Endoscopic Approach to Treat Thoracal Spine Deformity

Endoskopik Torakal Omurga Deformitesi Cerrahisi

Mehdi SASANI[1], Bilgehan SOLMAZ[2]

[1]*American Hospital, Department of Neurosurgery, Istanbul, Turkey*
[2]*Istanbul Research and Training Hospital, Department of Neurosurgery, Istanbul, Turkey*

Corresponding Author: Mehdi SASANI / E-mail: sasanim@gmail.com

ABSTRACT

Minimally invasive surgery is currently a goal for surgical intervention in the spine. The effectiveness of endoscopic thoracic spine surgery and technological improvements are considered to be two factors that are routinely applied to spine surgery, particularly in spine deformity surgery practice. The favorable results of thoracoscopic spine surgery encourage its application to situations in which a conventional thoracic approach is indicated. Thoracoscopic spine surgery is applicable to patients with spine deformity diseases.

KEYWORDS: Minimal invasive surgery, Thoracal spine disease, Thoracoscopic spine surgery, Video-assisted thoracoscopic deformity surgery (VATS), Scoliosis, Deformity

ÖZ

Son zamanlarda omurga cerrahi girişimlerinde az invaziv cerrahi hedef haline gelmiştir. Omurga cerrahisi pratiğinde endoskopinin etkin olması ve teknolojinin ilerlemesi nedenleri ile omurga cerrahi pratiğinde özellikle omurga deformite cerrahisinde uygulanmaya başlanmıştır. Torakoskopik omurga cerrahisinin, konvansiyonel torakal cerrahi yaklaşımlara göre olumlu sonuçları bu tekniğin uygulanması konusunda cesaret vermektedir. Deformite omurga hastalıkları olan hastalara torakoskopik cerrahi uygulanabilir hale gelmiştir.

ANAHTAR SÖZCÜKLER: Minimal invaziv cerrahi, Torakal omurga hastalığı, Torakoskopik omurga cerrahisi, Video destekli torakoskopik deformite cerrahi (VATS), Skolyoz, Deformite

INTRODUCTION

The use of minimally invasive surgical approaches for surgical procedures has been a goal for thoracic spinal surgery, but it is an alternative to thoracotomy for the correction of the scoliosis angle especially in the anterior approach or mobilization of the spine with discectomy or facet joint resection via the endoscopic anterior approach for posterior correction. Some technical advances in endoscopy have played an important role in the development of minimally invasive surgery. Thoracoscopic spine surgery is a relatively modern technique; it makes it possible to reach and treat spinal pathologies with same accuracy and integrity as open surgery (1).

The optical system of the endoscope (0-45 degrees) is an important factor in the effectiveness of thoracoscopic spinal surgery. Less post-operative pain due to small skin incisions, protection of pulmonary function and early return of the patient to his/her daily living activities are the advantages of the endoscopic technique in spinal deformity surgery and it can be applied easily to a very wide variety of thoracic spine pathologies (17). Current application areas for thoracoscopic surgery are scoliotic deformity treatment and correction of thoracic spinal deformity, central and calcified disc herniation, spinal vertebral corpectomy in scoliosis, and kyphosis deformity due to vertebral body fractures in case of tumors and infections such as tuberculosis.

Clinical studies have revealed that thoracoscopic surgery is significantly helpful in treating disorders of the spine compared with the open thoracic surgical approach (4,12,16). Although thoracoscopic spine surgery is a minimally invasive technology with many advantages, it may lead to some undesirable complications. The surgeon should therefore be experienced in the use of endoscopic techniques and should know the two-dimensional endoscopic anatomy of the thorax. Patients should be evaluated in detail before surgery and should be able to tolerate one-lung anesthesia, should be properly informed prior to surgery, and should understand that open thoracotomy may be performed if necessary.

HISTORY

Historical development of thoracoscopy can be divided into 3 periods, beginning, interval and late period. The first clinical report about thoracoscopic surgery was published in 1910 after Jacobeus used a thoracoscope to diagnose and lyse a tuberculosis lung adhesion.(8). Before that, thoracoscopy was also used for the diagnosis of pleural diseases (6). With the discovery of streptomycin in 1945 for tuberculosis treatment, there was a decrease in the clinical usage of thoracoscopy (7).

This interval period passed silently until 1991. Lewis defined the use of thoracoscope for the treatment of many pulmonary diseases once again.

The application of thoracoscope for spine disease was independently developed by two colleagues: Mack-Regan (12,15) and Rosenthal (16). The use of thoracoscopy for thoracic spinal diseases was generalized by them. The first article on thoracoscopy for spinal disease was published by Mack and associates (12). A significant interest was then seen on the use thoracoscopic techniques for a wide variety of thoracic spine diseases, and numerous articles demonstrated the effectiveness of this technique for such disorders.

