Video-assisted treatment of thoracolumbar junction fractures using a specific distractor for reduction: prospective study of 50 cases

Jean-Charles Le Huec · C. Tournier ·
S. Aunoble · K. Madi · Ph. Leijssen

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Abstract Posterior instrumentation allows good osteosynthesis for thoracolumbar junction fractures. However, in approximately 20% of cases, anterior bone defects may persist, leading to pseudoarthrosis and loss of reduction. Anterior approaches can circumvent this drawback, but they are considered aggressive with a high rate of complications. The advent of the endoscopic mini-invasive techniques has led to a reduction in the number of complications while maintaining the same consolidation rate. Nevertheless, poor restitution of anatomic curves is a reproach for this technique. This prospective study reports clinical and radiological result of 50 patients (19 women and 31 men) operated between April 2000 and March 2006 with a video-assisted anterior approach using an endodistractor for reduction and consequent insertion of the implant. There were A3 ($n = 44$), A2 ($n = 2$), A1 ($n = 3$) and C1 ($n = 1$) fractures (Magerl classification). The specific system for fracture reduction was used in the last 39 cases of this series. A Pyramesh cage (Medtronic, Memphis, USA) was used in 15 patients, a peek cage (Crespine, Bordeaux, France) in 30 patients and a tricortical graft in 5 patients. Standard X-rays and CT scan were performed pre-operatively. Kyphosis, and angulations were measured pre-, per- and post-operatively. Mean immediate postoperative gain in localized kyphosis was 12.18° and mean gain at last follow-up was 11.71° . Mean immediate postoperative gain in RA was 13.24° and remained

identical at last follow-up. Five patients had a transient pulmonary atelectasia and there was one pulmonary infection. No neurological complication occurred. Fracture reduction is comparable to the best thoracotomy series while limiting approach-related complications.

Keywords Thoracolumbar fracture · Anterior approach · Osteosynthesis

Introduction

Thoracolumbar junction fractures are frequent and their treatment has been the subject of much debate. Anterior approaches [29], posterior approaches [2] and combined routes [3, 37] are proposed. Magerl's classification [26] is the most thorough for analyzing fracture type but does not provide any therapeutic indication. The choice of treatment depends on the degree of instability, the rate of bone and/or ligamentous lesions and the eventual presence of medullary compression.

The most widely used techniques involve reduction and fixation by a posterior approach [2], recent available instrumentation allows good correction with either short [9] or longer [1] constructions. However, anterior vertebral bone defects may persist in approximately 20% of cases, leading to pseudoarthrosis and loss of reduction [5]. Somatic transpedicular grafts have not proved efficient [24]. While reduction and fixation by an anterior approach allows excellent reconstruction of the anterior spine and medullary decompression, they are known to be aggressive and to have a high rate of complications [10, 22]. The advent of endoscopic mini-invasive techniques [25] has led to a reduction in the number of complications while maintaining the same consolidation rate [23]. Poor

J.-C. Le Huec (✉) · C. Tournier · S. Aunoble · Ph. Leijssen
Spine Unit, Department of Orthopaedic Surgery,
CHU Bordeaux, 33076 Bordeaux Cedex, France
e-mail: j-c.lehuec@u-bordeaux2.fr

K. Madi
Department of Orthopedic Surgery, CHU Reims,
51100 Reims, France

restitution of the anatomic curves at the thoracolumbar junction is a drawback of this approach. From 1994 we have been using endoscopic video-assisted anterior approaches to the spine and have repaired thoracolumbar junction fractures with this technique since 1999. This study reports clinical and radiological results of 50 patients operated and followed up prospectively with the same method. A specific intra-operative system for reducing fractures was used in the last 39 cases.

