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Surgical outcome of thoracolumbar burst fractures with flexion–distraction injury of the posterior elements

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Abstract Between 1991 and 2002 we treated 48 patients surgically for thoracolumbar burst fractures associated with flexion–distraction injury of the posterior elements. The degree of kyphotic deformity and the degree of vertebral wedging deformity were measured on plain lateral radiographs. The spinal canal compromise was measured on computer tomography. The mean postoperative follow-up was 70 (24–108) months. The preoperative kyphosis averaged 25.7° and the mean sagittal index was 28.8°. The mean wedging deformity of the fractured vertebral body was 46% (24–66%). The mean preoperative spinal canal compromise secondary to retropulsed bony fragments was 64%. Immediately after surgery, the correction of kyphosis averaged 98%. There was no loss of correction at the final follow-up. A satisfactory reduction and good stabilisation with solid fusion were achieved in all cases.

Résumé Entre 1991 et 2002 nous avons traité chirurgicalement 48 malades pour fractures communitives dorsolombaires associées à des lésions par étirement des éléments postérieurs. Le degré de cyphose et le degré de déformation angulaire vertébrale ont été mesurés sur les radiographies de profil. L'altération du canal vertébral a été mesurée sur la tomodensitométrie. La moyenne de suivi postopératoire était de 70 (24–108) mois. Les cyphose préopératoire était de 25,7° et l'index sagittal moyen était de 28,8°. La déformation angulaire moyenne du corps vertébral éclaté était de 46% (de 24 à 66%). Le rétrécissement moyen du

canal vertébral secondaire au recul des fragments osseux étaient de 64%. Immédiatement après la chirurgie, la correction de la cyphose était en moyenne de 98%. Il n'y avait aucune perte de correction au dernier recul. Une réduction satisfaisante et une bonne stabilisation avec une fusion solide ont été obtenues dans tous les cas.

Introduction

It is well known that thoracolumbar burst fractures are frequently accompanied by sagittal splitting of the lamina and lower endplate. It is less well known that burst fractures may occasionally be accompanied by horizontal fractures of the lamina and spinous process similar to those that occur in seatbelt-type injuries [3]. This type of burst fractures seems to be more unstable and is more likely to progress to a kyphotic deformity than those without horizontal splitting of the posterior column [8]. Moreover, the radiographic findings in these fractures are very similar to those seen in flexion–distraction injuries with burst fractures, as first reported by Gertzbein and Court-Brown [5].

There is no standardised treatment of flexion–distraction injuries associated with burst fractures of the vertebral body. In this study, we present the outcome of 48 patients with flexion–distraction injuries associated with thoracolumbar burst fractures treated surgically by a combined anterior and posterior approach.

Materials and methods

We included 48 patients with thoracolumbar burst fractures associated with flexion–distraction injury of the posterior elements and treated surgically between 1991 and 2002 in the study. The average age of the patients was 39 (23–62) years, and the male to female ratio was 33 to 15.

All patients were evaluated by means of plain radiographs—antero-posterior (AP), lateral and oblique—(Fig. 1), computed tomography (CT) (Fig. 2), magnetic resonance imaging (MRI) (Fig. 3), clinical records and follow-up

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Fig. 1 AP (a) and lateral (b) radiographs of a 43-year-old woman with an L2 burst fracture and stage Frankel D

examinations. The degree of kyphotic deformity in each patient (local kyphosis angle and the sagittal index) was measured on plain lateral radiographs by the Cobb method, using the superior end plate of the vertebral body one level above and the inferior end plate of the body one level below. The degree of vertebral wedging was also measured on plain lateral films and expressed as the ratio of the anterior vertebral height of the involved vertebra to the average anterior vertebral height of those above and below the injured vertebra. The percentage of canal compromise was calculated using the ratio of the cross-sectional area occupied by the retropulsed fragments to the estimated area of the original spinal canal on CT. Neurological evaluation was graded according to Frankel [4] and was documented.

