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ORIGINAL ARTICLE

Percutaneous management of thoracolumbar burst fractures: Evolution of techniques and strategy

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KEYWORDS

Thoracolumbar fractures;
 Percutaneous osteosynthesis;
 Minimally invasive;
 Kyphoplasty

Summary

Introduction: A number of techniques have been described in the management of thoracolumbar spinal fractures, testimony to the absence of consensus on their treatment. For the past few years, minimally invasive techniques have been developed to limit surgery-related iatrogenic injury. The objective of this study was to report the results of percutaneous management of these lesions and the technical progress made based on our experience.

Patients and methods: Twenty-nine patients presenting an A3 fracture, with a mean age of 51 years, were included in this study. All had a balloon kyphoplasty and percutaneous osteosynthesis. Of the first 22 cases, kyphoplasty was the initial procedure performed associated with reduction maneuvers using distraction. Assessment was clinical (neurological status and pain intensity) and radiological (implant positioning, cement leakage, restoration of local kyphosis and any loss of correction).

Results: In the overall series, the mean local kyphosis correction was 11° with a 2° angle loss at the last follow-up. Pain assessment showed significant improvement, decreasing from 6/10 to 1/10 on discharge. The mean hospital stay lasted 4 days. On the follow-up radiological exams, no cases of extrapedicular screw migration were noted; in two cases, lateral cement leakage was found. The results were equivalent in terms of correction no matter which procedure was performed first, although for the second part of the series the technology was available to bend the spinal fixation rod to the desired curve.

Discussion: The results of this study support the growing interest in minimally invasive techniques in the management of spinal injuries with no neurological deficit. In addition, the evolving material makes it possible to come close to conventional techniques, including

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reduction maneuvers, while limiting muscle injury by using a purely percutaneous approach. Rigorous patient selection is necessary and the time to learn the procedure must be taken into account. Studies with a longer follow-up are required to confirm the stability of the correction over time.

Level of evidence: Level IV. Retrospective observational study.

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Introduction

Spinal burst fractures are frequent lesions, most often located at the thoracolumbar hinge (Been et al. [1]), which is a transition zone where the curvature of the more rigid thoracic component becomes the highly mobile lumbar region. Today, many techniques have been described for the management of these lesions, conveying the absence of a true consensus on how to treat them optimally. The series using a posterior approach, via an anterior or combined approach, report satisfactory long-term results (Been et al. [1], Okuyama et al. [2], Uchida et al. [3], Wood et al. [4]).

In parallel, the last several years have shown constant improvement of the minimally invasive approaches whose objective is to obtain the same results while limiting the surgical damage. Different techniques and ancillary instrumentation have been developed (Afzal et al. [5], Cho et al. [6], Maestretti et al. [7], Verlaan et al. [8]). Two techniques can be distinguished:

- (1) isolated kyphoplasty whose objective is to obtain reduction of the fracture deformity by inflation of balloons in the vertebral body, followed by reinforcement with injection of cement into the cavity created, at the same time limiting the risk of intraoperative leakage;
- (2) percutaneous osteosynthesis systems used in an isolated fashion in the management of thoracolumbar fractures with good initial results (Pelegri et al. [9]).

The progress in management of these lesions then took the direction of associating these approaches, with stable results at 2 years of follow-up (Gaye et al. [10]).

The objective of this report is to present the results from our experience (level IV retrospective observational study) on the progress made in terms of technique and strategy in managing thoracolumbar burst fractures.

Patients and methods

A total of 29 patients with a mean age of 51 years [range, 22–78 years] were included in this study. All had a burst fracture of the thoracolumbar spine classified A3 according to Magerl (Magerl et al. [11]), with no neurological signs at the initial examination.

At admission, each patient had a clinical neurological evaluation and pain assessment using the visual analogue scale.

Preoperative spinal imaging was systematic and included computed tomography (CT) with reconstructions and magnetic resonance imaging (MRI) to assess the integrity of the nerve and discoligamentous structures.

Surgical indication was retained for burst fractures with no neurological deficit or disk lesion on MRI (Fig. 1), when height loss in the vertebral body was greater than 25%, or when local kyphosis was greater than 15°.

