Percutaneous Vertebroplasty for Vertebral Compression Fracture

Indication, Technique, and Review of the Literature

Masahiro Kawanishi, Akira Morimoto, Yasuaki Okuda, Daisuke Satoh, Nahoko Matsuda, Yutaka Itoh, and Hajime Handa

Background: Percutaneous vertebroplasty is a less invasive method for the treatment of vertebral compression fractures. Several studies have reported the occurrence of severe complications caused by leakage of the injected materials after percutaneous vertebroplasty, however.

Objectives: Safe and accurate procedures of percutaneous vertebroplasty were examined, and the short-term results were evaluated. Methods for the prevention of complications were also evaluated.

Methods and Results: The subjects were 24 patients (30 vertebrae), consisting of 8 men and 16 women with a mean age of 78.4 years. Neurologic or systemic complications, such as pulmonary embolism, were not observed. After surgery, no aggravation of pain was observed, and pain was alleviated in 22 patients. The mean visual analog scale (VAS) score was 6.9 points before surgery and 1.2 points after surgery. Before surgery, 8 patients could walk by themselves, 4 patients could walk with a little help, and 12 patients could not walk, whereas after surgery, 20 patients could walk by themselves. Of these 20 patients, 14 could walk by themselves on the day of or next day after surgery and 6 could walk within 4 days after surgery.

Conclusions: Percutaneous vertebroplasty for the treatment of compression fractures removed pain in more than 90% of the patients, indicating good short-term results. To obtain good results without complications by this method, accurate determination of the vertebrae to be treated, the body position, needling under the guidance of fluoroscopy and computed tomography (CT), and cement injection based on venographic findings by CT and fluoroscopy are important.

Key Words: vertebroplasty, vertebral compression fracture, complication, intervention

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Elderly patients who cannot turn over because of back pain caused by vertebral compression fractures obtain relief from the pain by manual treatment under local anesthesia, which takes approximately 30 minutes, and can walk the next day. This is possible by means of percutaneous vertebroplasty for the treatment of compression fractures. This method removes pain derived from a fractured bone by percutaneous injection of bone cement into the vertebral body with a compression fracture and is applied to osteoporotic compression fractures, metastatic vertebral tumors, and primary vertebral body lesions. In Europe and North America, this method has been used for more than 15 years and its effectiveness has been established.[1–17] Complications caused by leakage of injection materials, such as pulmonary embolism and neurologic disorders, have been reported, however. In the present study, we describe our safe and accurate technique of percutaneous vertebroplasty and evaluate the short-term results. We also report on a representative patient and indicate procedures for the prevention of complications.

MATERIALS AND METHODS

Clinical Subjects and Methods

Of the 25 patients (32 vertebrae) who underwent percutaneous vertebroplasty in our hospital between July 2003 and August 2004, 24 patients (30 vertebrae) with a compression fracture, excluding 1 patient with a hematoma treated by ethanol injection, were studied. All patients had pain derived from the vertebrae caused by a compression fracture, and patients with neurologic symptoms, such as palsy, were excluded. The patients consisted of 8 men and 16 women with a mean age of 78.4 years (range: 45–93 years). The period between the occurrence of fracture and the start of treatment ranged from 4 days to 18 months in 23 patients, and 1 patient started treatment 15 years after the occurrence of a fracture. The affected vertebrae were 15 thoracic and 15 lumbar vertebrae. The causes of the compression fracture were metastatic vertebral tumor in 1 vertebral body and osteoporosis in 29 vertebrae. The injection volume of bone cement (polymethylmethacrylate [PMMA]), mean surgery time, and complications were examined. The pain level was evaluated using a visual analog scale (VAS) before and after surgery, and the walking condition was also evaluated using a 3-grade classification: walking by oneself, walking with help, and impossible to walk. The period required for the start of walking after surgery was examined in patients who could not walk by themselves before surgery.