Patients and methods

Fifty patients (19 women and 31 men) were treated between April 2000 and March 2006. Minimum follow-up was 24 months. Mean age of the patients was 43.3 year (16–65 year). Mean weight 65.58 kg (50–86 kg) and mean height was 169 cm (160–182 cm). All interventions were performed at 7, 8 days (7–15 days) after the initial trauma. Neurological data were normal in all patients. Fifteen Patients had associated thoracic rib fractures ($n = 4$) and/or limb trauma ($n = 11$). The circumstances of the accident consisted of 38 road accidents, 9 falls from a ladder and 3 defenestrations.

Preoperative workup included anamnesis, clinical examination, standard X-ray imaging and CT scan. Classification was done according to Frankel [14], Roy-Camille score and Magerl score [26].

Localized kyphosis and regional angulation (RA) were measured according to the technique of Stagnara et al. [36] (Table 1) pre-, per- and post-operatively and at follow-up. Vertebral kyphosis (VK) is the angle formed by two straight lines parallel to the vertebral plates of the fractured vertebra. RA is the angle formed by a straight line parallel to the superior plate of the subjacent vertebra and a straight line parallel to the inferior plate of the subjacent vertebra (Fig. 1). Corrected regional angulation (CRA) is obtained with the following formula.

Measured RA minus anatomical RA, which is provided for each thoracolumbar disc [36].

The CRA should be close to zero. Separate measures were taken for corrections obtained with an external reduction maneuver or by using the endodistractor.

Table 1 Anatomical regional angulation according to Stagnara

Fracture level	Anatomical regional angulation (°)
T11	9
T12	7
L1	1
L2	–8

Fig. 1 Regional angle (RA) vertebral kyphosis (VK)

We assessed duration of single lung ventilation, blood loss according to the technique of Budny et al. [6], pre- and intra-operative transfusion requirements, graft type and complications. All patients wore a brace for 6 weeks day and night and then a soft brace for 6 more weeks as they resumed walking.

In 15 cases the reconstruction was done with a titanium cage (Pyramesh Medtronic, Memphis, USA) filled with autologous cancellous bone, in 6 patients we used an autologous cortico-cancellous graft, and 29 patients received a new peek cage filled with autologous bone. All osteosynthesis was done either with an Antares titanium device (Medtronic, Memphis, USA) ($n = 43$) or a Z plate (Medtronic, Memphis, USA) ($n = 7$). Both devices ensure bicortical fixation with two screws in each vertebral body adjacent to the fracture. Connection is ensured by two rods in the Antares construct and by a plate in the Z plate. The last 39 patients benefited from a reduction with an endodistractor specially designed (Creaspine, Bordeaux, France) before the cage was implanted.

Operative technique

Patient installation is in left lateral decubitus with a cushion under the thorax. Selective intubation is performed under C arm amplifier. Sterile drapes are used as in classical

thoracoscopy with the possibility to convert to an open technique if necessary. The iliac crest is left within the operating field for harvesting graft tissue if required. The C arm amplifier is used to localize the lesioned vertebra. A skin incision is then made above the fracture level on the lateral view and 4–5 cm of rib can be excised and the bone is kept for grafting if necessary. This skin incision will be used for implant insertion. The right lung is then pushed aside. The first blunt trocar is inserted through a 2-cm incision along the anterior axillary line in the fifth or sixth intercostal space. The thorax is then inspected with a 0° rigid endoscope. Two other trocars are then set up along the median axillary line in order to insert a blunt pulmonary retractor. The fracture is then controlled radiographically with the C arm.

The parietal pleura is opened and the segmental vessels are coagulated with bipolar cautery and sectioned. The diaphragm is desinserted in order to approach the T12, L1 and L2 vertebral bodies concerned by the fracture. The osteosynthesis device is fixed to the vertebrae supra- and subjacent to the fracture. Discectomy and corporectomy are performed with an osteotome and/or bone drill and disc forceps. The anterior column is then reconstructed either with a Pyramesh cage (Medtronic, Memphis USA) (Fig. 1) or a peek cage (Creaspine, Bordeaux, France) filled with autologous bone (Fig. 2) or by a tricortical iliac graft. In 11 patients, the graft was inserted after reduction by an external maneuver (manual pressure on the spine from the back) followed by distraction on the supra- and subjacent vertebral screws. In the other 39, we used an endodistractor (Creaspine, Bordeaux, France), which allowed us to reduce the kyphosis harmoniously. The endodistractor ensures symmetrical correction because it is applied to the vertebral plates and allows the graft to be set up easily (Fig. 3). Osteosynthesis is completed and the correct position of the implants is controlled radiographically. The diaphragm is reinserted if necessary and thorough rinsing is performed. A pleural drain is set up under endoscopic control.

