pain relief was obtained (94.6%). The extent of collapse of the vertebral body was assessed as a parameter for prognostic significance ( $p=0.015$ ). Three months postoperatively, no improvement of the pain was observed in four of the 167 procedures that had undergone the vertebroplasty (2%). At long-term follow-up, the improvement of pain was not correlated with the compression grade of vertebrae ( $p=0.420$ ).

**Conclusion :** The immediate outcome of vertebroplasty are less effective in vertebrae more collapsed.

**KEY WORDS :** Vertebroplasty · Compression grade of vertebra · Osteoporotic vertebral compression fractures.

## Introduction

Vertebroplasty has recently been used to treat painful osteoporotic compression fractures. In the elderly, these compression fractures induce severe and continuous pain. Conventional treatment for painful osteoporotic fractures of the spine typically includes bed rest, narcotic analgesics, and bracing. Recently, stabilization of vertebral bodies has been attempted with injection of polymethylmethacrylate (PMMA) into fractured vertebrae through a needle<sup>2,6,7,9,13,16,21</sup>. This procedure, known as percutaneous PMMA vertebroplasty, has been reported to result in substantial and immediate pain relief<sup>1-5,10,14,17</sup>. Many patients experienced pain relief by this procedure. However, some patients experienced no improvement and persistent pain. Possible causes of this tre-

atment failure are the epidural leakage of PMMA and inadequate selection of fractured vertebrae<sup>13,21</sup>. In this study, we analyzed these results to assess the immediate and long-term efficacy of percutaneous vertebroplasty.

## Materials and Methods

We retrospectively reviewed the outcomes of consecutive percutaneous vertebroplasty procedures performed at our hospital between September 1999 and December 2004. Of 342 patients treated by percutaneous vertebroplasty, 284 patients underwent magnetic resonance image (MRI) for selection of acute fracture levels. Exclusion criteria were scores above -2.5 (T score) for bone marrow density (BMD); 38 patients; Prodigy Bone Densitometry Equipment, MEC

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Lunar Corporation, Minster, OH, USA) and patients who were not followed up for at least three months after the vertebroplasty (97 patients). Therefore, we analyzed the medical records and radiologic images of 149 patients. Pain was classified by the McGill-Melzack Pain Questionnaire<sup>19)</sup> (0=no pain, 1=mild pain, 2=discomforting pain, 3=distressing pain, 4=horrible pain, 5=excruciating pain). The indicator for vertebroplasty is a pain level of more than 3 on the McGill-Melzack pain scoring system without definite radicular symptoms and signs. The MRI was used to select the fractured body that would be treated. We treated the fractured bodies that showed hypointensity on sagittal T1-weighted image.

The vertebroplasty procedure was performed according to the technique described by Jensen et al.<sup>10)</sup>. Briefly, patients were placed in a prone position on an angiographic table. The involved vertebrae were identified fluoroscopically and the overlying skin was prepared and draped. Local anesthesia was applied to the skin and deep structure. Fluoroscopic guidance allowed the placement of an 11-gauge bone marrow needle (Jamshidi type bone marrow needle, Manan Medical Products, Wheeling, IL, USA) via a bilateral or unilateral transpedicular approach. When the needle was advanced to the margin of the anterior 1/3 and middle 1/3 of the vertebral body, intraosseous venography was performed. If the contrast material drained into the venous plexus or surrounding paravertebral soft tissue, the position of the needle was corrected. The PMMA, which was mixed to the consistency of toothpaste, was injected by hand into the vertebral body with the use of 1 cc syringes. The McGill-Melzack pain scoring system<sup>19)</sup> was used to assess pain relief. Scores were obtained before and immediately after the procedure and three months after the procedure. A reduction of one or more level on the McGill-Melzack pain scoring system was considered an improvement in pain. The mobility of patients was classified by the Maynard scale<sup>18)</sup> (0=full activity, 1=walks with assistance, 2=requires wheelchair, 3=bed-ridden but can sit, 4=flat bedrest), before, after vertebroplasty, and at three months follow-up. Patients were interviewed in a clinic or contacted by phone periodically for continued data collection.

