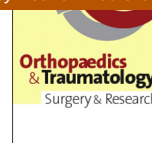


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Original article

# Early percutaneous fixation of spinal thoracolumbar fractures in polytrauma patients



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## ABSTRACT

**Introduction:** Care of polytrauma patients is complex and requires that a particular treatment sequence be followed during what is typically a short period of time. Early, temporary stabilization of injuries (damage control orthopedics [DCO]) is a validated strategy for the care of polytrauma patients. Application of this concept to spinal fractures has also led to good outcomes for patients. The recent development of percutaneous thoracolumbar fixation could improve the initial care of these vulnerable patients even more. The purpose of this study was to evaluate preliminary results in a series of polytrauma patients presenting with thoracolumbar fractures without neurological deficits who were treated according to DCO principles using early percutaneous fixation.

**Materials and methods:** All severe polytrauma patients admitted with a thoracic and/or lumbar spine fracture without neurological deficit were included in this prospective study. The care was standardized according to the degree of urgency of the initial injuries, with percutaneous spinal fixation being performed as early as feasible. The outcomes were evaluated using clinical parameters (duration of stay in intensive care unit, surgical data, blood loss) and radiographic parameters measured during a systematic postoperative CT scan (traumatic deformity, placement of pedicle screws, fusion rate). If needed, an anterior intervertebral graft was performed during a secondary procedure.

**Results:** In all, 10 patients (average age of 40 years) were included, corresponding to 18 vertebral fractures. During the initial assessment, at least one peripheral bone fracture was found in 90% of cases and at least one organ was injured in all patients (thoracic in 80% of cases, cerebral in 50%, facial area in 40% and abdominal-pelvis in 30%). The average time elapsed between admission and spine surgery was 4 days (80% of cases before day 7). There were no cases of deep infection in any of the patients. An additional anterior procedure was needed in three patients within 1 month of the initial surgery.

**Discussion:** The strategy for treating thoracolumbar fractures in polytrauma patients is still not widely accepted. The presence of associated lesions could make it difficult to perform conventional spine surgery early on. Development of percutaneous techniques that reduce perioperative morbidity seems to be an alternative approach well-suited to DCO, as long as there are no neurological deficits. However, a secondary evaluation of the anterior spine is essential to determining if an anterior graft remains needed.

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## 1. Introduction

Thoracolumbar spine fractures are common injuries; the estimated annual incidence in Western countries is 64 per 100,000 people [1]. These fractures are most often the result of high-energy trauma and are often associated with organ injuries that are life

threatening in the near term. In such clinical situations, the sequence of steps for treating these injuries is vital and the window of time during which surgery can be performed for bone injuries is often short. The concept of damage control orthopedics (DCO) [2,3] was derived from experience in caring for polytrauma patients. DCO consists of quickly and temporarily stabilising bone injuries until more definitive surgery can be performed once all organ-related problems have been resolved. Clinical validation of DCO was provided through the care of peripheral fractures in polytrauma patients [2]. It is accepted that early fixation of fracture sites reduces the risk of haemorrhagic shock, hemostatis problems, surgical site infections, and mortality, while making it easier to provide nursing

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care for these patients [4]. These treatment protocols have also been applied during the care of thoracolumbar spinal injuries in polytrauma patients and have resulted in fewer short and long-term complications [5,6].

In parallel, the recent development of percutaneous spinal fixation techniques has allowed surgeons to treat various types of vertebral injuries while reducing the invasive nature of conventional posterior surgery. Recent studies have shown that percutaneous posterior fixation is a viable alternative to open fixation [7–9]. Using minimally invasive techniques reduces intraoperative blood loss and postoperative pain, while producing similar radiographic results to conventional techniques in terms of the deformity correction [10].

Thus, it is reasonable to think that the benefits of these percutaneous surgical techniques could be even more significant in the context of the initial care of thoracolumbar fractures in patients with one or several associate organ-related failures [11,12]. The purpose of this study was to evaluate the preliminary clinical and radiological results of a prospective series of severe polytrauma patients presenting with thoracolumbar injuries, without neurological deficits, who were treated according to the principles of damage control orthopedics by using percutaneous posterior fixation during the initial treatment phase.