Treatment Procedures

To observe the patient easily, computed tomography (CT) and portable fluoroscopy (C-arm) are arranged and the

From the Department of Neurosurgery, Ijinkai Takeda General Hospital, Iseikai, Kyoto City, Japan.
Reprints: Masahiro Kawanishi, MD, Department of Neurosurgey, Ijinkai Takeda General Hospital, 28-1 Ishidamori Minamimachi Fushimiku, Kyoto City 601-1495, Japan (e-mail: mkawanis@takedahp.or.jp).

patient is placed in the prone position, with the head is close to the physicians. In patients with severe anterior curvature, fracture of ribs and overextension of the cervical vertebrae are prevented using pads and pillows. Patients with pain caused by instability of nonunion should be placed in the extension position. The height of the foregut osteophytes is adjusted so that the affected vertebrae are aligned perpendicularly, and the gantry is positioned perpendicularly. CT is performed by placing the marker on the median of the skin adjacent to the affected vertebral corpus. To indwell a needle in the front one third to one quarter of the median of the vertebral corpus, the insertion course is determined. In the lumbar vertebrae, the insertion point can easily be determined using the point at which the transverse process and the superior articular process encounter the pedicle of the vertebral arch or at the accessory process as the standard. In the middle to upper thoracic vertebrae, however, if only the course via the pedicle of the vertebral arch is tried, the needle cannot be introduced into the median of the vertebral corpus, because the puncture angle becomes nearly 90°. In such cases, needling can be performed via the rib and transverse process (Fig. 1). If needling in this course is difficult, bilateral needling and injection are used. After determination of the insertion site and angle on the skin, disinfection and local anesthesia are applied, and temporary needling up to the bone cortex is performed using a 23-gauge Cathelin needle while assistants measure the angle as determined by CT. Needling into the thoracic or upper lumbar vertebrae is performed with caution to prevent pneumothorax. The depth and direction of the needle are confirmed, and a 13-gauge or 11-gauge needle for bone biopsy (15-cm osteocyte needle, M2 type; Cook) is inserted along the temporarily inserted needle. Needling into thoracic or lumbar vertebrae with severe denaturation is performed so as not to slide from the needling course. Accurate needling can be performed by repeated motion of a half turn and a reverse turn by fixing the needle with both hands, as in drilling a hole into a board. When the needle penetrates the bone cortex, its position and direction are reconfirmed by CT, because the insertion course can be corrected at that time. Based on the depth of the needle tip as measured by CT, needling is continued by repeated motion of a half turn and a reverse turn while recognizing intramedullary resistance at a certain level. When resistance is felt above a certain level, the needle is striking the medial or lateral pedicle wall of the vertebral arch in most cases. CT must be performed after discontinuation of needling, and the needling direction is corrected by turning the needle back to the bone cortex. After the needle is indwelled in the front one third to one quarter of the median of the vertebral body, examination is performed using lateral fluoroscopy and contrast CT. CT is performed for imaging of dynamics and immediately after administration of contrast (Fig. 2A). When reflux to the vertebral canal or an outward vein from the vertebral corpus is observed in the early stage, the position of the needle is adjusted or the needle is reinserted from the opposite side. If reflux to the vertebral canal or an outward large vein from the vertebral body (ie, dangerous vein) is observed even after such treatment (see Fig. 2A), a small amount of Aviten dissolved in physiologic saline is injected to prevent early reflux to the vein (see Fig. 2B). After confirmation of safety, the injected contrast medium is flushed with physiologic saline under fluoroscopic guidance and the PMMA (Surgical Simplex; Nihon Stryker) is prepared. Solidification of PMMA is delayed by packing the PMMA container and syringe in ice. The visibility of commercially available PMMA, in which 10% barium has been mixed, is low. Because the visibility of PMMA containing 25% to 30% barium is good, approximately 4 g sterilized barium is added. Because the addition of a large amount of barium makes the viscosity of PMMA high, the preparation should be performed with caution. The dead space of the needle (eg, 0.7 mL in an 11-gauge needle) needs to be known. Approximately 3 minutes after starting to stir the PMMA liquid and powder, the injection of PMMA is begun under the guidance of lateral fluoroscopy using a 1-mL syringe with a lock. The injection is rapidly performed up to the dead space, and it is then slowly injected with caution with regard to its leakage from the vertebral body. It is important that the surgeon keeps the fluoroscopy monitor in view while receiving each 1-mL syringe from the assistant. If leakage is observed, the PMMA should be immediately sucked back in the syringe by negative pressure. After a short time, the injection is restarted by changing the direction of the needle or pulling the needle back. When PMMA reaches up to a position one quarter from the back of the vertebral corpus, injection with the needle is terminated irrespective of the amount of injected PMMA. After an inner tube is inserted, the needle is removed. For recovery of the needling site, the patient rests in bed for 1 to 2 hours after surgery before being allowed to stand up and walk. No postoperative treatment is needed. The patient may be discharged from the hospital on the day of surgery or the next day.