The surgical technique used systematically included balloon kyphoplasty and osteosynthesis via the posterior percutaneous approach. In all cases, the assembly was short, with screws in the vertebral pedicles supra- and subjacent to the fracture.

In our experience and with the recent development of new ancillary instrumentation, our strategy has progressively been modified. Therefore, the first 22 patients (group 1) received the kyphoplasty procedure first to reduce the fracture deformity and then osteosynthesis using the Sextant™ material (Medtronic, Memphis, TN, USA) following a previously described protocol (Gaye et al. [10]). This technique allowed us to place polyaxial pedicular screws and a prebent rod with no distraction maneuvers possible (Fig. 2).

In the second part of the series involving the last seven patients included in the study (group 2), the opposite strategy was used. Osteosynthesis was placed initially followed by secondary balloon kyphoplasty. In these situations, the material used was CD-Horizon Longitude™ (Medtronic, Memphis, TN, USA), which allowed percutaneously placing monoaxial screws associated with a stem bent to the curvature chosen preoperatively (Fig. 3). In addition, the ancillary instrumentation provides the possibility of reducing the fracture deformity by applying a distraction force



Figure 1 Sagittal T2-weighted MRI reconstruction showing an L2 burst fracture with a normal discal signal.

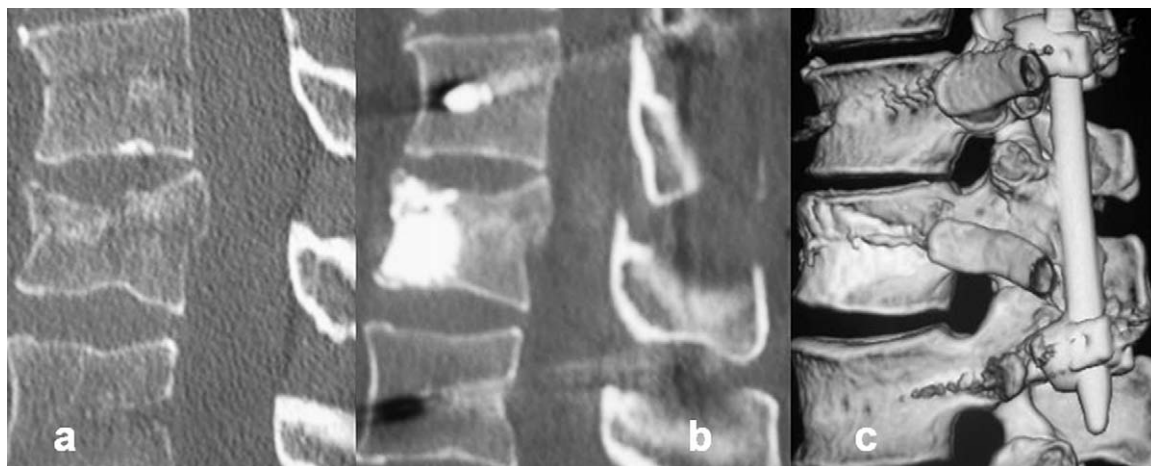


Figure 2 Preoperative (a), postoperative (b) and three-dimensional (c) CT reconstructions showing a burst fracture managed by kyphoplasty then percutaneous osteosynthesis (polyaxial screws).

between the screw-holders. The objective was to obtain maximal correction by ligamentotaxis and then to perform kyphoplasty secondarily so as to perfect the raising of the vertebral plateau and to consolidate the vertebral body by reducing the pressure necessary in the balloons and thus reduce the risk of cement leakage. In groups 1 and 2, the osteosynthesis was short, on either side of the fracture.

The cement used in the entire series was polymethylmethacrylate (PMMA, KyphX[®], Medtronic, Memphis, TN, USA) in the patients older than 50 years of age and phosphocalcic cement (Calcion[®], Biomet, Warsaw, IN, USA) in the younger patients.

Postoperatively, all the patients were followed up at regular intervals (3, 6, 12, and 24 months after surgery). The assessments were clinical (neurological exam and pain assessment) and radiological, with systematic CT to verify that the implants were properly positioned and the absence of cement leakage, the degree of correction obtained, and any loss of correction over time.

The statistical analyses were carried out with the Student *t*-test, with a significance level set at 5%.

