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Original article

Short-segment posterior instrumentation combined with calcium sulfate cement vertebroplasty for thoracolumbar compression fractures: Radiographic outcomes including nonunion and other complications

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ABSTRACT

Objective: To evaluate the radiographic outcomes of short-segment posterior instrumentation plus vertebroplasty using injectable calcium sulfate cement (CSC) for thoracolumbar compression fractures.
Materials and methods: Twenty-eight patients with a single-level thoracolumbar compression fracture, who underwent short-segment pedicle screw fixation and CSC vertebroplasty, were included in the study. The anterior vertebral body height ratio, local kyphosis angle, and the height of the intervertebral disc adjacent to the fractured vertebra were used to evaluate the radiographic results. Complications including bone nonunion, instrument failure, cement leakage, and disc vacuum formation were also assessed.
Results: The patients were followed up for an average of 24.20 ± 5.40 months. The relative preoperative anterior body height was $55.71 \pm 15.29\%$, which improved to $94.93 \pm 5.39\%$ immediately after surgery ($P < 0.001$), and at final follow-up showed a $6.50 \pm 3.89\%$ loss of height correction ($P < 0.001$). The mean preoperative local kyphosis angle was $22.23 \pm 5.65^\circ$, which corrected to $2.67 \pm 4.43^\circ$ immediately after surgery ($P < 0.001$), but reverted to $6.71 \pm 4.95^\circ$ at final follow-up, showing a $4.04 \pm 1.91^\circ$ loss of correction ($P < 0.001$). The mean height of the intervertebral disc proximal to the fractured vertebra was 9.87 ± 0.91 mm before surgery, 12.53 ± 0.98 mm after operation ($P < 0.001$), and the loss of correction at final follow-up was 2.35 ± 1.15 mm with a significant difference compared to immediate postoperative values ($P < 0.001$). Bone nonunion occurred in 7 patients, 2 patients had hardware failure, 9 patients had cement leakage, and 10 patients had disc vacuum phenomenon adjacent to the fractured vertebra.
Conclusions: The patients who underwent this procedure had a loss of correction of vertebral height and local kyphosis. Complications such as bone nonunion, instrument failure, cement leakage, and disc vacuum may occur. Rapid CSC resorption accounts for these radiographic outcomes and complications.
Level of evidence: Level IV, retrospective study.

1. Introduction

Thoracolumbar compression fracture caused by trauma is a common spinal injury [1]. Surgical treatment is necessary if stability or neurological function is impaired. Compared with anterior surgical procedures, posterior short-segment pedicle screw fixation, which results in indirect reduction of the collapsed vertebra, preservation of segment motion, lower blood loss, and a decrease in postoperative morbidity, remains an ideal technique to treat thoracolumbar compression fractures [2,3]. However, higher implant failure and loss of reduction are usually seen in patients with only posterior pedicle screw fixation due to insufficient anterior column support [4]. Therefore, anterior column augmentation via a posterior procedure is essential.

Augmentation of the fractured vertebral body is usually performed by injection of bone cement such as polymethylmethacrylate (PMMA), which provides good strength and fixation of the vertebral fractures, and excellent clinical results have been

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reported [5]. Unfortunately, PMMA has several disadvantages, including toxic monomers, thermal necrosis, non-bioabsorbability, and biomechanical mismatch between treated and untreated vertebral levels [6,7]. Therefore, injectable bone cements such as CSC (calcium sulfate cement) with bioabsorbability has been developed, and used for augmenting the fractured vertebral body by vertebroplasty [2]. A biomechanical study in a cadaverous vertebral compression fracture model showed that CSC can provide vertebral stiffness and strength immediately after surgery comparable to PMMA [8]. And two clinical studies have demonstrated that posterior short-segment instrumentation and vertebroplasty with injectable CSC is an effective procedure for thoracolumbar compression fractures [2,9].

From 2007 to 2009, 28 patients with thoracolumbar compression fracture accepted posterior short-segment instrumentation plus injectable CSC (MIIG X3; Wright Medical Inc., Arlington, TN) vertebroplasty. In this group, the patients showed satisfactory short-time clinical results as reported in the literature [2,9]. However, some complications associated with this procedure were also found according to imaging findings. Therefore, the purpose of this study was to evaluate the imaging outcomes of CSC vertebroplasty, importantly, to evaluate its complications.

