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Unpredictable Spontaneous Fusion after Percutaneous Vertebroplasty and Kyphoplasty in Osteoporotic Compression Fracture

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Introduction: We found a spontaneous fusion at adjacent vertebrae after percutaneous vertebroplasty (PVP) or kyphoplasty in osteoporotic compression fractures and analyze the radiologic & clinical characteristics.
Materials & Methods: Between January 2000 and December 2011, 555 patients were treated with PVP or kyphoplasty for osteoporotic compression fracture in our department. We classified the spontaneous fusion as two groups. One is solid spontaneous fusion group with at least three cortical continuity to adjacent vertebrae, the other is partially fusion group which progressed fusion compared to previous radiologic finding. We reviewed the plain film and analyzed the radiologic characteristics of those patients with duration of fusion, location and extent of fused segments. A clinical characteristic by visual analogue score (VAS) compared to our previous report was checked.
Results: Among them, 54 patients (9.7%) had an solid spontaneous fusion and 43 patients (7.7%) had partially fused on plane image. In solid fusion group, the average duration of fusion was 19 months ranged of 3 to 48 months. Forty six cases (85%) of solid fusion patients had occurred with proximal adjacent vertebrae and 7 cases (13%) had proximal with distal adjacent vertebrae. Forty one cases (76%) of spontaneous fusion occurred within 1 segment and 13 cases within multiple segments. The most cases of solid fusion group were occurred at thoracolumbar junction (40 patients, 74%). Mean VAS score of solid fusion group was 2.0 at final follow-up and were analyzed relatively low score compared to mean VAS of our previous report (2.0, 2.8 respectively).
Conclusion: After percutaneous vertebroplasty or kyphoplasty in osteoporotic compression fracture, unpredictable spontaneous fusion could develop more than 10% rate, especially with proximal vertebra within 1 segment at thoracolumbar junction in radiologic aspect. Clinically, patients with spontaneous fusion had a tendency of more reduced pain than others.

Key Words: Osteoporotic vertebral compression fracture, Percutaneous vertebroplasty, Spontaneous fusion, Kyphoplasty

The frequency of vertebral compression fractures caused by osteoporosis, metastatic disease, or trauma of the spine in the general population increases with age. Among these various causes of vertebral compression fractures, osteoporosis is the most common. Recently, studies have shown an incidence of approximately 30% prevalence of osteoporosis and 20% osteoporotic compression fractures in postmenopausal women.[1] Osteoporotic compression fractures that increase the rate of other osteoporotic compression fractures and kyphotic deformities are associated with chronic back pain in 84% of symptomatic patients.[2] Mobility losses and

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mortality rates due to medical complications of osteoporotic compression fractures are also increasing.[3,4]

There are two minimally invasive spine augmentation techniques for vertebral compression fractures, percutaneous vertebroplasty (PVP) and kyphoplasty (KP). PVP, introduced in France in 1984, involves the percutaneous injection of cement directly into the cancellous bone of a vertebral body. KP, introduced in 2001, is a modification of PVP in which a balloon device is inflated in the vertebral body to create a cavity for cement injection.[5] Both PVP and KP provide excellent short-term pain relief and functional restoration.[5-10] The area surrounding the osteoporotic compression fracture after PVP or KP goes through many healing-related changes in the long term.[11,12]

Numerous reports have demonstrated the effectiveness of PVP and KP. Our recent report detailed the long-term follow-up results of PVP after osteoporotic compression fractures.[13] We observed the progression of bony bridging across the adjacent vertebrae after PVP or KP in osteoporotic compression fractures on serial radiographs, and named this phenomenon “spontaneous fusion.”

The purpose of this study was to analyze the clinical and radiological characteristics of spontaneous fusion.

MATERIALS AND METHODS

1. Demography

We examined 555 patients (233 men and 322 women) with a mean age of 72 years (39-94 years) who underwent PVP or KP for osteoporotic compression fractures of the thoracic or lumbar vertebrae between January 2000 and December 2011. All patients were suffering from persistent pain after post-traumatic conservative treatment or vertebral collapse after the progression of compression fracture. In terms of the injured area, compression fractures in the 1st lumbar vertebra accounted for 208 cases, followed by 173 cases in the 12th thoracic vertebra, 64 cases in the 2nd lumbar vertebra, 46 cases in the 3rd lumbar vertebra, 46 cases in the 11th thoracic vertebra, and 18 cases in the 4th lumbar vertebra. Bone mineral densitometry showed a mean T-score of -2.9.