Surgical Anatomy

The majority of thoracoscopic approaches are from the right side where there is a wide spinal study area lateral to azygos vein than to the aorta. In case of scoliotic deformity, the first portal place would be changed. If scoliotic angle correction will be performed with anterior instrumentation, anterior screw implantations would be appropriate to improve the correction strength of rods (Figure 1A-C). Below the Th9 level, a left-sided approach becomes possible as the aorta has moved away from the left posterolateral aspect of the spine to an anterior position as it passes through the diaphragm.

If entrance to the thoracic cavity is performed according to the anatomical positions of organs, the morbidity would be less. The major vessels such as the aorta, vena cava and azygos vein should definitely be protected.

Our experience with thoracoscopic surgery taught us that radiological images should be meticulously evaluated. Knowing the anatomic variation of vessels can help approach the patient with less mortality. The ligation of the segmental intercostals vessels at the waist of the vertebral body is a controversial subject. Many authors oppose performing ligation of the segmental vessels and preserve these vessels when performing discectomies alone and without instrumentation and divide and retract the vessels to expose the vertebral body (10). Winter showed in 1197 patients that ligation of segmental vessels causes no neurological deficit. In our experience of thoracoscopic surgery, ligating these vessels when doing discectomies alone or with instrumentation led to no neurologic deficits.

Thoracoscopic surgery can be performed easily from Th3 to Th10. However, the thoracolumbar junction can be restricted regarding exposure with the thoracoscope. Intimate knowledge of the anatomic landmarks is necessary in surgery. The diaphragm has muscle fibers, and the spleen on the left and liver on the right cause the diaphragm to extend to the thoracic cavity like a dome and limit thoracoscopic exposure. A good retraction of the diaphragm downwards shows Th11 and even some part of Th12 perfectly (Figure 2).

Indications of Thoracoscopic Surgery

There is no precise defined indication for thoracoscopic deformity surgery. Thoracoscopic surgery can be performed for some thoracal spine deformities to release the vertebral column rigidity and prepare for correction, discectomy, costa-transverse joint resection or for spinal cord compressions that cause spine body fractures after trauma.

After anterior spinal release, there is an indication for screw instrumentation and fusion during anterior vertebral column correction in spinal deformity surgery.

a) Acquired deformities: Thoracal spinal fractures, intervertebral or paravertebral tumors (metastasis, plasmocytoma) that cause compressive spinal cord fractures

b) Congenital spinal deformities: Rigid kyphosis, scoliosis, neuromuscular spinal deformities.

Indıcations of thoracoscopic approach for spine deformity

- Single apex convex angle of thoracal scoliosis deformity
- Convex angle less than 70 degrees for the thoracal scoliosis deformity
- Physiological lordosis or hypokyphosis of the sagittal balance image

Contraindications for Thoracoscopic Deformity Surgery

Contraindications to the thoracoscopic approach resemble those of general surgery and thorax surgery. Systemic diseases such as cardiac or pulmonary disorders increase the morbidity of surgery. Briefly, the contraindications of thoracoscopic surgery are;

- **Systemic disorders:** Cardiac diseases, severe obstruction of coronary vessels
  1. Chronic obstructive pulmonary disease (COPD)
  2. Uncontrollable coagulopathy
- **Traumatic reasons**
  1. Hemothorax, emphysema
  2. Prior trauma that may have cause pleural adhesions
- **Surgical reasons:**
  1. Massive adhesions due to previous thoracotomy
  2. Emphysema

Comparison of Thoracoscopy with Conventional Approaches

Thoracoscopic spinal surgery has many advantages but also disadvantages when compared with thoracotomy or posterior costa-transversectomy. Comparison of surgical approaches is summarized in Table I.

In fact the main aim of the approaches are similar but the routes of approach are different. Therefore the degree of morbidity associated with thoracoscopy and thoracotomy such as for pain syndromes, intercostal neuralgia, and pulmonary dysfunction are not same. Although studies on thoracoscopic spine surgery usually advocate thoracoscopy when com-

