Treatment of subacute thoracic spine fracture-dislocation by total vertebrectomy and spine shortening

Technical note

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Vertebral resection with spine shortening has been primarily reported for the treatment of demanding cases of nontraumatic disorders. Recently, this technique has been applied to the treatment of traumatic disorders. The current treatment of vertebral fracture-dislocation when there is partial or total telescoping of the involved vertebrae is a combined anterior-posterior approach with corpectomy, anterior support implant, and further posterior instrumentation. These procedures usually require 2 surgical teams, involve longer operating times and greater risk of surgical complications related to the anterior approach, and commonly entail longer postoperative care before discharge. The authors report on 2 patients with high thoracic fracture-dislocations with telescoping (T-2 and T-4) who were treated in the subacute phase with total spondylectomy (T-3 and T-5, respectively) and spine shortening by using only a posterior approach. Complete recovery of the sagittal balance was achieved with this technique and the postoperative periods were clinically uneventful. One patient presented with asymptomatic hemothorax that did not require drainage. In paraplegic patients with anterior thoracic dislocation fractures in which one vertebral body blocks the reduction of the other, total spondylectomy and spine shortening seem to be a reasonably safe and effective technique.
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KEY WORDS • spine shortening • spondylectomy • vertebrectomy • spine fracture-dislocation • trauma

VERTEBRAL resection with spine shortening has been primarily reported for the treatment of demanding cases of nontraumatic disorders. It was first described in 1922 for the treatment of scoliosis through the posterior approach alone.¹⁵ Since then, this technique has been used in the management of congenital,^{7,21,27,28} tumoral,^{17,29} infectious,^{23,32,34} deformity,^{2–4,30,31} degenerative,^{9,10,13} and (recently) traumatic disorders.^{1,22}

The current technique for vertebral fracture-dislocation when there is partial or total telescoping of the involved vertebrae is a combined anterior-posterior approach with corpectomy, anterior support implant, and further posterior instrumentation.^{24,36} These procedures usually require 2 surgical teams, involve longer operating times and greater risk of surgical complications related to

the anterior approach, and commonly entail longer postoperative care before discharge.

We report on 2 patients with high thoracic fracture-dislocations with telescoping (T-2 and T-4) (Figs. 1A, 1B, and 2 left) who were treated in the subacute phase with total spondylectomy and spine shortening by using only a posterior approach.

Methods

Both patients were young adults who were victims of motor vehicle accidents and were paraplegic (ASIA Grade A) due to high thoracic spine translational fractures (Table 1).

Surgical Technique

Both operations were performed by the same surgeon (A.B.) using the same method (Fig. 3).

Abbreviations used in this paper: ASIA = American Spinal Injury Association; SCI = spinal cord injury; VB = vertebral body.

FIG. 1. Case 2. This 37-year-old man presented with T-4 fracture-dislocation after a motorcycle accident. **A and B:** Preoperative CT scans showing the fracture-dislocation and anterior telescoping of T-4 over T-5. A T-5 vertebrectomy and spine shortening procedure were done 8 weeks after trauma. **C and D:** Intraoperative radiographic studies. After vertebrectomy, a partial reduction of the deformity was already seen (C). After rods and caps were inserted and tightened, the reduction was fully accomplished and the sagittal balance restored (D).

Positioning. After induction of general anesthesia, the patient was placed prone and secured appropriately to the bed, so that the surgeon could safely rotate it slightly to the contralateral side when necessary.

Exposure. Through a midline incision, the vertebral posterior arches to be instrumented were exposed. The anterior dislocation fracture was evident. In both cases, posterior arch fractures were present (Fig. 3A and B). The paraspinal muscles were dissected subperiosteally from the spinous processes to the tips of the transverse processes.

Instrumentation. The pedicle screws were inserted 2 or 3 levels above and 2 levels below the lesion under

FIG. 2. Case 1. This 31-year-old woman presented with a T-2 fracture-dislocation after a car accident. **Left:** Preoperative CT scan showing the fracture-dislocation and telescoping of T-2 in front of T-3. **Right:** Radiograph obtained after 3 months showing maintenance of dorsal spine alignment.

fluoroscopy guidance. In the T2–3 fracture (Case 1), C-7 instrumentation was performed to include the cervicothoracic junction (Fig. 3C).