We analyzed age, sex, BMD scores, symptom duration, bone cement filling grade, number of fractured vertebrae, compression grade of vertebrae, leakage of bone cement, volume of bone cement injected and injection site (bilateral approach or unilateral transpedicular approach). The bone-cement filling grade was measured as the percentage of bone cement visible over the width of a vertebral body in a simple anteroposterior X-ray. Patients were divided into group 1=0~25% bone cement visible; group 2=25~50% bone cement visible, group 3=50~75% bone cement visible; and group 4=75~100% bone cement visible. Genant's semiquantitative visual

grading scheme<sup>8)</sup> was used to assess the compression grade of vertebrae. Each vertebra was graded by visual inspection of a lateral X-ray view as : mildly deformed (grade 1, approximately 20~25% reduction in anterior, middle, and/or posterior height and a reduction of area 10~20%); moderately deformed (grade 2, approximately 20~40% reduction); and severely deformed (grade 3, approximately 40% reduction in any height and area). Then, the each scores or classifications of the two or more fractured vertebrae belonged to higher group of the score or classification (fracture grade, filling grade).

## Statistical Analysis

Results are expressed as means  $\pm$  standard error of means. Statistical analysis was performed using commercially available software (SPSSWIN 10.0; SPSS, Inc. Chicago, IL, USA). Statistical analysis was performed using Fisher's exact test and linear-by-linear association. A p-value of less than 0.05 was considered statistically significant.

## Results

The mean age of patients was 70 years (range : 52~88 years). Eleven were male, and 127 were female (138 patients). Pain duration before vertebroplasty ranged from three days to 1095 days with a mean of  $33.52 \pm 93.09$  days. The mean BMD T-score was  $-3.80 \pm 0.84$  (range : -2.5 to -6.1). Of the 167 procedures conducted, a single vertebra was treated in 117 procedures, two vertebrae were treated in 46 procedures, and three vertebrae were treated in four procedures.

The site of compression fractures treated involved 103 thoracic spines and 118 lumbar spines. According to the McGill-Melzack pain scoring system<sup>19)</sup>, 82 procedures were rated level 3, 70 procedures were rated level 4, and 15 procedures were rated level 5. According to the Maynard scale<sup>18)</sup>, the mobility score of patients in 27 procedures was 0, the mobility score of patients in 38 procedures was 1, the mobility score of patients in six procedures was 2, the mobility score of patients in 36 procedures was 3, and the mobility score of patients in 59 procedures was 4. The mobility score was not determined for one patient. The compression grade of vertebrae was assessed : 66 were classified as group 1, 63 were classified as group 2, and 38 were classified as group 3.

The mean volume of injected PMMA was  $3.78 \pm 0.96$  cc, (range : 0.9 cc to 9.0 cc). Unilateral approaches were used in 185 procedures, and bilateral approaches were used in 36 procedures. The grade of the bone cement filling was distributed across several grades : six procedures were classified as grade 1, 41 procedures were classified as grade 2, 44 procedures were classified as grade 3, and 76 procedures were classified

**Table 1.** Immediate pain improvement according to compression grade of vertebra

FG	Immediate improvement of pain (procedures)	No immediate improvement of pain (procedures)
1	65	1
2	60	3
3	33	5

FG : fracture grade

**Table 2.** Late follow-up pain improvement according to compression grade of vertebra

FG	Late improvement of pain (procedures)	No late improvement of pain (procedures)
1	65	1
2	61	2
3	37	1

FG : fracture grade

as grade 4.

The McGill-Melzack Pain Questionnaire<sup>19)</sup> score after vertebroplasty improved in 158 procedures (94.6%, 158/167). Of these 158 procedures, almost all had resulted in improvement after one day (113patients); the remaining patients showed improvement between two and 30days. Immediate pain relief was not correlated with age, sex, BMD score, symptom duration, bone cement filling grade, number of fractured vertebrae, leakage of bone cement, and volume of bone cement injected ( $p > 0.05$ ). The compression grade of vertebrae was statistically significant ( $p = 0.015$ , calculated linear by linear association) (Table 1). In 146 (87.4%) procedures, at least one scale of improvement in mobility was noted (range of improvement, 1~4 points).

Three months after the procedure, pain intensity had improved in 163 of the procedures conducted on patients (98%) and was unchanged in four (2%). All variables, including the compression grade of vertebrae, were not related to long-term pain relief ( $p = 0.420$ , calculated linear by linear association) (Table 2).