2. Preoperative patient evaluation, surgical technique, and postoperative care

Surgical intervention was performed in patients experiencing persistent pain or with progressive collapse after conservative treatment, which was followed by a reassessment after 3 weeks. Vertebrae were identified as symptomatic when they showed compression fractures on plain radiographs, focal tenderness on physical examination, and hot uptake on a bone scan. In addition, the degree and displacement of the fracture fragments were analyzed using preoperative computed tomography, while the degree of osteoporosis was measured using bone mineral densitometry. Patients who were suspected with metastatic cancer were analyzed using additional magnetic resonance imaging (MRI). Cases in which MRI was performed for other non-treatment reasons were also included.

The surgical procedure involved the administration of fentanyl and midazolam as pre-medications after preventive antibiotics 30 minutes prior to surgery, administration of 1% lidocaine as a local anesthetic agent on the surgical area with the patient in the prone position, pinpoint skin incision, insertion of an 11-gauge J-type bone marrow biopsy needle into the lesion inside the vertebral body through both pedicles, and confirmation of the needle location under an image intensifier. Bone cement (Surgical Simplex P; Howmedica, Limerick, Ireland) was mixed with tungsten powder and injected into the vertebral body, while cement leakage was monitored by using a C-arm image intensifier. Immediately after the surgery, activities on the bed and early ambulation were allowed, and a Juwett brace was provided for most of the patients with thoracolumbar fractures.

METHODS

To confirm objectified changes in the pre- and postoperative pain levels, anteroposterior and lateral radiographs were taken to measure the anterior body height and kyphotic angle of the vertebral bodies. Changes in the injected cement were also retrospectively confirmed, and those in the symptomatic and adjacent vertebrae were observed on follow-up radiographs.

To evaluate the reproducibility of visual assessment, interpretation agreement among three independent orthopedic observers considering the plain radiographs of the 555 patients who underwent PVP or KP was evaluated. Serial radiographs showed progression of the bony bridging across the adjacent vertebrae.

The patients were distinguished into two groups, the solid spontaneous fusion group (Fig. 1) and the partial fusion group. The former included patients in whom continuity was achieved in at least 3 adjacent cortical vertebrae. The latter included patients in whom fusion had progressed compared to previous radiological findings.

We reviewed the plain radiographs and analyzed the radiological characteristics considering the fusion duration as well as the location and extent of fused segments.

Fig. 1. Solid fusion group defined fractured vertebrae which continuity was achieved in at least 3 adjacent cortical vertebrae.

We also compared the clinical characteristics with those of earlier reports using Visual Analogue Scale (VAS) scores of 0 (no pain) to 10 (most severe pain) to assess pain levels before the surgery and 2 days, 3 months, 1 year, and 2 years after the surgery.[13]

RESULT

A total of 54 patients (9.7%) experienced spontaneous fusion, while 43 patients (7.7%) experienced partial fusion as observed using plain radiography. In the solid fusion group, the average fusion duration was 19 months (range, 3 months to 48 years). A total of 46 cases (85%) of solid fusion occurred with the proximal adjacent vertebrae and 7 cases (13%) of the proximal with distal adjacent vertebrae. A total of 41 cases (76%) of spontaneous fusion occurred within a single segment, while the other 13 cases (24%) occurred within multiple segments. Most of the cases of solid fusion (40 patients; 74%) occurred at the thoracolumbar junction. The mean VAS score of the absolute fusion group was 2.0 at the final follow-up, which was relatively low compared to that of our previous report. (2.0, 2.8 respectively)

CASES

1) A 73-year-old female patient underwent percutaneous vertebroplasty due to an osteoporotic compression fracture of the 1st lumbar vertebra, which occurred when she fell. In the 3rd year of progression observation, the patient experienced another injury with a newly developed fracture of the 12th thoracic vertebra. Following that, findings of spontaneous fusion among vertebral segments were reported (Fig. 2).
2) A 69 years old female patient who underwent percutaneous vertebroplasty due to an osteoporotic compression fracture of the 3rd lumbar vertebra had consecutive, multiple new fracture at adjacent level

