

## Anterior thoracic and lumbar spine arthrodesis: a series of 23 consecutive cases and review of operative technique

Artrodese de coluna torácica e lombar: série de 23 casos consecutivos e revisão da técnica operatória

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### ABSTRACT

**Objective:** To present the most recent experience in the indications of the anterior approach to the thoracic and lumbar spine and the aspects of the operative technique with its results. **Methods:** From September 2002 to September 2004, 23 patients were admitted with surgical anterior lesions on thoracic and/or lumbar spine. The types of lesions were traumatic (12 patients), infectious (6 patients) and neoplastic (5 patients). All patients were treated by anterior vertebral replacement with titanium mesh cylinder filled with autograft or polymethylmethacrylate (PMMA) supplemented with anterior instrumentation (similar to the Z-plate system). **Results:** Twenty-two of the 23 patients obtained a good anterior decompression and stabilization through a single-stage approach and only one patient required subsequent posterior fusion for evident instability. Twenty-two patients demonstrated radiographic healing after anterior surgery. One patient has died for clinical reasons during follow-up. All except one patient (Frankel A) with neurological deficits recovered. During follow-up the radiographs and computed tomography (CT) scan showed satisfactory decompression and correction of deformities as well as they did confirmed fusion (in case of graft use) and stability, without losing reduction. **Conclusion:** Anterior arthrodesis using instrumentation after a single-stage anterolateral decompression and reduction procedure can yield successful clinical results in the treatment of anterior thoracolumbar disorders.

**KEYWORDS:** Arthrodesis, Thoracic vertebrae; Spine; Surgical procedures, operative

### RESUMO

**Objetivo:** apresentar experiência recente com abordagem anterior da coluna torácica e lombar no tratamento de diferentes doenças desse segmento vertebral. **Métodos:** avaliação de 23 pacientes no período de dois anos, com patologias cirúrgicas envolvendo o corpo vertebral, nos segmentos torácico e/ou lombar. Tipos de lesão: traumática (12 pacientes), infecciosa (seis pacientes) e neoplásica (cinco pacientes). Todos os pacientes foram tratados com substituição de corpo vertebral por cilindro de titânio, preenchido por enxerto autólogo ou polimetilmetacrilato, complementada com instrumentação anterior (similar ao sistema de placa-Z). **Resultados:** dos 23 pacientes, 22 obtiveram estabilização e boa decompressão anterior através de uma única abordagem anterior. Apenas um paciente necessitou de fusão via posterior complementar devido a instabilidade evidente. Um paciente faleceu por razões clínicas durante o seguimento. Exceto o paciente com déficit completo (Frankel A), todos os pacientes apresentaram recuperação neurológica. Durante o seguimento, radiografias e tomografia computadorizada evidenciaram adequada decompressão neural, correção das deformidades, bem como fusão (no uso de enxerto) e estabilidade. Complicações específicas do acesso ocorreram em cinco pacientes (21,7%): dois casos de hemotórax, um caso transitório de síndrome de Horner, um caso reversível de anestesia inguinal e um caso de perda do parafuso. **Conclusão:** artrodese anterior com instrumentação após decompressão ântero-lateral e redução em procedimento único proporcionou bons resultados clínicos e radiológicos no tratamento de diferentes doenças do segmento toracolombar da coluna vertebral.

**DESCRITORES:** Artrodese; Vértebras torácicas; Coluna vertebral; Procedimentos cirúrgicos operatórios

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## INTRODUCTION

There is a natural tendency of treating spine diseases by the approach that the surgeon is more used to. Yet there is also a premise that an anterior problem should demand a direct solution, that is, an anterior surgery.

Anterior surgery on the spine represents a less commonly utilized but important adjunct in the armamentarium of the spine surgeon. The anterior approach provides excellent exposure of the thoracic and lumbar spine<sup>5,8,9</sup>. Through a single-stage approach, direct visualization for spine decompression and stabilization is possible. Anterior approaches to structured insufficiency of the anterior and middle column and to anterior decompression of the neural structures are based on solid theoretical concepts with favorable clinical results<sup>10,11,34</sup>. Spinal reconstruction in cases of tumor, infection or trauma will continue, under certain circumstances, to be routine indications for anterior surgery of the thoracic and lumbar spine<sup>19,22,23,36-38</sup>. On the other hand, the anterior approach to the thoracic and lumbar spine is a more complex procedure, and requires anatomic and technical knowledge by the spine surgeon. The spine runs through anatomical regions which involve various specialties, so a surgeon working on the spine must be able to reach the spine by the thoracic, thoracolumbar, lumbar or abdominal routes. Without special training or help from an appropriate specialist, anterior surgery is difficult and dangerous. There is also peculiar morbidity directly related to this way of accessing the spine.