Vertebrectomy. First, the spinous processes and laminae of the upper and lower fractured vertebrae were resected (T-2 and T-3 in Case 1, and T-4 and T-5 in Case 2). The spinous process of T-1 in Case 1 and T-3 in Case 2 were also resected to expose the immediately inferior posterior arch (Fig. 3B). In both cases, the dura mater was injured and surrounded by dense fibrous tissue. No CSF leak was observed. No attempt to remove this fibrous tissue was made, to prevent further complications such as CSF leakage.

Second, the pedicles and transverse processes of the lower vertebra were resected (T-3 in Case 1 and T-5 in Case 2). At this moment, the upper and lower roots were exposed bilaterally. In both cases, no rib resection was necessary. Then, the corpectomy of the inferior vertebra was accomplished in piecemeal fashion by using the egg-shell technique. Using the high-speed drill, the central portion of the VB was removed (Fig. 3D and E). With use of curettes and impacters, the dorsal shell of the VB and the superior and inferior endplates were fractured into the defect and removed. The lateral wall of the VB was removed using the high-speed drill and rongeurs. Fluoroscopy was used to help define the limits of the VB resection. The underlying discs were completely removed. At that time, traction over the cranial and caudal spinous processes revealed unlocking of the luxation. After the

TABLE 1: Clinical data in 2 patients with VB fracture-dislocation*

Case No.	Age (yrs), Sex	Mechanism of Trauma	Fx Level	AO Fx Classification	ASIA Grade	Neuro Level
1	31, F	car accident	T-2	C3.1 + A1.2.1	A	T-2
2	37, M	motorcycle accident	T-4	C3.1 + A1.2.1	A	T-4

* Fx = fracture; Neuro = neurological.

corpectomy, the inferior endplate of the upper VB and the superior endplate of the lower VB were curetted until cancellous bone was exposed.

Reduction. After vertebrectomy, a partial reduction of the deformity was already noticed (Figs. 1C and 3F). At this time, one of the surgeons exited the surgical field to reposition the patient with larger thoracic pads to promote an additional postural reduction. The rods were

fixed first to the inferior pedicles and then to the superior pedicles with the use of the persuader. After rods and caps were inserted and tightened the reduction was fully accomplished, with an excellent realignment of the dorsal spine (Figs. 3G, 3H, and 1D). Autologous local bone graft was used to fill in the gap between the upper and lower VBs. The transverse processes and/or laminae of the in-

FIG. 3. Schematic illustrations of total spondylectomy and spine shortening. **A:** A 3D image of the thoracic spine fracture-dislocation. **B:** The posterior elements resected (colored red) and the corpectomy of the inferior vertebra (colored yellow). **C:** First the pedicle screws were inserted and then the posterior elements were resected. **D and E:** Upper and lower roots were exposed bilaterally and the corpectomy of the inferior vertebra was performed. **F:** After vertebrectomy, a partial reduction of the deformity was already noticed. **G:** After rods and caps were inserted and tightened, the reduction was fully accomplished. **H:** Complete fracture reduction.

Treatment of subacute thoracic spine fracture-dislocation

strumented vertebrae were decorticated and the intervals between them were packed with local bone graft (from the resected posterior arches and VB) and allograft (hydroxyapatite).

Wound Closure. The wound was closed in layers and a closed suction drain was left in place for 48 hours.

Results

Total vertebrectomy was done at T-3 (Case 1) and T-5 (Case 2). The operating times were 360 minutes (Case 1) and 405 minutes (Case 2). Both patients received packed red blood cell transfusion (Table 2). Prophylactic antibiotics were given for 48 hours. Although he was asymptomatic, the patient in Case 2 presented with bilateral hemothorax that did not require drainage. The patients' rehabilitation program began 1 day after surgery. Neither patient used spinal braces postoperatively. The patients went home on the 3rd and 7th postoperative day, respectively.

The immediate postoperative image showed excellent realignment of the dorsal spine (Fig. 1D). The complete reduction achieved after vertebrectomy and spine shortening followed by posterior fusion with pedicle screws resulted in restored coronal and sagittal balances. Follow-up images showed an excellent reduction and fusion in both cases without loss of correction (Figs. 4A and 2 right). When there was no proximal rib resection at the level of the vertebrectomy, the intercostal spaces between the 3 ribs adjacent to the upper and lower vertebrae were narrowed, although they did not touch each other. This finding did not result in intercostal neuralgia postoperatively (Fig. 4B and C). There was no implant failure. At latest follow-up, both patients were neurologically stable (ASIA Grade A) and their daily functional abilities were progressively improving. There was no spine-related pain. The local deformity was assessed using the Cobb method, from the upper endplate of the vertebra above the deformity to the inferior endplate of the vertebra below it (Table 3).