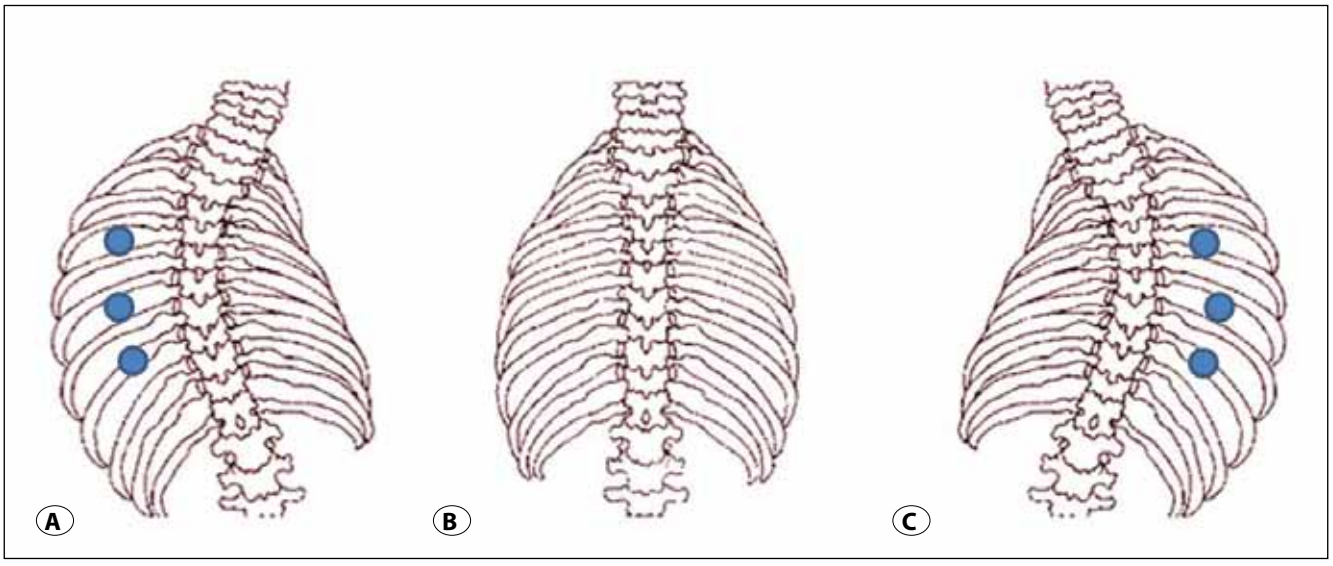

Figure 1: Thoracar entrance to the thorax cavity may differ according to the concavity or convexity of the scoliosis angle **A)** right convex apex of scoliosis **B)** normal **C)** left convex apex of scoliosis.

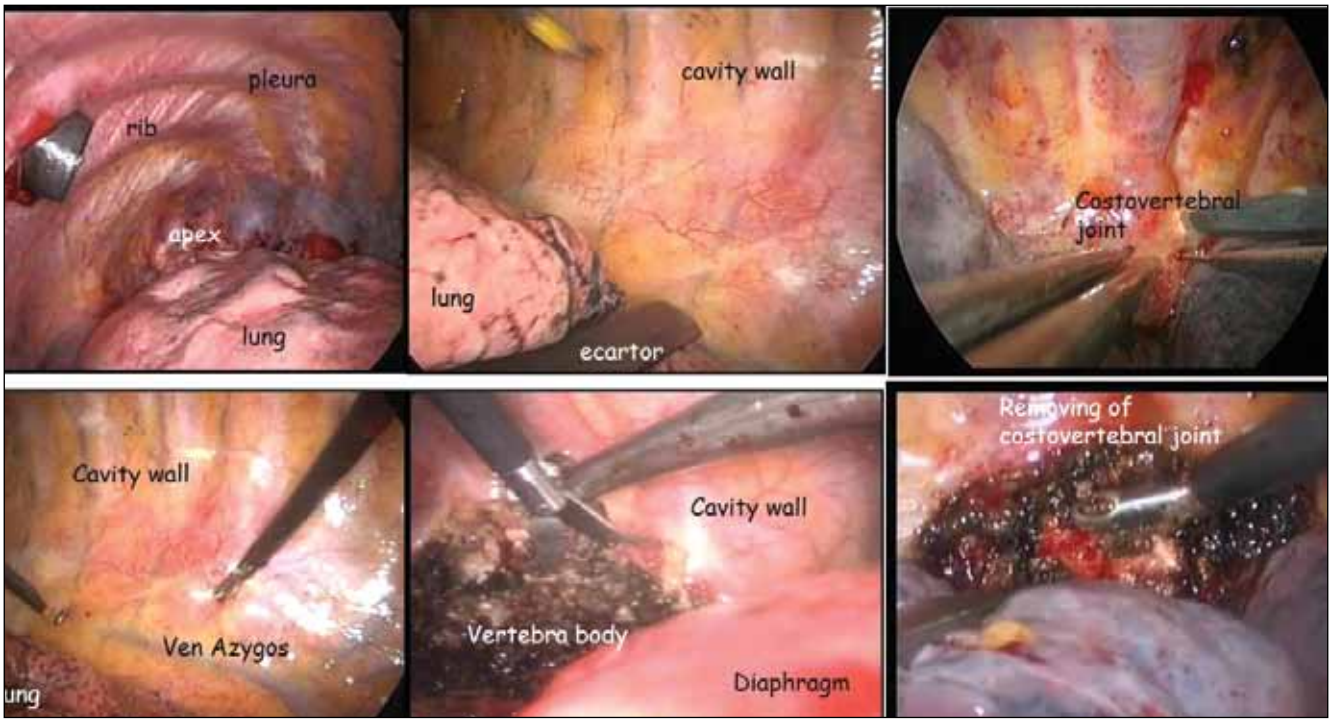

Figure 2: Endoscopical anatomy images of the patient operated by means of thoracoscopic surgery in our clinic.

pared with thoracotomy, open surgery has advantages that thoracoscopy lacks such as better exposure, easy surgical manipulation, and easy homeostasis in case of vessel damage. It is obvious that thoracoscopy reduces the morbidity and pain associated with the anterior transthoracic approach while preserving the broad, direct view and unobstructed surgical access to the entire ventral surface of the spine and spinal cord. The other benefits of thoracoscopy are minimal muscular incisions and no rib resection.