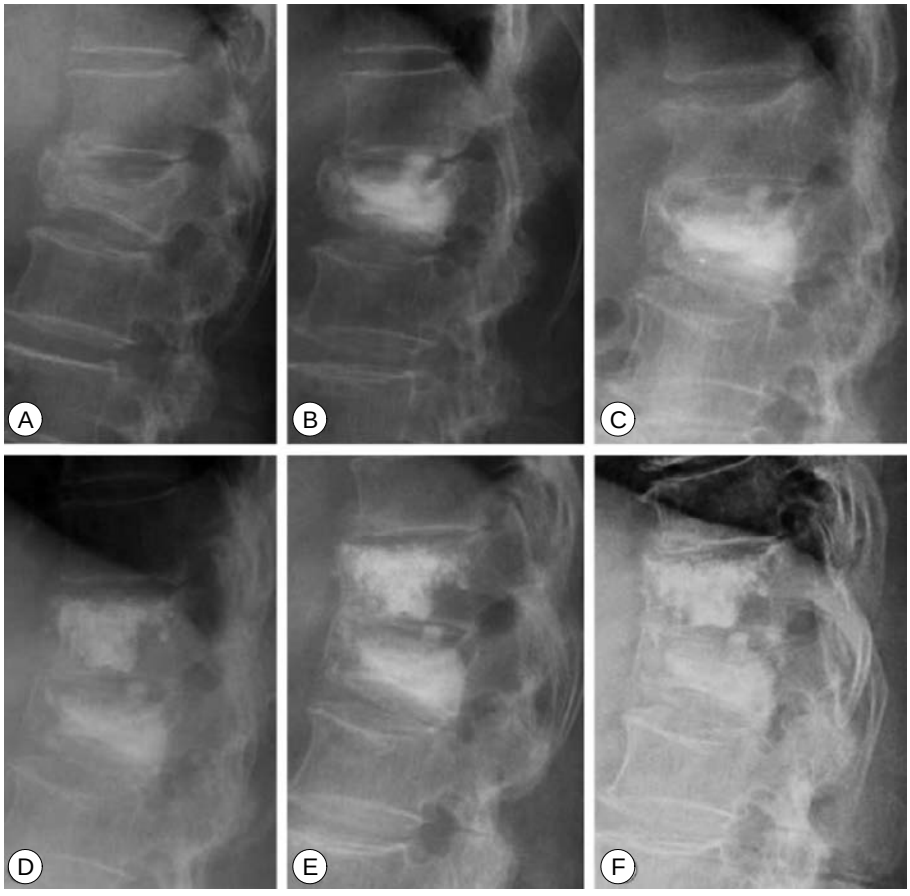

Fig. 2. Simple lateral radiographs of a 73-year-old woman with L1,T12 compression fracture. (A) Preoperative radiograph showed L1 compression fracture, (B) Immediately postoperative radiograph of L1, (C) Post-operative 3 years follow-up radiograph show a new compression fracture on T12, (D) Immediately post-operative radiograph of T12 (3 years after L1 postoperatively), (E) Two years after vertebroplasty on T12, follow-up radiograph show a progressive bony bridging between T12 and L1, (F) Four years after vertebroplasty on T12, follow-up radiograph show a spontaneous fusion between T12 and L1.

within 2 years. After initial L3 fracture, adjacent vertebrae had new fracture and progress solid spontaneous fusion (Fig. 3).

DISCUSSION

Numerous studies have successfully demonstrated the use of PVP and KP in the treatment of painful osteo-porotic compression fractures of vertebral bodies. Most patients who underwent PVP or KP experienced remarkable pain relief in the short-term follow-up period. Some of these patients also experienced spontaneous fusion during the healing process after PVP or KP.

This study tried to analyze whether spontaneous fusion after PVP or KP in osteoporotic compression fractures is important to the healing process. We believe that spontaneous fusion at the level of the vertebral body can increase intervertebral stability, and is responsible for the better clinical characteristics observed in patients with bony bridging across adjacent vertebrae. Premik Nagad et al[14] reported that post-vertebroplasty instability at the vertebral body was associated with collapse and micro-motion after PVP in 5 cases after an average follow-up of 2 years. We believe that this is due to the collapse of soft

