



## Original article

## Minimally invasive treatment of thoracolumbar flexion-distraction fracture



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## ABSTRACT

**Introduction:** Flexion-distraction fractures represent around 15% of all thoracolumbar fractures, with neurological deficit in 25% of cases. Optimal surgical strategy remains controversial. In neurologically intact patients, percutaneous fixation can offer quick stabilization with good deformity correction. If necessary, an additional minimally invasive anterior approach can complete the surgical strategy. We report results in a series of 28 thoracolumbar flexion-distraction fractures without neurologic deficit, treated using a minimally invasive approach.

**Method:** A single-center retrospective study was conducted for the period 2008–2015. Patients over 16 years of age with a flexion-distraction fracture without neurologic deficit were included. Analysis was based on preoperative CT-scan and measurement of post-traumatic kyphotic deformity. Surgery comprised posterior percutaneous fixation, alone or associated to an anterior step in case of discal lesion on preoperative MRI or of severe vertebral comminution. Operative time, blood loss and postoperative complications were recorded. Residual segmental kyphosis and bone healing were evaluated on CT at 1 year.

**Results:** Seventeen males and 11 females were included (mean age, 29.2 years). An anterior approach was performed in 11 cases (39%): 5 for B1 fractures due to severe comminution (corpectomy and expandable vertebral cage with bone and BMP-2) and 6 for B2 fractures due to discal involvement on MRI (discectomy and iliac graft fusion). Regional kyphosis was significantly reduced (17.3° vs. 5.7°;  $p < 0.05$ ) and bone healing was obtained in all cases. There were no cases of postoperative infection.

**Conclusion:** Patients with flexion-distraction fractures without neurologic deficit can be eligible for minimally invasive percutaneous posterior fixation, associated if necessary to a minimally invasive anterior approach. This technique provides excellent bone healing with low surgical trauma and bleeding.

**Level of evidence:** IV.

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## 1. Introduction

Flexion-distraction fractures represent around 15% of all thoracolumbar fractures. They mainly occur at the junction between the rigid thoracic and mobile lumbar regions [1]. The main causal mechanism is posterior distraction associated with anterior compression [2].

Classification includes transosseous or chance fracture [3] and non-osseous lesions involving the posterior and/or anterior ligament complex via the intervertebral disc [1].

They usually implicate high-energy trauma, or low-energy trauma in an ankylosed spine [4,5]. Neurologic disorder is associated in 25% of cases, and visceral lesions should be systematically screened for, being found in 30% of cases [4,6].

The various classifications of thoracolumbar spinal fractures consider them unstable, requiring surgical treatment to correct kyphotic deformity and prevent neurological sequelae [1,7].

Optimal treatment remains controversial, choice depending on various factors, such as type of instability, neurologic status, associated visceral lesions, and comorbidity [8].

Since their emergence, minimally invasive techniques have gained popularity, notably with the development of effective percutaneous internal fixation instrumentation in traumatology. The theoretic advantage lies in limiting muscular lesions, blood loss and surgery time in comparison with conventional open surgery [9–11]. They are thus an interesting alternative in unstable

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**Figure 1.** B1 fracture of L1, percutaneous posterior fixation alone, preoperative evaluation (left), postoperative reduction of the deformity (middle) and bone healing after removal of the implants (right).

flexion-distraction fracture not requiring neurologic decompression [12].

We therefore hypothesized that minimally invasive treatment of thoracolumbar flexion-distraction fracture provides results comparable to those of conventional surgery.

The study objective was to report our experience in 28 patients with thoracolumbar flexion-distraction fracture without neurologic deficit treated via a minimally invasive approach.

## 2. Material and methods

### 2.1. Study design and population

A single-center retrospective study included patients treated via a minimally invasive approach for thoracolumbar flexion-distraction fracture without neurologic deficit.

Inclusion criteria comprised: all patients aged over 16 years with thoracolumbar flexion-distraction fracture and strictly normal neurologic work-up, with minimum 1-year follow-up.

Fractures involving pathological bone and fractures in extension were excluded.

Between 2008 and 2015, 28 patients (17 male, 11 female; mean age, 29.2 years [range, 16–53 years]) met the inclusion criteria.

### 2.2. Study criteria

Retrospective data comprised: demographics, associated lesions [4,6], operative data (operative time, instrumented levels, complementary anterior approach, blood loss) and pre- and postoperative radiologic data.