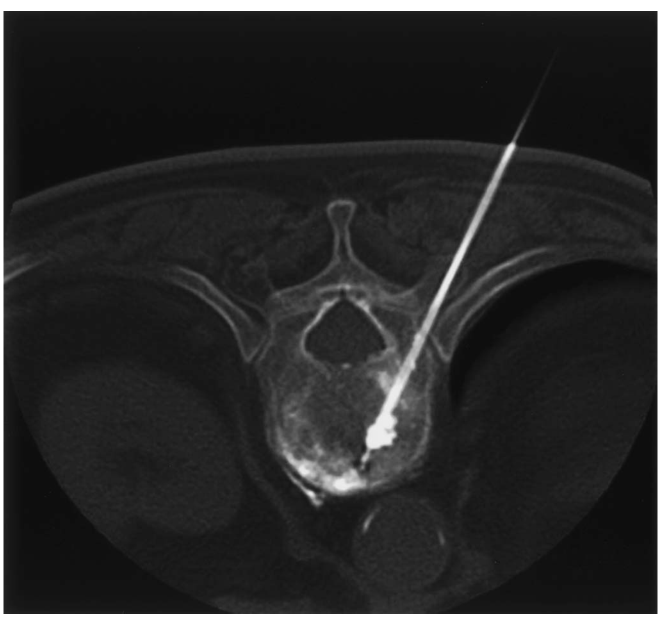

FIGURE 1. CT during surgery. Needling into the thoracic vertebra via the rib and transverse process is useful, as demonstrated in this patient.

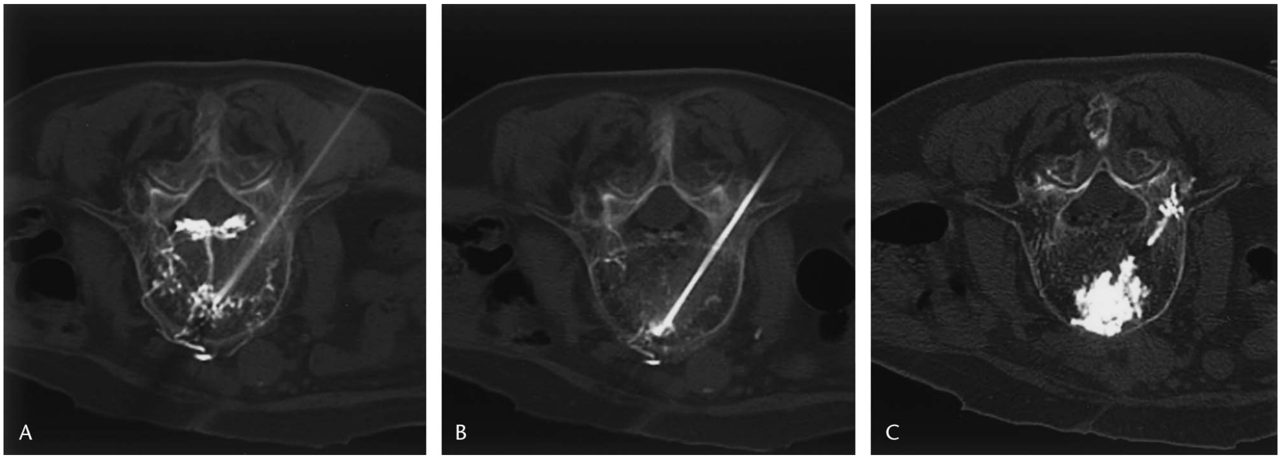

FIGURE 2. A, CT is performed for imaging of dynamics and immediately after administration of contrast. The internal vertebral venous plexus was visualized via a basivertebral vein, a dangerous anastomosis. B, CT after embolization. The internal vertebral venous plexus was not seen. C, Postoperative CT. The bone cement was almost homogeneously distributed in the vertebrae.

RESULTS

The mean amount of injected PMMA was 2.4 mL (range: 1.7–3.9 mL) in the thoracic vertebrae and 3.1 mL (range: 1.8–4.2 mL) in the lumbar vertebrae. The mean time of surgery per vertebral corpus was 34 minutes (range: 25–58 minutes). Systemic complications, such as neurologic disorders and pulmonary embolism, were not observed. Pain was alleviated in 22 of the 24 patients and unchanged in 2 patients, but no aggravation was observed (Fig. 3). The mean VAS pain score was 6.9 points before surgery and 1.2 points after surgery. The preoperative activities of daily living (ADL) classification was "walk by oneself" in 8 patients, "walk with a little help" in 4 patients, and "cannot walk because of pain" in 12 patients. After surgery, 20 patients could walk by themselves and 4 patients, including 1 patient who died of aggravated hepatic cancer, could not walk by themselves (Fig. 4). Of the 20 patients, 14 could walk by themselves on the day of or day after surgery and the remaining 6 patients could walk by themselves within 4 days after surgery (Fig. 5).

