Minimally Invasive Treatment for Traumatic Thoracolumbar Fractures

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ABSTRACT

Introduction: Minimally invasive techniques for the treatment of thoracolumbar fractures have been developed to reduce perioperative morbidity. The primary purpose of this work is to evaluate the clinical and radiological outcomes in a group of patients with traumatic thoracolumbar fracture treated with minimally invasive procedures. **Materials and methods:** Taking a group of patients within the inclusion criteria, we retrospectively analyzed demographic data, along with pre and postoperative radiographic measurements and postoperative functional scores, using the Oswestry Disability Index and the Visual Analog Scale for pain. We recorded the complications and the hospital stay. **Results:** 15 patients were analyzed (10 of them were male). The average age was 59 years, and the average follow-up was 32.9 months. The patients presented an average postoperative pain score of 2/10 and an average Oswestry Disability Index score of 14/100. The radiographic analysis showed an average preoperative segmental kyphosis value of 16º that was corrected to 10° (p = 0.01). The preoperative average height for compromised vertebrae was 18 mm, with an average height of 21 mm at the last follow-up (p = 0.02). There were 3 complications (20%) in 3 patients. Hospital stay was 9 days long on average. Three patients were rehospitalized within 90 days after surgery. **Conclusion:** The treatment of traumatic thoracolumbar fractures by minimally invasive techniques was a safe procedure, with good clinical and radiological results in the medium term of follow-up.

Key words: Thoracolumbar fracture; percutaneous stabilization; minimally invasive surgery; spinal fusion; thoracolumbar arthrodesis.
Level of evidence: IV

Tratamiento mínimamente invasivo para fracturas toracolumbares

RESUMEN

Introducción: Las técnicas mínimamente invasivas para tratar las fracturas toracolumbares se han desarrollado con el objetivo de reducir, al mínimo, la morbilidad perioperatoria. El objetivo primario de este estudio fue evaluar los resultados clínicos y radiológicos de una serie de pacientes con diagnóstico de fractura toracolumbar por causa traumática tratados con procedimientos mínimamente invasivos. **Materiales y métodos:** Se llevó a cabo un análisis retrospectivo de los datos demográficos, radiológicos pre y posoperatorios, y funcionales posoperatorios mediante el índice de Oswestry y la escala analógica visual para dolor, en una serie de pacientes que cumplían los criterios de inclusión. Se registraron las complicaciones y la estancia hospitalaria. **Resultados:** Se analizaron 15 pacientes (10 hombres) con una edad promedio de 59 años y un seguimiento promedio de 32,9 meses. Los pacientes tenían un dolor promedio posoperatorio de 2/10 y un valor promedio del índice de Oswestry de 14/100. El análisis radiológico mostró un valor promedio preoperatorio de cifosis de 16º, que se corrigió a 10° (p = 0,01). La altura promedio de la vértebra comprometida fue de 18 mm en el preoperatorio y de 21 mm en el último seguimiento (p = 0,02). Hubo tres complicaciones (20%) en tres pacientes. La estancia hospitalaria promedio fue de 9 días. Tres pacientes fueron internados nuevamente dentro de los 90 días de la cirugía. **Conclusión:** El tratamiento de las fracturas toracolumbares por causa traumática mediante técnicas mínimamente invasivas fue un procedimiento seguro y logró buenos resultados clínicos y radiológicos en el seguimiento a mediano plazo.

Palabras clave: Fractura toracolumbar; estabilización percutánea; cirugía mínimamente invasiva; fusión lumbar; artrodesis toracolumbar.
Nivel de evidencia: IV

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INTRODUCTION

Fractures in the thoracolumbar region are among the most frequent in the spine[1], generally caused by high-energy injuries, including motor vehicle accidents and high-level falls. These injuries cause pain, deformity and function loss[2]. The treatment aims at stabilizing traumatized regions and decompressing in cases of neurological compromise.

The conventional posterior approach is considered suitable for patients with or without neurological compromise, and with burst fractures or injuries in the posterior ligamentous complex, yielding good clinical and radiological results[3]. However, it has been linked to significant perioperative complications, such as blood loss, infections and extended hospital stay[4]. Denervation and devascularization of the paraspinal muscles during this approach entail the resulting muscular atrophy[5]. Such dysfunctionalization is associated with chronic lumbar pain[6, 7].