2. Subjects and methods

2.1. Subjects

Twenty-eight patients between March 2007 and May 2009 were enrolled in this retrospective study on the basis of the following criteria. Inclusion criteria were: a single-level fracture at T12–L3 without neurological symptoms; posterior short-segment pedicle screws fixation plus CSC vertebroplasty; type A3.1 or severely type A1.2 and 1.3 fracture according to Magerl classification [10]; local kyphotic angle >20°, or anterior body height collapse >30%; less than 60 years old and at least 12-month follow-up with imaging data. Exclusion criteria were: patients with spinal deformity; previous vertebral fracture in the adjacent vertebra; severe degenerative spinal disease; and previous spinal operation. Patients comprised of 16 men and 12 women with mean age of 41.64 ± 11.73 years (range: 19–60). Injury was caused by a fall in 22 patients, vehicle accident in 6 patients. The fracture level was T12 in 6 patients, L1 in 11 patients, L2 in 9 patients, L3 in 2 patients. Type A1.2.1 in 15 patients, type A1.2.2 in 1 patient, type A1.3 in 3 patients, and type A3.1.1 in 9 patients [10]. The mean time from injury to operation was 3.21 ± 1.75 days (range: 1–10). This study design was approved by the hospital's ethics committee. All patients provided informed consent for the procedure. Patients' clinical data are presented in Table 1.

2.2. Surgical procedures

Surgical procedures were performed under general anesthesia. The patients were placed in the prone position with the abdomen suspended. Closed reduction was performed by compression of the most prominent site in the thoracolumbar kyphosis with the hands. After restoring the shape of the fractured vertebra under C-arm fluoroscopy, a standard posterior midline approach was made to expose the lamina and facet joints with the posterior vertebral column intact. Pedicle screws were inserted into the vertebral body one level above and below the injured vertebra. After connecting the rods and pedicle screws, distraction force was applied using spreader forceps to further restore the height of the anterior column. After completing the fixation, a trocar in a cannula was inserted unilaterally into the fractured vertebra until it reached the optimal position. After removing the trocar, CSC was slowly injected into the defect in the fractured body through the cannula. Before closing the incision, a negative-pressure catheter drain was fitted. The surgical procedure was performed under continuous fluoroscopic monitoring. In this study, the fracture was Magerl type A3.1.1, type A1.2.1 and type A1.3, posterior column is not seriously damaged. Therefore, we did not perform posterior or posterolateral fusion.

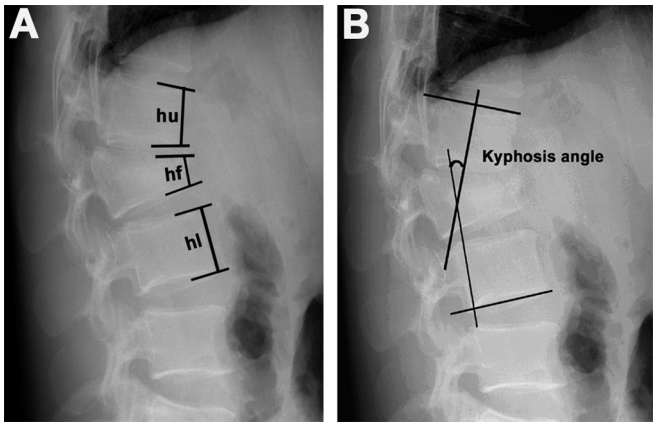

Fig. 1. Radiograph of the fractured vertebra height and the regional kyphotic angle. A. hf represents the anterior height of the fractured vertebra, hu and hl represent the anterior height of the vertebra above and below the fractured vertebra. B. The regional kyphotic angle.

After surgery, the patients were immobilized in bed in a supine position for 24 h. Drains were removed 48 hours postoperatively. During the postoperative period, the patients were encouraged to resume their daily routine but required to wear a brace for 12 weeks. Vigorous activities were restricted for six months after surgery. All patients were assessed using X-ray radiographs and CT scans before surgery and during follow-up.

2.3. Radiographic evaluations

Imaging was performed before and after surgery using anteroposterior and lateral radiograph and CT scans. The anterior height of the fractured vertebra was defined as the height of the fractured vertebra. The mean value of the anterior height of the vertebrae above and below the fractured vertebra was defined as the normal height of the fractured vertebra. The relative height of the fractured vertebra was defined as the height of the fractured vertebra divided by the normal height of the fractured vertebra, and was expressed as a percentage (Fig. 1A) [11]. The regional kyphotic angle of the affected segments was defined as the measured angle between the superior endplate of the upper vertebra and the inferior endplate of the lower vertebra (Fig. 1B) [11]. The height of the intervertebral disc above and below the fractured vertebra were also measured. The radiological data were measured using DICOM VIWERE software.

Patients were also monitored for radiographic complications including the development of nonunion which express no bone tissue growing into the defect of the vertebra at the final follow-up time; cement leakage into the paravertebral soft tissues, spinal canal, paravertebral vein and intervertebral disc; instrument failure which express implant breakage; and disc vacuum phenomenon adjacent to fractured vertebra.

2.4. Statistical analysis

Data are presented as mean ± standard deviation. A paired Student's *t*-test and the Wilcoxon nonparametric test were used to evaluate data changes before and after surgery. Statistical