Fluoroscopically-guided indirect posterior reduction and fixation of thoracolumbar burst fractures without fusion

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Abstract This article presents an evaluation of fluoroscopy for indirect, posterior reduction and fixation of thoracolumbar burst fractures. A prospective study of 25 patients with thoracolumbar burst fractures who underwent C-arm machine-guided posterior indirect reduction and short segment fixation without fusion is described. No laminotomies were performed. All patients had a mean follow-up of 30.4 months. At postoperative review, the average anterior and posterior vertebral heights were corrected from 57.9% to 99.0% and 89.0% to 99.5%, respectively. The Cobb angle was corrected from 18.4° to 0.17°. The canal compromise ratio was improved from 35.2% to 8.6%. In all 25 cases, neurological status was intact at last follow-up. Fluoroscopy guidance is an effective method to accomplish indirect reduction and fixation. Reduction was confirmed on lateral fluoroscopic views by looking for a “one-line sign,” which is the reconstitution of the posterior border of the vertebral body.

Résumé L’objectif de cette étude est d’évaluer l’intérêt de l’amplificateur de brillance dans les réductions et les fixations de fractures dorso-lombaires. Matériel et méthode: une étude prospective de 25 patients présentant une fracture dorso-lombaire a été réalisée. Ces patients ont été opérés avec une fixation courte sans greffe et sans laminotomie.

Résultats: tous les patients ont eu un suivi moyen de 30,4 mois. Après l’intervention chirurgicale, la hauteur vertébrale a été améliorée respectivement de 57,9%, 89,0% à 99,2% et 99,5%. L’angle de Cobb a été corrigé de 18,4 à 0,17. La largeur du canal vertébral est améliorée de 35,2 à 8,6%. Dans tous ces 25 cas, le statut neurologique des patients est normal au dernier suivi. En conclusion: l’utilisation d’un guidage par amplificateur de brillance est une méthode qui permet de réduire et de fixer de façon satisfaisante ce type de fracture. La réduction est confirmée par le signe « one-line » qui permet d’affirmer la bonne reconstitution du mur vertébral postérieur.

Introduction

Thoracolumbar burst fractures often result from a combination of acute hyperflexion and rotational forces, and are usually unstable [11, 15, 17]. The posterior fragments from the fracture usually enter the canal to some degree, which can sometimes result in neurological deficits.

The management of thoracolumbar burst fractures has been controversial [1, 6, 16]. Although there are proponents of anterior, posterior, or combined procedures, spinal fusion with instrumentation is a generally accepted part of the surgical management of burst fractures. Muller et al. has challenged the need for spinal fusion in the treatment of burst fractures by reporting that short segment pedicle screw fixation of the thoracolumbar fractures without fusion has satisfactory results [13]. However, a detailed technique regarding the use of fluoroscopy for burst fracture reduction through indirect posterior instrumentation has not been reported. The purpose of this study was to evaluate thoracolumbar burst fractures treated by indirect posterior reduction and pedicle screw instrumentation

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Fig. 1 Lateral (a) and anteroposterior (b) radiographs of a 42-year-old male after fall from a height (ASIA grade E)

without fusion and describe a technique using fluoroscopy to grade reduction.

Material and methods

Twenty-five consecutive patients with one level thoracolumbar burst fractures, without previous history of spine pathology, were enrolled. All patients had their neurological status evaluated preoperatively and at last follow-up using the ASIA scoring system [12]. A representative case is shown in Fig. 1.

The procedures were performed in the prone position with general anaesthesia. Pillows were used under the shoulder and iliac crest to relieve abdominal pressure. The incision was made posteriorly in the midline to first expose the spinous processes. The facet joints were then exposed, and finally the base of the transverse process from one level above and one level below the fractured vertebrae.

Using C-arm fluoroscopy, a lateral view of the thoracolumbar spine was set up to clearly show the inferior and superior endplates of the levels above and below the burst

fracture. In addition, the superior border of the proximal and distal pedicles were superimposed at both the superior and inferior levels. An anteroposterior view was also set up by clearly showing the inferior and superior endplates of the levels above and below the burst fracture. The spinous processes were also directly in the middle of the pedicles of the corresponding levels.

Pedicle screws were inserted parallel to the end plate in the vertebrae above and below the fractured vertebra. Fixation was achieved with connecting rods producing distraction and lordosis. Divergence of the pedicle screws at the two instrumented levels was an important goal, both to reduce the fracture and correct the kyphotic deformity. Distraction of the levels above and below the fracture was used to create tension of the posterior longitudinal ligament, to reduce the fracture by ligamentotaxis. To confirm the reduction of the fracture, the lateral view of the fluoroscopy was used to demonstrate a “one-line sign” of the posterior wall of the vertebrae at the fracture level (Figs. 2 and 3). No patient had bone grafting of the vertebral body nor was fusion performed.

