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Upper Thoracic Spine Fractures Treated by Posterior Transpedicular Corpectomy, Expandable Cage and Fusion: Literature Review and Report of a Case of T4 Severe Burst Fracture

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Abstract

Background: The transpedicular approach, fitting of an expandable cage, and posterior fusion, is a procedure that enables the neurosurgeons to treat severe burst fractures through a familiar access for them. This treatment has been described for selected patients in order to avoid the morbidity associated with the anterior approaches (vascular injury, aspiration, pleural effusions effusion, pneumothorax, decreased pulmonary function, etc).

Methods: We review the Literature about upper thoracic fractures treated with this procedure, analyze the indications and surgical technique, and present the case of a severe T4 burst fracture operated upon by transpedicular corpectomy, self-expanding cage and posterior transpedicular fusion.

Results: Literature review showed a relative rarity of reports of non-pathological fractures treated by this procedure in the upper thoracic region (about 7 upper spine fractures reported with a similar treatment to ours). A lesser incidence of complications, in comparison to anterior routes, is reported. According to the review and our experience, the procedure can provide both an effective decompression as a solid stabilization, along with less postoperative complications than the anterior routes.

Conclusions: Upper thoracic spine fractures have only rarely been treated with transpedicular posterior approach. Neurosurgeons are familiar with this route. Therefore, more similar cases need to be communicated, in order to assess the reliability and safety of the procedure in selected patients, eventually increasing the indications of the procedure and progressively involving upper levels of thoracic spine.

Keywords: Thoracolumbar spinal fractures; Posterior transpedicular approach; Corpectomy; Expandable; Cages

Introduction

The thoracolumbar spine is vulnerable to traumatic/osteoporotic fractures, neoplastic invasion or infection. The vertebral body represents a capital element in the maintenance of spine stability, and is responsible for the transmission of about 80% of the axial load applied to the column [1-9]. Extensive injury of anterior and medial columns may require the partial or complete removal of the vertebral body (corpectomy), compromising spine stability and sagittal balance and requiring stabilization. In most cases, the indication of surgery is the removal of an entire vertebral body, invaded by a tumor or another infiltrative or destructive condition [6]. In case of traumatic fractures, only selected cases (severe vertebral body burst fractures) can require corpectomy [10-12].

Corpectomy can be carried out through an anterior or posterior approach. Anterior approaches have been widely described in the literature, particularly in primary tumors and metastatic disease. The anterior route allows a direct exposure of the vertebral body, but it requires experience in thoracic or abdominal surgery and, frequently, multidisciplinary surgical approach (General and Thoracic Surgeons).

The posterior transpedicular approach has been recently described for the treatment of these patients in order to avoid the morbidity associated with the anterior approach [13]. Posterolateral thoracic corpectomy´s feasibility has been supported in 2011 by Kim (6 cadavers and 4 clinical cases; 2 T6 bust fractures, 2 tumors). Lower complications rates and lesser degree of morbidity have been communicated, in comparison to the anterior approaches [6,13-15].

Two technical advances have been proved to be a helpful aid in these posterior approaches. On the one hand, the introduction of expandable titanium cages allows a partial or subtotal replacement of the affected vertebral body, giving stability to the spinal segment through the correction of height loss, balance and restoration of sagittal alignment of the kyphotic deformity [12]. On the other hand, the development of microsurgical techniques, assisted by navigation, enables the removal of the vertebral body through a secure route, sparing noble structures.

Reduction and stabilization are the standard of treatment for thoracic-lumbar fractures, and it has been accomplished for decades through classical posterior approaches, using screws and rods, even at upper thoracic levels [8]. Anterior routes have also been widely used for the same proposal, providing a better way to reconstruct the vertebral body and stabilize the spine. For this goal, vertebral body replacement with expandable cages, associating anterior or posterior fixation, constitutes a reliable management [6,16]. Due to the large extension of bone removal that is usually required in these cases, self-expandable cages have proven to be a suitable implant to restore the alignment, stability and morphology of the damaged spine, with good biomechanical results. Cárdenas R J et al. [4] conducted a study in order to establish biomechanical stability of fibular allograft compared to self-expanding cages in 8 human cadavers [17]. The study was

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performed isolating vertebral segments T11 to L3 which underwent L1 corpectomy and transpedicular screw and plate fixation. Biomechanical parameters were analyzed in vitro (flexion, extension and lateral tilt). They concluded that the stiffness parameters of self-expanding cages were equivalent to those of fibular allograft [18,19].

