Minimally invasive thoracoscopic approach to thoracolumbar junction fractures

Jan Kocis, Martin Kelbl, Peter Wendsche, Radek Vesely

Aims. A retrospective analysis of patients with thoracolumbar junction fractures who underwent video-assisted thoracoscopic surgery via a minimally invasive approach (minithoracotomy) for reconstruction of the anterior spinal column.
Methods. Between 2002 and 2014, a total of 176 patients were treated by this technique. The patients received either posterior stabilization and, at the second stage, the minimally invasive technique via an anterior approach, or the minimally invasive anterior procedure alone.
Results. In the anterior procedure, the average operative time was 90 min. (50 to 130 min). Bony fusion without complications was achieved in all patients within a year of surgery. The loss of correction after the anterior procedure with an allograft or titanium cage was up to 2 degrees at two years follow-up.
Conclusion. The minimally invasive approach (minithoracotomy up to 6-7 cm) combined with thoracoscopy is an alternative to an exclusively endoscopic technique enabling us to provide safe surgical treatment of the anterior spinal column.

Key words: thoracolumbar junction; minimally invasive approach; transdiaphragmatic approach; thoracoscopy

Received: May 8, 2016; Accepted: September 15, 2016; Available online: October 3, 2016
http://dx.doi.org/10.5507/bp.2016.048

Department of Traumatology, Faculty of Medicine, Masaryk University, Brno, Czech Republic
Corresponding author: Jan Kocis, e-mail: jankocis@seznam.cz

INTRODUCTION

The anterior approach to the thoracolumbar junction of the spine was first described by Hodgson in 1960 (ref.[1]). This extensive approach to the Th/L junction provided excellent exposure of the surgical site but was associated with a significant morbidity of the thoracic and abdominal walls[2]. Therefore it was reserved for patients with a marked posttraumatic deformity or a structural disease of the spine requiring reconstruction of the anterior column of the spine. With the growing need of reconstruction of the anterior column of the spine and with the development of endoscopic techniques in surgery, a trend has increased in the recent years to use mini-invasive approaches to the anterior column of the spine by means of thoracoscopy[3,4] or mini-thoracotomy and thoracoscopy[5,6]. The aim of the present study was a retrospective evaluation of a group of patients with fracture in the region of the thoracolumbar junction. We reconstructed the anterior column of the spine by mini-thoracotomy in combination with thoracoscopy.

PATIENTS AND METHODS

In 2002–2014 we used this method to treat 176 patients. The average age of patients was 43.4 years (range, 18 to 77). The group included 112 men and 64 women. Fracture of L1 was treated 101 times and fracture of Th12 was treated 75 times. All patients with a suspected injury to the Th/L spine were indicated for clinical examination. The diagnosis was confirmed by radiographic examination in the a-p and lateral views. Subsequently all patients underwent CT examination on the basis of which the fractures of the Th/L spine are classified according to AO. Analysis of radiographs and CT scans serve as the basis for the choice of the proper therapeutic procedure. In case of a suspected injury to posterior structures and a rotational injury, primary treatment from the posterior approach is indicated. Where there is a simultaneous high-degree anterior column comminution (50% and more) anterior surgery for reconstruction of the anterior column is indicated after a specific time interval. The anterior only procedure is indicated in type A injuries to the vertebra. On the basis of CT and intraoperative examination 110 fractures were classified as type A, 59 as type B and 7 fractures as type C. The most frequent cause of injury was fall from a height in 93 cases, followed by fall on the ground in 43, motor vehicle accident in 37 and caving in 3 cases. On admission to the hospital, 25 patients had a neurological lesion, ten of which were Frankel grade A, five Frankel grade B, eight Frankel grade C and two Frankel grade D. All patients were treated either by posterior stabilization with a subsequent anterior approach using a mini-invasive technique, or by anterior-only surgery. Posterior stabilization by transpedicular internal fixation was performed in 82 patients. In the second step, the anterior column was stabilized with a simple screw-rod-screw construct and the vertebral body was replaced by allograft in 70 and an expandable titanium implant in 12 of these patients. The anterior-only surgery was performed in 94 patients using fixed-angle bisegmental in 62 and fixed-angle monosegmental instrumentation in 32 of them. The vertebra was replaced by allograft in 81 and an expandable titanium implant in 13 patients. Decompression of the dural sac from the anterior approach was required in 25 patients.