Fig. 2 a The posterior line is broken on the predistruction fluoroscopic image. b The post-distruction image shows a “one-line” sign, demonstrating reduction of the posterior burst fragment

Fig. 3 **a** The preoperative CT clearly shows a break in the posterior line. **b** The postoperative CT shows reconstitution of the posterior line, which corresponds to the “one-line” sign seen on the intraoperative fluoroscopic image

Postoperatively, patients were managed with bed rest until regaining trunk control and then were then allowed to mobilise with a thoracolumbar brace. Implants were routinely removed at six to 12 months following surgery. Initially, removal of the implants was planned at 12 months; however, after a few cases had implant failure, subsequent implant removal was routinely done at six months.

Patients were evaluated with radiographs and CT scan pre- and postoperatively (Figs. 3 and 4). From the imaging, the anterior vertebral height (AVH), posterior vertebral height (PVH), Cobb angle, and ratio or canal compromise were evaluated pre- and postoperatively. The AVH and PVH were measured from lateral radiographs at the anterior and posterior aspect of the vertebral body, respectively. Both the AVH and PVH were reported as ratios of the pre-injury heights, which were determined by averaging the AVH and PVH of the levels above and below the injury level. The Cobb angle was measured on the lateral radiograph as the angle between the superior endplate of

the level above and the inferior endplate of the level below the injury. The ratio of canal compromise was measured on the axial CT scan as the difference between the pre-injury canal size and the canal size after injury, as a ratio of the pre-injury canal size. The pre-injury canal size was determined by averaging the canal sizes above and below the fracture level [14].

Software statistical analysis was done with SPSS version 13 (SPSS, Inc., Chicago, Illinois). The paired *t* test was used for pre- and postoperative comparative analysis with a *p* value less than or equal to 0.05 for statistical significance. Linear regression analysis was used to determine any association of canal compromise with postoperative results.

Results

Twenty-five consecutive patients were enrolled, composed of 15 males and ten females. The average age was 44.9

Fig. 4 **a** Preoperative CT scan. **b** Postoperative CT scan. The canal was decompressed with indirect reduction

Table 1 Average pre- and postoperative variables

	AVH	PVH	Cobb angle (°)	Ratio of canal compromised
Pre-op	57.9% ± 14.7%	89.0% ± 6.6%	18.4 ± 5.5	35.2% ± 13.3%
Post-op	99.0% ± 6.4%	99.5% ± 4.4%	0.17 ± 3.2	8.6% ± 4.4%

AVH anterior vertebral height, PVH posterior vertebral height

years (range, 24–66 years), and follow-up averaged 30.4 months (range, 6–48 months). The mean time from injury to surgical stabilisation was 4.6 days (range, two to ten days). The cause of injury was a fall from a height in 16 cases, motor vehicle accident in seven cases, and crush injury in two cases. The numbers of each level fractured were 2, 15, and 8 at T12, L1, and L2, respectively. CT results showed that two of 100 pedicle screws penetrated the medial wall of the pedicle and partially entered the spinal canal, but none caused clinical symptoms. No cases required surgical decompression, and at time of implant removal, the pedicle screws were removed under local anaesthesia. During removal, the local anaesthesia provided adequate pain relief, while allowing the patient to give feedback for any problems that could potentially occur during screw removal. There were no complications.

At last follow-up, the AVH was improved from 57.9% to 99.0%, and the PVH was improved from 89% to 99.5% of the calculated pre-injury heights (Table 1). The Cobb angle was improved from 18.4° to 0.17°, and the canal compromise ratio was improved from 35.2% to 8.6%

(Table 1). All pre- and postoperative outcome variables had statistical significance ($p < 0.01$). Also, the canal compromise ratio was negatively correlated to the AVH ($B = -0.410$, $p = 0.042$). All 13 cases of preoperative ASIA grade D were improved to grade E, as measured at the last follow-up. There were no complications of perineal area numbness or sphincter dysfunction. The 12 cases with preoperative ASIA E grades continued to have normal neurological evaluations at last follow-up.

Discussion

The goal for treatment of the thoracolumbar burst fracture is to restore the vertebral height, alignment, and lordosis, decompress the spinal canal, and restore spine stability. However, there is some controversy regarding the approach to achieve this goal. Some authors [9, 10, 16] propose that spinal canal compromise from the posterior vertebral wall is treated better with an anterior approach and decompression, as the pathology is anterior to the thecal sac. Following this logic, these authors also argue that results from a posterior decompressive procedure may be inferior, as it does not address the pathology and may leave residual compression anteriorly. In contrast, Wood et al. [18] has reported that patient outcomes are similar for both approaches, but anterior fusion and instrumentation for thoracolumbar burst fractures may involve fewer complications or additional operations. Another study [8] has advocated that a combination of an anterior and posterior approach with 360° fusion should be applied for highly unstable fracture subluxations.