We report our provisional results in 23 patients undergoing anterior reconstruction for a variety of surgical indications. Rational anatomic approaches to the spine in these areas are presented, and the authors explain the relevant thoracic and abdominal concerns to a spinal surgery.

## METHODS

A prospective series of 23 consecutive patients submitted to anterior lumbar and/or thoracic spine arthrodesis during a 24-month period was analyzed (Table 1). The criteria for surgical intervention were: partial or progressive neurologic deficit, kyphotic angulation  $\geq 25^\circ$  at one segment, progressive kyphosis, lesion with loss of 50% of vertebral height with angulation and residual canal diameter 50% of normal. All patients had failure of the anterior and middle columns as viewed on CT scan. In these criteria were included severe burst fractures and destructive infectious or neoplastic body vertebral lesions<sup>1,2</sup>. All patients were submitted to standard anterior spine surgery: thoracotomy (in nine patients), thoraco-phreno-lumbotomy (in nine patients) and lumbotomy (in five patients). Only three of them were operated on by the right side. In all cases, it was used Z plate fixation and autologous bone (rib or vertebral bone) inside the cylinder, except in the tumor cases. In these ones, the cylinder was filled in with PMMA.

Pain and neurological deficit (Frankel scale) were evaluated in each patient before and after the procedure. Pain was assessed using a visual analog scale, with scores ranging from zero to ten, before and after the operation.

Postoperatively patients were mobilized immediately, but should wear a custom-molded thoracolumbar orthosis. Only

one patient who was submitted to anterior and posterior fixation did not wear orthosis. The patients were out of bed with physical therapy as soon as the chest tube was discontinued (48-72 hours). For three months, the thoracolumbar orthosis was worn whenever the patient was out of bed.

All patients had preoperative anteroposterior and lateral radiographs and a CT scan. The determination of a percentage of canal compromise from the axial CT scan was performed by drawing an oval to approximate the true spinal canal, using the maximal A-P distance as the denominator, and measuring the depth of retropulsion of bone as the numerator. It was also observed the position of the aorta and vena cava for surgery planning. The kyphosis angle were measured from the superior endplate of the vertebral body above to the inferior endplate of the affected vertebral body using the Cobb technique (Figure 1D and E). The percent of collapse was calculated by measuring the height of the anterior cortex of the affected vertebral body and dividing it by the average anterior heights of the intact vertebral bodies above and below. The cases of neoplasm and infection diseases were also evaluated by magnetic resonance image (MRI) on the research of epidural compomising. These cases were also treated with complementary radiotherapy and antibiotic therapy respectively.

Plain radiography was performed for follow-up examination at one, two, and six month to assess vertebral column stability. At three month, a CT sagittal and coronal reconstructions and a functional radiography were done to assess fusion and/or stability.

## SURGICAL TECHNIQUE

The transthoracic approach to the spine begins by placing the patient in the lateral decubitus position. The left-side approach is most often chosen because it is easier to elevate the aorta from the spine than the vena cava on the opposite side. If vessel injury occurs, the aorta is much easier to repair<sup>3</sup>. The right-sided approach has advantages in higher thoracic levels because there are no important structures except the azygos venous system.

When exposure of the spine higher than T6 level is required, a double-lumen tube must be utilized so that the lung may be deflated in order to aid visualization of the thoracic spine. After the patient is positioned in the lateral decubitus position, the table is flexed to pull out the soft tissues of the flank and chest<sup>3,4</sup>.

The surgeon must select a rib for resection in order to expose the spine and he can use it as if bone graft (Figure 2A). The rib resected should be the rib that is one level above the highest working area, or "the rib two levels proximal to lesion site level". It is easier to work caudad than cephalad in the chest due to the slightly downward angulation of the rib cage<sup>4</sup>.

The skin and subcutaneous tissues are open from the lateral border of the paraspinal musculature to the sternocostal junction over the rib to be resected. If necessary higher exposure, the incision may curve around the scapular border and the scapula is retracted cephalad.