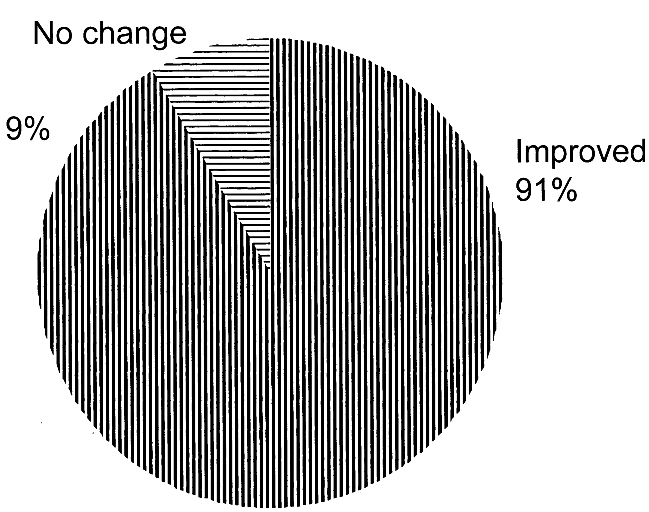

FIGURE 3. Postoperative changes in the pain. Pain was alleviated in 22 of the 24 patients (improvement [91%]) and unchanged in 2 patients (no change [9%]), but no aggravation was observed.

Illustrative Case Presentation

An 83-year-old woman had severe back pain when bending forward 2 weeks before and could not walk or stand. The patient was admitted to a local hospital and underwent conservative treatment. Because the pain was severe, however, the patient was referred to our hospital. At admission to our hospital, the patient lay in bed all day because of back pain without palsy in the lower limbs and could not turn over by herself. The patient avoided clearing her throat or even talking, and disuse dementia symptoms were observed. Pain was induced by tapping on the 11th thoracic vertebrae. The vertebral corpus demonstrated high signal intensity by fat-suppression magnetic resonance imaging (MRI) (Fig. 6). Percutaneous vertebroplasty was performed in the vertebral body under local anesthesia. The pain disappeared on the night of surgery, and the patient could sit on the next day of surgery, walk with help on the second day, and walk by herself on the fourth day. The patient was discharged from the hospital 7 days after surgery and lived the same life as before the injury without dorsalgia as of 6 months after surgery.

DISCUSSION

In conventional methods for the treatment of compression fracture, patients remain in bed for several weeks to several months before being allowed to leave bed under careful control so as not to crush the vertebrae. In an osteoporotic compression fracture, the incidence of which is high in elderly patients, systemic complications attributable to lying in bed for a long time, such as disuse muscular atrophy, dementia, and pneumonia, often occur, damaging the patient's ADL markedly. Conversely, percutaneous vertebroplasty can be performed under local anesthesia using a signal needle, and pain relief can be obtained immediately, indicating this is a treatment that