Systematic preoperative CT enabled diagnosis, classification on the AO-Spine system described by Vaccaro et al. [7], and measurement of traumatic regional kyphosis as angle between the intact under- and over-lying vertebral plates; kyphosis was measured again postoperatively and at 1 year. Comparison between initial and 1-year kyphosis used Student t test for matched series, with the significance threshold set at 5%. Bone healing (in predominantly osseous fractures) or intervertebral fusion, as appropriate, was assessed on 1-year CT.

### 2.3. Surgical technique

The surgical strategy systematically consisted in a minimally invasive approach with isolated percutaneous posterior fixation

or, depending on radiologic findings, with an associated minimally invasive extrapleural retroperitoneal anterior approach [13]:

Systematic CT and MRI (T1, T2 and STIR sequences) assessed posterior ligament elements and under- and over-lying discs. In case of discal lesion or severe vertebral body comminution, the complementary anterior approach was performed, either in the same step or secondarily (at a mean 1 week) in case of associated visceral lesion.

- B1 or Chance fracture (Fig. 1): In such transosseous fractures, percutaneous fixation was performed, with the patient in lordosis to begin deformity reduction and compression of the percutaneous assembly on uniaxial screws. Fixation was performed 1 level above and 1 below the fracture, except in case of high thoracic lesion, in which case it included 2 levels above and 2 below. In case of severe vertebral body comminution, a complementary anterior approach was used for corpectomy and fusion by expandable cage (VLIFT<sup>®</sup>, Stryker, Michigan, USA) filled with corpectomy bone and BMP-2;
- B2 fracture (Fig. 2): After positioning in lordosis and initial percutaneous posterior fixation, strategy depended on the presence of discal lesion on preoperative MRI; if present, circumferential fusion was performed. In our experience, this mainly concerned multiple trauma victims with associated visceral lesions; the strategy was one of “damage control” [9], with short initial percutaneous posterior fixation followed by discectomy and interbody fusion by tricortical-cancellous graft or expandable cage (VLIFT<sup>®</sup>, Stryker, Michigan, USA) filled with BMP-2. In predominantly



**Figure 2.** B2 fracture of L1, percutaneous posterior fixation and inter-body graft.

osseous fracture, an anterior approach was performed in case of severe vertebral body comminution, either in the same step or secondarily, with corpectomy and expandable cage [14].

Percutaneous posterior fixation was systematically performed under frontal and lateral fluoroscopy. In case of anterior approach, an expandable cage was used to maximize implant stability using the vertebral plates as support.

#### 2.4. Follow-up

Medical and surgical postoperative complications and any blood transfusion were recorded.

Follow-up was at least 1 year and included control CT to check bone healing or fusion. In isolated posterior fixation, percutaneous removal of material was proposed at 1 year, to restore intervertebral motion.

### 3. Results

#### 3.1. Demographic data

Lesion mechanism in all 28 patients (mean age, 29.2 years) was high-energy trauma. In 2 cases (7%), there was an associated visceral lesion, and in 2 cases (7%) an associated adjacent spinal lesion.

Mean follow-up was 3.1 years [range, 1–7 years].

#### 3.2. Surgical and follow-up data

Radiology located fractures between T6 and L4, with the thoracolumbar junction most frequently involved (T12, 25%; L1, 17.8%). On Vaccaro's classification, 19 fractures were B1 (Chance fracture) and 9 B2.

Twenty-one of the 28 patients received short posterior fixation and 7 long (2 levels above and 2 below), all in the thoracic region except for one L4 fracture with associated visceral lesions. An anterior step was associated in 11 cases (39%): 5 for B1 fracture with severe comminution (corpectomy and expandable cage with bone and BMP-2) and 6 for B2 fracture with discal lesion on MRI (discectomy and intervertebral fusion by iliac graft).

Mean operative time was 70 minutes [range, 50–120 min] for percutaneous internal fixation and 100 minutes [range,

70–150 min] for the complementary anterior step. There were no intraoperative complications.

Mean blood loss was 75 mL [range, 50–200 mL]; no postoperative transfusions were required.

No neurologic deterioration or surgery site infection occurred during follow-up. Material was removed in 3 patients by last follow-up (B1 fracture with isolated percutaneous internal fixation), without technical problems, radiologic deterioration or complications.

#### 3.3. Radiology data

Mean regional kyphosis was 17.3° (SD, 10°) preoperatively, with significant ( $p < 0.05$ ) immediate postoperative correction (mean, 5.7°; SD, 12°) and no significant loss at 1 year (mean loss, 2°;  $p > 0.05$ ).