The rib is then subperiosteally stripped from the angle of the rib to the costal cartilage, using a curved tipped elevator

**TABLE 1 - Consecutive patients who underwent a anterior thoracic and/or lumbar arthrodesis**

Number	Age (years) / Sex	Clinical finding	Diagnosis	Frankel	Approach
1	31 / M	LL dysesthesias LL weakness Hypoesthesia at T10	Burst fracture (T12)	D	Left thoraco-phreno-lumbotomy
2	29 / M	Dorsal pain	Burst fracture (L1)	E	Left thoraco-phreno-lumbotomy
3	72 / M	Intercostal pain	Spondylitis (T6)	E	Right thoracotomy
4	41 / M	Paraplegia Anesthesia at T12 level	Fracture-dislocation (T12-L1)	A	Left thoraco-phreno-lumbotomy
5	63 / M	LL weakness Hypoesthesia at T10 level Urinary retention	Hemangioblastoma (T8)	C	Left thoracotomy
6	69 / M	LL weakness Lumbar pain	Mieloma (L1)	D	Left thoraco-phreno-lumbotomy
7	45 / W	Lumbar pain	Burst fracture (L1)	E	Left thoraco-phreno-lumbotomy
8	33 / W	Dorsal pain Fever Kyphotic deformity	Spondylitis (T8)	E	Right thoracotomy
9	58 / M	Lumbar pain LL weakness	Burst fracture (L3)	D	Left anterior retroperitoneal (lumbotomy)
10	21 / M	Lumbar pain	Burst fracture (L2)	E	Left anterior retroperitoneal (lumbotomy)
11	19 / M	Dorsal pain	Burst fracture (T12)	E	Left thoraco-phreno-lumbotomy
12	48 / M	Dorsal pain	Burst fracture (L2)	E	Left anterior retroperitoneal (lumbotomy)
13	52 / M	Dorsal pain LL weakness	Burst fracture (T12)	D	Left thoraco-phreno-lumbotomy
14	62 / W	LL weakness Lumbar pain	Adenocarcinoma metastasis (L2)	C	Left anterior retroperitoneal (lumbotomy)
15	28 / M	Dorsal pain Kyphotic deformity	Spondylitis (T8)	E	Right thoracotomy
16	77 / W	Lumbar pain LL weakness Urinary incontinence	Spondylitis (L2 / L3)	C	Left anterior retroperitoneal (lumbotomy)
17	55 / M	Dorsal and intercostal pain	Adenocarcinoma metastasis (L1)	E	Left thoraco-phreno-lumbotomy
18	45 / M	Dorsal pain	Burst fracture (T12)	E	Left thoraco-phreno-lumbotomy
19	55 / M	Dorsal pain	Burst fracture (T12)	E	Left thoraco-phreno-lumbotomy
20	45 / W	Dorsal pain	Burst fracture (T11)	E	Left thoraco-phreno-lumbotomy
21	45 / W	PainLL weakness	Spondylitis (psoas abscess) (L1)	D	Left thoraco-phreno-lumbotomy
22	67 / M	Pain	Spondylitis (T8)	E	Left thoracotomy
23	69 / W	Pain LL weakness	Adenocarcinoma metastasis (T10)	C	Left thoracotomy

M= Man; W= Women; LL= Lower Limbs

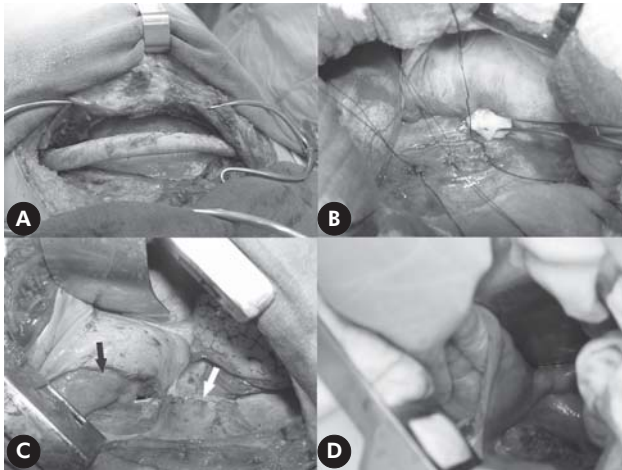


Figure 1

A) Postoperative CT scan demonstrating the right position of the screws. B) Lateral radiographs 12 weeks following subtotal L3 vertebrectomy and spinal cord decompression (burst fracture). C) Postoperative CT scan demonstrating fusion mass inside titanium mesh cylinder. D) Preoperative and (E) postoperative lateral radiographs in a case of tuberculous spondylitis causing kyphotic deformity