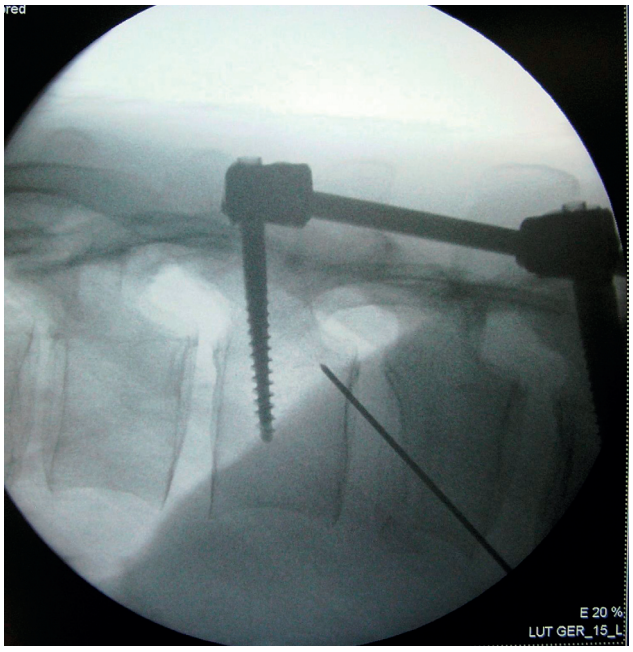

Fig. 1. K-wire is placed under fluoroscopic control on the skin to determine place of incision.

Surgical technique using the anterior mini-invasive approach (mini-thoracotomy) with thoracoscopy

The patient is intubated in the supine position with a two-way cannula, allowing collapse of the left lung. Bronchoscopy was used to control the position of the cannula. However, intubation is not absolutely necessary for treatment of the thoracolumbar junction using this method. After intubation, the patient is positioned on a vacuum mat on the right hip and fixed in this position. The surgeon stands in front of the patient's abdomen, two assistants standing opposite to the surgeon. Good visualization of the planned instrumentation and the correct position of the patient are checked under fluoroscopic control. After draping, a K-wire is placed under sciascopic control on the skin to determine the place of incision which is then made in length, 6-7cm (Fig. 1). This is followed by dissection of the intercostal space along the upper edge of the inferior rib with careful bleeding control, down to the parietal pleura. The anaesthesiologist induces the left lung collapse, the parietal pleura is dissected and distractor inserted into the surgical wound. The collapse of the left lung is continuously checked and pleural effusion, if any, evacuated. Where the lung collapse is not used, the lung is covered by a wet abdominal drape and with a slight pressure by the Langenbeck retractor it is pushed cranially. Next, an incision is made to insert a port for a 30 degree endoscope in the 2nd or 3rd intercostal space cranial to minithoracotomy in the anterior axillary line (Fig. 2). The diaphragm is retracted using a long Langenbeck retractor caudally. The spine is palpated by long surgical tweezers and the parietal pleura is incised with coagulation or harmonic scalpel. The disc is identified and a K-wire is, used to check the correct level of dissection under sciascopic control. Then it is necessary to identify the segmental blood vessels and coagulate them. If instrumentation is planned below the Th12/L1