Surgical technique

A posterior approach was performed first, after placing the silicon pillows without any reduction effect to the fracture. Pedicle screws were inserted one level above and one level below the fractured vertebra. A laminotomy was done at the fracture level in the absence of lamina fracture. If there was a vertical lamina fracture on one side, laminotomy was performed on the opposite unfractured side to prevent any iatrogenic spinal cord injury. After dural exploration; the

Fig. 3 MRI from the same patient showing disruption of the posterior ligamentous complex

haematoma was drained and ruptured and inverted ligaments were excised. Dural tears if present were repaired. Then, the rods were placed and fixed temporarily without any reduction manoeuvre and the wound closed.

For the subsequent second stage, the patient was placed in lateral decubitus position and re-draped in order to permit both anterior and posterior access. Exploration and decompression was conducted through the anterior approach. The posterior wound was re-opened and the rods were contoured according to the appropriate sagittal index and re-inserted. Strut autografts (fibula or iliac crest) or a titanium mesh cage filled with autograft were placed into the vertebrectomy defect. In 14 cases we used strut autografts and in 34, titanium mesh cages. When mesh cages were used, a supplementary autogenous non-vascularised rib graft was placed beside the cage. Then, the posterior rods were securely locked. Finally, two screws, one above and one below the fractured vertebra, were applied and connected with a single rod anteriorly to prevent displacement of the strut graft or titanium mesh cage (Fig. 4).

Fig. 2 CT of L2 from the same patient showing a retropulsed bone fragment (a) and illustrating fracture (b) and spinal canal encroachment

Fig. 4 AP (a) and lateral (b) radiographs from the same patient at 3-year follow-up after surgery

Results

In 28 patients the injury was caused by a traffic accident, in 16 by a fall from a height and in four the patient was hit by a heavy falling object. In two patients the fracture was located at T11, in 11 at T12, in 18 at L1, in 15 at L2 and in two at L3. There were associated distal radial fractures in five patients, distal tibial fractures in four patients, and pelvic fractures in eight patients.

The preoperative kyphosis averaged 25.7° and the mean sagittal index was 28.8° . The mean wedging of the bursting vertebral body was 46% (24%–66%). The preoperative mean compromise of the spinal canal was 64%. Immediately after surgery, the correction of kyphosis averaged 98%. There was no loss of correction at the final follow-up. In all cases we achieved a satisfactory reduction and good stabilisation with solid fusion. The mean follow-up was 70 (24–108) months.

Eleven patients had preoperative neurological deficits. Four patients were Frankel B and seven Frankel D. In eight patients we found an improvement of the Frankel staging, whereas three remained unchanged. There was no loss of correction, no implant failure and no pseudoarthrosis at the final follow-up.

Discussion

Burst fractures classified as Denis type B or C result from failure of the vertebral body to withstand an axial load (compression) in combination with flexion. They are frequently accompanied by a vertical laminar fracture, which in itself does not greatly impair the stability of the posterior column [3]. The injuries in patients with burst fractures and a horizontal fracture of the posterior column (either ligamentous or osseous), however, seem to be associated with greater instability than injuries without horizontal splitting of the posterior column [1, 2, 7–9].

The evaluation of traumatic spinal instability remains controversial. Many surgeons accept the three-column

concept defined by Denis. Using this concept, the number of injured columns is evaluated in terms of traumatic instability. On the other hand, Nagel et al. [10] experimentally showed that instability increased remarkably in anterior–middle column injury accompanied by an injury to the posterior column, either a transverse laminar fracture or an injury of the posterior ligamentous complex (PLC). In a biomechanical study, James et al. [8] revealed that burst fractures with associated posterior element disruption are unstable and at risk for kyphotic progression. Therefore, accurate diagnosis of the posterior column injury is important for the assessment of traumatic spinal instability.

