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ORIGINAL ARTICLE

Severe thoracolumbar osteoporotic burst fractures: Treatment combining open kyphoplasty and short-segment fixation

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KEYWORDS

Spine;
Osteoporotic
vertebral fracture;
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Summary

Introduction: The majority of osteoporotic, spinal cord compressive, vertebral fractures occurs at the thoracolumbar junction level. When responsible for neurological impairment, these rare lesions require a decompression procedure. We present the results of a new option to treat these lesions: an open balloon kyphoplasty associated with a short-segment posterior internal fixation.

Materials and methods: Twelve patients, aged a mean 72.3 years, were included in this prospective series; all of them presented osteoporotic burst fractures located between T11 and L2 associated with neurological impairment. The surgical procedure first consisted of a laminectomy, for decompression, followed by an open balloon kyphoplasty. A short-segment posterior internal fixation was subsequently put into place when the local kyphosis was considered severe. A CAT scan study evaluated local vertebral body's height restoration using two pre- and postoperative radiological indices.

Results: All of the patients in the series were followed up for a mean 14 months. Local kyphosis improved a mean 10.8 ($p < 0.001$). Vertebral body height was also substantially restored, with a mean gain of 26% according to the anterior height/adjacent height ratio and 28% according to the Beck Index ($p < 0.001$). Two cases of cement leakage were recorded, with no adverse clinical side effect. Complete neurological recovery was observed in 10 patients; two retained a minimal neurological deficit but kept a walking capacity.

Discussion: The results presented in this study confirm the data reported in the literature in terms of local kyphosis correction and vertebral body height restoration. The combination of this technique with laminectomy plus osteosynthesis allowed us to effectively treat burst fractures of the thoracolumbar junction and led to stable results 1 year after surgery. This can be

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advantageous in a population often carrying multiple co-morbidities. With a single operation, we can achieve neurological decompression and spinal column stability in a minimally invasive way; this avoids more substantial surgery in these fragile patients.

Level of evidence: Level IV. Therapeutic prospective study.

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Introduction

The thoracolumbar junction is the area that is the most susceptible to vertebral fractures since 60% of these lesions are located between T11 and L2 [1,2]. At the same time, vertebral compression fractures caused by osteoporosis are increasingly frequent because of the aging population. Today, between 40,000 and 50,000 are identified per year in France [3]. When these compressions are simple with no neurological complications, they can be treated orthopaedically with a brace and analgics. However, they can also be more severe, with the appearance of localized kyphosis and neurological signs from intrusion of a vertebral fragment into the medullary canal. Treatment of these compression fractures varies according to the dominant symptom: pain or a neurological complication. Other than medical treatment with analgics, bed rest, and a brace when the compression fracture is not associated with neurological complications, vertebroplasty or balloon kyphoplasty using a percutaneous balloon tamp are becoming the reference [4–7]. However, when neurological deficit is present, these techniques do not treat the medullary compression and can therefore become dangerous. A surgical act associating decompression and spinal column stabilization are necessary.

The objective of this study was to propose, in a single procedure, a simple and effective treatment for medullary compression and spinal column instability by associating laminectomy and balloon kyphoplasty combined with osteosynthesis during the reduction of these compression fractures. We present the preliminary results of a prospective, consecutive, and continuous series of 12 patients presenting with vertebral compression fracture in the thoracolumbar region associated with a neurological deficit.

Material and methods

Material

Between July 2005 and October 2007, 12 patients (10 women and two men) were included in this prospective study; they had a mean age of 72.3 years [range: 44–86 years]. All of them presented vertebral compression fracture of the thoracolumbar junction associated with a medullary or spinal cord neurological deficit assessed using the Frankel score [8]; preoperative pain was evaluated using the visual analog scale.

The objective of this study was to assess the validity of a simple and effective treatment of medullary compression and spinal column instability, by associating a laminectomy and a balloon kyphoplasty combined with osteosynthesis to reduce these compression fractures.

Surgery was indicated and patients were included in the study when they had an osteoporotic compression fracture associated with neurological deficit requiring decompression (Fig. 1). Vertebral compression fractures with neurological impairment resulting from trauma or neoplasms were excluded from the study. A total of 13 vertebrae were treated in these 12 patients, one presenting compression fracture at two levels.

The preoperative workup included two-dimensional CT and MRI to assess the degree of neurological compression.

The areas treated were distributed between T11 and L2, with T11 in three cases (23.1%), T12 in four cases (30.8%), L1 in five cases (38.5%), and L2 in one case (7.6%). One patient was treated at two areas: T12 and L1.