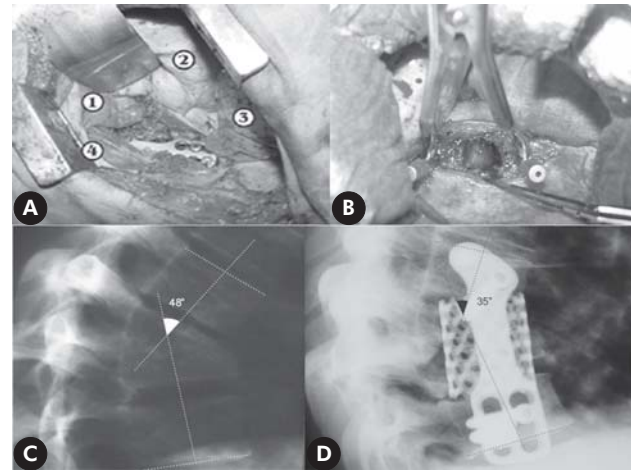


Figure 2

A) The selected rib in subperiosteally stripped. B) Two fingers placed below the diaphragm to make easier peripheral incision of it. C) Left thoraco-phreno-lumbotomy: retroperitoneal fat (1), diaphragm (2), lung (3) and psoas muscles (4). D) Parietal pleura is closed back over spine (open arrow) and the diaphragm (black arrow) will be reapproximated of this peripheral wall attachment

(Figure 2A). Care is taken to prevent injury to the inferior neurovascular bundle. The periosteal and pleural bed of the rib is then carefully incised using scissor. Blunt dissection is performed with a finger or sponge stick to prevent injury to the lung. The lung is retracted medially, or if a double-lumen tube has been placed, it can be deflated at this time. The rib spreader is then inserted and opened.

The parietal pleura overlying the lateral spinal border is identified and elevated utilizing forceps and scissors so that following reconstructive procedures a flap of pleura may be closed back over the operated area.

Next, the segmental vessels overlying the vertebral body are ligated in their midsubstance and blunt exposure of the spine is continued (Figure 3A). A sponge may be packed anterior to the vertebral body in order to elevate and retract the pleura and aorta from field.

The identification of the pedicle and the resection of the rib-head can help in the location of the spinal canal. For complete exposure of the vertebral body, the disc above and below may be resected. Diagonally crossing sympathetic nerves may be incised in order to expose multiple vertebral levels.

The parietal pleura is closed back over the spine wherever possible (Figure 2D). Closure of the chest cavity is performed after visualizing the lung fully inflated. A chest tube is placed through a separate incision and it is usually removed within 48 to 72 hours depending on the drainage and reexpansion of the lung. The chest is closed by planes using a rib approximator.

Approach to the thoracolumbar spine is preferred from the left side, in order to avoid the liver and the vena cava. The incision is usually made directly over the tenth rib until the junction of the rib and the costal cartilage. The incision is carried out and it may be curved anteriorly over the abdomen.

After the tenth rib is released and the lung is retracted, the anterior costal cartilage is sharply split length-wise. The two pieces of cartilage are then tagged and retracted. The loose areolar tissue of the retroperitoneal space is identified. Blunt dissection of the retroperitoneal space below the diaphragm is performed mobilizing the peritoneum forward. When two fingers may be placed into the space below the diaphragm, electrocautery is used to incise the diaphragm 1 to 1,5 cm from its peripheral wall attachment (Figure 2B). In most of our cases it was not necessary to split the cartilage, but only open the posterior half of the diaphragm through thoracotomy.

During this process, marker sutures may be placed so that subsequent reattachment is facilitated. The abdominal wall is then incised protecting the peritoneum. A large rib retractor can be used pushing on the iliac wing, and the ninth rib. The pleura overlying the spine, the crus of diaphragm and the proximal attachment of the psoas muscle are incised and elevated from the spinal column (Figure 2C).

Closure is performed on the diaphragm by heavy interrupted suture. Care is taken to match up the previously placed marker sutures. The tips of the costal cartilage are then reapproximated and the closure on the layer of the abdominal musculature is then performed. A chest tube is inserted under direct vision, prior to closure the thoracic wall.

Retroperitoneal exposure through a flank incision affords ideal visualization for vertebrectomy at L1 through L4<sup>5</sup>. The patient is positioned in lateral decubitus position and the operating table is extended at the level of the lesion in order to open up the surgical site. The oblique flank incision begins over the lateral aspect of the 12<sup>th</sup> rib, which is resected. Using blunt dissection, a plane is developed between the transversalis fascia and retroperitoneal fat posteriorly and the quadratus and psoas muscles dorsally (Figure



2B). During the exposure of the retroperitoneal space, if the peritoneum is injured, repair should be performed immediately to prevent herniation of the bowel.

The plane of dissection is carried anterior to the psoas muscle to the great vessels. Dissection should be centered at the disk space in order to avoid injury to the ligated segmental vessels. The psoas is retracted back to the base of the pedicle, an important landmark identifying the anterior margin of the dural sac.

After all steps of the approaches already described the intervertebral disks above and below the operative level are excised back to the posterior longitudinal ligament. For routine decompression and strut grafting only two thirds of the vertebral body are removed, preserving a thin ring of contralateral annulus. The vertebral body can be debulked utilizing rongeurs or curettes, or it can require use of a high-speed burr to remove the cancellous bone back to a thin shell of the posterior cortex. Entry into the canal can be accomplished utilizing the burr or excising the base of the pedicle (Figure 3B). The defect in the posterior cortex can be enlarged utilizing curettes and Kerrison rongeurs. The posterior cortical wall can be removed by impacting it into the vertebral body defect.