## 2. Material and methods

### 2.1. Study outline

During this prospective study conducted from August 2011 and April 2012, all the patients admitted for treatment of severe trauma who presented with single- or multi-level thoracic and/or lumbar spinal fracture without signs of neurological deficit were included. Severe trauma was defined according to the criteria proposed by the French Society of Anaesthesia and Intensive Care (SFAR): presence of at least one potentially lethal organ injury in association with an Injury Severity Score (ISS) of 25 or more and predicted mortality rate of 10% or more.

Since the presence of medullary compression or nerve root injury is a contraindication for percutaneous posterior fixation, this finding was an exclusion criterion for the study.

For each patient, the initial injury assessment was performed using whole body CT scan and MRI of the entire spinal cord. The ISS and predicted mortality were calculated upon the patient's arrival by the anesthesiologist.

### 2.2. Treatment strategy

The treatment sequence for patients was standardized and determined according to degree of urgency of the initial lesions. Any life-threatening injuries were cared for first. Spinal injuries were then treated second, as quickly as possible after admission.

The same treatment strategy was used for all the patients enrolled in the study: percutaneous posterior fixation (CD Horizon Longitude®, Medtronic; Mantis®, Stryker) under A-P and lateral fluoroscopy control. The fracture site was reduced by placing the patient in lordosis over blocks and through percutaneous intraoperative manoeuvres using specific instrumentation and in situ rod bending as needed [13]. In every patient, long-span fixation consisted of pedicle screws placed in the two vertebrae above and below the level of the fracture.

### 2.3. Evaluation criteria

To determine the benefits of this treatment strategy, patients were evaluated based on the following clinical criteria: time

between accident and procedure, operative time, intraoperative fluoroscopy duration, estimated intraoperative blood loss (evaluated by comparing preoperative and immediate postoperative hemoglobin), PAFI (PaO<sub>2</sub>/FiO<sub>2</sub> ratio) before and after the surgery, duration of postoperative mechanical ventilation, number of days spent in intensive care, amount of morphine-based drugs consumed during the first 24 hours after surgery, number of postoperative blood transfusions, number of early and late surgical site infections.

In parallel, CT scans were carried out immediately after the surgery, then 3 months, 6 months and 1 year after the trauma to determine the radiological outcomes. The following parameters were assessed: reduction of segmental and regional kyphosis, rate of malpositioned pedicle screws (extra-pedicular cortex breach > 2 mm [14]) and rate of fracture site healing at 3, 6 and 12 months postoperative evaluated on consecutive CT scans (presence of bone bridge, absence of implant movement or rupture). All of the radiological evaluations were performed prospectively by a spine surgeon other than the surgeon who performed the initial fixation.

### 2.4. Additional care

Once the acute phase of injury had passed, the need for an additional anterior intervertebral graft procedure was determined based on the postoperative CT scan. The indication was made based on the percentage of bone loss in the fractured vertebral body after reduction, instability of the fracture site and severity of any disc injuries. In cases where anterior stabilisation was deemed necessary, this procedure was performed through a video-assisted mini-incision. It consisted of right thoracotomy for upper thoracic vertebrae (> T9), left thoracotomy for lower thoracic vertebrae (T9–T11), thoracophrenolombotomy for vertebrae at the thoracolumbar junction (T12–L1) or lumbotomy for lumbar vertebrae. Corpectomy and discectomy were then performed in combination with reconstruction using an intervertebral cage (V-LIFT®, Stryker) and autologous bone graft.

## 3. Results

### 3.1. Demographic data

Between August 2011 and April 2012, 10 severe polytrauma patients presenting with single or multiple thoracic and/or lumbar spine fractures without neurological signs were included prospectively. The average age was 40.3 years (range 18–68) and the gender ratio was 1:1 (Table 1).

The 18 spine fractures cared for within this protocol were distributed in the following manner: 6 upper thoracic spine fractures, 8 lower thoracic spine fractures, 3 thoracolumbar junction fractures and 1 lumbar spine fractures. Three patients had a single-level fracture, four patients had a two-level fracture and three patients had a three-level fracture.