Burst fractures with horizontal splitting of the posterior column are not rare. However, the Denis classification does not address the existence of this type of injury [3]. To our knowledge, there are few reports that focus on horizontal fractures of the posterior columns with associated burst fractures. Gertzbein and Court-Brown [5] found two flexion–distraction burst fractures among 26 patients with flexion–distraction injuries. In their burst fracture series Abe et al. [1] reported an associated flexion–distraction injury in as many as 21% of cases. Because the supine position brings about spontaneous reduction, a horizontal fracture of the posterior column is likely to be overlooked when conventional radiographs are used. Furthermore, a horizontal fracture of the posterior column is not readily revealed by CT. Surgeons tend to evaluate this fracture of the posterior column as a minor trauma and to focus, not on the posterior column, but rather on the vertebral bodies when assessing plain radiographs of burst fractures. Perhaps for these reasons, the occasional coexistence of a horizontal fracture of the posterior column and a burst fracture may be missed.

In the flexion–rotation injury associated with burst fracture, the axis is located in the anterior column, and the distraction force is exerted on the middle and posterior columns behind the axis of rotation [3]. In burst fractures with horizontal fractures of the lamina and spinous process in the posterior column, however, the axis of rotation is located in the spinal canal in the anterior part of the posterior column. Therefore, the compressive force is exerted on the anterior and middle columns in front of the axis of motion, while the distraction force is exerted on the lamina and spinous process in the posterior column behind the axis. This may explain why the ligamentous structures of the middle column are not ruptured.

Several authors have described the value of MRI for diagnosing the posterior ligamentous injury [1, 5, 11]. The study by Haba and co-workers [6] showed a high diagnostic accuracy and interobserver reliability for MRI, and the authors concluded that MRI is a powerful diagnostic tool for evaluation of PLC injuries associated with thoracic and lumbar vertebral fractures. All the patients in the present study were evaluated by preoperative MRI. A posterior ligamentous injury was found in all except four patients (87%). A posterior approach was used first when vertebral wedging was associated with a laminar fracture. During surgery we observed an injury of the PLC in all cases. Therefore, the PLC injury should be borne in mind in

patients with burst fractures, especially when they present with preoperative frontal plane translation.

The optimal management of thoracolumbar burst fractures is a most controversial topic among spine surgeons. Moreover, there is no consensus as to the best surgical treatment for spinal flexion–distraction injuries in combination with vertebral burst fractures. Treatment of burst fractures should be systematised to address the various levels of severity of the anterior column disruption. Posterior compression instrumentation is contraindicated, as compression may increase canal encroachment. Posterior distraction instrumentation may also be hazardous, as the injury involves considerable ligamentous damage.

Abe et al. [1] recommended using the anterior approach. They indicated that posterior overstretching can be avoided if anterior distraction is performed after posterior rod fixation. On the other hand, Sar and Bilen [11] recommended performance of posterior stabilisation first, followed by anterior decompression and fusion.

The isolated anterior approach is known to involve the risk of overdistraction, when there is a posterior column insufficiency. Furthermore, uncontrolled translations of the vertebral column may occur during anterior decompression as there are no structures to provide posterior stability. To avoid these risks, it is necessary that posterior stability be achieved using a posterior approach before turning to anterior surgery. In addition, the dural tears that often occur in flexion–distraction injuries can be identified and repaired. There is a great risk of inflicting an iatrogenic neurological deficit if reduction manoeuvres are performed before dural exploration and inverted ligament excision. We therefore advocate first performing a temporary posterior fixation and dural exploration without any reduction. We think that iatrogenic impingement of neural structures can be prevented in this way.

At the second stage, using an anterior approach, the spinal canal is decompressed. At the same stage, via the posterior approach, the rods are re-contoured to obtain an appropriate sagittal correction without any risk of entrapment of the neural elements.

In our opinion, the temporary fixation during the first stage and the placement of strut grafts or mesh cages will help to stabilise the spine during the surgery and prevent possible frontal and sagittal plane translation of the vertebral column.

It should be borne in mind that burst fractures may be associated with flexion–distraction injuries of the posterior elements. Careful diagnostic imaging examination, especially MRI, should be conducted in order to eliminate the existence of posterior ligamentous or osseous pathologies. By means of two-stage surgery under the same anaesthetic, first with the posterior approach and then via both anterior and posterior access, it is possible to securely decompress and reduce the fracture without any risk of neurological impairment.

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