Application for Thoracoscopic Deformity Surgery

Surgical Equipment: The instruments used in thoracoscopic deformity surgery are the same instruments as those used in endoscopic thorax surgery, but the distance in the thoracoscopic approach is longer than in classical procedures. Therefore longer equipments are used in thoracoscopy. The equipment is shown in Figure 3.

Table I: Comparison of Operative Approaches to the Thoracic Spine

Surgical Approaches	Thoracoscopy	Thoracotomy	Costotransversectomy
Direction of approach	Anterolateral	Anterolateral	Postolateral
View of ventral surface of spinal cord	Full, direct	Full, direct	Oblique, indirect
Size of incisions	1-2.5 cm (x 7.7-10 cm)	15-37.5 cm	10-30 cm
Muscle transaction	Minimal	Extensive	Moderate or extensive
Postoperative chest tube	Yes	Yes	No
Access to posterior spinal elements for decompression or fixation	No	No	Yes
Access to vertebral bodies for screw-plate fixation	Yes	Yes	No
Extent of rib resection or rib retraction	2.5 cm of rib head and proximal rib removed, no retraction	15-30 cm of rib removed, extensive retraction	7.5-17.5 cm of rib removed, moderate retraction
Incidence of postoperative intercostal neuralgia	Uncommon, often transient	Common, often prolonged	Uncommon, often transient

From Dickman CA, Karahalios DG: Thoracoscopic spinal surgery. Clin Neurosurg 1996;43: 392-422.

Figure 3: The equipment used in thoracoscopic spine surgery is longer than in classic procedures.

Operation Room setting: A spacious operating room is advisable for thoracoscopic deformity surgery. Two monitors, flouroscopy and related personnel and surgeons are needed in the large operation room. The anesthesiology team is positioned at the head of operating table. Flouroscopy equipment is covered with a sterile wrap and is positioned at the foot of operating table (patient) to verify the disease level before incision and to obtain lateral and anteroposterior intraoperative images (Figure 4).

Patient Positioning: The procedure is performed under general anesthesia on a radiolucent operating table. Endotracheal intubation with a double-lumen tube is applied to all patients. All initial preparations such as arterial line, central nervous catheter, pneumatic compression stockings and urinary catheter placement are performed. All patients are also prepared for conventional thoracotomy that might be performed if complications occur during thoracoscopic surgery. Then the patients were generally turned and placed in a right- or left-up lateral decubitus position with the side to be operated on facing up.

Surgical Technique: Three to four portal trocars are used depending on localization of the scoliotic deformity apex. The first 10 mm portal is placed directly over the target spine or disc segment posterolaterally between the posterior axillary and the midline. The second portal is at the junction of the anterior axillary line and transverse line that passes from the first portal (Figure 5). This method permitted us compatible manipulation during the procedure and the use of 0 and 30 degree-angled optics in all varieties of spine disorders. Basic considerations such as operating room setup and patient positioning, thoracoscopic imaging and instruments, portal insertion and wound closure and early postoperative management are basically similar for all thoracic spine disorders A 32-Fr chest tube is inserted before lung expansion and wound closure.