Salas et al reviewed a series of 23 high-energy trauma patients with thoracolumbar fractures treated with vertebral body expandable cages [20]. In this series were both 12 thoracic fractures and 12 lumbar fractures (2 cases T5, 1 case T6, 1 case T8, 1 case T10, 1 case T11, 6 cases T12, 5 cases L1, 4 cases L2, 2 cases L3 and 1 case L4). Posterior osteosynthesis was associated to 12 cases. A video-assisted minimally invasive approach was performed to 17 patients. A satisfactory functional recovery was obtained.

Nevertheless, anterior routes increase the rate and severity of complications, particularly in patients with poor health conditions. Therefore, a less hazardous route to access the spine could be helpful [6].

Posterior transpedicular approaches were initially described to treat spinal metastatic tumors [3]. Afterwards, several works using this method in vertebral tumors, including in upper thoracic levels, were communicated, emphasizing the avoidance of the anterior routes complications [1,10,21,22]. Later on, in 2000, Bilsky [3] approached spine for corpectomy and posterolateral reconstruction with polymethyl-methracrylate and Steinmann pin with long segmental fixation [12]; and in 2011 Eck performed a posterior transpedicular corpectomy with titanium mesh cage reconstruction and posterior stabilization in 1 patient with lumbar fracture [6]. Similar results to those of expandable cases were reported in correction of kyphotic deformity, stabilization and functional status in both thoracic and lumbar spine [7].

Since 2006, several authors have proposed the usage of expandable cages, placed through posterolateral or posterior approach, firstly in the lumbar and secondly in the thoracic vertebral body reconstructions [5,11]. The indications are reserved to treat severe injuries, mainly burst fractures, where, as in the tumors, a complete body removal, along with replacement, would be required. Sasani et al. [21] carried out a study comprising 14 patients who underwent burst fractures T8-L4, in which they recommend the posterior approach in selected cases, reducing the complications of anterior or combined-approaches. The technique is proposed as an equivalent to the anterior route for decompression and stabilization of the injured segment. This procedure allows neural decompression, vertebral body reconstruction, and posterior stabilization with pedicle screws. Moreover, it facilitates a shorter hospital stay [2].

Keshavarzi [12] conducted in 2011 a study with a sample of 35 patients who underwent vertebral body reconstruction with self-expanding titanium cages at thoracolumbar levels. Within the sample, 20 patients presented primary or metastatic neoplastic processes, 7 infections and 8 traumatic fractures. Posterior approach was performed in 22 of them, including posterior instrumentation of 3-4 levels, depending on bone quality and pathological location. Antero-posterior combined approach was performed in 8 patients; and anterior approach with instrumentation in 5 patients. Only 8 fractures were included in this study; 3 were approached through an anterior route and 5 through a posterior route. No patient experienced neurological deterioration during follow-up; no mortality either. The authors concluded that intersomatic expandable devices represent an effective treatment for the reconstruction of the vertebral body to give the spinal segment a biomechanic stable structure, allowing the correction of the kyphotic deformity, the deviation of the sagittal balance and the decrease of painful symptoms.

Ruban et al. [19] presented in 2011 a series of 8 patients with thoracic injuries indicating decompression and fixation. Metastatic disease was diagnosed in 7 patients; post-traumatic fracture in 1 patient. Patients underwent corpectomy with interposition of a cage and instrumentation by a posterior approach (2 levels above and below the affected area). The authors added a technical detail consisting of a diagonal temporary rod fixation of the affected segment, in order to perform the corpectomy, by the placement of a slash from the transpedicular screw of the immediately higher level to the contralateral lower level. They justified this technique to ensure no anatomical distortion, biomechanics, and a great extraction of the vertebral body by two surgeons at the same time without being hampered by the clamp bars, shortening surgical timing. In conclusion, they affirm that posterior transpedicular approach is a valid technique for patients with vertebral thoracolumbar injuries which are subsidiary of corpectomy and instrumentation. They emphasize the advantage of reducing morbidity caused by anterior approaches [23].

Despite the wide use of these surgical approaches and reparations in the treatment of spinal tumors [6,13,16,24], few cases of vertebral fractures treated by the posterior placement of an expandable device have been described [6,13,22]. In addition, most of these works deal with lower thoracic or lumbar levels. Cases of upper traumatic thoracic fractures treated by these procedures are very infrequently reported in Literature. Due to this rarity, more cases need to be communicated. We report a severe T4 burst fracture treated with this procedure and review the literature on the subject.