Results

No patient had any preoperative neurological disorder and none experienced any postoperative neurological spinal cord complication. Four patients had transient intercostal nerve pain but did not require medication. One patient was treated for lung infection with complete recovery. Fracture sites were as follows: 32 fractures at L1, 16 at D12 and 2 at T11. According to the Magerl classification, they were A3 ($n = 44$), A2 ($n = 2$), A1 ($n = 3$) and C1 ($n = 1$). No conversion was required. Mean pulmonary exclusion was 155 min (75–240 min). Mean blood loss was 620 ml

Fig. 2 Vertebral body reconstruction with Pyramesh (Medtronic, Memphis, USA) and Antares osteosynthesis (Medtronic, Memphis, USA). Reduction with external maneuvers: limited gain

Fig. 3 Vertebral body reconstruction with Substance Cage (Creaspine, Bordeaux, France). **a** Reduction with endodistractor. **b** Insertion of the cage over the endodistractor

(200–1,900 ml) and 4 patients needed blood transfusion postoperatively. A Pyramesh* cage (Medtronic, Memphis USA) was used in 15 cases, a peek cage (Creaspine, Bordeaux, France) in 30 cases and a tricortical iliac crest graft in the first 5 patients. The endodistractor was used in 39 patients. The only subsequent complications were five cases of pulmonary atelectasia that regressed within 2 months. No pseudoarthrosis was found. X-rays were used to assess vertebral kyphosis and corrected localized regional angulation preoperatively (VK and CRA), immediately postoperatively (VKp and CRAp) and at last follow-up (VKf and CRAf). We then analyzed the results with regard to use of the endodistractor.

Table 2 shows that correction was satisfactory and lasting. Mean immediate postoperative gain in localized kyphosis was 13.87° and mean gain at last follow-up was 13.54°. Mean immediate postoperative gain in CRA was 13.54° and remained unchanged at follow-up. Gain in localized kyphosis and RA was twofold greater with the endodistractor compared to using external maneuvers and this difference is significant (Tables 3 and 4).

Discussion

This series cannot readily be compared with others series in the literature. Most studies using a thoroscopically guided mini-invasive anterior route involve a preceding [2] or simultaneous [3, 37] posterior approach. Studies using a unique anterior approach to treat thoracolumbar hinge trauma have included very few subjects, such as that by Hertlein et al. [17] in which only two patients were included. Only Khoo et al. [21] included a large series but they used a combined approach for the majority of their patients. Reports of thoroscopically guided anterior approaches concern either degenerative [33–35] or tumoral [27] pathologies. Thoracoscopic guidance has been shown to decrease postoperative morbidity and the rate of intra- and postoperative complications [7, 8, 13, 16, 18, 21, 27, 30, 33, 34].

Table 2 Vertebral local kyphosis angulation and corrected regional angulation

	VK initial	VKp	VKf	CRA initial	CRAp	CRAf	Gain between VK initial and post-op	Gain between VK initial and last follow-up VKf	Gain between CRA initial and post-op	Gain between CRA initial and last follow-up
Mean (°)	20.55	6.68	7.01	20.15	6.05	6.35	13.87*	13.54*	14.1*	13.80*
Min–max	6–30	0–16	0–18	5–29	1–19	1–19				

Gain of correction between initial angle, postoperative correction and gain at last follow-up

