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Short segmental pedicle screw fixation combined with percutaneous vertebroplasty in treatment of nonadjacent thoracolumbar fractures

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Objective: To evaluate the short-term outcomes of short segmental pedicle screw fixation combined with percutaneous vertebroplasty in treatment of nonadjacent thoracolumbar fractures.

Methods: Twenty patients who suffered from nonadjacent thoracolumbar fractures were treated by short segmental pedicle screw fixation for burst fracture and by percutaneous vertebroplasty for compression fracture. X-rays, CT and MRI scans were conducted using the same protocol before and after surgery and during follow-up. Pre- and postoperative American Spinal Injury Association (ASIA) grades, fusion of fracture sites, visual analog scale (VAS) of back pain, and Oswestry disability index (ODI) were accessed.

Results: All patients were followed up for an average period of 12 months. The sagittal profile of the thoracolumbar spine was restored satisfactorily. No patient had neurologic deterioration after surgery, and 9 patients with incomplete lesions improved postoperatively by at least one ASIA grade. The fusion rate was 100%. The average VAS of back pain was 7.6 preoperatively and 3.2 postoperatively. The average ODI was 72.5 preoperatively and 35.5 postoperatively.

Conclusions: Short segmental pedicle screw fixation combined with percutaneous vertebroplasty in treatment of nonadjacent thoracolumbar fractures exhibits such advantages as preserving functional segment units, reliable fixation, good neurologic recovery and early mobilization and, therefore, is suitable for treating nonadjacent thoracolumbar fractures.

Key words: ***Bone screws; Vertebroplasty; Fracture fixation; Spinal fractures***

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The incidence of multi-segmental spinal fractures is 3%-5%, and the factures may be either adjacent or nonadjacent. With medical advances, the incidence of this condition tends to increase.[1] From January 2004 through December 2006, 20 patients with nonadjacent thoracolumbar fractures were treated in our department. We treated vertebral burst fractures with short segmental pedicle screw fixation and vertebral compression fracture with percutaneous vertebroplasty. The outcomes were satisfactory.

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METHODS

General data

There were 20 patients in this series, including 15 men and 5 women. Their ages ranged from 20 to 53 years (mean, 35 years). The causes of injury included traffic accident (10 patients), fall (7), and crushing (3). The injured sites included T_5, T_6, T_{12}, L_4 (1 patient), T_6, L_1 (1), T_5, T_{12} (1), T_8, L_2, L_3 (2), T_{10}, L_1 (3), T_{12}, L_3 (3), T_{12}, L_4 (2), L_1, L_5 (3), L_2, L_3, L_5 (2), and L_2, L_4 (2). All fractures were compression ones combined with burst fractures. Ten patients presented with spinal nerve injuries. According to the American Spinal Injury Association (ASIA) grading system, the preoperative spinal nerve functional injury was graded as A in 2 patients, B in 3, C in 1, and D in 4. The concomitant conditions included cerebral trauma (2 patients), pulmonary contusion (5), rib fracture and hemopneumothorax (2), extramalleolus fracture (1), and pelvic fracture (1).

The affected vertebrae were subject to MRI and thin-

layer CT scans. For vertebral burst fractures, short segment pedicle screw fixation and bone fusion were conducted; for simple flexion vertebral compression fractures, percutaneous vertebroplasty was performed.

Surgical procedures

Short segmental pedicle screw fixation and bone fusion Under general anesthesia, spinal processes, vertebral plates, articular processes and transverse processes of the affected vertebrae and adjacent ones were exposed through a posteromedian approach. Register pins were inserted into vertebral pedicles adjacent to the affected vertebrae according to Mergerl's method. Under a C-arm radiographer, Tenor screws and rods of appropriate length (Sofamor Danek, USA) as well as bolts and nuts were used for fracture reduction. Vertebral plates of the affected vertebrae were resected for decompression, and then the vertebral canal was explored. Bone blocks that protruded into the vertebral canal were pushed forward using an L-shaped device for reduction. For large or mobile bone blocks, reduction can be performed using an L-shaped device, and then restitution and fixation of the affected vertebrae were conducted using connecting rods. Following reduction and fixation, the vertebral canal was explored again. Bone fragments that protruded into the vertebral canal and were refractory to reduction were removed. After reduction was proven satisfactory by a second fluoroscopic examination, the nuts were tightened, and transverse connecting rods installed. Finally, the vertebral plates resected were used for bone grafting between transverse processes.

