Analysis of safety and effect of reconstructing anterior and middle columns by single posterior approach in treating lumbar burst fractures

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Objective: To explore the safety and effect of the technique of reconstructing anterior and middle columns by posterior approach in treating lumbar burst fractures.

Methods: From July 2005 to January 2007, 22 cases (18 males and 4 females, aged 28-57 years, 42.7 years on average) of lumbar burst fractures were treated with surgical procedures in our hospital. Based on the routine posterior approach, one of the transverse processes of the injured vertebra was incised to get access to the lateral side of the injured vetebral body. After all the displaced fracture fragments were cleared away and the spinal canal was decompressed, the titanium mesh packed with autografts was implanted from the lateral side to reconstruct the anterior and middle columns. The adjacent above and below segments of the vetebral body were fixed with transpedicular screws. The operation time, intraoperative blood loss, vertebral height, degree of kyphotic deformity and comprised spinal canal were documented.

Results: The average operation time was 3.5 hours (ranging 2.8-5.8 hours) and the average blood loss was 820 ml (ranging 650-2 100 ml). All the cases were followed up for 17.2 months on average (ranging 12-28 months). The height of the injured vetebral body was restored from 24 % (12%-45%) preoperatively to 96% (95%-99%) postoperatively (P<0.05). The natural spinal curvatures and spinal canal were restored. Three cases were involved in transient iatrogenic nerve root injury and 1 case was involved in the loosening of the connected rod of the pedicle screw system 3 months postoperatively.

Conclusions: The technique of implanting the titanium mesh by posterior approach is effective and safe enough to reconstruct the anterior and middle columns in treating lumbar burst fractures.

Key words: ***Lumbar vertebrae; Fractures; Spine; Safety***

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The options for the treatment of lumbar burst fractures are still challenging. For unstable lumbar burst fractures, which are characterized by collapsed corpus and compressed vertebral canal, the success of treatment is based on the full decompression of the vertebral canal, correction of the local kyphosis and stabilization of the vertebral column. The current way to decompress the vertebral canal and stabilize the vertebral column adopts anterior and posterior approaches. But the morbidity risk of anterior and posterior approaches is higher than that of single approach. Our aim of this study was to assess the feasibility and efficacy of reconstructing anterior and middle columns with titanium mesh and stabilizing three columns through single posterior approach.

METHODS

General data of patients

A total of 22 patients (18 males and 4 females, aged 28-57 years, 42.7 years on average) with lumbar burst fractures hospitalized in our department from July 2005 to Janurary 2007 were included in this study. Eight patients suffered from L_1 fractures, 5 from L_2, 5 from L_3 and 4 from L_5. Sixteen patients were injured by falls from heights and 6 by traffic accidents. Three patients were combined with bilateral calcaneus fractures. The inclusion criteria were as follows: kyphotic angle≥20°, decreased vertebral body height ≥ 50% and a canal

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occlusion ⩾ 50%. Before operation, the average kyphotic angle was 21.3°, the average decreased vertebral body height was 66.8%, and the average canal occlusion was 72.3%.

The types of fractures were assessed according to Dennis classification system:[1] 11 patients belonged to Type A, 4 to Type D and 7 to Type E. The preoperative neurological deficits were evaluated according to the ASIA (American Spinal Injury Association) scale:[2] 3 patients were in Grade A, 5 in Grade B, 11 in Grade C and 3 in Grade D. Emergent operations were performed in 3 patients who had progressive neurological deficits within the first 24 hours after admission. The other operations were performed about 5 days after admission.

Internal fixation systems

Two types of transpedicular screw systems were used: TSRH and TENOR (Sofama Danek Medtronic, USA). The diameter of the titanium mesh was 19 mm.

Operative procedures

All the operations were performed under general anesthesia. The patients lay in the prone position and the surgical table was adjusted to make the patients in the posture of excessive extension. The laminae, the articular joints and the transverse process of the fractured corpus and its adjacent upper and lower corpora were exposed through routine posterior approach. Transpedicular screws were twisted into the upper and lower corpora.Through extending the transpedicular screw system, the height of the fractured corpus was restored.