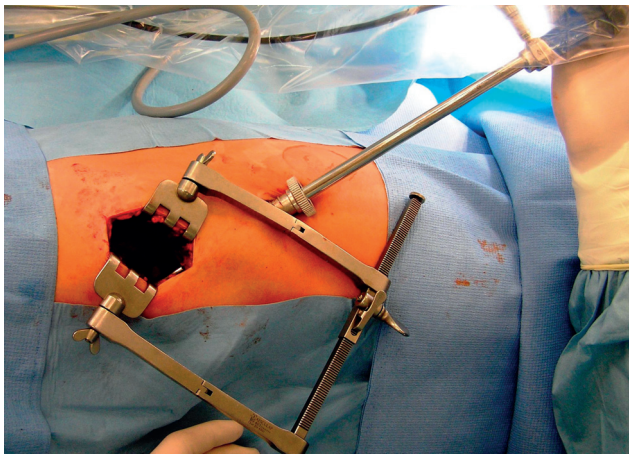

Fig. 2. OP view retractor is placed and port for endoscope is located cranially.

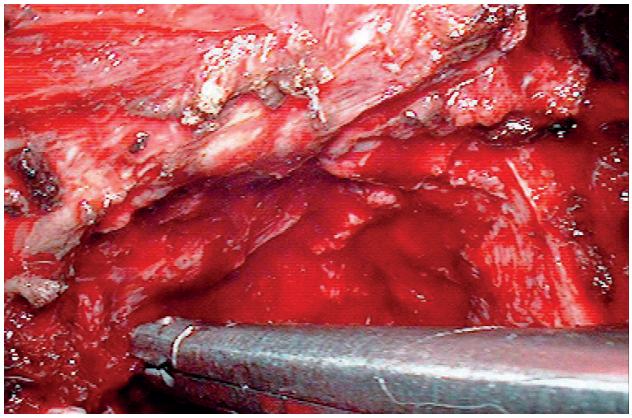

Fig. 3. OP view where dural sac is released and decompressed with ronquer.

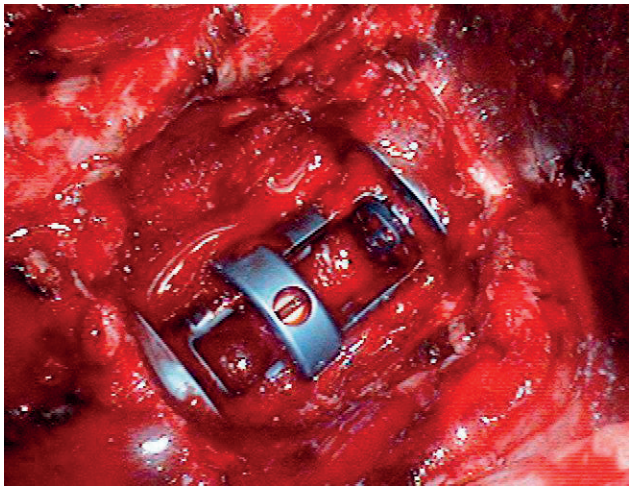

Fig. 4. OP view expandable cage in correct position.

segment, the diaphragm must be incised to the extension of the incision of the parietal pleura. Screws are placed to the vertebral bodies under sciascopic control. Discs and endplates of vertebral bodies are removed. This is the time to measure the size of the replacement of the vertebral body by a gauge and choose the proper allograft or titanium implant to replace the vertebral body. The next step

is corpectomy in the required scope. Where necessary, decompression of the dural sac is performed from the distal portion of the vertebral body cranially (Fig. 3). Distally, the dural sac is visualized by removal of the posterior edge of the vertebra by a long curved spoon.

Subsequently, the bone fragment between the pedicles compressing the dural sac is released. The fragment is often entrapped between the pedicles of the injured vertebra and resection of the left pedicle is required to release it. Decompression of the dural sac may be associated with blood loss. For this reason, instrumentation screws should be in place and an exactly sized allograft or a properly chosen replacement of the vertebral body prepared (Fig. 4). After implantation of the replacement of the vertebral body, the assembly of the instrumentation is finalized and a chest drain inserted. The diaphragm is sutured only in case where the incision is longer than 4cm long. The chest drain is inserted using the port for the endoscope. Finally, re-expansion of the upper lobe of the left lung is checked thoracoscopically from mini-thoracotomy. The surgical wound is sutured. The chest drain is removed when the fluid from the drain does not exceed 100 mL/24 h, as a rule between 2nd and 4th postoperative day.