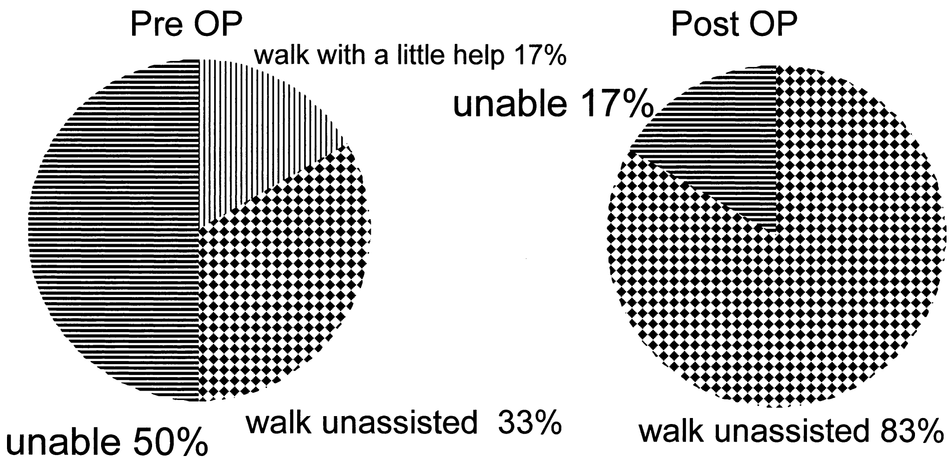

FIGURE 4. Changes in walking conditions before and after surgery. The preoperative ADL was ''walk by oneself'' in 8 patients (ambulation [33%]), ''walk with a little help'' in 4 patients (assistance required [17%]), and ''cannot walk because of pain'' in 12 patients (unable to walk [50%]). After surgery, 20 patients could walk by themselves (ambulation [83%]) and 4 patients, including 1 patient who died of aggravated hepatic cancer, could not walk by themselves (unable to walk [17%]).

makes it possible for patients to move around much earlier. Approximately one third of the patients in this study were admitted from distant regions and discharged from the hospital the next day after surgery, indicating that day surgery is possible and this method is economically useful. The most severe complications caused by percutaneous vertebroplasty are neurologic disorders caused by leakage of bone cement and pulmonary embolism, but neither complications nor mismanagement occurred in our patients. Percutaneous vertebroplasty performed using procedures for the prevention of complications, as described here, is a safe method for the treatment of compression fractures.

Purpose and Application of Percutaneous Vertebroplasty

Percutaneous vertebroplasty can be applied to osteoporotic compression fractures, metastatic vertebral tumors, and primary vertebral corpus lesions, and this treatment is performed to remove bone-derived pain caused by these diseases.[1–17] This method was initially considered to be useful for the treatment of patients in the acute stage, but recent studies[18,19] as well as our study have indicated that pain was alleviated even in chronic patients with nonunion. It has been considered that this method does not provide effective fixation and is ineffective, but it has been reported that a combination of injection of bone cement and internal fixation with pedicle screws reduced instrument failure[20] and was useful for the treatment of nonunion,[18] suggesting that vertebrae are stabilized by inhibiting the development of microfractures.[21] The mechanism

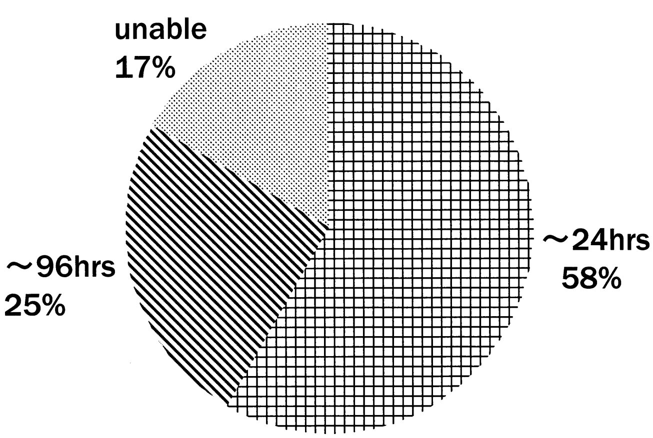

FIGURE 5. Period required to begin walking after surgery. Of the 20 patients, 14 could walk by themselves on the day of or day after surgery (~24 hours [58%]) and the remaining 6 patients could walk by themselves within 4 days after surgery (~96 hours [25%]).

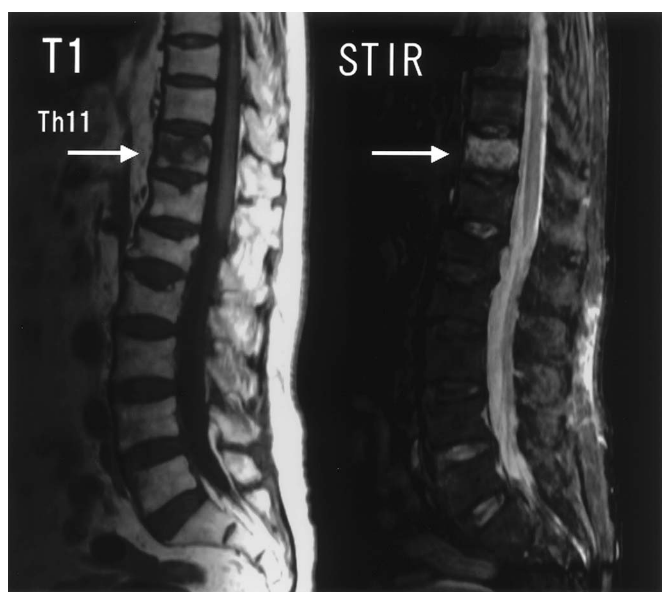

FIGURE 6. MRI scans. A T1-weighted scan (left) and fat-suppression scan (right) are shown. Because fresh compression fractures show high signal intensity (→) by fat-suppression imaging, this imaging is useful for the identification of the affected vertebrae.

of pain relief has not been clarified, but past studies[1–19] as well as the present study have indicated that pain was removed in approximately 80% to 90% patients.