### 3.2. Associated injuries, severity score and progression

During the initial evaluation, every patient had one or multiple associated lesions. Thoracic injury (Fig. 1) was found in 80% of cases (2 pneumothorax, 1 aortic dissection, 4 hemothorax and 1 pulmonary contusion). Brain-related injury was found in 50% of cases (1 case of cerebral petechial hemorrhage, 2 intraparenchymal hematoma, 1 meningeal hemorrhage, 1 internal carotid artery dissection and 1 acute sub-dural hematoma). Abdominal or pelvic injuries were found in 30% of cases (1 vesicular rupture, 1 renal artery dissection, 2 spleen ruptures). Associated peripheral

**Table 1**  
Demographic data for the series along with pre- and postoperative kyphosis measurements.

Patient	Gender	Age	Level	Preop SK (°)	Postop SK (°)	Preop RK (°)	Postop RK (°)	Anterior approach
1	M	33	T7, T9, T12	10	8	12	9	No
2	F	23	T12, L1, L5	8	8	20	17	No
3	M	60	T9, T10	17.5	11	21	20	No
4	F	34	T8	28	9	42	18	Yes
5	M	51	T6	13	9.5	20	17.5	Yes
6	M	59	T6, T7	7	7	23.5	23	Yes
7	F	28	T4, T5	14.5	10	24	16.5	No
8	M	29	T6	15	14.5	28.5	26	No
9	F	68	T7, T8	19	13	22	17	No
10	F	18	T6	13	5	19	15	No

Preop: preoperative; Postop: postoperative; SK: segmental kyphosis; RK: regional kyphosis; M: male; F: female.

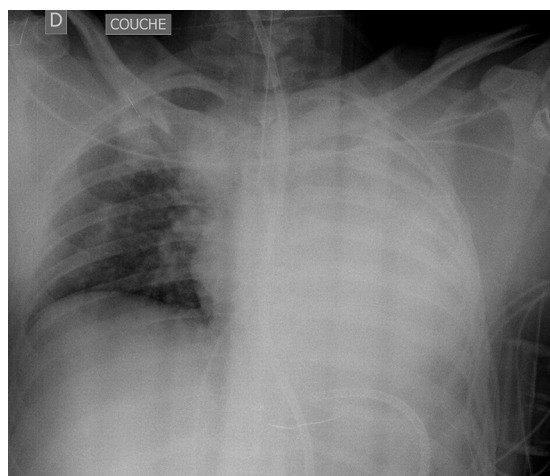
fractures were present in 90% of cases and facial fractures in 40% of cases.

The average ISS score was 35.5 (range 14–64) with a predicted mortality rate of 24.9% (range 1.7–75). One patient required preoperative red blood cell transfusion. The average PAFI was 319 (range 54–530) before the surgery and 362 (range 185–570) after the surgery. The average duration of mechanical ventilation was 89.4 hours (range 0–288) before the surgery and 6.2 hours (range 0–24) after the surgery; 70% of patients no longer required mechanical ventilation at day 1 postoperative. The average stay in the intensive care unit was 8.25 days (range 1–25) and was mainly determined by the type of associated organ injuries. The average amount of morphine-type agents used in the first 24 postoperative hours was 7.8 mg (range 0–19); 50% of patients did not require any morphine.

In the overall series, no postoperative transfusion was needed during the recovery from spine surgery and no deaths were reported in the period after vertebral stabilisation. Two patients had postoperative respiratory complications: one residual pneumothorax requiring a new drain and one pneumonia that was treated with antibiotics.

### 3.3. Surgical data

The average time between hospital admission and the vertebral fracture fixation was 3.9 days (range 1–15); fixation was performed at day 1 in 40% of cases and before day 7 in 80% of cases.



**Fig. 1.** Initial chest X-ray from a polytrauma patient with thoracic vertebral fracture and pleural effusion.

The highest pedicle screw insertion was made at T2 and the lowest at S1. The average operative time was 1 hour 34 min (range 1:15 to 2:10) with average intraoperative blood loss of 88 mL (range 50–140), which was estimated by comparing preoperative hemoglobin levels with immediate postoperative levels. The average intraoperative fluoroscopy time was 2 min 51 s (range 2:33–3:01).