Preoperatively, the mean VAS was 7/10, in nearly all cases requiring level III pain relievers. The preoperative Frankel score was evaluated at D in nine patients and C in three patients.

Surgical technique

The surgical procedure was identical for all patients, who were installed in the ventral decubitus position under general anesthesia. After a posterior approach to the spinal column, a laminectomy was performed at the medullary or spinal cord compression. Short-segment pedicle screw osteosynthesis was set up in case of local severe kypho-



Figure 1 Preoperative T2-weighted MRI showing a medullar compression related to a 12th vertebral fracture.

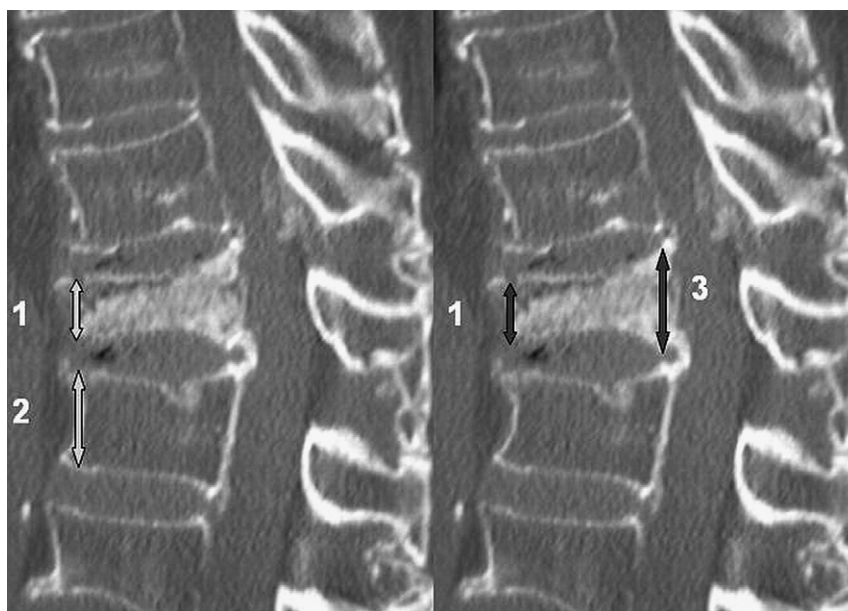


Figure 2 Evaluation of the restoration of vertebral height, measured between the anterior part of the fractured vertebra (1) and the anterior part of the adjacent level (2); measurement of Beck's Index between the anterior part of the fractured vertebra and the posterior part (3).

sis. This fixation system reduced the compression first with distraction and then with a lordosing maneuver at the lumbar region. The second operative period consisted of a kyphoplasty with inflatable balloons. The balloon size was chosen depending on the estimated size of the vertebra, most often 20 ml (10 patients) or 15 ml when the vertebral body was small (two patients). The procedure included cannulation of the two pedicles of the fractured vertebra guided by lateral fluoroscopic assistance, insofar as the orientation was determined by the approach and direct palpation of the pedicles. Cement was injected under the guidance of the image intensifier, with intraoperative verification that leakage had not occurred within the spinal canal.

Evaluation methods

Patients were evaluated postoperatively for pain using the VAS and for neurological recuperation with the Frankel score. Restoring vertebral height and distributing the cement in the vertebral body was checked with postoperative CT. Restoration of vertebral body height was measured using the two indices: the first compared the pre- and postoperative height of the anterior part of the fractured vertebral body with the height of the adjacent anterior vertebral body [9]. The second was the Beck Index [10], which compared the height of the anterior part of the fractured vertebral body with the height of the posterior part of the same vertebra (Fig. 2). Local vertebral kyphosis was evaluated before and after the surgical procedure.

After discharge, all patients were followed up in consultation in the department, with residual pain and neurological recuperation evaluation as well as CT follow-up at 3 months, 6 months, and 1 year after surgery.

The statistical analysis was carried out at several stages: the normal distribution of the measurements was verified using a Kolmogorov-Smirnov test, matching of the pre- and postoperative measurement series was checked by a Pearson correlation coefficient, and then we compared the different series of pre- and postoperative measurements looking for a significant difference (the Student-*t* test for paired series with an alpha risk set at 5%).

Results

A total of 12 patients were included in this study (Table 1), 10 women and two men, who were a mean 72.3 years of age [range: 44–86 years], and 13 vertebrae were treated using the procedure described. The mean time to appearance of neurological problems after the compression fracture was 17.6 days [range: 1–60 days]. Seven compression fractures were flat fractures, six were wedge fractures.