Results

Twenty-nine patients (20 males and nine females) presenting a thoracolumbar burst fracture were treated using a percutaneous technique associating balloon kyphoplasty and osteosynthesis. The first 22 patients underwent cement injection initially, whereas the last seven patients first had percutaneous osteosynthesis with partial reduction of the deformity by application of distraction force.

The lesions were distributed between T9 and L5 (Fig. 4), corresponding to the extreme levels of osteosynthesis between T8 and S1. According to Magrel's classification, 17 patients presented an A3.1 fracture (59% of the cases), three an A3.2 fracture (10% of the cases), and nine an A3.3 fracture (31% of the cases). All the fracture types are summarized in Fig. 5.

During the postoperative clinical evaluation, none of the patients presented a neurological deficit. The intensity of the spinal pain evaluated on the visual analogical scale was a mean 6.6/10 preoperatively [range, 3–8] and a mean 1/10 the day of discharge from the hospital [range, 0–2].

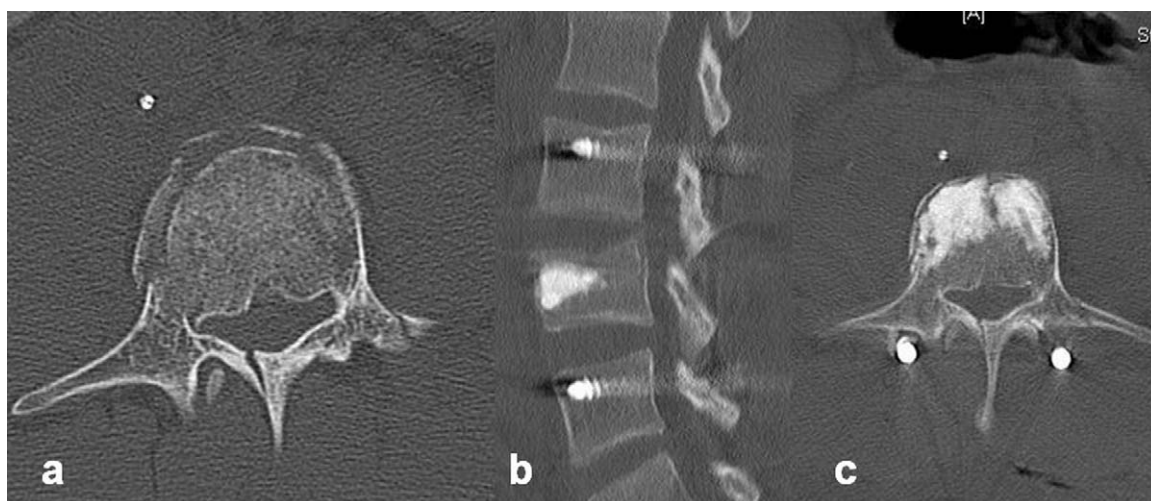


Figure 3 Management of a burst fracture (a) by a percutaneous osteosynthesis (monoaxial screws) then kyphoplasty (b and c).

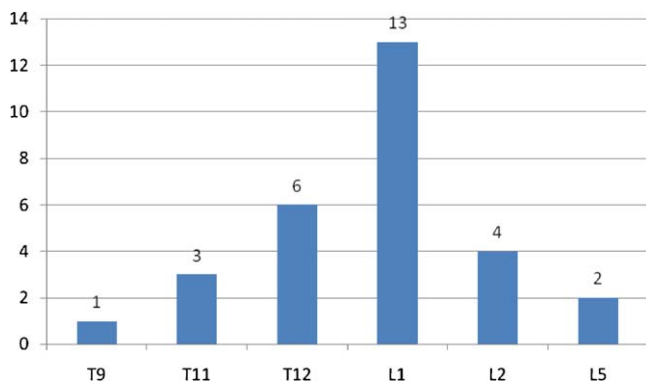


Figure 4 Fracture levels on the whole series.

The mean length of surgery was 80 min [range, 45–120 min], with blood loss in all cases less than 150 mL; none of the patients needed postoperative blood transfusion.