RESULTS

The operative time in anterior surgery was 50 min - 130 min (average 90 min), and blood loss 200 mL - 2300 mL. The thoracic drain was removed in all patients between the 2nd and 4th postoperative day (average 3 days). No conversion of the mini-invasive approach to conventional open procedure for visceral or vascular injury and no postoperative revision for pleural effusion were required in any of the patients. Similarly, no loosening of the anterior hardware or of the replacement of the vertebral body was recorded. Complications of the surgical approach, such as hypesthesia around the surgical wound, was seen in 4 patients. One patient in the followed-up group developed a deep infection requiring removal of both the posterior and anterior hardware as well as the titanium replacement of the vertebral body. In the remainder of the patients the bone healed uneventfully. Loss of correction in patients after the anterior surgery and replacement of the vertebral body by allograft or a titanium cage did not exceed 2° at two-year follow-up. Neurological improvement of at least one grade of the Frankel scale was recorded in 10 out of 25 patients.

DISCUSSION

Approximately two thirds of injuries to the thoracic and lumbar spine are located in the region of the Th/L junction. Most frequently they are burst fractures to the anterior column of the spine, caused by compression forces or a combination of hyperflexion and/ or rotational forces[7]. The result is a fracture of a different grade of kyphosis due to destruction of the anterior column and injury to the bony or ligamentous posterior structures with a compression of the spinal canal[8]. These fractures are also associated with a high incidence of neurological lesions[9]. In recent years, the treatment of fractures of the thoracic and lumbar spine has significantly changed. Long-term conservative treatment of spinal injuries by bed rest is associated with a higher morbidity and mortality. The situation improved with the introduction of reduction by positioning, subsequent application of a corset brace and mobilization of the patient[10]. Development of transpedicular stabilization has contributed to a higher stability of the spinal fixator, and allowed for the use of a short segment instrumentation to stabilize the injured spine. Correction of kyphosis is achieved by bisegmental transpedicular stabilization[11]. Although correction of segmental kyphosis using transpedicular screws is an efficient method, there is often a secondary loss of correction by 7-16 degrees during the first postoperative year[12] that cannot be prevented by posteromedial, posterolateral or transpedicular cancellous bone grafting[13,14]. Decompression of the spinal canal through the posterior approach may be achieved indirectly by ligamentotaxis. Distraction can be used to reduce indirectly the posterior edge by ligamentotaxis, particularly between Th12 and L3, where the double-layered posterior longitudinal ligament is located[15]. Ligamentotaxis is inefficient in the case when the spinal canal is narrowed by more than 50% (ref.[16]). An alternative to indirect decompression by ligamentotaxis is direct decompression by laminectomy, hemilaminectomy or transpedicular technique or costotransversectomy with removal of the fragment or, where appropriate, reduction[17]. The use of decompression is questionable in the case of negative neurological findings as the correlation between decompression and neurological sequelae is unclear. The literary reports spontaneous remodelling of the spinal canal within 1-5 years[13,18]. Decompression from the posterior approach is, however, often imperfect and a short instrumentation frequently results in failure of the implant and loss of correction. Currently, the anterior approach is reported as the best method for direct decompression of the spinal canal and reconstruction of the anterior column of the spine[3]. With the development of fixed-angle implants for stabilization of the anterior column of the spine, there a growing number of studies that recommend an isolated anterior approach to decompression, replacement of the vertebral body and stabilization of only two segments of the spine[19]. In case of application of the anterior approach alone, loss of correction has been reported in the range of 1-4 degrees[9,20]. Biomechanical studies recommend a combined posterior-anterior approach[8,21] which has been used in indicated cases of spinal injuries by a number of authors[6,22]. The problem of the anterior approach in the conventional technique is a long surgical wound (20 cm) that creates morbidity of the thoracic or abdominal wall[3,23].