The severely-injured side of the fractured corpus was chosen for performing hemilaminectomy and transverse process resection. The transverse process of the fractured corpus was cut at its attachment to the corpus. Then the resected transverse process and the adjacent psoas major muscle were retracted laterally to expose the lateral side of the fractured corpus (Figs.1A and 1B). The pedicle of the fractured corpus was removed to enlarge the window created by the hemilaminectomy (Fig.1C). Through the enlarged window, the posterolateral side of the spinal canal was totally exposed. After distinguishing and retracting the nerve roots, the posterior two-thirds of the fractured corpus and the adjacent intervertebral discs were removed. Thus decompression of the spinal canal was achieved. The gap between the endplates of the neighboring vertebrae was measured to determine the length of the titanium mesh. Then the titanium mesh packed with autogenous bone grafts (harvested from the resected laminae, pedicle and fractured fragments) was inserted into the middle of the fractured corpus through the enlarged posterolateral window. The ideal position of the titanium mesh could be assured under the monitor of the C-armed photoscopy. From the posteroanterior view, the titanium mesh should be on the midline; from the lateral view, the posterior wall of the mesh should not enter the spinal canal; and from both of the upper and lower views, the surfaces of titanium mesh shoud keep good contact with the endplates.

Following the insertion of the titanium mesh, the transpedicular screw system was used to compress the mesh. The compressive effect was useful to stabilize the mesh and restore the normal lordosis curve. Finally, the posterolateral bone fusion was performed as a routine. The patients were allowed to sit or stand 3 weeks after operation with the aid of customed waist braces.

RESULTS

All the cases were followed up for 17.2 months on average (ranging 12-28 months), the average operation time was 3.5 hours (ranging 2.8-5.8 hours), and the average intraoperative blood loss was 820 ml (ranging 650-2 100 ml). The most obvious blood loss (2 100 ml) occurred in the case of injured segmental vessels. The blood loss was under controll by packing and electronic cautery. The local kyphotic deformity was totally corrected. The normal sagittal alignment was restored and the average postoperative lordosis was 8.1°. The injured spinal canal was decompressed fully, which was compressed for 72.3% on average preoperatively. The typical preoperative and postoperative pictures of the operations are shown in Figs.2-4.

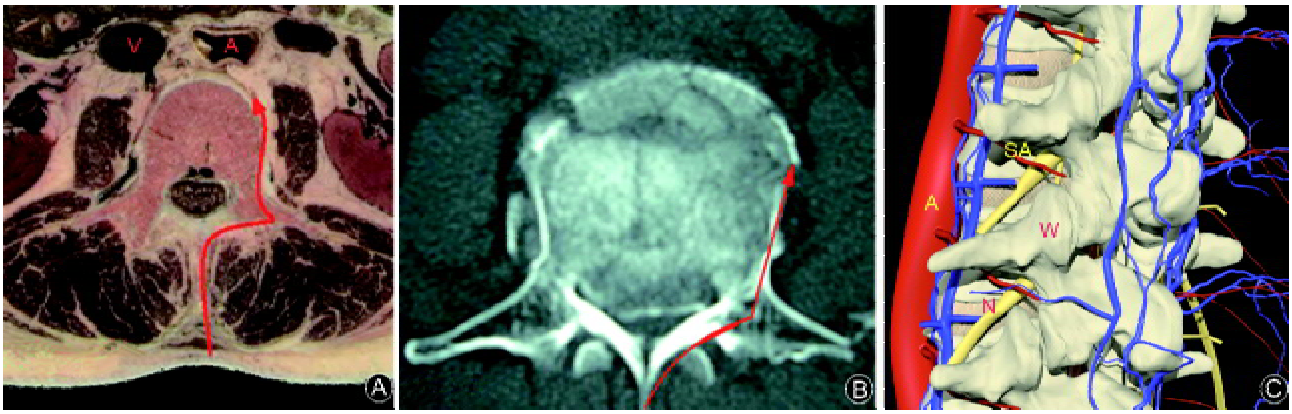

Fig. 1. A and B: The three columns are exposed along the red arrows as indicated on the transverse view of specimen and CT. **C:** As showing on the oblique view of the lumbar vertebrae, the pedicle and displaced fractured fragments are removed between the adjacent nerve roots. And the titanium mesh is inserted into the fractured corpus through the window (W) created by hemi-laminectomy and removal of the pedicle. A: aorta; V: vena cava; N: nerve root; SA: segmental vessel.