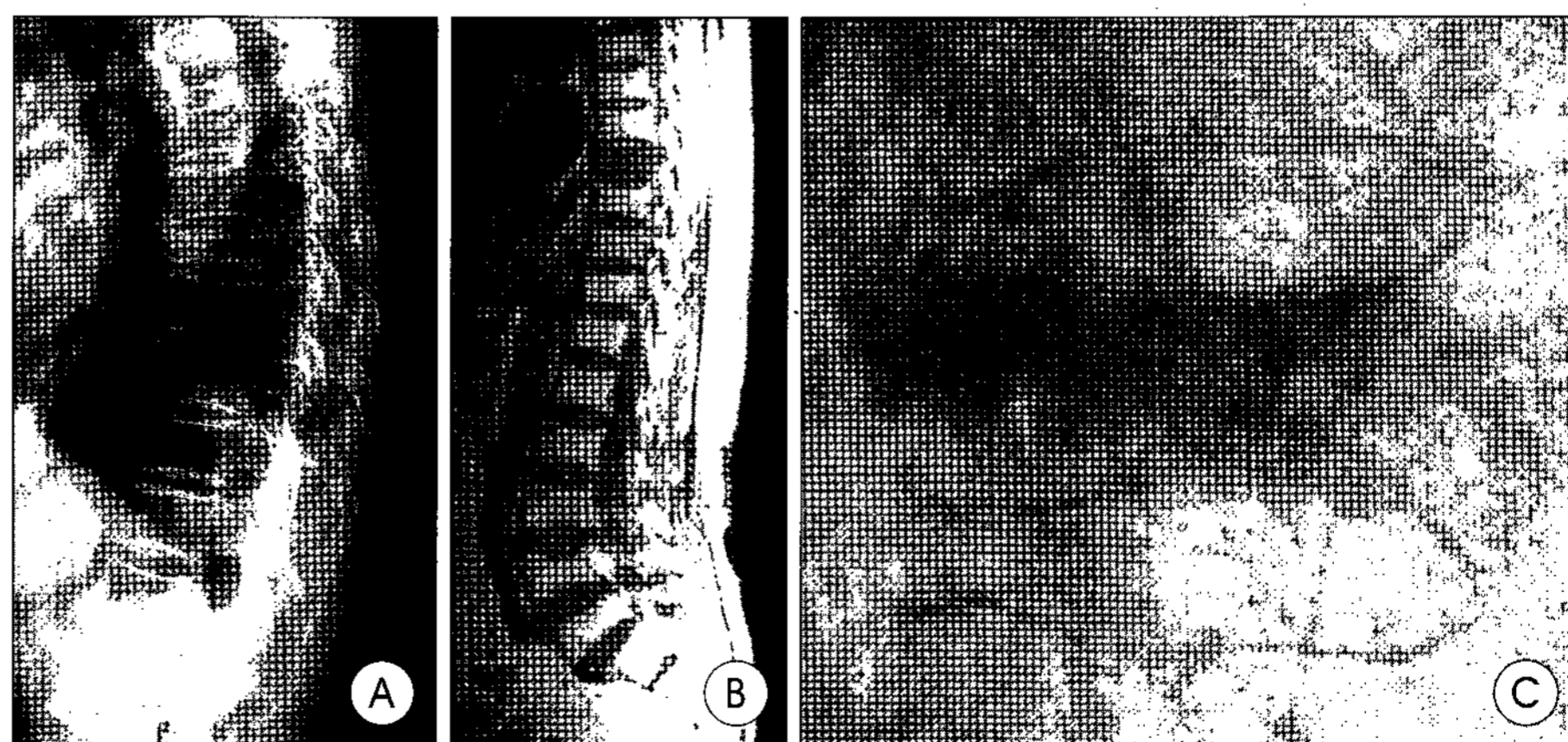
Intra- or post-operatively, two patients had chest wall pain along the rib. Two other patients briefly complained about difficult respiration due to probable pulmonary embolism. One patient, who was treated for the thoracic eighth and 12th vertebrae, developed a paraparesis from a massive PMMA leakage into the spinal canal. She received emergent laminectomy with bone cement removal. Two months later, she could walk with assistance.

Seventy-one patients underwent simple imaging three months after the procedure. Images from 48patients had not changed. However, compression fractures in neighboring vertebral bodies were noted in 23patients.