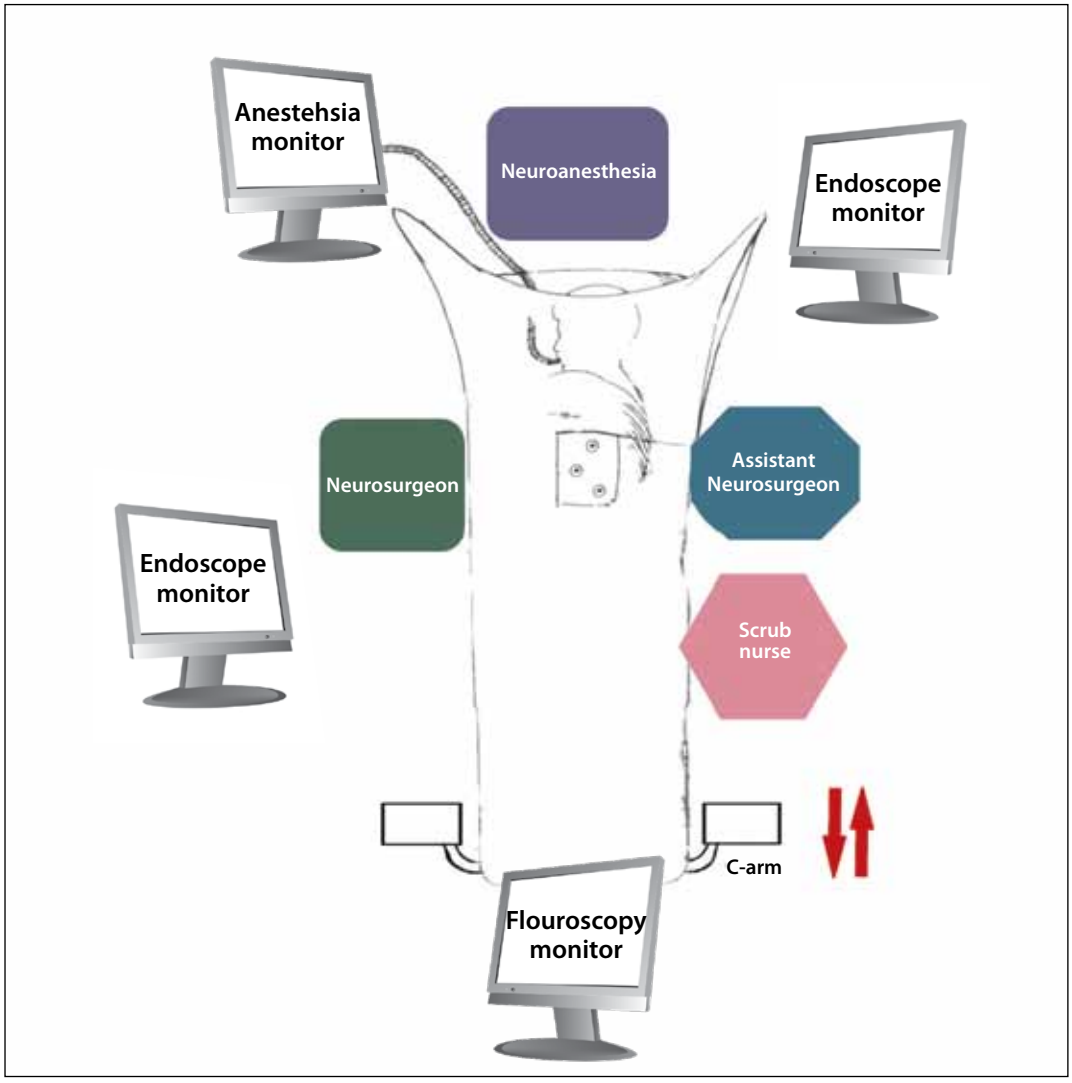

Figure 4: Operating room setup and position of the surgery and anesthesiology team, scrub nurse and equipment used for thoracoscopic spine surgery.

Postoperative care: The chest tubes were placed at 20cm H2O of suction. All patients were kept in the recovery room ward and monitored closely for heart rate, arterial pressure, respiratory rate, oxygen saturation and any respiratory complications. All patients were examined by plain chest X-ray for adequate lung inflation, and chest CT's obtained in patients to determine any pulmonary complications.

Complications: Many potential complications of thoracoscopic spinal surgery have been reported. The most common complications encountered in thoracoscopic spine surgery are intercostal neuralgia (7.7%) and symptomatic atelectasis (6.4 %). Post-operative atelectasis and pneumonia can be decreased by temporarily reinflating the lung intraoperatively. Ventilating the lung for10 minutes for every 2 hours of surgical time is recommended (17). Other thoracoscopic spine surgery complications are excessive (over 2lt) intraoperative blood loss (2.5-5.5 %), pneumonia (1-3%), wound infections (1-3%), and chylothorax (1%) (Figure 6). Cardiac arrhythmias have been reported. These complications are prevented by avoiding monopolar cauterization near the heart and pulmonary lacerations are avoided by minimizing or avoiding lung retraction (17).

Hemidiaphragm and pericardial penetration, tension pneumothorax, long thoracic nerve injury, pulmonary embolism simultaneous bilateral pneumothoraxes and pneumoretroperitoneum which subcutaneous emphysema have been reported less commonly after thoracoscopic spine surgery.

DISCUSSION

Thoracoscopic spine surgery is a minimally invasive technique used to access and treat spinal disorders. Excellent results have been obtained and these are encouraging for the use of this approach (2). Thoracoscopy can be used in a wide variety of spinal disorders such as thoracic spinal deformities. Indeed, thoracoscopic spine surgery is less invasive and as a result it is more advantageous for patients compared with thoracotomy and costotransversectomy; this is supported by recent literature. Rosenthal and Dickman reported their results for 55 patients who underwent thoracic discectomy with thoracoscopic

microsurgery (16). They compared the results of patients treated with open surgery to those who underwent thoracoscopic surgery. They showed 50% less bleeding and a shorter duration of surgery, less than an hour, with thoracoscopic discectomy. Anand and Regan reported an 84% long-term satisfaction rate for thoracic disc disorders with thoracoscopic surgery and a clinical success rate of 70% for resistant thoracic disc disorders. The dural sac can be seen directly during thoracoscopic surgery and radical debridement can therefore be performed. Kyphotic deformity can be corrected by theuse of an interbody cage and anterior screwing.