Percutaneous fixation with pedicle screws and minimally invasive surgery have evolved as an alternative in the treatment of thoracolumbar fractures, intending to reduce soft tissue injury[8] and perioperative morbidity[9] to a minimum. The percutaneous technique in particular was initially described to treat degenerative spinal disease[10]; it requires 1 cm incisions for each screw and tubular retractors which bluntly dissect the paraspinal muscles. By preserving them, hemorrhage is limited, and both the risk of infection and postoperative pain are reduced. Likewise, it makes for a reduced hospital stay and hastens recovery, improving postoperative functional results[11-13]. Reducing blood loss is particularly important in the cases of spinal trauma, as well as in high-risk geriatric patients[14].

In our Service, the treatment of thoracolumbar fractures has evolved towards less and less aggressive techniques, and the conventional approach has been limited to patients who specifically need it. In the last years, we have achieved positive results with four-level, short posterior arthrodesis[15] or two-level, ultrashort posterior arthrodesis[16]; at present, we have come to treat them with minimally invasive or percutaneous techniques.

The main purpose of this study was to evaluate the clinical and radiological outcomes in a group of patients with traumatic thoracolumbar fracture treated with minimally invasive or percutaneous surgery in our healthcare center.

Our secondary objective was to assess the safety and precision of percutaneous screw placement.

MATERIALS AND METHODS

Having had the research protocol previously approved by our institution's Ethics Committee, we retrospectively analyzed the patients diagnosed with traumatic thoracolumbar fractures who met the following inclusion criteria: 1) >18 years of age at the time of surgery; 2) being operated between January 2012 and December 2017 in our institution, 3) being treated through percutaneous fixation in isolation (Figure 1) or associated to minimally invasive anterior arthrodesis (Figure 2), 4) a follow-up of at least 6 months.

During this period, 129 traumatic vertebral fractures were treated. The following patients were excluded: 1) those with cervical fractures, 2) those who were treated with conventional posterior approaches, 3) those with percutaneous vertebroplasty (Figure 3) and 4) those lacking complete electronic health records.

The information was taken from our institution's electronic health records, and we collected the patients' demographic data. The data were taken from the clinical evaluation in the last follow-up and from the analysis of pre and postoperative radiological parameters in the last control.

We analyzed thoracolumbar pain clinically, according to the visual analog scale (VAS) and through the Oswestry Disability Index (ODI)[17]. The degree of neurological compromise according to the Frankel scale[18], upon admission and in the last follow-up consultation, was taken from the health record.

We assessed the mechanism of injury (high- or low-energy), the fractured vertebra level according to the Magerl/AO system[19] and the ThoracoLumbar Injury Classification and Severity Score (TLICSS)[20].

Regarding the surgical procedure, the following data were collected: surgical times for the percutaneous surgery and the minimally invasive procedure (if applicable); number of stabilized levels; number of pedicle screws placed percutaneously; waiting days between the hospitalization and the procedure; days in hospital until medical discharge; new unscheduled hospitalization within 90 days after surgery and its cause, complications and treatment given.

Figure 1. Patient 7. 81-year-old man who suffers a standing height fall, diagnosed with a fracture of the 10th thoracic vertebra AO B3. Upon admission, the injury is confirmed by a profile radiography of the dorsal spine (**A**), the sagittal planes of the computerized tomography (**B**) and the MRI T2 sequence (**C**). The patient undergoes surgery three days after admission, by means of percutaneous stabilization from T9 to T11 (**D** and **E**). **F.** Follow-up computerized tomography, after 36 months. The fracture has consolidated without height loss or kyphotization of the vertebral body.