Material and Methods

Case study

We present the case of a 59 year-old male with a history of high blood pressure, severe obesity and unilateral nephrectomy secondary to nephrolithiasis. He suffered a work accident when he fell from 3 meters high. There was no loss of consciousness. He was unable to move the inferior limbs since the moment of injury. The patient was transferred by helicopter to our hospital; suffering from traumatic shock with hypotension and bradycardia, being admitted to the intensive care unit. Traumatic shock recovered after general treatment.

From the onset, flaccid paraplegia at T4 level was appreciated. Neurological status was classified using the ASIA scale (American Spinal Injury Association). Our patient didn´t preserve any sensory or motor function (ASIA A).

X ray showed a closed dorsal fracture (T4 burst fracture). CT and MRI revealed multiple bone fragments inside the spinal canal along with an intense spinal cord injury at the fractured level. CT study with three-dimensional reconstruction was carried out for preoperative planning (Figures 1-3).

Due to intense destruction of the T4´s vertebral body, we initially considered anterior 360 degree stabilization. However, this decision was modified after checking out the deterioration of the general condition of our patient, who developed a respiratory failure due to a respiratory distress. A transthoracic anterior approach would have entailed a high morbidity risk. The chosen alternative was a posterior transpedicular approach with corpectomy and posterior fusion; and both the patient and her family agreed with the procedure.

Finally, five days after the injury, the patient was operated on using the following technique:

A classic exhibition of posterior midline sheets, facets and transverse joints of the levels T3 to T8, was performed. Transpedicular screws were used to fix levels T3 to T5, under X-ray guidance. After complete laminectomy, removal of bone intracanalar fragments, and meningeal repairing, the surgery was completed with sequential bilateral transpedicular approach and corpectomy of T4 body using high speed drill and curettes, under microscope.

Once retrieved enough vertebral body space (bilateral transpedicular corpectomy) we performed under X-Ray guidance the placement of a titanium self-expanding cage (Synthes Synex™ System, West Chester, PA 19380. Blue model: Paralel endplates; 23-31 mm.). After the implant was secured, posterior rods were tightened to the screws. Autologous bone, from the laminectomy was placed on intertransverse-facets space bilaterally, once refreshed.

Surgical outcome can be appreciated in Figures 4 and 5. No postoperative complications were observed. Respiratory distress improved after surgical reconstruction of the affected level. Rehabilitation after surgery started 2 weeks later. The follow up was 8 months, without record of the cage´s displacement. After this period, the patient was discharged to a Rehabilitation Unit.

Discussion

Commonly, unstable thoracic spine fractures have been treated either conservative or surgically through an anterior approach. The advantages of anterior approaches includes a more direct visualization for reconstruction purposes, and a wider surgical field that render easier the implant placing and securing. Between the disadvantages are: dysphagia, vascular injury, risk of aspiration, pleural effusion, pneumothorax, decreased pulmonary function, post-thoracotomy pain, and others [1,10,22].

Alternatively, the posterior approach allows sparing of visceral-vascular structures, provides an easy access to the injured spine, and offers a reliable way to decompress the spinal cord and to repair dural tears. Therefore, the familiarity with the posterior approach [15,22], fitting of expandable cage and fixation, is a procedure that enables the neurosurgeons to treat severe burst fractures in a complete way through a familiar route for them. Between the disadvantages of the procedure are the needing of training in the microscope use, more difficulties in accessing the vertebral body (because the route is through the pedicles), and a more laborious implant placing (requiring x-ray guidance and some tips, as tapes tied to the cage to drive it to a correct placement). Other disadvantages included narrow working space, significant blood loss and risk of injury to neural parts [10].

Meta-analysis comparing the anterior vs posterior procedures in burst spinal fractures has shown that the anterior approach was associated with longer operative time, greater blood loss and higher cost than the posterior approach [2]. Also, a better pulmonary function after posterior operation has been communicated [14].