Once decompression has been completed, reconstruction of the anterior column is undertaken through strut grafting. A careful layer-by-layer closure is essential in avoiding visceral herniation.

Some points should be noted to facilitate the thoracolumbar spine surgery:

- A left-sided approach is preferred because of the relative ease of mobilization and repositioning of the aorta when compared with the vena cava. Besides, at abdominal level, the liver is larger than spleen and more difficult to mobilize.
- Care should be taken so that the vessels are ligated and incised in their midportions to prevent the failure and release of the sutures (Figure 3A).
- A strut graft of appropriate length and wide is mandatory, and it is common to require an amount of pressure in order to impact the graft into a stable position.
- Reversing the hyperextended position of the operating table locks the graft into place and can facilitate its impactation.
- As the surgeon is placing the graft, the assistant can apply external pressure in the midline of the spine posteriorly in order to correct any kyphosis present (Figure 1D and E).
- Care needs to be taken to ensure that the graft does not encroach upon the spinal canal.
- Cobbs elevators and curettes are used to thoroughly remove all remnants of cartilaginous endplate back to the bony endplates; the bony endplate is then partially decorticated, but it is important to preserve at least some of the endplate mechanical stability. Avoid injury end-plate to avoid titanium-mesh for dislocation.
- Intercostal block and placement of an epidural catheter under direct visualization are recommended.

## RESULTS

The average duration of follow-up was six months. One patient died during follow-up period.

Concerning etiology, there were three types of vertebral body lesions: traumatic, infectious and neoplastic.

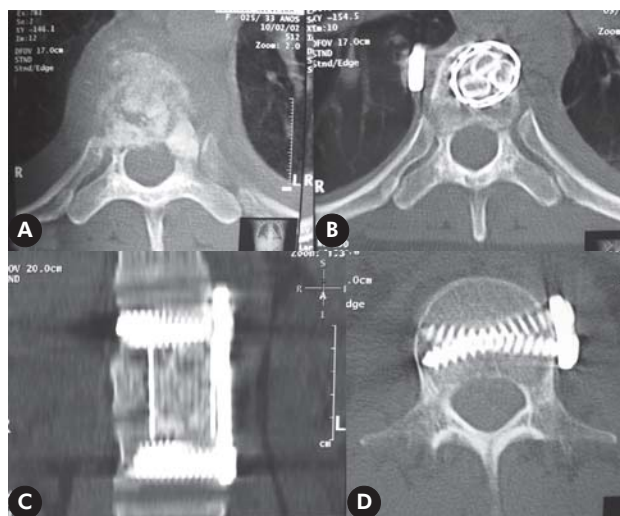


Figure 3

A) Surgical view showing the segmental vessels ligated in their midpositions. B) Subtotal corpectomy and spinal cord decompression (black arrow) and the use of a distractor (open arrow). C) Tuberculous spondylitis at T8. D) Late CT demonstrating that reconstruction was performed utilizing a Harms cage filled with rib autograft

There were 12 patients with traumatic lesions. Vertebral lesions were classified by the Magerl et al.<sup>6</sup> scheme modelled on the AO classification of limb fractures. The mean age was 40 years (range, 19-58). There were 10 male and 2 female patients. Eleven patients had a burst fracture (type A3), with compression failure of the anterior and middle columns of the spine (level T12 in 6, level T11 in 1, level L1 in 2, level L2 in 2, level L3 in 1). None of them had complete lesion. One of these 11 patients presented with osteoporotic compression fracture. One patient presented unstable fracture-dislocation (type C1) of the thoracolumbar spine and had complete deficit. Initially, all patients with traumatic lesions underwent single-stage anterior fusion with instrumentation and surgical mesh implants filled with autograft (rib and morselized vertebral bone). The case of unstable fracture-dislocation also has been treated by open reduction, short segment fixation and fusion. In this case, anterior dural laceration was found during procedure, but without postoperative cerebrospinal fluid leakage. The patient had complete neurological deficit and remained unchanged.

Five patients presented with tumoral disease: three cases of adenocarcinoma metastasis (at L1, L2 and T10), one case of plasmocytoma (at L1) and one case of hemangioblastoma (at T8). The mean age was 63 years (range, 55-69). There were three male and two female patients. All patients were managed by corpectomy, and antero-lateral internal fixation with the titanium mesh cylinder filled with polymethylmethacrylate (PMMA).