Since the 1990, there has been a trend of development of thoracoscopy in the treatment of the anterior column of the spine and the intervertebral disc, using the transdiaphragmatic approach to treat the Th/L junction[24,25]. Good results of the endoscopic technique in the treatment

of the anterior column of the spine are also reported in the therapy of spinal deformities[26]. Injuries to the spine in the region of the Th/L junction and particularly below L2 can be treated with the technique of retroperitoneal endoscopic approach[27]. On the other hand, purely endoscopic methods are frequently burdened by a higher percentage of intraoperative and postoperative complications compared to open techniques, as highlighted in the study by Escobar[28]. As an alternative to treatment of the anterior column of the spine with endoscopic techniques using four ports, in 2001 Kossmann described a minimally invasive technique using SynFrame retractor to open mini-thoracotomy about 4-6 cm long[5]. A similar procedure was used by Verheyden. However, he prefers the patient in the prone position during the treatment of the anterior column, as it provides for simultaneous reduction from the posterior and anterior approaches in one stage[6] In our department, we prefer to treat the anterior column with the mini-invasive technique in the second stage, as a rule after 5 days, if the wound heals without complications after the posterior approach. To replace the vertebral body we preferably use allogenic tibial shaft bone filled with cancellous bone grafts from the resected vertebral body. In this way, we eliminate potential chronical pain at the autologous graft harvesting site and reduce the operative time by the time required for graft harvesting (35 min) (ref.[29]). The vertebral body can be reconstructed with the use of an autologous tricortical graft from the iliac crest bone[3], allograft[30,31] or a titanium replacement[29]. The titanium cage may become displaced or subside into the vertebral body and a number of authors recommend augmenting the stability of the anterior column by an implant[32,33.] The reasons for displacement of the implant or its subsidence into the vertebral body include a primarily incorrect placement of the cage, insufficient expansion of the cage, insufficient contact between the flat surface of the cage and the concave endplate of the vertebra, damage of the endplate during discectomy and preparation of the contact surface of the endplate and osteoporosis of the vertebral body. The reported problems associated with the cage itself are addressed by the manufacturer in the new generation of an expandable replacement.

Minimally invasive techniques using mini-thoracotomy (4-5 cm) eliminate the disadvantages of a purely endoscopic approach, particularly a long operative time (ranging between 70 min and 9 h; average 3.5 h), expensive endoscopic equipment and a long learning curve necessary to master the purely endoscopic technique[3,6]. The minimally invasive, open technique has the advantage that is provides a direct three-dimensional visualisation of the anterior column of the spine, ensuring safe dissection of blood vessels, a faster decompression of the spinal canal, smooth application of the replacement of the vertebral body (allograft, expandable titanium cage), shorter operating time and, consequently, reduced blood loss. The benefits of mini-invasive techniques in the treatment of the anterior column of the spine include cosmetic effect, pain reduction, reduced intraoperative morbidity and early resumption of routine daily activities[3,5,25,34].

Author contributions: JK: study design, patient enrollment, manuskript writting; MK: data analysis, patient enrollment, manuskript revision; PW: study design, manuskript approval; RV study design, manuskript revision and approval.

Conflict of interest statement: We declare that we have no material or moral interest regarding the diagnostic/treatment methods reported, the results presented, the devices and/or equipment used.