In the early postoperative recovery, one case of superficial surgical site infection was detected that required wound excision and oral antibiotics therapy; the outcome was favourable and the instrumentation did not need to be removed. At the last follow-up, no cases of delayed surgical site infection were found.

### 3.4. Radiography evaluation and additional care

The radiology evaluation showed that percutaneous fixation had corrected the fracture deformity (Figs. 2 and 3). There was a significant reduction of 4.9° (range 0–17;  $P=0.021$ ) in the average segmental kyphosis and 5.2° (range 0–24;  $P=0.038$ ) in the average regional kyphosis.

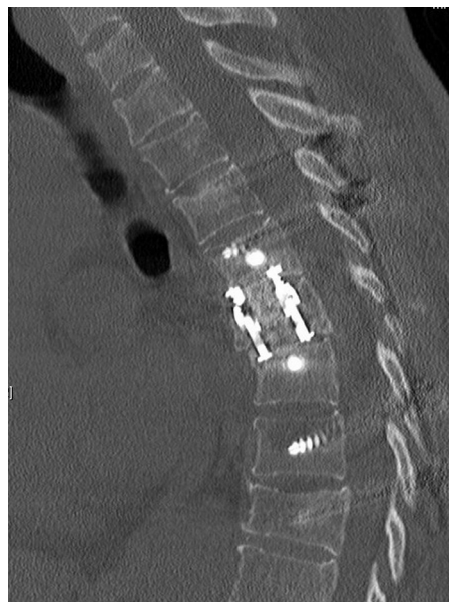
No instances of poorly positioned pedicle screws (pedicle breach > 2 mm) were detected in the entire series based on postoperative radiographs. Union of the fracture site was evident in



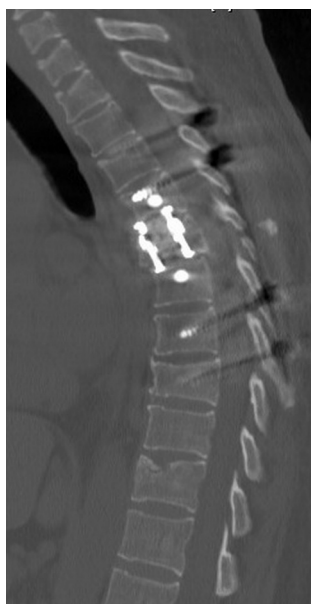
**Fig. 2.** Initial sagittal CT scan reconstruction from a polytrauma patient with T6 fracture.



**Fig. 3.** Sagittal CT scan reconstructions after percutaneous posterior fixation (same patient as Fig. 2).



**Fig. 5.** Sagittal CT scan reconstructions showing bone union, obtained on average at the 6th postoperative month (same patient as Fig. 2).



**Fig. 4.** Sagittal CT scan reconstructions after an additional anterior approach using an intervertebral body cage (same patient as Fig. 2).

all cases at 6 months postoperative. Three patients required an additional anterior procedure; corpectomy in combination with autologous grafting was performed (Fig. 4) 1 month after the posterior fixation with no signs of non-union at the last follow-up (Fig. 5).

#### 4. Discussion

There is currently no clear consensus about the optimal time frame and treatment methods for spinal fractures in severe polytrauma patients without neurological deficits [6,15]. These patients often have multiple injuries [16], which can make complex bone surgery in a prone patient quite delicate in the hours or days following the trauma; this leads to a poor prognosis in the short- and long-term [17]. It is not unheard of for these fractures to be treated

3–4 weeks after the trauma, which makes it difficult to obtain satisfactory reduction of sagittal plane deformities and increases the risk of union in kyphosis [18].