Discussion

The major characteristics of thoracolumbar injuries that influence the surgical decision are the injury's morphological features, the patient's neurological status, and posterior ligament integrity.³⁵ Anterior and posterior element injuries with rotation represent the most harmful traumas of the thoracic spine, and are associated with the highest rate of neurological deficit. Neural injury is caused by bone fragments and/or encroachment of the spinal canal resulting from translational displacement. It is rare for these dislocations not to cause neurological deficits.²⁶ Rotational shear injuries with slice fracture (C3.1;

and not oblique fracture) represented 3 of 1212 patients in the series by Magerl et al.¹⁶ According to Holdsworth,¹¹ these fractures are "by far the most unstable of all injuries of the spine." Magerl considered slice fractures to be more dangerous than rotational shear oblique fractures with regard to spinal cord compression, because of the shear on the horizontal plane.¹⁶

The primary goals of surgical treatment of thoracic fracture-dislocation with complete spinal cord transection are reduction of the deformity and rigid spine stabilization with fusion. According to Vaccaro et al.,³⁵ patients are best treated surgically via a posterior approach in the presence of distraction, disrupted posterior ligamentous complex in anterior translation, and complete SCI. However, to restore the anterior weight support and the spine sagittal balance it is necessary to reduce the anterior dislocation prior to posterior instrumentation. In cases of vertebral fracture-dislocation, some authors recommend a combined anterior-posterior approach with corpectomy, anterior support implant, and further posterior instrumentation.^{5,18,24,36} The posterolateral approaches such as lateral extracavitary and costotransversectomy also allow surgeons to access the ventral thoracic spine for a wide range of spinal disorders including tumor, degeneration, infection, and trauma.^{14,33} As stated in his comment on a paper by Resnick and Benzel,²⁵ Sonntag thought that these approaches are appropriate for an injury such as a fracture subluxation of the thoracic and thoracolumbar spine, for which both anterior and posterior approaches may be indicated. Nevertheless, a systematic review that included 774 patients showed a mean complication rate of 39%, 17%, and 15% for thoracotomy, lateral extracavitary approach, and costotransversectomy, respectively.¹⁴ For the anterior approach the main complications are hemothorax, chylothorax, pneumonia, dural tear, vessel injury, postoperative ileus, infection, intercostal neuralgia, post-thoracotomy pain, and deep venous thrombosis.^{6,8,38} Even via a posterior midline approach, the proximal ribs can be resected if needed. The surgical approach is a tool used to achieve a predetermined operative objective. The rate of complications is also related to the surgeon's selection criteria, timing, judgment, operative objective, and technical performance.¹⁸

Total vertebrectomy and spine shortening via a posterior approach have been used in the management of different nontraumatic disorders.^{2-4,6,9,10,13,15,17,21,23,27-32,34} Despite the avoidance of an anterior approach, these are also demanding procedures that may be complicated with hematomas, infections, hemopneumothorax, fixation failures, and also neurological deficits. The latter have been attributed to the excessive straightening of the spinal cord in the concave side after correction,^{30,31} or to dural buckling with ischemic results.⁴

TABLE 2: Surgical data in 2 patients with VB fracture-dislocation*

Case No.	Fx Level	Fusion Level	Surgical Delay Posttrauma (wks)	Op Time (mins)	RBC Transfusion (ml)
1	T-2	C7-T5	15	360	986
2	T-4	T3-7	8	405	630

* RBC = red blood cell.

Fig. 4. Case 2. Follow-up images obtained 20 months after surgery. Radiograph (**A**) shows T4–6 interbody fusion and maintenance of the reduction. The 3D CT images show posterolateral fusion of the instrumented vertebrae. Note the narrowing of the 4th and 5th intercostal spaces (**B and C**).

