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ORIGINAL STUDY

Table-mounted ring retractor for consistent visualization in endoscopy-assisted anterior reconstruction of burst fractures of the thoracolumbar junction

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The authors tested an autoclavable external ring retractor, fixed to the operation table, for the endoscopic reconstruction of anterior column injuries of the thoracolumbar junction. It served as a retractor for the diaphragm, and offered a stable support for the scope and other instruments, making an assistant superfluous. Moreover, it allowed bimanual manipulation. Of course, the two-dimensional image, provided by the scope, necessitated proper eye-hand coordination. Twenty-eight consecutive patients underwent either a monosegmental (n = 10) or a bisegmental (n = 18) anterior stabilization in the area Th11L1. Three portals were necessary, but an assistant was not needed. The overall (mean ± SD) operating time was 196 ± 56 min, the blood loss was 804 ± 719 mL. Intraoperatively, one epidural bleeding and a single screw cut-out occurred. All complications were managed endoscopically. Postoperatively, evacuation of a haemothorax (n = 1) was necessary. In all patients, wounds and fractures healed uneventfully. The combination of the endoscopic technique and the retractor system was feasible, successful, safe, and time efficient. Moreover, it allowed for anterior instrumentation of thoracolumbar fractures by a single surgeon. It became the standard approach in the authors' department.

Keywords : anterior column injuries ; thoracolumbar junction ; endoscopic reconstruction ; ring retractor.

INTRODUCTION

Restoration of the anterior column is recommended in thoracolumbar junction compression fractures (*13*). However, an open anterior approach often leads to access morbidity, while a posterior reconstruction without anterior approach frequently is associated with loss of correction (*7,10,19,20*). The ideal approach for these injuries would be a less invasive anterior approach with minimal access morbidity. An endoscopic anterior approach to the

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thoracolumbar junction has minimal access morbidity (*5,6,9,15,18*), and allows anatomic restitution of the anterior column (*12*).

The authors developed the idea to combine the endoscopic technique with a fully autoclavable ring retractor, already known as a useful aid in open anterior surgery (*1,11,14,17*). They focused on the technique and the feasibility, rather than on the mid-term results.

MATERIALS AND METHODS

Patients

A ring retractor (Synframe® ; Synthes, Oberdorf, Switzerland) was used for endoscopic reconstruction of the anterior column in 28 consecutive fractures of the thoracolumbar junction, between 02/2007 and 09/2008 (*1*). There were 12 females and 16 males. Their mean age was 42 years (SD ± 17 yrs). The indication for operative treatment was based on the classification of Magerl (*13*). Table I reproduces patients' demographics, mechanism and level of injury, fracture type according to the Magerl classification (*13*), neurologic deficit according to the Frankel scale (*8*), Injury Severity Score (ISS) (*2*) and additional injuries. Prior to anterior endoscopic reconstruction an open posterior stabilization

(Universal Spine System, USS®, Synthes) was performed in 14 cases : 3 type A fractures with neurologic deficit, 7 type A fractures without neurologic deficit but with significant kyphosis (> 50% loss of anterior vertebral body height), and 4 type B injuries.

Surgical Technique

All operations were performed by the first author, assisted by a scrub nurse. A double-lumen tube was used for endotracheal intubation, to allow for one-lung ventilation. Patients were positioned on their right side, with an inflatable pillow beneath their flanks (Fig. 1). The sterile ring retractor, applied to the operating table, enabled a stable fixation of the scope, the diaphragm retractor (MicroFrance® Laparoscopic Instruments, Medtronic, Tolochenaz, Switzerland) and other instruments. The anterior and posterior margins and the endplates of the affected levels were identified with the image intensifier and marked on the skin (Fig. 1-B, 3-D), for placement of the working portal. An oblique skin incision of about 2.5 cm was made, from the anteroinferior to the posterosuperior edge of the affected vertebra. Subsequently an anterosuperior portal was made for the scope. Finally an anteroinferior portal was made for the diaphragm retractor, with the aid of a scope with a 30° angled optic. These two portals formed a triangle with the working portal. A mini-thoracotomy with stepwise dissection of the thoracic wall further established the working portal (Fig. 2) ; it also served for suction and irrigation. The diaphragm was incised for exposure of L1 and L2 ; this technique was described elsewhere (*4*). After placement of the diaphragm retractor and the scope, the fractured vertebra was again localized with the image intensifier. The pleura was incised, and if necessary, the diaphragm. Next, segmental vessels of the fractured vertebra were mobilized and clipped. Discectomy was performed prior to corpectomy, as disc tissue is avascular. The corresponding endplates were freed from the overlying cartilage. Only a partial corpectomy was performed in cases without neurological compromise. The posterior cortex of the vertebral body was removed in patients with neurological deficit, in order to expose the dura (e.g. case 6 ; Fig. 3), and in case of intraspinal fragments after posterior instrumentation.