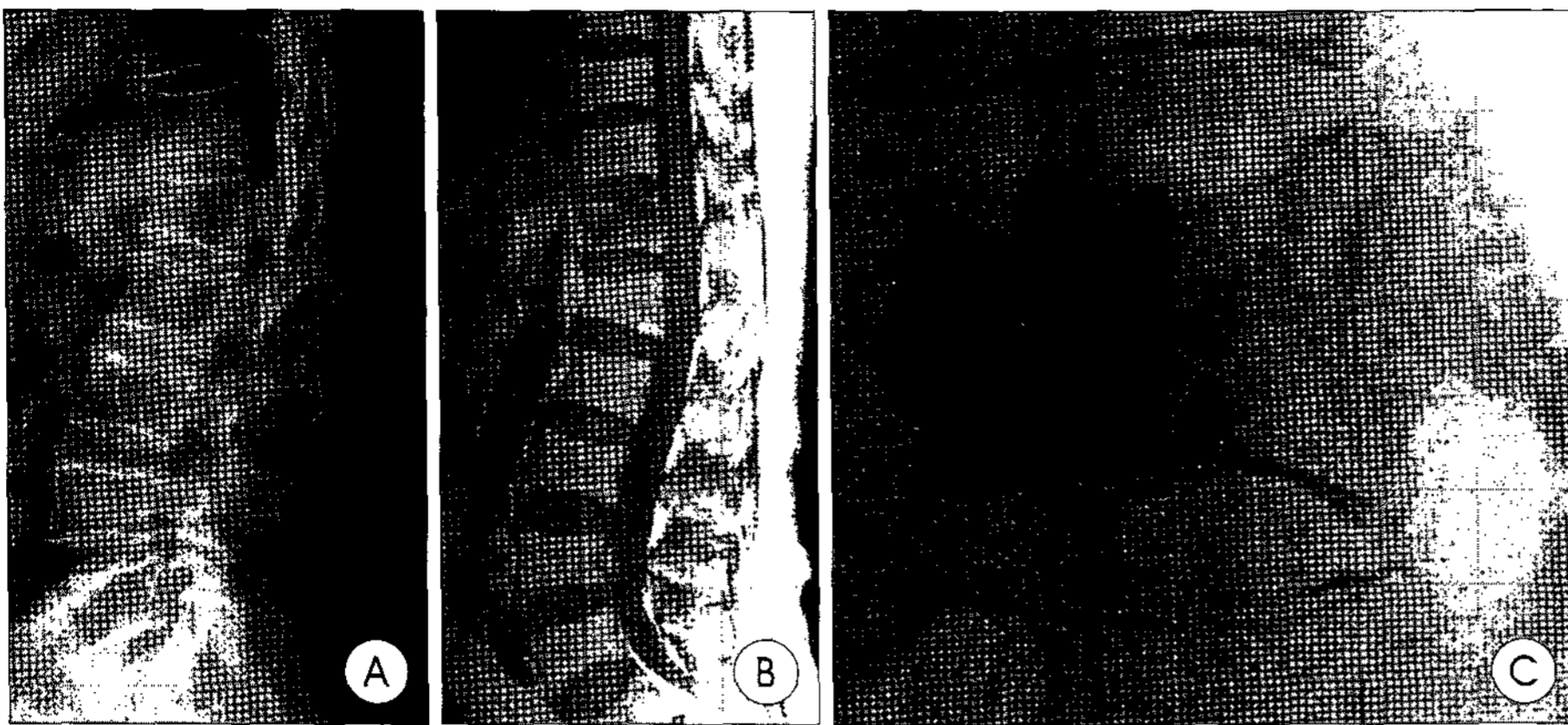
## Discussion

Percutaneous vertebroplasty using PMMA is very beneficial and well tolerated in patients with painful vertebral compression fractures. Some authors report that the effect of vertebroplasty on pain relief may be 75~90%<sup>1-5,10,14,17,22,23)</sup>. Although vertebroplasty has been applied clinically for more than 15years, inclusion and exclusion criteria of the procedure for treating osteoporotic compression fractures have varied widely in the case series reported<sup>1-5,10,14,17,23)</sup>. Response to the treatment also varies according to the patient, and some patients do not improve and have persistent pain. Thus, we assessed the factors affecting the outcome of percutaneous vertebroplasty for the treatment of persistent painful osteoporotic fractures.

Maynard et al.<sup>18)</sup> reported subjective pain relief in 26 (93%) of 28patient sessions that showed increased activity revealed by bone scan imaging, which is highly predictive of a positive clinical response to vertebroplasty. Some investigators consider that the age at which a fracture occurs is an important predictor of expected pain relief after vertebroplasty<sup>11)</sup>. However, others report that clinical outcomes after vertebroplasty do not directly correlate with the age at which a fracture occurs<sup>11,13)</sup>. Recently, some authors have suggested that the epidural leakage of PMMA may attenuate the immediate therapeutic effects of vertebroplasty<sup>21)</sup>. Kim et al.<sup>12)</sup> report that vertebroplasty in patients with more collapsed vertebrae results in decreased immediate and late therapeutic effects however, neither MRI



**Fig. 1.** A simple X-ray showing a fractured vertebral body in the eighth thoracic spine (grade 3, approximately 40% reduction in height and area) (A). A T1-weighted magnetic resonance sagittal image revealing hypointensity in a fractured vertebral body (B). Postoperative radiography demonstrating the eighth thoracic spine filled with the bone cement (C). The patient is an 81-year-old woman who experienced no immediate pain relief after vertebroplasty.