The important procedures for achieving good results without complications are summarized below.

Determination of the Affected Vertebrae

When a compression fracture occurs in a single vertebral body, its determination in the acute stage is easy in most cases. In chronic vertebrae with osteoporotic compression fractures, however, the affected vertebrae cannot always be determined using plain radiographs of crushed lesions alone. It is important to identify the affected vertebrae based on pain by tapping under the guidance of fluoroscopy and to confirm the agreement with the vertebrae showing high signal intensity on fat-suppression MRI. The final determination is made based on clinical symptoms, such as pain by tapping and pain in the median region, changes in the signal intensity of the vertebrae and their contrast by fat-suppression MRI, and accumulation of images using osteoscintigraphy.[22] There are opinions that osteoscintigraphy is unnecessary because of the difficulty in evaluating images and the considerable costs,[23] but osteoscintigraphy is sometimes useful for the examination of chronic multiple lesions in which neither changes in the signal intensity nor contrast effects are obtained by MRI. We have performed osteoscintigraphy only in lesions that are difficult to identify with MRI. Accumulation by osteoscintigraphy should be observed until 2 years after the fracture occurs, and osteoscintigraphy is useful for the examination of fractures in the subacute stage 3 to 6 months after the fracture occurs and for fractures occurring at an unknown time.[22]

Needling

When CT is performed in elderly patients with severe osteoporosis in the prone position, it is important to prevent the fracture of ribs or overextension of the cervical vertebrae. Generally, needling is easy when monitoring clear fluoroscopic images, but easy and accurate needling into flat vertebrae and upper and middle thoracic vertebrae requires guidance by CT as well as fluoroscopic observation.[9]

We have performed needling with a combination of CT and lateral fluoroscopy. In principle, lateral observation is performed by fluoroscopy and horizontal sections are observed by CT. Additional observation of lateral sections by CT makes needling more accurate.

Cement Injection

To prevent complications attributable to leakage of cement, we perform contrast imaging of the affected vertebrae with a contrast medium before injection of cement. Contrast imaging of the vertebrae has been reported to be unnecessary, but recent studies have indicated that neurologic symptoms were aggravated by reflux of cement to pulmonary emboli and the extradural venous plexus.[24–26] Therefore, we perform contrast imaging of the affected vertebrae in all patients. In particular, we consider that imaging of horizontal sections (ie, CT kymography) and thin-slice CT immediately after contrast imaging are useful for the prevention of complications caused by leakage of cement. When veins into and from the vertebral canal are imaged in the early stage by CT kymography, the veins are embolized with Aviten and cement injection is safely performed after confirmation of their obstruction (see Fig. 2). A significant outflow into the vein, for which even embolization of the vein with Aviten carries a risk, is sometimes observed. In such a case, the vein is obstructed by injecting a small amount (approximately 0.1 mL) of cement with slightly high viscosity without pressure. The needle is changed, and cement is injected using another needle under fluoroscopic guidance. It is important to note that in a vein in which significant outflow is observed, the leakage from the needling course cannot be prevented only by changing the position of the needle tip, because the route generated by the needle remains.

Problems of Percutaneous Vertebroplasty

The short-term results of percutaneous vertebroplasty were good, and immediate pain relief was stably obtained, as in past studies, indicating that this method is useful. The incidence of a postoperative compression fracture in the adjacent vertebrae is 10% to 20%, however.[27] Of the patients evaluated in this study, a postoperative compression fracture in other regions was observed in 2 patients. Follow-up observations of these patients have been performed as well as lifestyle guidance for patients with osteoporosis and oral administration of drugs. In the future, the development of new filling materials is expected.

CONCLUSIONS

Percutaneous vertebroplasty of compression fractures, which is less invasive, removed pain in more than 90% of the patients and allowed the patients to leave bed early after surgery. The short-term results were good. To obtain good results without complications by this method, accurate determination of the affected vertebrae by clinical findings, MRI, and scintigraphy; the body position; needling under the guidance of fluoroscopy and CT; and cement injection based on venographic findings by CT and fluoroscopy are important.

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