Percutaneous vertebroplasty Patients were placed in a prone position, and vertebral pedicles of the affected vertebrae were located under C-arm. Under C-arm, the access site was determined in an anteroposterior prospective, which was frequently 2-3 cm away from the spinal processes, and then a thoracolumbar access needle (Cook Medical, UK) was inserted, with an angle between the needle and the sagittal plane being 15°-20°. For lumbar lesions and some thoracic spinal lesions, a percutaneous, per-pedical access was used. Under anteroposterior and lateral fluoroscopic monitoring, the vertebrae were punctured *via* vertebral pedicles using an access needle with stylet. As the needle tip was shown in the lateral perspective to reach the posterior vertebral margin, it should not extend beyond the medial margin of the vertebral pedicle projection in the anteroposterior perspective, that is, the needle tip should be within the bull's eye configuration of vertebral pedicles. Then the needle tip was pushed to the junction of anterior 1/3 and middle 1/3 of the vertebra. Under C-arm, calcium phosphate bone cement was used appropriately. Injection of bone cement was stopped once bone cement approached the posterior vertebral margin. A total of 4-5 ml bone cement was injected into each vertebra.

Postoperative management

Antibiotics were administered conventionally. Dehydrating agents and glucocorticosteroids were administered in those patients with spinal nerve injury. The drainage tubes were pulled out at 24-48 hours postoperatively. The patients were allowed to turn the body in bed immediately after operation, and to sit with the back resting with a fully custom thoracolumbosacral orthoses (TLSO) 3-4 days after operation. Patients who were graded C or D according to the ASIA grading system were allowed to walk on crutches with TLSO 4-6 weeks after operation.

Postoperative follow-ups and assessments

During follow-ups, radiologic and clinical assessments were performed. Radiologic assessments including pre- and post-operative X-rays, CT, MRI, were intended to assess bone fusion. Upon pre-, post-operative, and follow-up clinical assessments, the patients' neurologic function was graded by using the ASIA grading system, the severity of back pain was assessed using a visual analog scale (VAS), and the patients' function was rated by using Oswestry disability index (ODI).

RESULTS

All patients were followed up for 12-36 months. Cobb's angle of vertebrae with burst fractures increased by 5° on average and the height of vertebrae with compression fractures restored by 50.2% after surgery. According to neurologic functional assessments based on the ASIA grading system, one of the two patients graded A preoperatively was graded B postoperatively and the other patient showed no neurologic improvement; two of the three patients graded B preoperatively were graded C postoperatively and the other was graded D; one patient graded C preoperatively was graded D postoperatively; all of the four patients graded D preoperatively were graded E postoperatively. The average VAS of back pain was 7.6 preoperatively and 3.2 postoperatively. The average ODI was 72.5 preoperatively and 35.5 postoperatively (Figs. 1-5).

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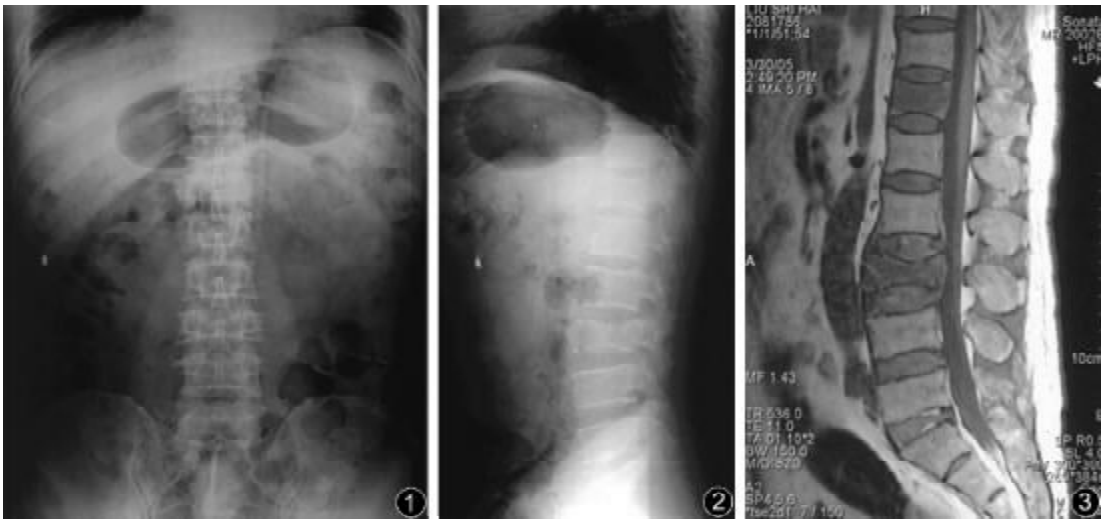
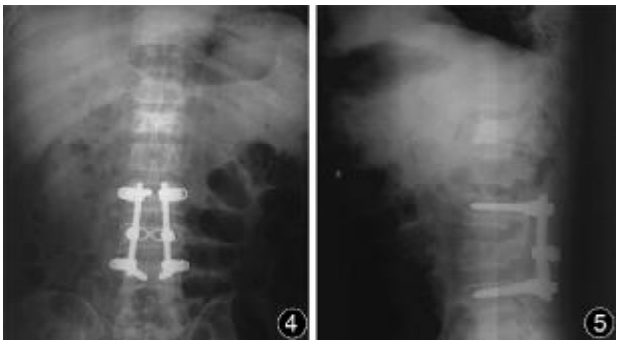


Figs.1 and 2. Preoperative X-rays (AP) indicate T_{12} compression fracture and L_3 burst fracture. **Fig.3.** Preoperative MRI indicates T_{12} compression fracture and L_3 burst fracture.