VK vertebral kyphosis initial, VKp vertebral kyphosis postoperative, VKf vertebral kyphosis last follow-up, CRA corrected regional angle initial, CRAp Corrected regional angle postoperative, CRAf corrected regional angle last follow-up

* Significant difference, $P < 0.05$

Table 3 Remaining correction obtained for VKp and CRAp in the group operated with the endodistractor: better correction

With endodistractor	VKp	CRAp
Mean (°)	3.75	3.57
Min–max	0–17.5	0–13.2

VKp vertebral kyphosis postoperative, CRAp Corrected regional angle postoperative

$P > 0.05$: no significant difference

Table 4 Remaining kyphotic correction obtained for VKp and CRAp in the group operated without the distractor

Without endodistractor	VKp	CRAp
Mean (°)	8.9	8.09
Min–max	3–19	3–11

VKp vertebral kyphosis postoperative, CRAp Corrected regional angle postoperative

$P > 0.05$: no significant difference

The five cases of pulmonary atelectasia regressing spontaneously over 2 months are in agreement with previous reports [27, 33]. One lung infection occurred, and even though this risk is classically increased after trauma [32], the minimal invasive character of the surgery is likely responsible for this. The mean pulmonary exclusion time (155 min) is comparable to that found in other series where an arthrodesis and osteosynthesis were used [33].

Thoracoscopy has a learning curve [8, 21] that, if not respected, can lead to serious complications [20]. Our technique is reliable as demonstrated by the homogeneity of our series. Mean blood loss (620 ml) was comparable to that in other series [10, 23, 26] and less than in the reports by Huang et al. [19] and Haas et al. [15], where it ranged from 1.5 to 2.25 l.

Our measurements are presented as absolute values so that they may be compared to others in the literature [18, 31], but are also expressed as corrected values of physiological curves. This allows sagittal equilibrium to be assessed and provides a view of what the long-term impact might be if the defect is not corrected.

Mean gain in vertebral kyphosis was 13.87° which is similar to the values found with classic thoracotomy by Onimus et al. [31], although CRA was not indicated in that study. Khoo et al. [6] reported 18° reduction but many patients received a combined antero-posterior approach and the anatomical angle correction at the level at which the patients were operated was not included in their calculations. Been et al. [3] found similar figures to ours in their series. There was no loss in vertebral kyphosis at 15-months follow-up. Correction of localized kyphosis (13.54°) and in CRA (13.80°) was stable compared to the immediate postoperative assessment. This is in agreement with the

findings of Kirkpatrick et al. [23] and Eysel et al. [12] who reported greater stability over time with the anterior approach. The endodistractor gave a much better CRA correction (3.57°) than did external manoeuvres or a system involving the vertebral plates (8.09°). This confirms the findings of Ebara et al. [11] and Beisse et al. [4] who found mandatory the use of a specific device in thoracoscopy.

As demonstrated by McAfee et al. [28], a fracture with a 50% loss of vertebral substance associated with orthopedically-treated stenosis of the medullary canal leads inevitably to a lumbar pathology 10 years after the accident. We agree with this point of view and believe that re-establishing the physiological curves and obtaining a good sagittal balance can avoid such long-term complications. Mini-invasive thoracoscopy without any posterior surgery is efficient for the treatment of Magerl type A and for some type C thoracolumbar junction fractures. Our technique providing a suitable reducing device is used as well as a good-quality osteosynthesis and vertebral body reconstruction. The use of the Peek cage for vertebral body repair allows artifact-free CT and MRI scanning.

Conclusion

In view of the learning curve, intra-, post-operative and long-term complications are less frequent with the video-assisted mini-invasive approach [8, 21] than with classic thoracotomy [33, 34] or a combined approach [21]. The correction obtained is satisfactory and lasting. A specific distractor is essential for reducing and inserting the anterior graft without loss of correction. The outcome is as good as in the best thoracotomy series [31] while the complications associated with the approach are limited.

Conflict of interest statement None of the authors has any potential conflict of interest.

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