Surgery

All patients underwent a laminectomy and 11 also had posterior short-fragment osteosynthesis. The only patient in whom osteosynthesis was not performed presented a flat compression fracture with appearance of neurological impairment 2 months after the initial injury.

The mean surgical duration was 90 min [range: 50–140 min]; none of the patients required intraoperative transfusion. The mean quantity of cement injected into the vertebral body was 6.2 ml [range: 3.5–9 ml].

Following surgery, the mean VAS was 2/10; all patients were allowed to get up starting the second day, after removal of the drain. The hospital stay lasted a mean 7 days [range: 3–45 days].

Table 1 Clinical summary.

No.	Age	Sex	Level	Type of fracture	Osteosynthesis	Preoperative Frankel score	Postoperative Frankel score	Preoperative kyphosis	Postoperative kyphosis
1	65	M	L1	Flat	Yes	D	E	18	6
2	80	F	T12	Wedge	Yes	D	E	10	4
3	71	M	T11	Flat	Yes	D	E	20	8
4	78	F	L1	Wedge	Yes	D	E	18	6
5	65	F	T11	Wedge	Yes	D	E	18	8
6	86	F	T12	Wedge	Yes	D	E	8	0
			L1	Flat	Yes	D	E	12	2
7	78	F	L1	Flat	No	D	E	14	6
8	63	F	L1	Wedge	Yes	C	D	16	4
9	73	F	T12	Flat	Yes	C	D	16	6
10	83	F	T12	Flat	Yes	D	E	20	6
11	44	M	L2	Flat	Yes	D	E	16	2
12	82	F	T11	Wedge	Yes	C	E	18	6

Complications

Following surgery, we found two superficial wound infections, one resolving with antibiotic therapy and one requiring surgical revision for wound care and cleaning secondarily complicated by pulmonary embolism treated medically. Two urinary tract infections were also diagnosed and treated with antibiotics.

Results

All patients were later seen in consultation in the department with a mean follow-up of 14 months [range: 3–29 months].

Neurological evaluation after the intervention showed an improvement in all patients, 10 presented a score evaluated at E (strictly normal neurological exam results). In two patients, the score was evaluated at D (with a C score before surgery), with walking possible using canes. One patient presented an antecedent of multiple sclerosis with walking problems before the intervention.

On the radiographic study (Fig. 3) and the CT study (Fig. 4) done postoperatively and at the last follow-up, vertebral height restoration was judged satisfactory for the entire series of patients. The results of the statistical analyses demonstrated a significant difference ($P < 0.001$) in the values of the two indices indicating vertebral body height restoration, with an increase in the ratio. The evaluation of the ratio comparing the height of the anterior part of the fractured vertebral body to the height of the anterior part of the adjacent vertebra was a mean 58% [range: 39–77%] preoperatively and a mean 84% [range: 68–100%] postoperatively, for a 26% restoration of vertebral body height. The Beck Index also found a 28% statistically significant increase in vertebral height, with mean preoperative values of 59% [range: 44–73%] and 87% [range: 76–100%] at follow-up.

Similarly, there was a statistically significant difference ($P < 0.001$) between the local vertebral kyphosis measurements at the fracture, with a mean gain of 10.8° (preoperative mean, 15.7° [range, 8–20°], postoperative mean 4.9° [range, 0–8°]). The results of the statistical

tests are presented in Table 2. There was no statistically significant loss of correction between the immediate postoperative measurements and the measurements taken at the last follow-up.

Two cases of cement leakage were found during the CT follow-up study (Fig. 5), one in the subjacent discal space and one lateral; neither had clinical consequences.

Discussion

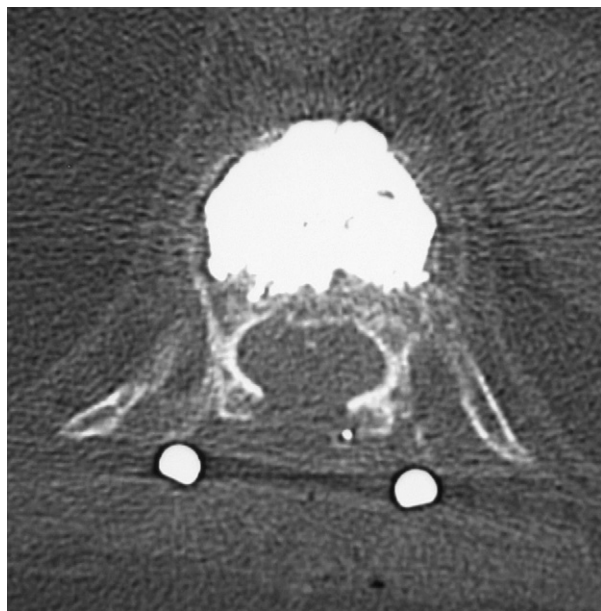
Since the first description by Galibert et al. [4] for treating vertebral angiomas, the techniques and indications for percutaneous vertebroplasty have been in constant development. Like any surgical technique, cementoplasty presents risks of complications, including cement leaking into the spinal cord. The study by Ryu et al. [11] estimated the risk of leakage in relation to the volume of cement injected and the vertebrae treated. Leakage is greater when more cement is injected and when the vertebra treated is greater than



Figure 3 Pre- and postoperative radiographies (same patient).