Figs.4 and 5. Postoperative X-rays (AP) indicate T_{12} percutaneous vertebroplasty and posterior short segment pedicle screw fixation and bone fusion of L_3

DISCUSSION

All patients in this series had both vertebral compression fractures and burst fractures. Due to concerns on bone cement leakage into the vertebral canal, pedicle screw fixation and bone fusion were used to manage burst fractures. Percutaneous vertebroplasty was performed for compression fractures.

It is still controversial about how to treat nonadjacent multi-segmental thoracolumbar fractures. Some authors believe that all of the affected vertebrae should be treated by long segment vertebral pedicle screw internal fixation and bone fusion. This is because multiple spinal fractures per se are indications to internal fixation, and because internal fixation of all of the affected vertebrae allows patients to resume ambulation early after surgery; moreover, an increased number of vertebral pedicle screws enhance spinal stability. Nevertheless, this method has many disadvantages such as massive bleeding, substantial surgical trauma, and high expenses of internal fixation devices. Moreover, long segmental fixation of the spine, particularly, the lumbar spine is likely to cause pseudoarthrosis, resulting poor spinal fusion or failure of internal fixation devices;[2] on the other hand, normal spinal physiology will be influenced greatly even if long segment spinal fusion has been achieved, and degeneration of vertebrae adjacent to the fixed segment may accelerate and result in chronic back pain.[3]

Other authors hold that vertebral burst fractures should be treated by short segmental pedicle screw fixation and bone fusion, and that no surgical intervention but body position reduction be performed in simple flexion compression fractures of vertebrae, and the patient be instructed to lie in hard bed. This is because minimizing the use of internal fixation in most threatening fractures such as vertebral burst fractures may reduce complications due to long segmental spinal fixation. Nevertheless, this method requires patients to lie in bed for long time periods, and patients are unable to sit up or ambulate freely. As a result, the benefits of this method are greatly compromised.[4]

Individual treatment should be performed on nonadjacent multi-segmental thoracolumbar fractures. The vertebral anteromedian column is destroyed in vertebral burst fractures. As spinal anteromedian column normally bears appropriately 80% load, progressive collapse of the affected vertebrae and secondary or aggravated spinal injury may occur if effective fixation fails.

Pedicle screw fixation of the affected vertebrae and adjacent vertebrae realizes robust, three-dimensional fixation due to the special configuration of the screws and connecting rods. Moreover, three-dimensional correction and robust internal fixation can be achieved through such actions of vertebral pedicle screws and perpendicular connecting rods through distraction and compression, so as to restore the height of the affected vertebrae and normal sagittal spinal profile.[4] Percutaneous vertebroplasty is considered for simple flexion vertebral compression fractures. Generally, 4-8 ml bone cement is sufficient to restore the biomechanical properties of thoracic and lumbar vertebrae.[5]

As compared with traditional bone cement (PMMA), calcium phosphate cement (CPC) exhibits good biocompatibility, degradability and bone conduction ability. It does not produce heat during reaction, and its absorption rate is largely consistent with the rate of new bone formation. Hence, it will not influence bone remodeling or fracture healing process.[6] Mermelstein et al[7] performed percutaneous vertebroplasty for vertebral fractures by filling calcium phosphate bone cement through vertebral pedicles. They found that this method enhanced anterior column stability of the fractured vertebrae, with bending torque of vertebral pedicle screws decreased by 59% at flexion and 38% at extension, and with average initial stiffness increased by 40% on the flexion-extension plane. According to a preliminary clinical report in 20 patients with thoracolumbar burst fractures, Verlaan et al[8] performed reduction and fixation of burst fractured vertebrae using posterior vertebral pedicle screw systems, and realized end-plate reduction of the affected vertebrae by balloon dilation through bilateral vertebral pedicles, and then injected calcium phosphate bone cement. Postoperative X-rays and MRI scans indicated that the central and anterior heights of the affected vertebrae were restored by 78% and 91%, respectively. However, bone cement leakage occurred in 5 patients.

Short segmental pedicle screw fixation combined with percutaneous vertebroplasty in the treatment of thoracolumbar burst and compression fractures not only preserves functional segment units as many as possible through fixation and enhancement of all of the affected vertebrae, but also allows patients to sit up and ambulate early after operation, thus benefiting postoperative rehabilitation.

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