The anterior column was reconstructed with the extendable Synex™ (Synthes) and VLIFT™ (Stryker, Selzach, Switzerland) cages, or a Harms cage (mesh type, DePuy, Le Locle, Switzerland). In cases with mono- or bisegmental anterior spondylodesis without posterior stabilization the MACS-TL® - (Modular Anterior Construct System Thoracic Lumbar, Aesculap, Tuttlingen, Germany) or the Arcofix® - system (Synthes) were used for additional stabilization. Autologous bone from the corpectomy filled the cage and was applied around it. The diaphragm, if opened, was sutured to prevent a hernia. The re-inflation of the lung was monitored endoscopically. A chest tube was inserted into the thoracic cavity through the anteroinferior endoscopic portal (Fig. 3). Portals were closed stepwise. In general, patients were mobilized on the first postoperative day. The thoracic drains were left *in situ* until less than 150 ml. of fluid was collected within 24 hours.

Evaluation

Preoperatively, plain radiographs and CT-scans were obtained in the supine position for fracture classification according to Magerl (*13*). Operation time, intraoperative blood loss, blood transfusion, conversion from an endoscopic to an open approach, and intraoperative iatrogenic injuries to large vessels, nerves or organs in the thoracic and upper abdominal cavity were documented. The correction of the kyphosis and/or the occurrence of

Table I. — Demographics and injury patterns of all patients

N°	Age	Sex	Mechanism	Level	Fracture	Frankel	ISS	Additional injuries
1	45	M	Sport Injury	L1	A 3.2.1	E	22	Chest, Pelvis, Integument
2	17	F	Sport Injury	Th 12	B 2.1	E	9	-
3	25	F	Fall	Th 12	A 3.2.1	E	34	Head, Face, Extremity
4	61	M	Fall	L1	A 3.1.1	E	10	Extremity
5	60	F	Fall	L1	A 3.1.1	E	13	Extremity
6	28	F	Fall	L1	B 2.3	C	29	Chest, Abdomen, Pelvis
7	58	M	Fall	L1	A 3.2.1	E	9	-
8	61	M	Traffic Accident	Th 11	A 3.2.1	E	10	Extremity
9	54	M	Fall	Th 12	A 3.2.1	E	9	-
10	28	M	Fall	Th 11	A 3.2.1	E	13	Head
11	20	M	Fall	Th 12	B 2.3	E	13	Extremity
12	25	M	Traffic Accident	Th 12	A 3.1.1	E	27	Head, Face, Integument
13	23	M	Fall	L1	A 3.1.1	C	20	Pelvis
14	43	M	Sport Injury	Th 12	A 3.1.1	E	9	-
15	37	F	Sport Injury	Th 12	A 3.3.1	C	16	-
16	68	F	Fall	L1	A 3.3.1	E	9	-
17	21	M	Fall	Th 12	A 3.2.1	E	14	Extremity, Pelvis
18	33	M	Fall	L1	A 3.1.1	E	13	Extremity
19	47	M	Sport Injury	L1	A 3.2.1	E	9	-
20	21	F	Sport Injury	L1	A 3.1.1	E	9	-
21	51	M	Fall	Th 12	A 3.2.1	E	10	Integument
22	49	F	Fall	L1	B 2.3	E	13	-
23	74	M	Fall	L1	A 3.1.1	C	16	-
24	55	F	Fall	Th 12	A 3.1.1	E	9	-
25	26	F	Sport Injury	L1	A 3.1.1	E	9	-
26	28	F	Traffic Accident	L1	A 3.1.1	E	9	-
27	47	M	Sport Injury	Th 12	A 3.1.1	E	9	-
28	68	F	Fall	L1	A 3.1.1	E	9	-

Injury Severity Score (ISS).

iatrogenic scoliotic deformities were assessed by comparison of the pre- and postoperative CT-scans as described below.