Dickman et al. compared the results of patients who underwent open thoracotomy and thoracoscopic surgery (5). They reported a serious decline in the length of stay in the hospital or intensive care unit and the use of narcotics in the thoracoscopic group.

In 1990, Picetti et al. began to perform thoracoscopic deformity surgery at the Kaiser Sacramento spinal center. Only thoracoscopic discectomy with spinal manipulation and costotransverse joint resection was performed to the first few patients (14). Later in 1996, they broadened the use of the thoracoscopic spinal deformity surgery technique by applying instrumentation and fusion after correction with the thoracoscopic approach in patients with scoliosis. Initially, 150 patients underwent this technique. They concluded that their objective was to define a more effective, robust and reproducible method.

Another important issue in thoracic spinal scoliosis deformity is correction of spinal column deformities. After correction, the spinal deformity is generally reduced below 10 degrees or completely corrected according to measuring by the Cobb system. This procedure is performed with the posterior or anterior or combined approach. The spine is made flexible usually with an anterior approach and correction and fixation is achieved with posterior instrumentation. Especially in some younger patients with scoliosis, the spine is made flexible only after resection of the posterior spinal facet joint with the posterior approach and even correction can be achieved. In this group of patients, anterior thoracoscopy or open thoracotomy may not be needed to loosen the spine (Figure 7).

Reduction of the apical convexity angle of spinal deformity according to the Cobb system is proportional to the flexibility of the spine. Therefore, the spine can be freed with the anterior or posterior approach and flexibility of spine can be achi-

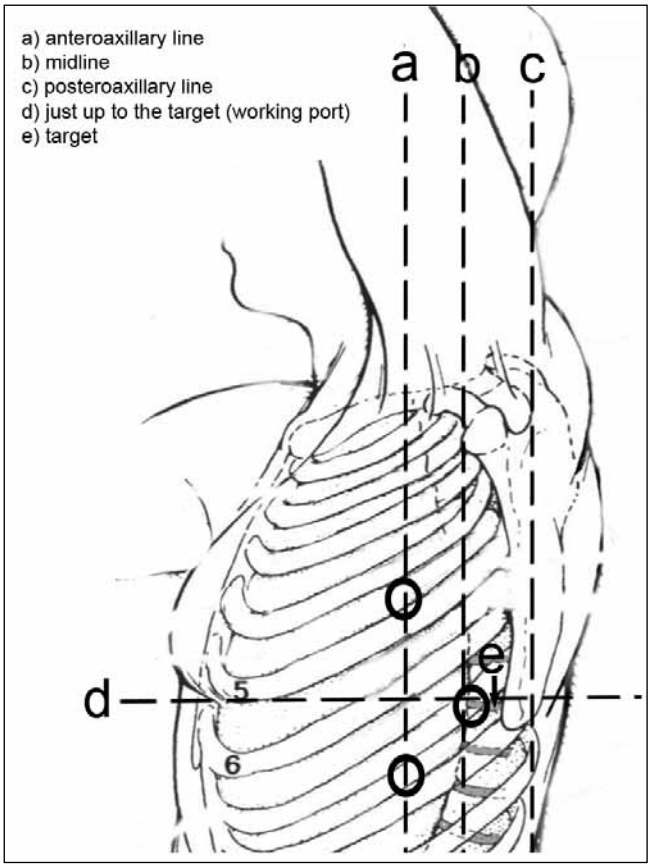

Figure 5: Three to four portal trocars can be used depending on localization of the target as regards the entire thorax cavity. The number and location of the trocars depends on the kind of spine pathology and anatomic level of the spinal disorder.

Figure 6: Chest tube for chylothorax that developed on the second postoperative day after the oral feeding due to injury during thoracoscopic surgery.