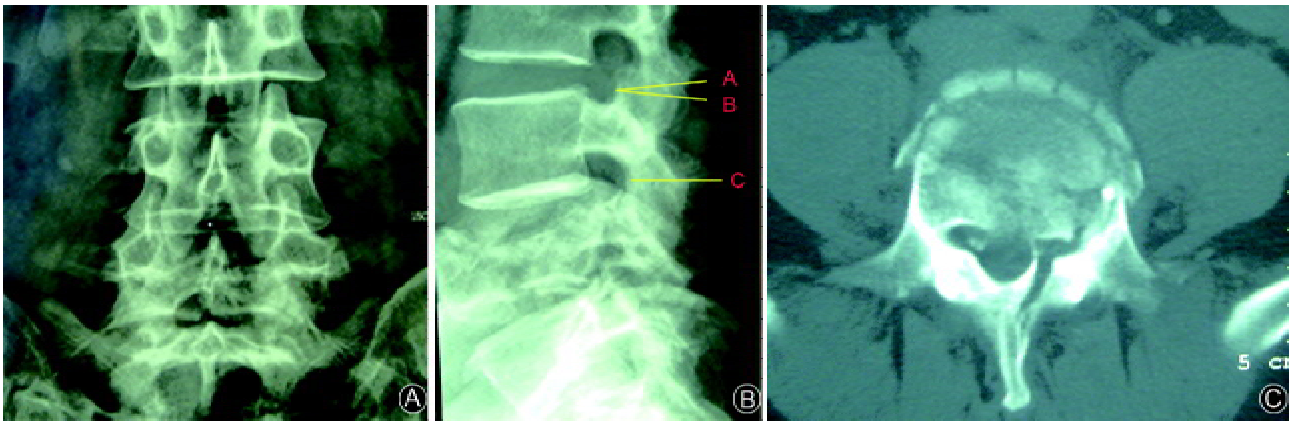

Fig. 2. Decreased vertebral height and the kyphotic deformity (formed by Line A and Line B, Line A is tangential to the inferior surface of the above corpus. Line B is parallel to Line C. Line C is tangential to the superior surface of the below corpus) of L_3 burst fracture. **A:** Preoperative posteroanterior X-ray view. **B:** Preoperative lateral X-ray view. **C:** Preoperative axial view on CT, indicating the posterior displaced fragments resulting in compromised spinal canal.