Follow-up : after 1.5 , 3, 6 and 12 months. The clinical follow-up focused on healing disorders, haemopneumothorax, atelectasis, pneumonia, intercostal neuralgia and others. The radiological follow-up consisted of plain radiographs of the thoracolumbar/lumbar spine (anteroposterior and lateral projections, in the upright position) and focused on nonunion, misalignment of the instrumentation, and displacement or fatigue fracture of the hardware. The construct was considered to be stable when progressive kyphosis and hardware failure at the “screw-bone”, or “cage-bone” interface were absent. The construct stability was considered as a measure of bony fusion.

CT-scans of the thoracolumbar/lumbar spine were conducted with the patients placed in the supine position on a 64-slice CT system (Somatom Definition AS, Siemens Healthcare, Forchheim, Germany ; slice collimation 64×0.6 mm, pitch factor 0.8, tube voltage 120 kV). Reconstructions in coronal and sagittal planes (slice thickness 2 mm, increment 2 mm) were performed. In general, CT scans were obtained before and after

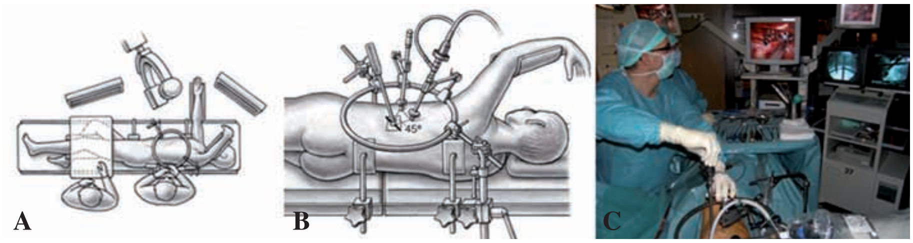

Fig. 1. — Setup : (A) placement of the patient, surgeon, scrub nurse, thoracoscopic setup and image intensifier ; (B) triangulation of the three portals : the working portal, an anteroinferior portal (diaphragm retractor placement), and an anterosuperior portal (scope placement) ; (C) peroperative photograph.