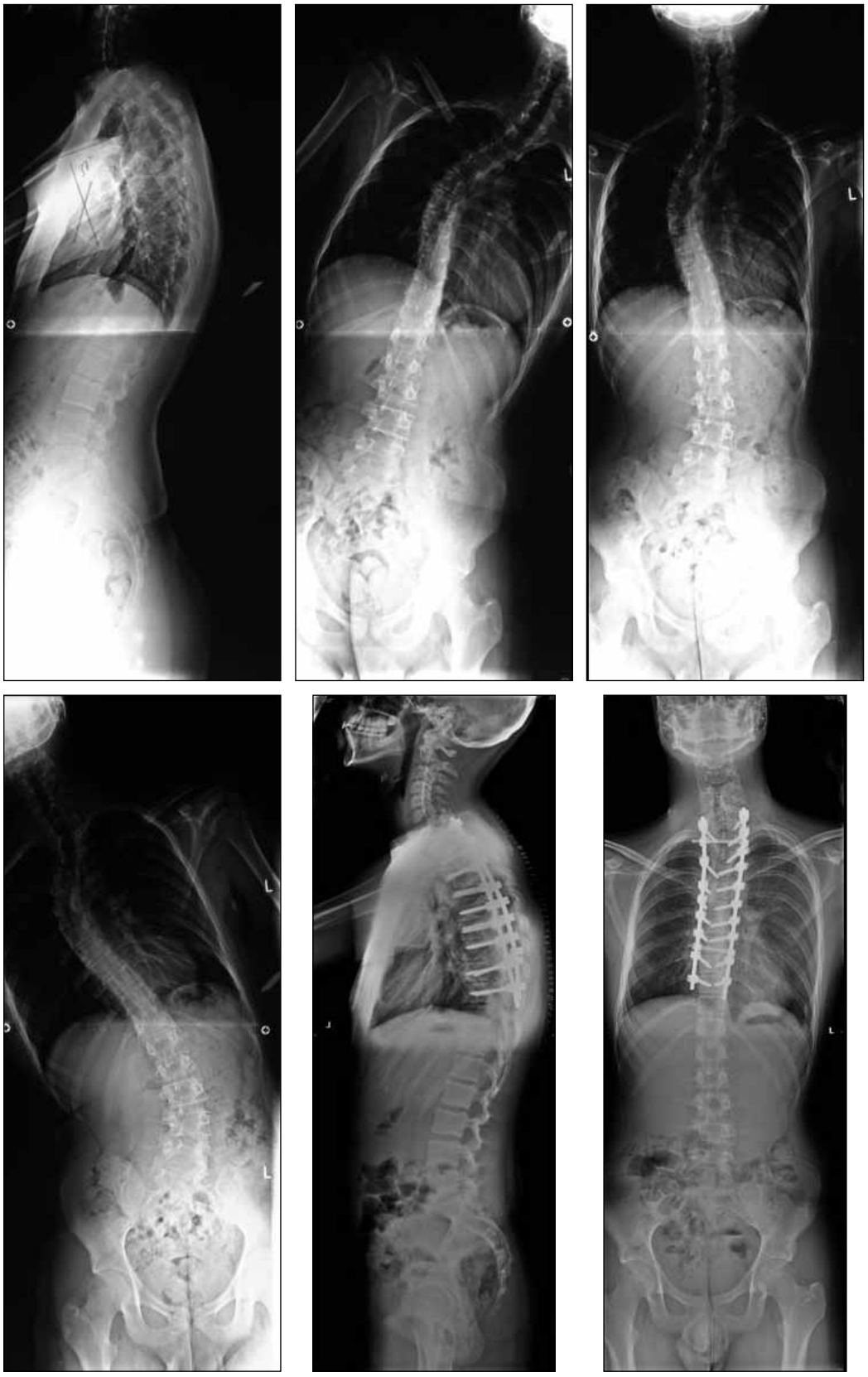

Figure 7: Anteroposterior and lateral preoperative x-ray of a 17-year-old male patient. The apex on the convex side angle is 45 degrees according to the Cobb system. After anterior release and posterior instrumentation, the scoliosis convex angle reduced to below 5 degree.

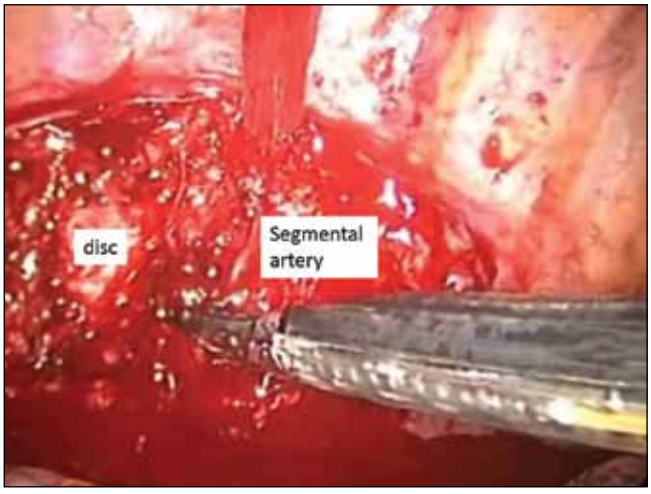

Figure 8: Flexibility obtained by spine release by means of thocoscopic discectomy and costotransversectomy.

eved for correction. Spinal flexibility is provided with anterior discectomy, costotransverse joint resection or corpectomy with thoracotomy (Figure 8). All these operations can be also done easily with thoracoscopy. Spinal flexibility was demonstrated experimentally to be equal by both methods (11).

Thoracotomy and thoracoscopy were performed in 138 patients with spinal deformity and results have been published as non-randomized studies (9). According to this study; the required correction in sagittal, coronal and axial planes can be provided with thoracoscopic deformity surgery as with open surgery. It has been reported that the average correction is 50.2% degrees in scoliosis and 20.7 degrees in hypokyphosis; a reduction of axial rotation from 16 degrees to 5 degrees according to the scoliometer was also achieved (14).

When patients treated with thoracoscopic surgery are compared with patients treated with thoracotomy in regards of early pain and morbidity; pain, shoulder dysfunction and pulmonary failure rates are reported to be very low (9).