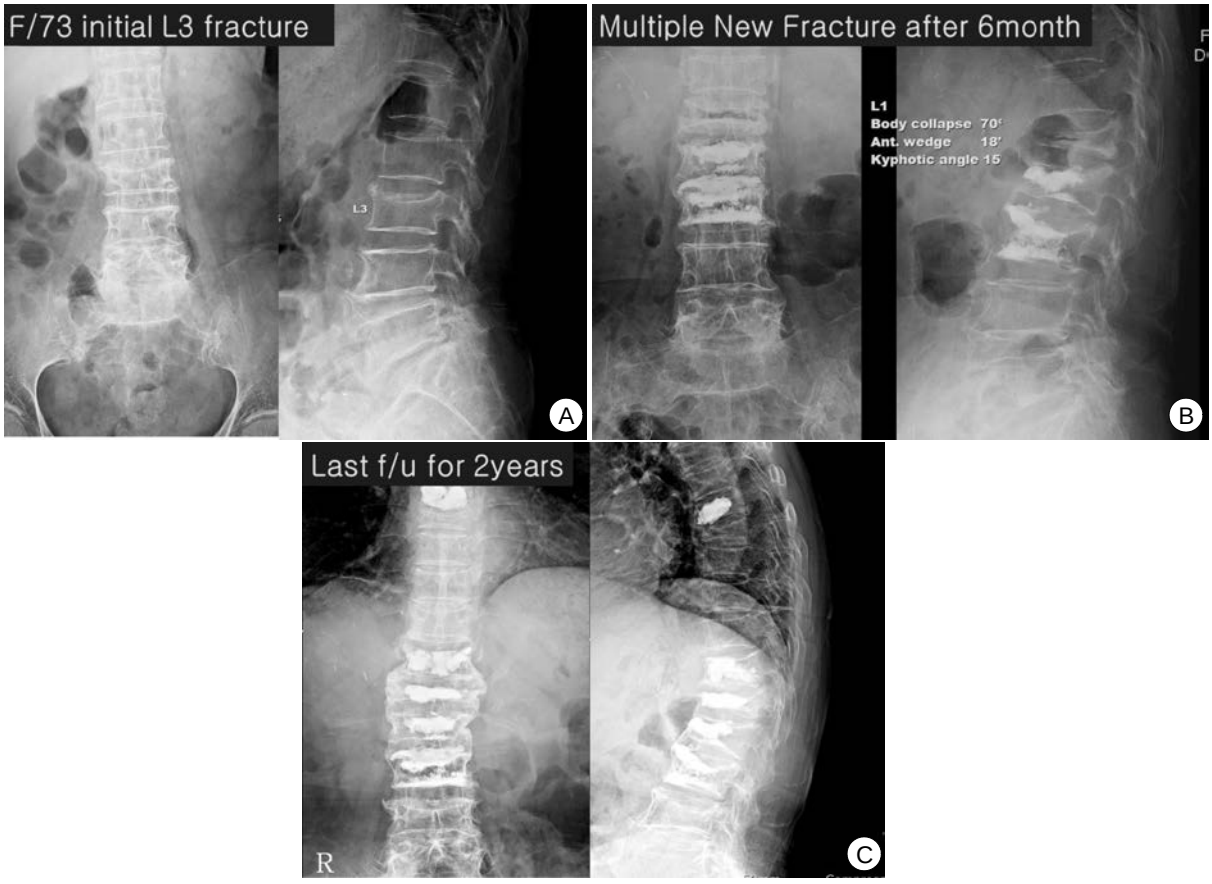

Fig. 3. (A) A 69 years old female had 3rd lumbar vertebrae fracture with minor trauma, (B) Six month later with L3 vertebroplasty, adjacent level fracture were occurred and repeated vertebroplasty, (C) Multiple level fracture with solid spontaneous fusion achieved within 2 years after initial fracture.

osteoporotic bones around the adjacent vertebral body that has been rendered stiff by the cement after PVP.

Spontaneous fusion occurs in some patients with osteoporotic compression fractures who undergo PVP or KP. However, it is unknown whether spontaneous fusion can occur without PVP or KP intervention. Why does spontaneous fusion occur? We have 2 hypotheses to explain this phenomenon. The first hypothesis is about the mechanical effect; polymethylmethacrylate does not have any kind of biological effect. This spontaneous fusion phenomenon came only from the mechanical stability of the fractured vertebral body.[15,16] In particular, the thoracolumbar junction is a transitional area of the relatively stiff thoracic spine to the flexible lumbar spine. It is vulnerable not only to fracture but also to easy union due to kyphosis after the fracture.

Another hypothesis is that spontaneous fusion occurs most often in comminution of the upper end plate with slight kyphosis. Under the force of a kyphotic deformity, some comminuted fragments at the fractured vertebrae could be fused with the proximal adjacent vertebrae. The fact that spontaneous fusion after PVP or KP in osteoporotic compression fractures usually occurs in the anterior vertebral aspect supports both of the above hypotheses.

Nevertheless, the result of this study might be a better clinical outcome for all patients in the spontaneous fusion group, which means that spontaneous fusion after PVP or KP in osteoporotic compression

fractures acts as a mechanical stabilizer at the fracture site and provides structural support. This can eliminate interbody motion and expedite the healing process. However, further studies are required to clarify the clinical relevance of our findings.

This study had a number of limitations. First, it was retrospective study without a control group. Second, comparisons with conservative treatments and other treatment modalities were not conducted. Finally, the natural course of spontaneous fusion is unclear.

CONCLUSION

After PVP or KP in osteoporotic compression fracture, unpredictable spontaneous fusion could develop at a rate ≥10%, especially with the proximal vertebrae within one segment at the thoracolumbar junction. Patients who experienced spontaneous fusion reported a greater degree of pain relief than those who did not.

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