**Fig. 2.** In a simple X-ray, the 12th thoracic vertebral body and 1st lumbar vertebral body showing a suspicious fracture (grade 1, approximately 20~25% reduction) (A). The 12th thoracic vertebral body showing hypointensity on T1-weighted magnetic resonance sagittal image (B). The patient underwent vertebroplasty at the 12th thoracic vertebral body (C). The patient is a 72-year-old woman and experienced no pain after vertebroplasty.

or whole body bone scan images were performed for some of these patients before vertebroplasty, and therefore the study might have selection bias<sup>12)</sup>. Recently Alvarez et al.<sup>1)</sup> reported that better results can be expected in those patients who have a loss of vertebral body height of less than 70%, and where the level of fracture is confirmed by MRI.

Ryan et al.<sup>20)</sup> suggest that clinically significant associations can be found between back pain and degree of kyphosis, number of collapsed vertebrae and score for fracture severity. Some authors propose that altered biomechanics secondary to vertebral compression may contribute to the pain syndrome. However, with rare exception, percutaneous vertebroplasty does not restore lost vertebral height<sup>2,23)</sup>, which may explain the partial or absent pain response in some patient after treatment.

Compared with previous reports, in our study, whole patients were performed MRI for osteoporotic vertebral fracture. The more collapsed vertebrae appear to decrease the immediate benefit of pain reduction after vertebroplasty for osteoporotic vertebral fracture (Fig. 1, 2). The long-term benefits, however, did not statistically correlate with the degree of the compression grade of vertebrae. We propose that the changed biomechanics secondary to vertebral compression, after stabilization with time, may be a cause of pain relief in long-term follow-up. That is, at the three-month follow-up, fractured vertebrae had stabilized and the pain experienced by the patients sub-sided regardless of vertebroplasty.

In our study, we made no mention of the kyphosis correlated with spinal biomechanics that might illustrate pain relief<sup>20,23)</sup>. Another problem is that we did not consider epidural leakage after vertebroplasty. Ryu et al.<sup>21)</sup> report that the long-term benefits of vertebroplasty are realized after three months in all patients, regardless of whether epidural leakage of the PMMA occurred<sup>21)</sup>. In our study, epidural leakage was not confirmed by plain radiography or computed tomographic scanning, except

for some patients. Therefore, we cannot analyze epidural leakage in patients who continue to experience pain. Our study is limited by its sample size and the selection and review biases inherent in many retrospective observational studies. However, it helps selection of those patients who are likely to be more satisfied once the procedure has been decided on. Finally, large controlled prospective studies are needed for determining prognostic factors, for example the degrees of kyphosis, the number of collapsed vertebrae, epidural leakage, etc.

## Conclusion

The immediate outcome of vertebroplasty may be less effective in vertebrae more collapsed. So this may enable the short-term outcome of patients to be predicted, but more prospective research is needed to identify other factors that related with outcomes of the vertebroplasty.

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## Commentary

I read the article with great interest. I highly estimate the author's idea that correlates between the degree of vertebral

body collapse and pain reduction. It is known that the mechanism of pain reduction after vertebroplasty is that first, polymethylmethacrylate PMMA strengthens the collapsed body mechanically second, polymerization of PMMA injected into the spine occurs and heat damage in the peripheral nervous area. Third, PMMA monomer that is not polymerized is toxic to nociceptive nerve in the spine. Thus the pain is reduced by vertebroplasty. In other words, through vertebroplasty, the pain caused by nociceptor of bone itself could be resolved. But, both facet and costovertebral joints are well innervated and are agreed to be a source of pain. Any significant abnormal angulation of the spine caused by collapse cause alteration to neutral position and stresses the joint capsule and articular cartilage. This alters the local biomechanics causing pain. It is also likely to provoke spinal reflexes in the affected segments causing paraspinal muscle spasm. The pain caused by such mechanism is not resolved by vertebroplasty especially in more severely collapsed cases. Particularly in some severe compressions, the overburden of the facet joints is increased.

I suggest this kind of pain can be resolved by radiofrequency neurotomy of the involved joints. In our clinic we block the involved facet joints with local anesthetic in severely compressed cases. If pain reduction is significant we do RF neurotomy.

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