Corpectomy through posterior approach was indicated in our patient as a better choice compared to the anterior thoracic route. Firstly, he suffered from a complete somatic burst fracture as it can be seen in (Figures 1-3). Vertebral body replacement appeared to be the best method to regain normal spine shape, rigidity and stability. Secondly, his poor respiratory condition and obesity rendered

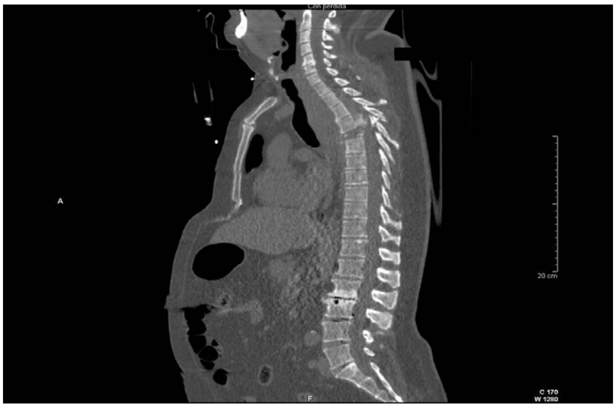

Figure 1: T4 burst fracture (ASIA A)

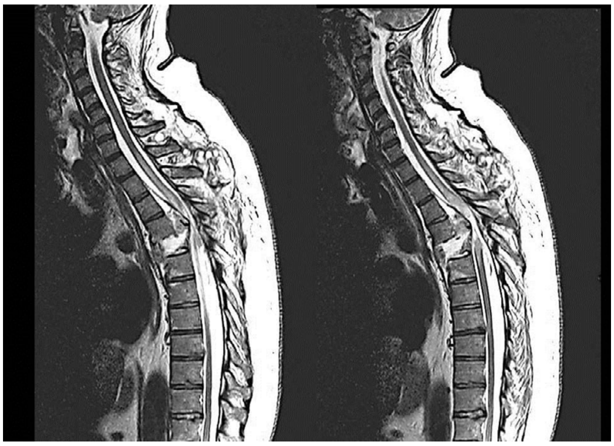

Figure 2: MR study shows an intense spinal cord injury at the fractured level

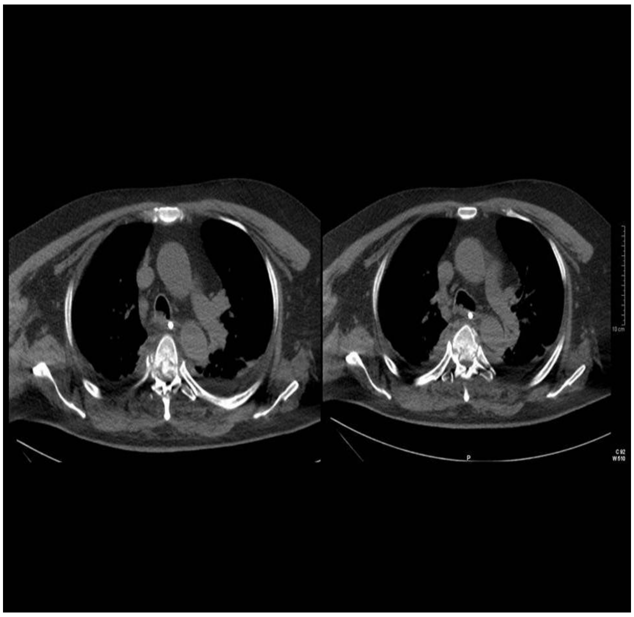

Figure 3: CT scan shows multiple bone fragments inside the spinal canal

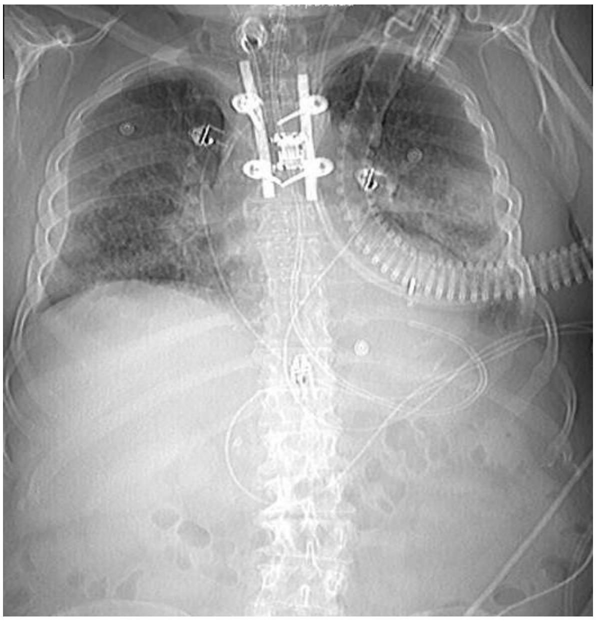

Figure 4: Postsurgical image showing expandable cage and posterior arthrodesis

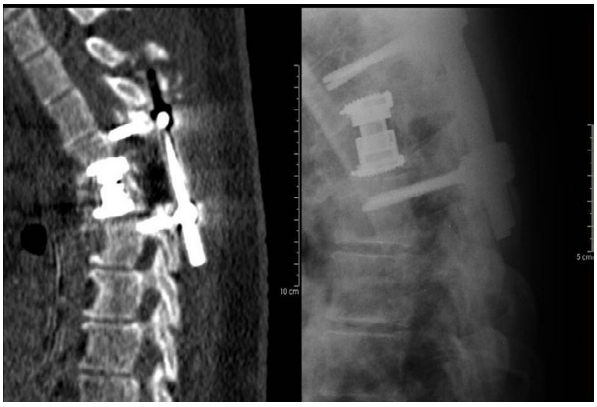

Figure 5: Lateral view of Rx and CT sagittal reconstruction, showing postoperative result

dangerous a transthoracic approach, even endoscopically (Figures 1 and 4).

The main objective in this case was to provide the patient a way to achieve spinal stabilization and fixation enough to start with Physiotherapy, and to accomplish this goal with the less morbidity as possible.

Technically, in our case, the procedure was performed without difficulties, since the risk of neural damage was excluded from the precedent medullar lesion. Bleeding from fracture sites was the main problem found, not due to its amount but to its interference in the microsurgical approach. We controlled it readily by using bone wax, and microfibrillar collagen hemostatic agents.

We did not need to divide the corresponding nerve root to gain room for the cage placement, as some authors have pointed out in other occasions [22]. We were able to find room enough to place the expandable cage easily, performing the bone removal from both sides.

Other authors found useful to tie the cage with two tapes. One of them is passed from one side to the other in order to aid in handling the implant in a correct position, by stretching the strips as needed [6]. We did not need it either. It could be argued that in a neurologic indemnity context, the movements necessary for cage implantation would have been more restricted than in our case, depending on neurophysiological monitoring. In such cases, the cited maneuvers would have been useful.