During the last decade, the damage control orthopedics concept, which consists of quickly stabilising bone injuries, has been shown to be effective in caring for polytrauma patients. Taeger et al. [3] described a series of 409 patients where the effectiveness of DCO was shown through reduced operative time and blood loss, without an increase in the number of complications. This treatment strategy has also been applied to patients presenting with thoracolumbar spine fractures. Various studies have shown that early spine fixation (less than 3 days after the trauma) is superior to delayed fixation. Quickly stabilising the spine is a feasible alternative [19] that allows patients to quickly be mobilised in the postoperative phase [20], and reduces respiratory complications and morbidity-mortality in polytrauma patients [11,21–23].

In parallel, with the emergency fixation concept for thoracolumbar spine fractures, indications for percutaneous techniques have broadened with the development of instrumentation that can be used to correct fracture deformity and perform long-span fixation [24]. These minimally invasive techniques can reduce and stabilize spine fractures in one step in a manner comparable to fixation through the conventional approach [12,25–27]. Some of the advantages of minimally invasive techniques are less muscle damage, less intraoperative bleeding and lower postoperative infection risk [28]. The combination of quick fixation of spine injuries and a minimally invasive technique seems to be particularly relevant in severe polytrauma patients who have a very short surgical window.

The results of the current study confirm the hypothesized limited postoperative complications and satisfactory fracture reduction. The latter finding is especially relevant because 89% of fractures were in the thoracic spine, which are typically difficult to reduce because of the stiffness of the rib cage. This fixation technique is relatively fast, causes minimal blood loss (generally below 150 mL) and does not require postoperative transfusion when compared to delayed fixation. In our opinion, this is a major advantage of percutaneous fixation because complex bone surgery can be performed quickly in patients who are unstable and often have a precarious respiratory condition [29]. In addition, this technique seems to cause less postoperative pain than conventional



surgery, as evidenced by the small number of patients who needed morphine in the 24 hours after surgery; this reduces the risk of opiate-related side effects, while also reducing the risk of infection because patients can be mobilized more quickly.

Our findings are in accordance with the Schmidt et al. study [30] of 27 patients with an ISS above 16 who were treated by percutaneous fixation. They reported two cases of acute respiratory distress and three cases of postoperative lung infections.

Use of A-P and lateral fluoroscopy also ensures safe insertion of the pedicle screws, notably in the upper thoracic area. In the current study, none of the patients had pedicle cortex breach > 2 mm.

However, percutaneous fixation is not the solution to all clinical problems and has several limitations. It is a simple spinal fixation technique that does not allow the surgeon to add a posterior graft or perform neurological decompression. Thus, careful selection of indications is crucial to obtaining the best possible clinical outcomes. The presence of a neurological deficit is a contraindication to isolated percutaneous fixation. This can be problematic in a polytrauma patient who is admitted to intensive care already intubated and ventilated, as it would be impossible to perform a reliable neurological exam. Another fundamental requirement is the need to perform a detailed radiological evaluation of thoracolumbar injuries, in particular the bone quality in the anterior spine. After initial percutaneous stabilisation has been performed, the condition of the anterior spine structures must also be evaluated. The presence of an unstable injury with disc or ligament involvement or injury with significant vertebral body comminution will require an additional anterior approach that can be performed secondarily after the associated lesions have been treated.

Technical requirements of percutaneous fixation require that a certain amount of radiation be delivered to the patient and to the surgical team, which justifies the need for strict radiation-protective measures. Percutaneous surgery requires three times more radiation (effective dose) than conventional surgery, but this is still less than the radiation received by the patient during a postoperative CT scan [31,32]. This aspect cannot be ignored. In the current study, the average fluoroscopy time was 2 min 51 s, which was comparable to findings in an animal model [33]. Development of a guidance system or use of intraoperative CT scan may increase the precision of pedicle screw placement and reduce surgeon irradiation, but these techniques are controversial themselves [28,34].

## 5. Conclusion

Percutaneous posterior fixation is a treatment method adapted to the damage control concept during the initial care of non-neurological spine fractures in severe polytrauma patients. It can be an alternative to direct fixation in this indication, as it allows for quick stabilisation of spinal injuries with deformity correction in the sagittal plane and less complicated postoperative recovery [9]. However, the anterior spine must be evaluated to determine if any injuries are present that require an additional anterior procedure. These preliminary results should be confirmed in a study with a larger number of patients and longer follow-up.

## Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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