Six patients were operated because of the thoracic and lumbar tuberculous spondylitis (1 at T6, 3 at T8, 1

at L1, 1 at L2/L3). The mean age was 52 years (range, 28-77). There were 4 male and 2 female patients. Fusion with autologous bone (rib) and metallic osteosynthesis was performed (Figure 3C and D) and open psoas abscess drainage was performed in two. Prolonged chemotherapy was administered.

Twenty-one patients were treated with anterolateral instrumentation only. In two patients were indicated a second posterior surgery with pedicle screw fixation. One patient with a T12 fracture and unrecognized osteoporosis failed, manifesting increasing kyphotic deformity 40 days after the initial surgery. This occurred with loss of stability at the bone-screw interface. He underwent another surgery and methylmethacrylate was injected into vertebral body and into the screw hole, because of the presence of significant osteopenia, to improve pull-out strength of the screw. Even so, the spine remained unstable and the patient had posterior instrumentation performed in addition to anterior surgery. The second patient with burst fracture who also had posterior instrumentation performed showed posterior elements fractured, although the anterior surgery had seemed to reach a good result.

All patients were graded using the Frankel classification system. Ten patients presented with a neurological deficit: 1 patient were Frankel grade A, 4 were grade C, and 5 were grade D. Pain levels were significant preoperatively in all

patients. After the procedure, all patients rendered nonambulatory by neurological deficit or pain became ambulatory, except one (Frankel grade A).

On the 12<sup>th</sup> day after the surgery, the patient number 5, who presented with severe paraparesia, experienced dyspnea and chest pain after standing and walking exercise, and lethal pulmonary thromboembolism was diagnosed.

Computed tomography (CT) and radiographic study after surgery showed satisfactory decompression and correction of deformities (Figure 1D and E). The mean preoperative canal compromise was 50% (range, 10-80) and percent collapse of the anterior cortex was 60% (range, 20-80). After surgery, canal compromise was 10%, and radiographic height had been restored to 90% of the adjacent levels. When present, preoperative kyphosis improved to a mean of 12° (range, 6-18). At the time of follow-up, except in the patient with osteoporotic fracture, no loss of reduction or fixation was noted in any patient and satisfactory functional result was found in all patients. CT examinations with sagittal and coronal reconstructions were effective for evaluation of fusion (Figure 1C). All of them demonstrated radiographic healing and were out of their brace before four months.

The average operative time was 240 minutes (range, 210-360) and the average length of hospitalization after surgery was 10 days. Mean estimated blood loss was 1700 cc (range, 300-3500).

No major or permanent neurologic complications were encountered. There were no cases of neurologic worsening,

**TABLE 2 - The surgical and medical perioperative complications**

Complications	Patients	Treatment	Comentary
Hemothorax*	Number 3 Number 6	Thoracotomy for irrigation and chest tube	In cases of inflammatory or neoplastic disease, consider to insert two chest tube or prolonged drainage
Horner Syndrome*	Number 8	-	Severe osteopenia; even after vertebroplasty it was necessary posterior surgery.
Screw loosening*	Number 13	Reintervention and vertebroplasty	Transient
Inguinal dysesthesia*	Number 14	-	
Superficial wound infection	Number 9 Number 13	Antibiotics	Diabetic patients
Urinary tract infection	Number 2 Number 4 Number 8	Antibiotics	Infection related with urinary retention and / or catheterization
Venous thrombosis	Number 4	Anticoagulation	Paraplegia
Pulmonary thromboembolism	Number 5	Resuscitation	Severe lower limb weakness before surgery

\*Complications that were directly attributed to the anterior spinal surgery.

vascular complications, CSF leakage, pneumothorax, diaphragmatic rupture and no plate or screw fractures. One case of screw loosening was related above. Two patients reported minimal pain or no pain at final follow-up observation. None reported severe pain or taking narcotic medications. After surgery (at T8), one patient developed a right-sided Horner's syndrome that resolved five months later. There were two cases of hemothorax related to the surgical approach and they were treated with irrigation of pleural cavity and new chest tube. One patient has complained passing inguinal dysesthesia attributed to psoas muscle traction. Other complications like urinary infection, superficial infection, and deep venous thrombosis and thromboembolism were related to the primary disease and patient clinical condition (Table 2).

## DISCUSSION

The anterior approach to thoracolumbar spine was initially used to treat tuberculous abscesses. Afterwards the retroperitoneal approach was used for direct decompression of burst fractures<sup>7,8</sup>.

Dunn developed an anterior device with initial success<sup>9</sup>. Kaneda et al. developed an anterior device that combined two vertebral staples and two cross-linked longitudinal rods<sup>10,11</sup>. After that the use of anterior instrumentation has been supported by biomechanical research<sup>1,12-17</sup>.