The cement injected for the kyphoplasty procedure was polymethylmethacrylate (PMMA) in 18 cases and phosphocalcic cement in the last 11 cases. Phosphocalcic cement was used in patients under 50 years of age and its use was related to our learning period because it was less radio-opaque and crystalized more rapidly, requiring a rapid injection that could increase the risk of leakage. The mean quantity of cement injected was 7.8 cc [range, 6–9 cc].

During the postoperative radiological assessments, a CT scan was systematically done the day after the intervention. There were no cases of extrapedicular screw displacement found in the series. In two patients, a lateral cement leak was visible, with no clinical consequences.

The mean restoration of vertebral kyphosis in all the patients was 11°, decreasing from a preoperative 14° [range, 5–35°] to a postoperative mean of 3° [range, –5 to 10°]. There was no significant difference in terms of reduction of the fracture deformity when the kyphoplasty was performed initially or after osteosynthesis.

The different mean reduction values are summarized in Fig. 5.

The patients were allowed to stand on postoperative D1 after the follow-up CT, without having to wear a brace or orthosis.

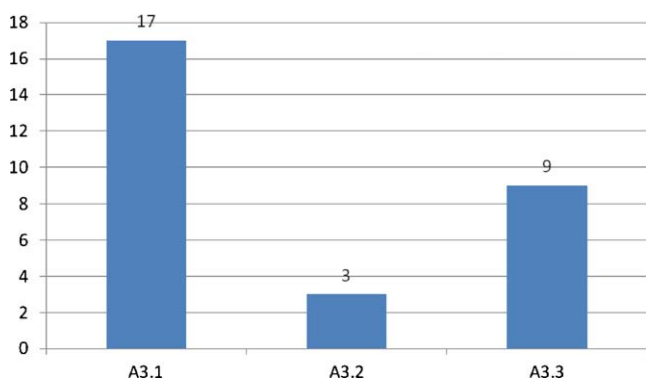


Figure 5 Fractures types on the whole series according to Magerl scale.

The mean hospital stay was 4 days [range, 3–7 days], and the day of discharge, none of the patients required step III analgesics. No cases of infection were diagnosed and no surgical revision was necessary up to the last follow-up.

All the patients were then followed up in consultation and with regular CT scans (3, 6, 12, and 24 months postoperative) to screen for any complications and loss of correction. In the first part of the series, with kyphoplasty performed first (group 1), the mean follow-up was 24 months and the loss of correction was a mean 2°C. At the last follow-up, the values were equivalent in the patients who had had osteosynthesis first (group 2) (Table 1); however, the duration of observation was shorter (mean, 12 months) and longer follow-up will be necessary to confirm these data.

Discussion

Many surgical techniques via the posterior, anterior, or combined approach to manage thoracolumbar burst fractures have been described, testifying to an absence of a clear consensus on their treatment. Whatever approach is used, the objective is identical: correcting the deformity caused by the fracture and stabilizing the spine so as to obtain bone union in favorable conditions. The most classical approach remains a posterior approach with pedicle screw osteosynthesis reducing the fracture deformity by means of distraction maneuvers more or less associated with lordosis, thus providing a satisfactory vertebral body height and reintegrating the bone fragments inside the spinal canal by putting the posterior longitudinal ligament under tension.

The last few years have been marked by the development of a minimally invasive approach to the spine, whose objectives are identical to conventional treatment while limiting iatrogenic injury, notably to the muscles. These strategies therefore present an advantageous alternative in the management of these lesions by reducing postoperative pain and rapidly mobilizing patients.

An isolated kyphoplasty treatment has been proposed (Maestretti et al. [7], Voggenreiter [12]) in A3.1 fractures with good clinical results and a mean local kyphosis correction of 9.9° that was stable over time. Other authors have performed isolated percutaneous osteosynthesis using polyaxial screws and a prebent stem (Pelegri et al. [9], Palmisani et al. [13]). However, in this case, because of the lack of rigidity in the fixation system, the loss of correction was 5.1° at 14 months of follow-up.

Recent research (Afzal et al. [5], Verlaan et al. [8], Acosta et al. [14]) has also described good results in managing thoracolumbar fractures by associating conventional osteosynthesis, most often consisting of a short assembly and balloon kyphoplasty.

To combine the advantages of these different percutaneous techniques, it seemed logical to associate them to preserve the minimally invasive aspect of the procedure while attempting to improve the quality of the correction obtained.