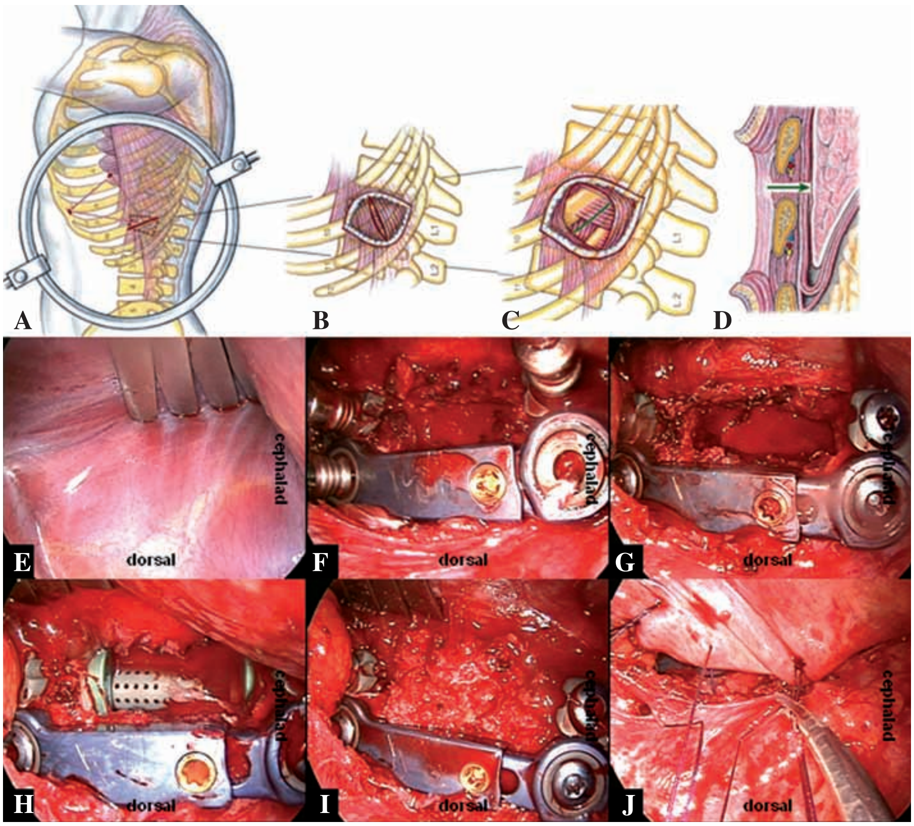

Fig. 2. — Operating field. (A-D) : schematic drawings showing (A) skin incisions for portals and mini-thoracotomy, (B) splitting of the latissimus dorsi muscle, (C) visualization of the ribs, (D) entering the intercostal space. (E-J) : photographs obtained from the thoracoscope (case 19) : (E) retraction of the diaphragm, (F) corpectomy, discectomy, positioning of the plate, (G) distraction and lordosing, (H) placement of the cage, (I) application of local bone, (J) repair of the diaphragm.

anterior reconstruction or – in cases with previous posterior stabilization – prior to second-stage anterior reconstruction. Image evaluation was performed by an independent and experienced radiologist (GP) on a standard PACS (Picture Archiving and Communications System) workstation (Impax ES DS 3000, Agfa HealthCare GmbH, Bonn, Germany).

Statistical analysis

A Wilcoxon signed-rank test for paired groups was performed for the comparison of pre- and postoperative kyphosis and scoliosis, measured on CT scans. All data were presented as the mean ± SD. The level of significance was set at $p < 0.05$. Analyses were

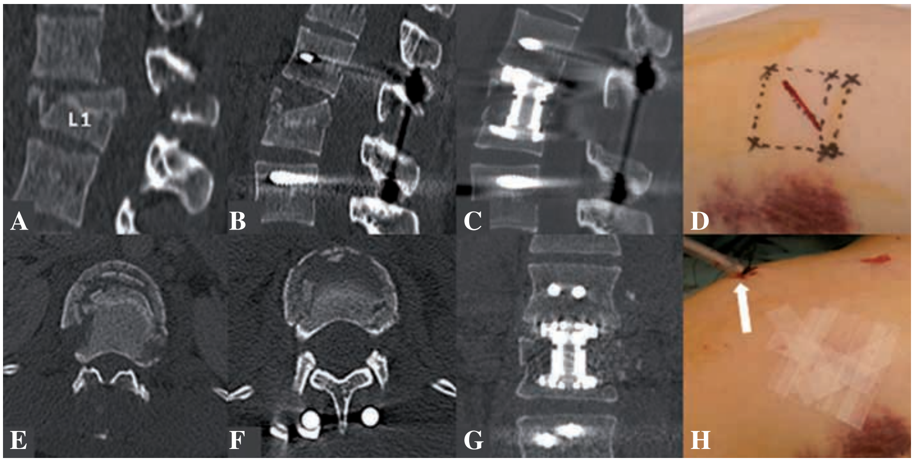

Fig. 3. — Case 6 : CT-scans : (A, E) after trauma, (B, F) after dorsal instrumentation and (C, G) after additional anterior reconstruction. Intraoperative photographs showing (D) the skin incision for the working portal and (H) insertion of a chest tube (arrow) through the anteroinferior endoscopic portal plus closure of the wound of the working portal above the fractured vertebra.

performed with SAS 9.1 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Endoscopic anterior stabilization was performed monosegmentally in 10, and bisegmentally in 18 patients. A preliminary posterior instrumentation was deemed necessary in 14 cases. Release of the diaphragm was necessary in 18 patients. For reconstruction of the anterior column a VLIFT-system (n = 16), a Synex-cage (n = 10) or a Harms-cage (n = 2) was used. For additional anterior stabilization a MACS-TL-system (n = 15) or an Arcofix-system (n = 1) was used. Anterior decompression and clearance of the spinal cord were performed in 2 cases ; posterior decompression, via laminectomy, in 5 cases. The delay (mean ± SD) between injury and posterior instrumentation (14 cases) was 1.1 ± 1.9 days. The delay between posterior and anterior instrumentation was 5.7 ± 4.7 days. The delay (mean ± SD) between injury and anterior reconstruction without posterior instrumentation (14 remaining cases) was 6.5 ± 5.9 days.