Zdeblick reported the use of Z-plate for stabilization following anterior column reconstruction<sup>18</sup>. We have used a similar anterior plating system. Advantages of the Z-plate system include the plate design, which allows for distraction and compression and conforms to the normal contour of the thoracolumbar spine. It is also made of titanium, allowing postoperative imaging. The original contraindications are translational injuries and fracture dislocation of the spine.

Anterior approaches to the spine are utilized for the correction of metastatic, congenital, degenerative, traumatic, and other conditions. The anterior column can be reconstructed with autograft, allograft, or methylmethacrylate, all of which can be augmented with prostheses such as Harms cages<sup>19,20</sup>.

Anterior surgical treatment allows direct decompression of the neural elements and correction of deformity. Newer anterior instrumentation devices, combined with a structural graft, allow a stable construct that may obviate a posterior procedure. An anterior procedure generally requires fusion of only two levels compared to posterior fusion, which generally requires more<sup>21-23</sup>.

Through posterior distraction, limited vertebral height restoration, kyphotic reduction and indirect reduction of spinal canal encroachment was possible<sup>24-26</sup>. Using posterior distraction, canal encroachment is improved indirectly by ligamentotaxis. Alternatively, a transpedicular or costotransversectomy decompression technique can be used<sup>27</sup>. Canal decompression is limited, though, and often incomplete. In addition, short segment fixation has been associated with a high rate of hardware failure with recurrence of deformity<sup>28-30</sup>. Short segment instrumentation with pedicle

screws has been associated with a higher rate of construct failure ranging from nine to 54%. Also, the increase in kyphosis after posterior surgery ranged from three to 12 degrees<sup>7,21,22,27,28,30-32</sup>. That is particularly true in cases of tumor. Fourny et al. reported their experience with pedicle screw fixation in the management of 100 consecutive cases of spinal column tumors<sup>33</sup>. They concluded that posterior stabilization alone is usually inadequate for managing most spinal tumors because the anterior column is frequently involved with disease. Only 25 patients in the series reported could be treated with posterior decompression/stabilization alone. Besides the rostral and caudal ends of the posterior construct often extended several levels above and below the lesion.

Posterior elements disruption, including laminar fracture, spinous process split, or nondisplaced facet fracture do not preclude anterolateral plate treatment. Fracture subluxation with comminuted facet and pedicles fractures and true fracture dislocation (type C) demand posterior fixation, combined or not<sup>34</sup>. One of our patients with burst fracture who also had posterior instrumentation performed showed posterior elements fractured, although the anterior surgery had seemed to reach a good result. The pedicle screws were used as a supplemental method of fixation rather than as primary mechanical support devices. The final spinal fixation in such patient allowed him to walk without external orthoses. We think that we could have done only anterior approach. Despite of one of our patients to have a fracture dislocation, what would be a relative contraindication for Z-plate<sup>35</sup>, we have obtained a good resulting in terms of reduction and stability.

We have succeeded on to treat spine infectious disease with autologous bone and instrumentation. In two of the infectious cases, the anterior surgery also allowed the proper psoas abscess drainage. Benli et al. reported the surgical results of 63 patients with Pott's disease who underwent anterior radical debridement with anterior fusion and anterior instrumentation (23 patients with Z-plate). They concluded that this procedure is a safe and effective method in the treatment of tuberculosis spondylitis<sup>36</sup>.

Option for autografting include the resected rib, vascularized rib, iliac crest, free fibula, and vascularized fibula. Some authors advocate use of allograft<sup>37</sup>. Each technique varies in its level of sophistication, technical demands, morbidity from the donor site, and mechanical stability. Iliac crest is preferred due to its relatively broad surface area, strength in compressive loading, and favorable ratio of cancellous to cortical bone<sup>38</sup>. Iliac graft was not necessary in any our cases. Autologous grafting, following through debridement, has been shown to be safe even in the presence of active pyogenic infection<sup>39</sup>. Methylmethacrylate has been shown to be strongest in compression and susceptible to early fatigue fracture in tension, and is usually used in conjunction with bone grafting in patients with a life expectancy more than 1 year. Liquid PMMA may be inserted into boltholes before bolt insertion to increase purchase if the bone manifests osteopenia. This increase in pullout force

is believed to be due to the anchoring effect of bone cement, which mainly penetrates the intratrabecular space<sup>40</sup>. In one of our cases involving corpectomy, PMMA-augmented screw fixation was performed using a Z-plate. Even so, this procedure did not avoid further posterior surgery.