REFERENCES

1. Hodgson AR, Stock FE, Fang HS, Ong GB. Anterior Spinal Fusion. The Operative Approach and Pathological Findings in 412 Patients with Pott's Desease of the Spine. Brit J Surg 1960;48:172-8.
2. Kalso E, Perttunen K, Kaasinen S. Pain after Thoracic Surgery. Acta Anesthesiol Scand 1992;36:96-100.
3. Beisse R. Endoscopic Surgery on the Thoracolumbar Junction of the Spine. Europ Spine J 2006;15:687-704.
4. Dickman CA, Rosenthal D, Karahalios DG, Paramore CG, Mican CA, Apostolides PJ, Lorenz R, Sonntag VK. Thoracic Vertebrectomy and Reconstruction Using a Microsurgical Thoracoscopic Approach. Neurosurgery 1996;38:279-93.
5. Kossmann T, Jacobi D, Trentz O. The Use of a Retractor System (SynFrame) for Open, Minimal Invasive Reconstruction of the Anterior Column of the Thoracic and Lumbar Spine. Europ Spine J 2001;10:396-402.
6. Verheyden AP, Hoelzl A, Lill H, Katscher S, Glasmacher S, Josten C. The Endoscopically Assisted Simultaneous Posteroanterior Reconstruction of the Thoracolumbar Spine in Prone Position. Spine J 2004;4:540-9.
7. Magerl F, Aebi M, Gerzbein S, Harms J, Nazarian S. A Comprehensive Classification of Thoracic et Lumbar Injuries. Europ Spine J 1994;3:184-201.
8. Schreiber U, Bence T, Grupp T, Steinehauser E, Muckley T, Mittelmeiner W, Beisse R. Is a Single Anterolateral Screw Plate Fixation Sufficient for the Treatment of Spinal Fractures in the Thoracolumbar Junction? A Biomechanical in Vitro Investigation. Europ Spine J 2005;14:197-204.
9. Kaneda R, Taneichi H, Abumi K, Hashimoto T, Satoh S, Fujiya M. Anterior Decompression and Stabilization with the Kaneda Device for Thoracolumbar Burst Fractures Associated with Neurological Deficits. J Bone Jt Surg 1997;79-A:69-83.
10. Chow GH, Nelson BJ, Gebhard JS, Brogman JL, Brown CW, Donaldson DH. Functional Outcome of Thoracolumbar Burst Fractures Managed with Hyperextension Casting or Bracing and Early Mobilization. Spine 1996;21:2170-5.
11. Viale GL, Silvestro C, Francaviglia N, Carta F, Bragazzi R, Bernucci C, Maiello M. Transpedicular Decompression and Stabilization of Burst Fractures of the Lumbar Spine. Surg Neurol 1993;40:104-11.
12. McLain RF, Sparling E, Benson DR. Early Failure of Short-Segment Pedicle instrumentation for Thoracolumbar Fractures. A Preliminary Report. J Bone Jt Surg 1993;75-A:162-7.
13. Alany A, Acaroglu E, Yazici M, Aksoy C, Surat A. The Effect of Transpedicular Intracorporeal Grafting in the Treatment of Thoracolumbar Burst Fractures on Canal Remodeling. Europ Spine J 2001;10:512-6.
14. Knop C, Blauth M, Bastian L, Lange U, Kesting J, Tscherne H. Fractures of the Thoracolumbar Spine. Late Results of Dorsal Instrumentation and its Consequenses. Unfallchirurg 1997;100:630-9.
15. Kuner EH, Kuner A, Schlickewei W, Mullaju AB. Ligamentotaxis with an Internal Spinal Fixator for Thoracolumbar Fractures. J Bone Jt Surg 1994;76-B:107-12.
16. Schnee CL, Ansell LV. Selection Criteria and Outcome of Operative Approaches for Thoracolumbar Burst Fractures with and without Neurological Deficit. J Neurosurg 1997;86:48-55.
17. Zdeblick TA, Shirado O, McAfee PC, deGroot H, Warden KE. Anterior Spinal Fixation after Lumbar Corpectomy. A Study in Dogs. J Bone Jt Surg 1991;73-A:527-34.