Fig. 5 Postoperative radiographs. **a** Anteroposterior. **b** Lateral

In addition, Muller et al. reported that short segment fixation of thoracolumbar burst fractures without fusion gives satisfactory results [13]. However, this study was limited because patients with neurological deficits were excluded. Butt et al. have reported the outcome of 50 patients with unstable thoracolumbar fractures treated by posterior short segment fixation (Steffee VSP) with bilateral fusion. They found that, except for the significant improvement of the kyphotic angle and anterior vertebral body height, no neurological deterioration was seen; in 24 cases a one grade or better improvement was observed [3]. However, in our study, we used indirect posterior reduction and instrumentation without fusion, where 13 of 25 patients had some degree of neurological deficit preoperatively. As measured at last follow-up, all of these cases improved to ASIA E, and this result supports the conclusion that our approach is successful, at least in the short to intermediate term, in treating mild neurological deficiency from burst fractures.

There were 11 cases in this study with a sagittal canal compromise of more than 33%, averaging 45.7% (range, 37.2–57.8%); postoperatively, it was 7.8% (3.6–13.2%). In these cases with more than 33% canal compromise, our treatment method resulted in sufficient reduction of the fragment, and in neurological recovery in those with preoperative ASIA D neurological function.

Fluoroscopy is the key to indirect reduction of thoracolumbar burst fractures. However, a detailed technique has not yet been reported. We believe that it is extremely important to adjust the C-arm to show excellent, and specific, anteroposterior and lateral fluoroscopic images to monitor reduction. In addition, if the fluoroscopic images show that the posterior wall of the injured vertebrae is in one line (Fig. 2), this means that the reduction of the fracture and decompression of the spinal canal has been satisfactorily achieved (Figs. 3 and 4). In situations with the “one-line sign,” we do not consider laminectomies for further decompression. In the 25 cases of this study, the posterior wall of the fractured vertebrae all showed the “one-line sign”, and the postoperative CT showed the averaged canal compromise ratio reduced from 35.2% to 8.6%. These results suggest that our method to reduce burst fractures is valid (Figs. 4 and 5).

Exact insertion of the pedicle screw is fundamental for this surgery. The angles between the pedicle screws of the two instrumented levels should be divergent, which helps to reconstitute lordosis. In this study, 15 cases at last follow-up had Cobb angles less than or equal to 0°, and the other ten cases had angles between 0° and 5°. This result shows that pedicle screw fixation can satisfactorily correct the kyphotic deformity of the burst fracture. In addition, we recommend distracting 5–10° beyond a neutral Cobb angle at the fracture segment to help the long-term reconstitution of the vertebral height. This study showed that the postoperative canal compromise ratio was negatively

associated with the AVH ($B=-0.410$, $p=0.042$). This result suggests that increasing the AVH generally correlates with a better reduction.

Indirect posterior reduction mainly depends on an intact posterior longitudinal ligament. If the fragment has a reversed orientation or is seriously compromising the canal, the posterior longitudinal ligament is likely to be injured and indirect reduction is not as effective [2, 5]. Others [4, 7] believe that indirect reduction not only depends on the posterior longitudinal ligament but also on the elements of the posterior column. These elements include the facet joint, spinous processes, and the inter- and intraspinal ligaments. In addition, the spinal musculature likely plays a role in indirect reduction of burst fractures.

We advocate that fully restored vertebral height and correction of the kyphosis is important for indirect reduction of the posterior wall in burst fractures. Even if the posterior fragment significantly compromises the spinal canal, indirect reduction can still be attempted, but abandoned if the reduction is not satisfactory. In these cases, an open decompression and direct reduction must be considered.

In summary, pedicle screw instrumentation and indirect reduction for treatment of thoracolumbar burst fractures is safe and effective. The instrumentation provides sufficient immobilisation to restore spine stability until healing can occur. This procedure also avoids facetectomy, so that after instrumentation removal, the stability of the spine is preserved. In addition, percutaneous pedicle screw placement could be used to limit posterior dissection and postoperative pain. The overall theoretical advantage for treatment in this manner is that it may be beneficial as it maintains motion at this segment after instrumentation removal. However, motion at this segment may, in the future, prove to be a pain generator, as there is no proven long-term follow-up. Thus far, short-term clinical follow-up has shown promising results.

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