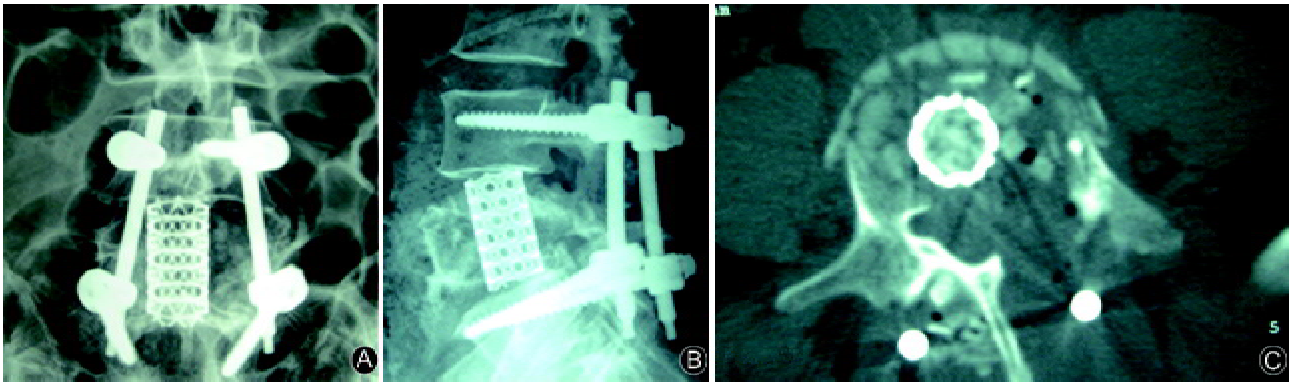

Fig. 3. A: Postoperative posteroanterior X-ray view of the internal fixation hardware and titanium mesh. **B:** Postoperative lateral X-ray view, indicating the good positioning of internal hardware and the recovery of vertebral height and lordosis (Line A is tangential to the inferior surface of the above corpus. Line B is parallel to Line C. Line C is tangential to the superior surface of the below corpus); **C:** Postoperative axial view on CT, indicating the good positioning of titanium mesh and the decompressed spinal canal.

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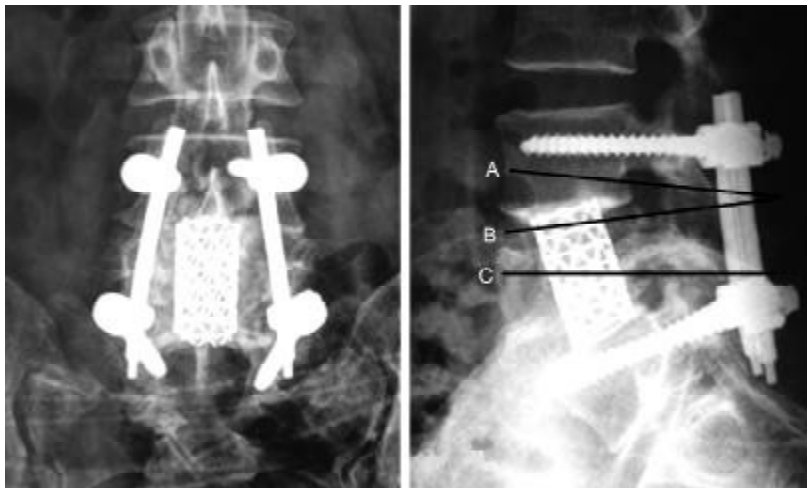

Fig. 4. After 2 years of follow up, the good positioning of internal fixation hardware, titanium mesh and the nearby bone fusion. **A:** Postoperative posteroanterior X-ray view. **B:** Postoperative lateral X-ray view.

For the recovery of neurological function from preoperation to postoperation, according to ASIA scale, the injury severity in no patients was deteriorated. Three cases in Grade A had no improvement, 1 case in Grade B was improved to Grade D, and 11 cases in Grade C and 3 cases in Grade D were improved to Grade E. As for the postoperative complications, there were 3 cases of transient iatrogenic nerve root injury and 1 of loosening of a connected rod of the pedicle screw system. The iatrogenic nerve root injury was caused by the excessive retraction during the insertion of the titanium mesh. And the function of the nerve root recovered 3 months after conservative treatment. The loosening of the connected rod was resolved by changing and tightening the locking screws in the revisional operation.

DISCUSSION

Burst fractures are very common fracture pattern in the lumbar spine. Most of the lumbar burst fractures are caused by high energy forces. The injuries occur with the spine in a neutral position, resulting in axial loading of both anterior and middle columns of the spine. The classic unstable lumbar burst fractures are characterized by loss of anterior vertebral body height, local kyphosis and compressed spinal canal.[3] Meves et al[4] reported that the narrowing of the spinal canal was proved to be a predictive factor in establishing early neurological deficits in lumbar burst fractures, showing a positive correlation between occlusion of the spinal canal and the severity of the incomplete neurological deficit. The probabilities of neurological deficits in patients with 25%, 50% and 75% occlusions of the lumbar spinal canal were found to be 8%, 30% and 68%, respectively. Patients with complete spinal cord injuries (Frankel A) did not show this correlation.