The titanium mesh cylinders act like an adjunct to bone grafting by encapsulating morselized autograft, polymethylmethacrylate (PMMA) or allograft and providing increased strength. In case of spinal tumor, autogenous bone grafts are also implanted with PMMA to enhance fusion when life expectancy exceeded 1 year<sup>41</sup>. The serrated edges of the cage interdigitate with the bony endplates and minimize the propensity for dislodgment of the system. The reconstruction with the titanium mesh cage usually is supplemented with anterior instrumentation.

Anterior bone grafts alone are subject to a high rate of nonunion (10-20%)<sup>42</sup>, are unable to withstand the compressive load of an erect spine, and are unable to provide adequate rotational stability. Therefore, most authors feel that anterior decompression requires some form of internal fixation. Internal spinal fixation helps fusion to occur, correct deformities, and provide early biomechanical stabilization.

We have used the Z-plate for stabilization following anterior column reconstruction. Following discectomy, corpectomy, and decompression, a depth gauge is used to measure the coronal diameter of the vertebral body. The starting point for insertion of the first bolt is approximately 1cm anterior to the base of the pedicle and 1cm cephalad to the inferior endplate of the inferior vertebral body. The bolt is angled 10° from posterior to anterior in the transverse plane and parallel to the endplate in the coronal plane (Figure 1A). A bolt is similarly placed in the cephalad half of the superior vertebral body. A distractor is attached to the two bolts and strut grafting is performed (Figure 3B). The vertebral bodies that will contact the plate are leveled with a burr or rongeur to allow maximal contact. The plate is placed over the bolts with the slot oriented superiorly. Compression is maintained until the plate is secured into place. A screw is then placed into the anterior portion of each body through the designated holes in the plate, angled approximately 10° posteriorly (Figure 1A). Both the bolts and the screw should obtain bicortical purchase.

We have noticed some aspects that demand variation on this technique. The cases of discitis have a particular difficulty. After proper radical debridement, only part of the superior and inferior vertebra is left. Due to the exiguous quantity of healthy bone, it demands ability to place the screws or extend the corpectomy. It is not uncommon to have enough room for only one screw. Other observation is that when we consider a second and posterior approach we must have in mind the suitability of the classical technique. The insert point of the anterior screw should allow the placement of the pedicle screw.

Complications are often approach specific. Faciszewski et al., in a review of 1223 procedures, reported that the complication rate that was directly attributed to the anterior spinal surgery was 11.5%<sup>43</sup>. McDonough et al. reported

successful fusion with single-stage anterior reconstruction with allograft and Z-plate in 27 of 28 patients with thoracolumbar fractures. One patient with osteoporosis failed and required posterior fusion. In their series others two patients were treated with a planned two-stage procedure because of significant facet and pedicle fractures. In thirty patients, occurred one case of instability, one case of transient increased weakness and one had prolonged chest tube output.

Based on our experience and on McDonough et al.<sup>34</sup>, osteoporotic fracture is not a good indication for anterior approach, at least without vertebroplasty and a combined posterior approach. There is a greater risk of cylinder migration and/or the pull out of the screw like what happened with our patient number 13.

We had one case of transient Horner Syndrome that was not explained by the usual anatomy of the autonomic innervation of eye (surgery at level T8).

There were two cases of hemothorax in our series. In light of this rate of complication, we have now introduced several measures in an attempt to avoid this problem. At the end of the surgical procedure, extensive irrigation is conducted prior to closing. We must keep in mind that neoplastic, infectious diseases are prone to hemorrhage, and we must pay more attention to hemostasis and to consider the use of double thoracic drain or continuous aspiration.

Adequate exposure of the lumbar spine requires careful dissection to mobilize the psoas and retract it posteriorly, taking care not to injure the genitofemoral nerve. The traction over psoas can justify the occurrence of transient dysesthesia in one of our patients.

## CONCLUSION

It must be noted that this report are case collection study involving very short follow-up and a variety of indications. It is not expected that this article will be all-inclusive, but the authors could testify some important aspects from literature concerned.

The anterior approaches provide excellent exposure of the relevant bony anatomy and can be used to secure anterior column support with bony fusion. It is possible direct visualization for anterior decompression and stabilization through a single-stage approach, and lessened the need for second-stage posterior stabilization. Anterior instrumentation alone can usually be used if decompression is isolated to one or two levels, if the posterior column is not very damaged, and if there is no severe translation instability.

Surgery, consisting of anterior decompression, strut grafting, and fusion, results in a higher recovery rate in patients with neurologic deficit, earlier fusion, decreased kyphosis and decreased dural penetration.

Most complications do not alter the improvement in ultimate functional outcome when they are recognized and treated appropriately. The main factor influencing the occurrence of complications is surgical experience. Anterior spinal fusion surgery is a safe procedure and can be used with confidence when the nature of a patient spinal disorder dictates its use.



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