The prevalence of idiopathic scoliosis by Cobb measurement is more than 10 degrees and is 2-3% below the age of 16. Surgery is performed usually for deformities above 40 degrees. The female to male ratio is 10/1 (18).

Lonner et al. reported that the results are similar for deformity surgery with thoracoscopic and open thoracotomy in patients with deformity apex angle less than 70 degrees, one convex apex and normal or hypokyphotic angle (11).

In addition, the 5 -year follow-up results of patients who underwent posterior and anterior surgery due to thoracic deformity showed that radiological findings, lung function and clinical values were not different in the first 2 and 5 years (13).

Chong et al. also used the SRS-22 Patient Questionnaire in patient evaluation in their series like Lonner et al (3). They reported that the result is better than open surgery in patient groups that underwent endoscopic spine mobilization with thoracoscopy in thoracic scoliosis deformity and retroperitoneal mini-incision in lumbar scoliosis deformities (3).

In conclusion, thoracoscopic spine deformity surgery can be performed in patients with normal lordosis or hypokyphosis with one apex convex below 70^0. Postoperative surveillance and length of stay in the intensive care unit is shorter with a thoracoscopic approach compared to patients undergoing thoracotomy. Postoperative morbidity and pain is less with the thoracoscopic approach than with thoracotomy.

REFERENCES

1. Al-Sayyad MJ, Crawford AH, Wolf RK: Early experiences with video-assisted thoracoscopic surgery: Our first 70 cases. Spine 29(17):1945-1951, 2004
2. Burgos J, Rapariz J, Gonzalez-Herranz P: Anterior endoscopic approach to the thoracolumbar spine. Spine 23(22):2427-2431, 1988
3. Chong HS, Kim HS, Ankur N, Kho PA, Kim SJ, Kim do Y, Park JO, Moon SH, Lee HM, Moon ES: Video-assisted thoracoscopic surgery plus lumbar mini-open surgery for adolescent idiopathic scoliosis. Yonsei Med J 52(1):130-136, 2011
4. Dickman CA, Karahalios DG: Thoracoscopic spinal surgery. Clin Neurosurg 43:392-422, 1996
5. Dickman CA, Rosenthal D, Karahalios DG, et al: Thoracic vertebrectomy and reconstruction using a microsurgical thoracoscopic approach. Neurosurgery 38:279-93, 1996
6. Jacobaeus HC: Possibility of the use of cystoscope for investigation of serious cavities. Munch Med Wochenschr 51:2090-2092, 1910
7. King AG, Mills TE, Loe WA Jr et al: Video-assisted thoracoscopic surgery in the prone position. Spine 25(18):2403-2406, 2000
8. Kuklo TR, Lenke LG: Thoracoscopic spine surgery: Current indications and techniques. Orthop Nurs 19(6):15-22, 2000
9. Landreneau RJ, Hazelrigg SR, Mack MJ, Dowling RD, Burke D, Gavlick J, Perrino MK, Ritter PS, Bowers CM, DeFino J, et al: Postoperative pain-related morbidity: Video-assisted thoracic surgery versus thoracotomy. Ann Thorac Surg 56(6):1285-1289, 1993
10. Liu GK, Kit WH: Video assisted thoracoscopic surgery for spinal conditions. Neurol India 53(4):489-498, 2005
11. Lonner BS, Auerbach JD, Estreicher M, Milby AH, Kean KE, Panagopoulos G, Chang D: Video-assisted anterior thoracoscopic spinal fusion versus posterior spinal fusion: A comparative study utilizing the SRS-22 outcome instrument. Spine (Phila Pa 1976) 34(2):193-198, 2009
12. Mack MJ, Regan JJ, Bobechko WP, et al: Application of thoracoscopy for diseases of the spine. Ann Thorac Surg 56(3):736-738, 1993
13. Newton PO, Upasani VV, Lhamby J, Ugrinow VL, Pawelek JB, Bastrom TP: Surgical treatment of main thoracic scoliosis with thoracoscopic anterior instrumentation. A five-year follow-up study. J Bone Joint Surg Am 90(10):2077-2089, 2008

14. Picetti GD 3rd, Pang D, Bueff HU: Thoracoscopic techniques for the treatment of scoliosis: Early results in procedure development.Neurosurgery 51(4):978-984, 2002
15. Regan JJ, Mack MJ, Picetti GD, et al: A comparison of video-assisted thoracoscopic surgery (VATS) with open thoracotomy thoracic spinal surgery. Today's Therapeutic Trends 2(4): 203-218, 1994
16. Rosenthal D, Dickman CA: Thoracoscopic microsurgical excision of herniated thoracic discs. J Neurosurg 89(2):224-235, 1998
17. Theodore N, Dickman CA: Thoracoscopic approaches to the Spine. Winn HR (ed), Youmans Neurological Surgery, cilt:4,s Philadelphia: Saunders, 2004: 4757-4770
18. Weinstein SL: Adolescent idiopathic scoliosis: Prevalence and natural history. Instr Course Lect 38:115-128, 1989