Table 2 Student *t*-test results.

	Preoperative		Postoperative		<i>P</i>	Mean variations
	Mean values	Range	Mean values	Range		
Local kyphosis	15.7°	8–20°	4.9°	0–8°	<0.001	–10.8°
Anterior height/adjacent height index	58%	39–77%	84%	68–100%	<0.001	+26%
Beck Index	59%	44–73%	87%	76–100%	<0.001	+28%

**Figure 4** CT scan after surgical procedure, measurement vertebral height restoration.**Figure 5** Search for cement leakage on the postoperative CT scan.

T7, with the risk reaching up to 26.5% of the cases treated. Use of balloon kyphoplasty reduces this risk of leakage and therefore the risk of mechanical compression and exothermic reaction when contact is made with the nerve structures [12].

Open vertebroplasty was described for the first time by Wenger et Markwalder [13] following a neurological complication caused by posterior cement leakage; they reported satisfactory results with this technique, which allowed intra-operative verification of the nerve structures. Another case of open balloon kyphoplasty was reported in 2003 by Hsiang [14] for osteoporotic vertebral compression fracture with disruption of the posterior wall, providing an excellent result.

More recently, Boszczyk et al. [15] described an open balloon kyphoplasty using a microsurgical interlaminar approach. However, they reported five cases of cement leakage and two cases of dural puncture. It therefore seems preferable to use an open transpedicular approach, as described by Wenger and as done in our study, so as to reduce the risk of neurological complications.

A study on the treatment of osteoporotic vertebral burst fractures with medullary canal stenosis was conducted by Singh et al. [16] in 2005. The authors associated osteosynthesis in 36% of the cases. The results were good, with 20% complications, including two severe complications with neurological involvement.

We found two cases of cement leakage in our series, one in the discal space subjacent to compression and one case of lateral leakage with no clinical consequences. No intracanal leakage was observed or injury to the dural sheath because the transpedicular approach was used. Systematic postoperative CT allowed us to check that there was no intracanal leakage after weightbearing was resumed.

The results presented herein are in agreement with the data reported in the literature, notably the study by Garfin et al. [17] and Hulme et al.'s meta-analysis [18], which concluded that balloon kyphoplasty for symptomatic vertebral compression fractures gives rapid and effective results, with significant improvement in terms of pain, function, and quality of life for older individuals. All of the patients in our series presented acute or semi-recent compression fractures, all of them less than 3-month-old, which provided better reduction of the fracture by the posterior approach compared to chronic compression fractures [19].

Uchida et al. [20] recently demonstrated that vertebral kyphosis correction was better via a posterior approach but with progressive loss of the correction, which made it equivalent to an anterior approach at the last follow-up, with no differences in the neurological results. Using an anterior

approach would give better neurological results in cases of wedge fractures but not for flat compression fractures.

The originality of the method used in our study resides in the fact that the patients included in the study presented osteoporotic compression fractures with neurological complications at the thoracolumbar junction, which classically contraindicates percutaneous treatment. A laminectomy therefore becomes necessary, with balloon kyphoplasty added so as to restore the vertebral body height and reduce pain. This procedure provided good results with stable correction of the local kyphosis while using the least invasive approach possible in patients who are often advanced in age with, sometimes, severe co-morbidities. It reduces the operative time, blood loss, and the duration of the hospital stay. In thoracolumbar junction vertebral lesions, it can treat neurological compression and consolidate the vertebral body in a single operation, thus avoiding surgery via an anterior approach in elderly patients. The results presented are in agreement with the results reported in the literature with restoration of vertebral body height greater than 20% [21] and a mean 9.9° gain in local kyphosis [22].

This surgical treatment seems to present the advantages of posterior surgery in terms of vertebral kyphosis correction, but with results that are more stable over time because of the injection of cement in the anterior part of the vertebral body. After its use in treatment of spinal cord metastases [23], we now find it to be the treatment of choice for osteoporotic compression fractures with neurological signs.

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