The results of our initial experience (group 1) associating balloon kyphoplasty and percutaneous osteosynthesis with polyaxial screws (Gaye et al. [10]) demonstrated an improvement in the mean local kyphosis (11.3°), with 2° angle loss at 24 months of follow-up.

Table 1 Changes in pre- and postoperative vertebral kyphosis and mean loss of correction at last follow-up.

| | Preoperative kyphosis | | Postoperative kyphosis | | Loss of correction at last follow-up |
|---------|-----------------------|--------|------------------------|------------|--------------------------------------|
| | Mean | Range | Mean | Range | Mean |
| Group 1 | 13° | 5°–35° | 3.2° | –5° to 10° | 2° (mean follow-up, 24 months) |
| Group 2 | 12.1° | 5°–25° | 2.6° | –5° to 9° | 1° (mean follow-up, 12 months) |

Group 1: patients who underwent kyphoplasty first then osteosynthesis; group 2: patients who underwent osteosynthesis first and then kyphoplasty.

Progress then came in parallel with the development of new ancillary instrumentation. The possibility of doing percutaneous osteosynthesis using monoaxial screws, the possibility of bending the rod to the desired curve magnitude, but also the possibility of doing distraction maneuvers all contributed to changing our practices. This means coming even closer, from a mechanical point of view, to conventional surgery and the possibility of reducing fragments inside the spinal canal with ligamentotaxis, while limiting injury to the paravertebral muscle masses. Placing the osteosynthesis first (group 2) also presented a second theoretical advantage in our opinion. Since the major part of the reduction of the fracture deformity had already been carried out by positioning the patient and the vertebral fixation in distraction, the force required to inflate the balloons and raise the vertebral plateau would be reduced, decreasing the already low risk of cement leakage. However, this risk of leakage has to be taken into account during any vertebroplasty procedure. According to Ryu et al. [15], it depends on the volume injected and the vertebral level, with an increased risk above T7. The results of this study showed leakage in 7% of the cases, in agreement with the data of the meta-analysis conducted by Hulme et al. [16] reporting 9% leakage in 69 clinical series.

Moreover, placing pedicular screws under scopic guidance alternating AP and lateral views is an additional asset in terms of safety, confirmed by the absence of extrapedicular screw displacement in the entire series. This “neurological” safety should always be compared to the increase in irradiation received by the patient and the operator, as reported by Bindal et al. [17].

The results of this study demonstrate the ability of this type of assembly to reduce local kyphosis and maintain stability over time. However, we found no significant differences in terms of correction between the two groups and the reduction in the risk of cement leakage remains theoretical. Other studies with a longer follow-up period and a precise analysis of the pressure exerted in the balloons will be necessary to substantiate this opinion.

Material ablation after fracture union also remains subject to debate. In our experience, the osteosynthesis can be removed percutaneously with no major technical difficulties; however, longer follow-up will be necessary to ensure that correction is not lost over the long term.

This technique therefore uses a combined fracture deformity reduction method. Partial reduction is initially obtained by patient installation and curarization. It is then completed by placing posterior percutaneous instrumentation for distraction maneuvers, once the screw–stem connection has been made using specific ancillary instru-

ments. The last step consists of filling the vertebral body bone defect by cement injection. However, cases with a McCormack score greater than 7 (McCormack et al. [18]), corresponding to a major loss of resistance in the anterior column, and a significant vertebral body burst fracture should encourage reconsidering kyphoplasty in favor of a complementary anterior approach with intervertebral bone grafting.

Conclusion

The percutaneous technique of managing A3 thoracolumbar burst fractures is a valuable alternative in the spinal surgeon’s armamentarium. The quality of the results is comparable to those of conventional techniques with reduced hospital stay and postoperative pain. This percutaneous principle could be extended to other spinal pathologies, notably post-traumatic deformities or lesions requiring intersomatic grafting using minimally invasive anterior procedures. However, these techniques require a certain learning period and rigorous patient selection. The ideal indication is a fracture with no neurological deficit, with the disk intact, and with neural arc ligaments intact and a deformity warranting surgical correction (15° kyphosis or 25% loss in height).

Disclosure of interest

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

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