Other surgical aiding as navigation (three-dimensional image guidance for Nottmeier or laser-guided pre-incision for Pakzaban [17,18], high speed drills, microsurgery and neurophysiological monitoring appear as useful tools.

An interesting advantage of expandable cages is that a proper fit and gentle axial loading may create biomechanically and biologically favorable conditions for fusion [13,22]. The large endplate of the expandable cage maximizes the surface area for fusion to the adjacent endplates [13]. An inclusion in the fusion of more than one level above and below the burst body is usually unnecessary if the cage is used. Circumferential primary and secondary stabilization provided by cage combined to transpedicular arthrodesis are usually enough to guarantee a good biomechanical restoration of the injured spine region. In other reports, a combination of locally harvested bone, demineralized bone matrix, silicon substitutes, calcium phosphate and/or bone morphogenetic protein were used to fill the implants [7]. In our patient, autologous bone from the laminectomy was placed.

Between the disadvantages of the posterior technique, the cost of the implant has been described as more expensive than allograft or rigid titanium strut grafts [22]. Nevertheless, the reduced surgical time and morbidity may outweigh the higher cost of the procedure [6]. Another inconvenient is that a complete decompression and reconstruction of the anterior spinal column in the upper thoracic spine and lumbosacral junction can be a great challenge [13]. Correction of lordosis is also difficult with expandable cages. A revision of the implant's failure (expandable box) has been reported in few traumatic fractures, 18% for Hofstetter et al. [10].

In our case the main difficulty found was the correction of lordosis, due the narrow surgical space and the needing of a small cage in order to be passed anteriorly and get a proper fitting to the bone defect. The resulting Cobb angle was 19,38 degrees, fairly acceptable for the high thoracic spine. However, this pathway requires the frequent use of small intersomatic devices, since the transpedicular posterior space, whereby the self-expanding cage is inserted, is much smaller than the exposure achieved in the anterior approach.

We reviewed the Literature on transpedicular approach, conducting an extensive search in Medline in the last five years. The strategy of search with the words "transpedicular approach thoracic lumbar fracture" produced only 70 Articles. When the term "corpectomy" or "replacement" were added, the search gave only four papers.