18. De Klerk LW, Fontijne WP, Stijnen T, Braakman R, Tanghe HL, Van Linge B.Spontaneous Remodeling of the Spinal Canal after Conservative Management of Thoracolumbar Burst Fractures. Spine 1998;23:1057-60.
19. McDonough P, Davis R, Tribus C, Zdeblick T. The Management of Acute Thoracolumbar Burst Fractures with Anterior Corpectomy and Z-Plate Fixation. Spine 2004;29:1901-9.
20. Ghanayem AJ, Zdeblick TA. Anterior Instrumentation in the Management of Thoracolumbar Burst Fractures. Clin Orthop 1997;335:89-100.
21. Pflugmacher R, Schleicher P, Schaefer J, Scholz M, Ludwig K, Khodadadyan-Klostermann C, Haas NP, Kandziora F. Biomechanical Comparison of Expandable Cages for Vertebral Body Replacement in the Thoracolumbar Spine. Spine 2004;29:1413-39.
22. Vaccaro AR, Lim MR, Hurlbert RJ, Lehman RA Jr, Harrop J, Fisher DC, Dvorak M, Anderson DG, Zeiller SC, Lee JY, Fehlings MG, Oner FC; Spine Trauma Study Group. Surgical Decision Making for Unstable Thoracolumbar Spine Injuries: Results of a Consensus Panel Review by the Spine Trauma Study Group. J Spinal Disord 2006;19:1-10.
23. Faciszewski T, Winter RB, Lonstein JE, Denis F, Johnson L. The Surgical and Medical Perioperative Complications of Anterior Spinal Fusion Surgery in the Thoracic and Lumbar Spine in Adult. A Review of 1223 Procedures. Spine 1995;20:1592-9.
24. Khoo LT, Beisse R, Potulski M. Thoracoscopic-Assisted Treatment of Thoracic and Lumbar Fractures: A Series of 371 Consecutive Cases Neurosurgery 2002;51:104-17.
25. Kim DH, Jahng TA, Balabhadra RSV, Potulski M, Beisse R. Thoracoscopic Transdiaphragmatic Approach to Thoracolumbar Junction Fractures. The Spine Journal 2004;4:317-28.
26. Lieberman IH, Salo PT, Orr RD, Kraetschmer B. Prone Position Endoscopic Transthoracic Release with Simultaneous Posterior Instrumentation for Spinal Deformity: a Description of the Technique. Spine 2000;25:2251-7.
27. Olinger A, Hildebrandt U, Mutschler W, Menger MD. First Clinical Experience with an Endoscopic Retroperitoneal Approach for Anterior Fusion of Lumbar Spine Fractures from Levels T12 to L5. Surg Endosc 1999;13:1215-9.
28. Escobar E, Transfeldt E, Garvey T, Ogilvie J, Graber J, Schultz L. Video-Assisted Versus Open Anterior Lumbar Spine Fusion Surgery. Spine 2003;28:729-32.
29. Kossmann T, Rancan M, Jacobi D, Trentz O. Minimally Invasive Vertebral Replacement with Cages in Thoracic and Lumbar Spine. Europ J Trauma 2001;27:292-300.
30. Liljenqvist U, O Brien JP, Renton P. Simultaneous Combined Anterior and Posterior Lumbar Fusion with femoral Cortical Allograft. Europ Spine J 1998;7:125-31.
31. Molinari RW, Bridwell KH, Klepps SJ, Baldus C. Minimum 5-Year Follow-up of Anterior Column Structural Allografts in the Thoracic and Lumbar Spine. Spine 1999;24:967-72.
32. Gradl G. Combined Stabilization of Thoracolumbar Spine Fractures. Europ J Trauma 2006;32: 249-52.
33. Matschke S, Wagner CH, Davids D, Wentzensen. A Complications in Endoscopic Anterior Thoracolumbar Spinal Reconstructive Surgery. Europ J Trauma 2006;32:215-26.
34. Landrenau RJ, Hazelrigg SR, Mack MJ, Dowling RD, Burke D, Gavlick J, Perrino MK, Ritter PS, Bowers CM, DeFino J, Nunchuck SK, Freeman J, Keenan RJ, Ferson PF. Postoperative Pain-Related Morbidity: Video-Assisted Thoracic Surgery Versus Thoracotomy. Ann Thorac Surg 1993;56:1285-9.