An experimental study in swine assessed the SCI after spine shortening. The authors monitored spinal cord function and blood flow simultaneously with the use of transcranial motor evoked potentials and laser Doppler flowmetry, respectively. An SCI occurred when shortening was equivalent to the height of 1 vertebra at the thoracolumbar level, or higher than the mean segmental height of the entire thoracic and lumbar spine.²⁰ Therefore, we do not recommend total vertebrectomy and spine shortening in patients with incomplete SCIs. In these cases the combined anterior-posterior or posterolateral approaches followed by spinal cord decompression, restoration of the vertebral segment height with structural interbody graft or titanium surgical mesh filled with graft, and stabilization are preferred because they are rarely associated with neurological deterioration.^{5,14,25}

There are few reports concerning total vertebrectomy and spine shortening in the treatment of traumatic injuries, all of them involving paraplegic patients.^{1,22} Although this technique provides decompression of the spinal canal and spine stabilization, this is essentially a mechanical surgery. In spite of the great efforts to date to improve neurological function after SCI, patients with complete lesions (ASIA Grade A), especially above T-9, are not expected to achieve functional recovery.^{8,37}

Barberá¹ reported the case of a young posttraumatic paraplegic patient (ASIA Grade A) with severe chronic (8 months) thoracolumbar (T12–L1 telescoped) kyphotic deformity that was corrected by a single-level spondylectomy with spine shortening; this was accomplished using a posterior approach. Obeid et al.²² reported total vertebrectomy and spine shortening for acute thoracic spine fracture dislocation. They described some advantages of

this technique, such as a single approach (posterior) and the fact that the apposition of the adjacent healthy endplates permits an excellent reconstruction of the anterior spinal column and might provide an excellent interbody fusion rate. According to them, total vertebrectomy facilitated reduction and shortening of the spine, avoided traction on adjacent vascular elements, and seemed to be less traumatic for the adjacent structures. These authors considered it safer to perform long posterior instrumented fusion with at least 3 levels above and below the injury. Because spine shortening provided an excellent realignment without biomechanical stress and the preoperative images and intraoperative inspection suggested posterior ligamentous complex injury only at the level of dislocation, we applied posterior instrumentation only 2 levels above and below the injury in Case 2 (T4–5). In Case 1 (T2–3), C-7 was also instrumented to avoid stopping fusion immediately below the cervicothoracic junction.

During the surgical decision making, the choice for a total vertebrectomy and spine shortening must also consider the degree of the dislocation. If the anteroinferior edges of the adjacent vertebra's endplates (for example T-2 and T-3 in Case 1, and T-4 and T-5 in Case 2) are almost at the same horizontal plane, total vertebrectomy might allow full reduction, with a gap no larger than the height of the intervertebral disc space. This should be packed with cancellous bone. However, if a large interbody gap remains after the vertebrectomy and the reduction, resection of the proximal ribs and placement of a structural interbody graft might improve closure of the gap and provide anterior support to improve fusion and preserve the sagittal balance.¹² In some fracture-dislocations, the resection of the injured disc and partial corpectomy of

TABLE 3: Follow-up data in 2 patients with VB fracture-dislocation

Case No.	Kyphosis (°)			Pain	ASIA Grade	Follow-Up (mos)
	Preop	Immediate Postop	Late Postop			
1	28	20	20	no	A	3
2	32	16	16	no	A	20

Treatment of subacute thoracic spine fracture-dislocation

the inferior vertebra involved might be enough to allow reduction and superimposition of the adjacent vertebrae.

All preoperative images of T4–5, T6–7, and T9–10 dislocations presented by Obeid et al.²² showed traumatic hemothoraxes that might have been related to the spine fractures themselves or to other injuries not mentioned in the report. However, the postoperative period was uneventful. These patients all underwent operations during the acute phase. One of our patients (Case 2) had surgery in the 8th week posttrauma and experienced bilateral hemothoraxes postoperatively that did not require drainage. Probably the bleeding occurred from vessels in scar tissue that were stretched during the reduction. This fact does not seem to override the other benefits of this technique.

Conclusions

Thoracic spine dislocation results in some of the most difficult biomechanical conditions for internal fixation. The recovery of sagittal balance to a physiological alignment certainly minimizes the stress on the implants. Therefore it is of paramount importance to reduce the dislocation as much as possible to provide a rigid fixation and fusion. In paraplegic patients with anterior thoracic dislocation fractures where one VB blocks the reduction of the other, total spondylectomy and spine shortening seem to be a reasonably safe and effective technique.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Barcelos. Acquisition of data: Barcelos. Analysis and interpretation of data: Barcelos. Drafting the article: Barcelos. Critically revising the article: both authors. Reviewed submitted version of manuscript: both authors. Approved the final version of the manuscript on behalf of both authors: Barcelos.

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