Postoperative CT showed good implant positioning in all cases. At 1 year, bone healing and/or intervertebral fusion was achieved in all cases.

### 4. Discussion

Flexion-distraction fracture requires specific attention to select the optimal surgical strategy. Denis et al. [15] reported a rate of only 5%, while Magerl et al. [1] found 15%; the difference is probably due to better understanding of the lesion mechanism and greater use of modern imaging.

Rajasekaran et al. [16] consider CT sufficient for diagnosis and surgical indication in thoracolumbar fracture, but also find MRI contributive, especially in flexion-distraction fracture. We now agree with Pizones et al. [17] that MRI is of major interest in case of fracture, revealing discal and ligamentous lesions unseen on CT, leading some type A lesions to be reclassified as type B. These soft-tissue lesions may cause instability requiring fusion. MRI is therefore indispensable, in our experience, in preoperative assessment of fracture, although it should not delay emergency treatment in case of neurologic deficit.

Treatment of osseous flexion-distraction fractures is still controversial, with strategies ranging from non-operative brace treatment to surgical fusion. In the present study, the context was often one of multiple trauma, hindering primary nursing care and tolerance of non-operative management. Percutaneous internal



**Figure 3.** Poor preoperative evaluation associated with deficient intraoperative correction. Unfavorable progression at 3 months postoperatively requiring a two-step conventional revision procedure.

fixation is thus particularly indicated in multiple trauma [9], enabling rapid mobilization without postoperative contention and the risks inherent to brace treatment [9]. This minimally invasive technique shows fewer postoperative complications (bleeding, infection or muscle lesion) than conventional techniques, for comparable radiological results [9,10].

The present results agree with the literature, and notably with Chu et al. [18], who highlighted the interest of percutaneous internal fixation, which acts like an “internal brace” in flexion-distraction fracture.

In discal and ligamentous lesions, one possible strategy consists in posterior fixation and a complementary anterior approach for intervertebral fusion. Although adapted to spinal biomechanics, this may increase the rate of postoperative complications, and notably of infection. Percutaneous posterior fixation is another useful possibility, limiting surgical trauma and complications [9]. To minimize invasiveness, the complementary anterior step can also be minimally invasive, notably at the thoracolumbar junction [13].

The double approach is, however, surgically demanding, and associated visceral lesions may prevent performing both in the same anesthetic step. When, however, it is feasible, as also for spinal burst fracture [19], we now perform percutaneous fixation and anterior fusion in a single step. The present results are encouraging, with significant radiologic correction and few complications, notably with no infection in patients requiring intensive care. Follow-up found systematic healing and/or solid fusion. Bone healing, especially in purely osseous fractures, also offers the possibility of removing the fixation material percutaneously, to restore motion in immobilized segments, with, as reported by Ntilikina et al. [20], less fatty infiltration of muscles in young patients than with conventional techniques.

Analysis of the literature is concordant with the present findings. According to Chu et al. [18], percutaneous fixation provides excellent bone healing rates, with no difference in correction compared to conventional techniques but with reduced muscle trauma [10,14]. Results also seem to be stable over time, with a mean correction loss of around 2° [19].

Like any surgery, however, minimally invasive treatment of thoracolumbar flexion-distraction fractures is difficult, with an indispensable learning curve. Furthermore, it needs to provide the same results as conventional surgery if it is to be of interest; it is therefore essential to reduce the fracture effectively and to determine whether anterior support is necessary to avoid failure and revision surgery, which is often very aggressive (Fig. 3).

The present study had certain limitations. The cohort was small, the design retrospective and angles were measured on CT scans. Further larger-scale studies with longer follow-up will be needed to confirm the present results.

## 5. Conclusion

Treatment of flexion-distraction fractures remains controversial, and is primarily based on neurologic assessment and full radiologic work-up. In patients free of neurologic disorder and with osseous lesions, isolated percutaneous internal fixation by “internal brace” is an interesting alternative. In case of permanent instability, intervertebral fusion is essential. Minimally invasive treatment associating percutaneous posterior fixation and a minimally invasive anterior approach gives good results and offers an alternative to open surgery, with a lower risk of complications.

## Disclosure of interest

The authors declare that they have no competing interest.

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None.

## Contributions

N. Laghmouche, S. Prost and K. Farah collected the data and wrote the manuscript.

T. Graillon supervised manuscript writing.

B. Blondel and S. Fuentes directed the study and revised the manuscript.

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