The aim of operations is to correct the kyphotic deformity, decompress the spinal canal and reconstruct normal vertebral alignment. Currently, based on the biomechanical data, combined anterior and posterior approach can provide the most stable biomechanical stabilization of three columns for unstable lumbar burst fracture.[5-8] According to Denis' three columns concept,[1] the middle column is strongly stressed. The reconstruction of the middle column is very important for the treatment of unstable lumbar burst fractures. If the collapsed middle column is not well-reconstructed, most of the load-bearing forces would go through the posterior implant system. The overload forces will result in high occurrence of implant failure and development of progressive kyphosis. At the same time, single anterior reconstruction is not enough to resist rotation.

Although the combined anterior and posterior approach is very effective to decompress the canal, reconstruct middle column and stabilize three columns, for a trauma patient, the approach with two incisions is of a great risk, particularly for the anterior approach. It is reported that the incidence of vascular complications with anterior lumbar spine surgery varies from 5% to 15%.[9-14] The complications include venous and arterial lacerations, thromboembolic phenomena, femoral nerve and sympathetic plexus injury, and postoperative hematomas.[15] The single posterior approach has no such complications. At the same time, the position of

the patient needs to be changed during the anterior-posterior approach. Therefore, recently, many techniques have been used to reconstruct anterior and middle columns through single posterior approach,[16,17] such as the reconstruction of anterior and middle columns with bone grafts or cement *via* the pedicles. But all the techniques have some shortcomings: the decompression and reconstruction are not enough for the limited view from the narrow pedicle. In the patients with unstable burst fractures, it is of high risk of cement leakage and the adjacent intervertebral discs are involved. However, reconstructions without dealing with intervertebral discs would result in progressive disc problems.

The technique used in our study was characterized by single posterior approach, which eliminated the complications of anterior approach. Half of the laminae and pedicle was removed to open a big window to decompress the canal. The posterior two-thirds of the fractured corpus were removed, but the anterior portion of the fractured corpus was left intact to protect the aorta and vena cava. In our study, the lumbar psoas muscle acted as the barrier to separate the aorta, vena cava and surgical field. There was no case of injury of the aorta and vena cava, but there was one case of obvious intraoperative blood loss for injury of the segmental vessels. Therefore, the manipulation should be very careful during the course of removing the displaced bone fragments. Bone wax could be used to minimize the blood loss. In our opinion, the intraoperative transfusion of the lost blood is strongly recommended to minimize the complications caused by blood loss.[18] The diameter of the titanium mesh is 19 mm, which is enough to reconstruct the anterior and middle columns. The titanium mesh packed with autografts can significantly decrease the load over the posterior fixation system.[19-22] With the compressive force from the posterior transpedicular system, there is no displaced titanium mesh. After operation, the patients included in our study have improved neurological functions.

During the procedure of the technique performed through single posterior approach, some techniques shoud be highly stressed. When we detach the lumbar psoas muscle, an electrotome shoud be used to minimize the blood loss. Before the insertion of the titanium mesh, the transpedicular screw system shoud be extended aggressively to enlarge the space in the fractured vertebra. The pedicle and the posterior two-thirds of the fractured corpus shoud be removed fully and the adjacent nerve roots shoud be distinguished and loosened fully to minimize the injury coming from retraction. In our study, there were 3 cases of nerve root injuries coming from extensive retraction. The function of the three injured nerve roots recovered after 3 months of conservative treatment. Failure of the above steps would result in difficult insertion of the titanium mesh. After the insertion of the titanium mesh, the transpedicular screw system was used for compressing the titanium mesh. The compression coming from the transpedicular screw system was good to stabilize the mesh and restore the normal lordosis of the lumbar spine. Before the posterolateral bone fusion, the position of the titanium mesh shoud be affirmed again with C-arm photoscopy. Three weeks after operation, the patients were allowed to sit and walk with the protection of a customed plastic brace.

In conclusion, the technique of single posterior approach has shown satisfactory results. This technique is safe without the complications of anterior approach. The reconstruction of the anterior and middle columns with titanium mesh is stable and strong enough. This technique may be one of the suitable options to treat unstable lumbar burst fractures.

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