Most of the works found refer to destructive lesions, mainly malignant tumors, but only few papers communicated acute non-pathological fractures treated by posterior body replacement and fusion. Between these, the number of upper thoracic fracture is even rarer.

Table 1 summarizes the studies that included patients treated with corpectomy, vertebral body replacement with expandable cage and fixation. It shows a resume of up to date studies on this subject, recording only 7 upper thoracic level cases; 3 T6 [24], 2 T5 - 1 T6 [20], and 1 T4 (present paper, 2013). Other authors didn´t specify the

Author; Year	Number of patients and etiology	Fractures in Thoracic spine	Approach
Hunt; **2006**	1 patient; 1 metastases	**0**	Corpectomy + **expandable** cage (Synthes Synex Cage, West Chester, PA) + posterolateral transpedicular stabilization
Zeman; 2007	18 patients (20 cages); 4 posttraumatic kyphosis, 14 thoracolumbar fractures, 2 metastases	**3 T6**, 4 T12 (most frequent thoracic levels)	Corpectomy + **expandable** cage (Synthes Synex Cage, West Chester, PA) + posterior transpedicular stabilization in 14 patients of the study
Sasani; **2008**	14 patients; 14 burst fractures	1 T8, 1 T10, 1 T11, 1 T12	Posterior corpectomy + **expandable** cage (Obelisc, Vertebral body replacement; Ulrich Gmbh & Co., Ulm, Germany) + transpedicular screw fixing
Shen; **2008**	21 patients; 21 tumors	0	Posterior corpectomy + **expandable** cage (Synex; Synthes, Paoli, PA) + posterior instrumentation and fusion
Chou; **2009**	1 patient; 1 L1 fracture	0	Posterior transpedicular corpectomy + **expandable** cage + instrumented fusion
Keshavarzi; 2011	35 patients; 20 neoplasms, 7 infections, 8 fractures (3 anterior routes; **5 posterior routes**)	5 thoraco- lumbar; not specified	Vertebrectomy + **expandable** cage (**VLIFT; Stryker Spine, Allendale, New Jersey**) + posterior instrumentation of 3-4 levels
Ruban; 2011	7 patients; 1 fracture, 6 metastases	1 T7	Posterolateral transpedicular corpectomy + **expandable** cage (not specified) + temporary diagonal fixation + T5T9 instrumented fusion
Salas; **2011**	23 patients; 23 fractures	**2 T5, 1 T6,** 1 T8, 1 T10, 1 T11, 6 T12	Corpectomy + **expandable** cages+ posterior osteosynthesis (in 12 patients)
Hofstetter; 2011	67 patients; 17 fractures	**7 thoracic;** not specified	Corpectomy + **expandable** cage (Synthes Synex Spine; VBR, Ulrich; Globus expandable cage, Globus Medical; and VLIFT, Stryker) + arthrodesis
Metcalfe; 2012	50 patients; 50 spinal tumors	0	Posterior transpedicular corpectomy + **expandable** cage (Pyromesh, Medtronic, Minneapolis, MN, USA or ADD Cage, Ulrich Medical, Ulm, Germany) + instrumented fusion
Present study	1 patient; 1 fracture	**1 T4**	Posterior transpedicular corpectomy + **expandable** cage (Synthes Synex™ System, West Chester, PA 19380) + instrumented fusion

Table 1: Studies including patients treated with corpectomy, vertebral body replacement with expandable cage and fixation. Thoracic levels are specified as the emerging spine levels treated through a posterior approach.

treated levels, in the thoracic or thoracolumbar spine [12,17] (Table 1). Therefore, in acute non-pathological fractures of upper thoracic spine, posterior approach is specified as an emerging procedure [25].

Conclusions

According to Literature review and our experience in this case, we recommend posterior transpedicular approach for Neurosurgeons more experienced in this field, in selected patients with upper thoracic severe burst fractures. Corpectomy through this route, along with self-expandable cages and posterior transpedicular stabilization allow decompression, stabilization and circumferential fusion in one stage without cavity involvement. Especially in complicated patients with respiratory distress, this emergent approach avoids the complications of the anterior approaches in particular when dealing with upper thoracic fractures.

There is a rarity of reports about non-pathological fractures treated by this procedure in upper thoracic levels. Therefore, more cases similar to ours need to be communicated, in order to assess the reliability and safety of the procedure in this region.

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