Conversion to an open approach was not necessary. The overall operating time was 196 ± 56 min (cage alone : 161 ± 30 min ; cage with anterior plate : 222 ± 57 min ; p = 0.007). Release and repair of the diaphragm required from 32 to 48 minutes. Overall blood loss during anterior reconstruction was 804 ± 719 mL. Two patients needed a blood transfusion. In one patient (case 23) an epidural bleeding occurred during endoscopic anterior decompression. In another patient (case 28) a screw of the MACS system cut out of the first lumbar vertebral body. In both cases, complications were managed endoscopically, and surgery was finished successfully. No iatrogenic injuries to large vessels, nerve structures or organs in the thoracic and upper abdominal cavity were observed. Revision surgery was necessary due to the occurrence of a haemothorax in one patient (case 19). No wound healing disorders or intercostal neuralgia were noted.

The preoperative kyphosis measured 9 ± 3° in the patients treated with anterior reconstruction only, and 14 ± 7° in the patients treated with the combined anterior and posterior reconstruction. A statistically significant correction (p = 0.018) of the kyphotic deformity to 5 ± 3° was achieved by anterior reconstruction only ; the correction amounted to 5 ± 5° (p = 0.005) after the combined posterior/anterior procedure. No iatrogenic scoliosis was observed : the mean preoperative scoliosis amounted to 3 ± 1°, and the mean postoperative scoliosis to 3 ± 2° (p = 0.824). Nonunion, fatigue fractures of the hardware or significant loss of reduction were not observed. All fractures healed uneventfully and the reconstruction was regarded as being stable.

DISCUSSION

Endoscopic treatment of thoracolumbar junctional fractures significantly reduced the access morbidity (*5,6,9,15,18*). However, the two-dimensional view may adversely affect the surgeon's perception of the anatomic topography on the video screen. Moreover, the lack of physical verification and depth perception may lead to a disorientation of the surgeon. To overcome the two-dimensionality, the surgeon relies on indirect evidence from spatial relations such as focusing, changes in size, or differences in color or shade. In addition, proper eye-hand coordination might be necessary for the successful interpretation of a two-dimensional image on a video screen if instruments are to be coordinated correctly in the absence of depth perception. A permanent and stable operation field has therefore to be provided by the assistant holding the camera (*15*). Moreover, the surgeon has to come to terms with the difficulties mentioned, in order to acquire new psychomotor and technical skills.

In the current series, however, an optimally illuminated, permanent and stable operation field was obtained by the use of the self-holding ring retractor system with bimanual operation through the working portal, together with the use of instruments and a suction device without the need of an assistant. As measured on CT-scans, a significant fracture reduction with a decrease in fracture-related kyphotic deformity was achieved ; all anterior reconstructions healed uneventfully without significant loss of reduction within six months to one year postoperatively. The presented technique was therefore found to be both feasible and successful.

Approach-related complications have been seen to range from 5.4% (*3*) in endoscopic to 11.5% (*7*) in open anterior spinal fusion surgery. In the current series, neither organ complications nor major vessel injuries were noted. Two minor complications were managed intraoperatively without the need for conversion to an open approach. The overall blood loss was comparable to either an endoscopic (*15*) or an open, minimally invasive approach (*11*) for anterior reconstruction of thoracolumbar spine injuries. In summary, the presented technique was found to be safe.

The mean operation time in the current series was longer than the time reported by others, using an open approach (*11*), but somewhat shorter than the time reported by others using an endoscopic anterior approach (*3*). An accurate comparison of the operation times in different reports is, however, hindered by differences in the surgical steps additionally applied and the implants used. Moreover, additional bone graft harvest (e.g. from the iliac crest), clearance of the spinal cord, cage interposition with or without additional anterior stabilization, and release of the diaphragm also play a role. Splitting and subsequent repair of the diaphragm in about two-thirds of the patients in the current series increased the operation time, albeit within the range of data found in the literature (*4*). The authors went through a learning curve, so that the potential for a further reduction in operation time may still exist. Although longer operation times include an increased risk for wound healing disorders, especially infections, no infections were seen and all wounds healed uneventfully.

From an economical view-point, an assistant was no longer necessary, thanks to the ring retractor. This is in sharp contrast with the past (*5,11,14-16*).

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