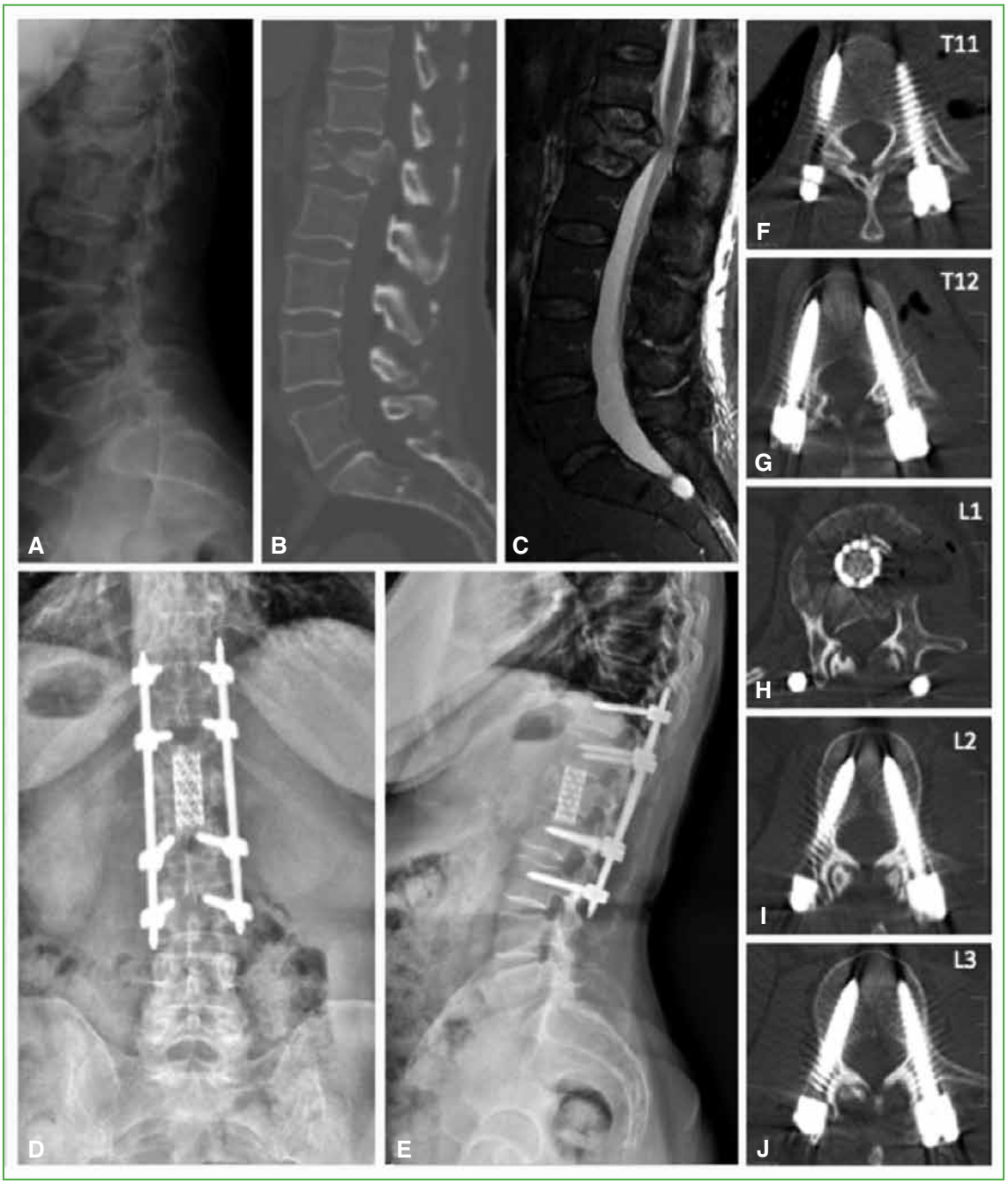

Figure 2. Patient 6. 60 year-old woman who suffers a motor vehicle collision. **A.** Profile radiography of the lumbosacral column, **B.** Computerized tomography, sagittal planes, **C.** MRI T2 sequence. An AO A4 fracture of the first lumbar vertebra is confirmed. The vertebral body has collapsed, compromising the posterior wall. There is a 15º segmental kyphosis, and the vertebral height is 15 mm. Four days after admission, she undergoes a percutaneous stabilization from T11 to L3 (**D** and **E**). In a second surgical time, with the patient being clinically stable, a lateral minimally invasive arthrodesis is performed from T12 to L2, using a mesh cage and an autologous crest and rib bone graft. **F-J.** Follow-up computerized tomography, after 36 months. There can be observed the position of the pedicle screws (5 in 1A and 3 in 1B, according to Zdichavsky).

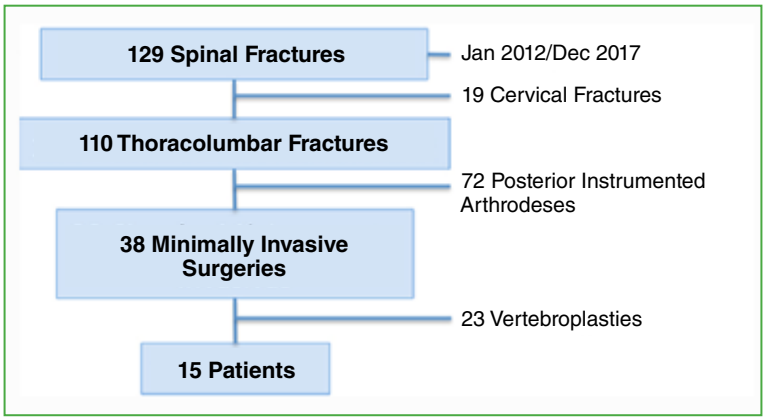

Figure 3. Flow chart for patient selection.

We noted the cases in which the percutaneous implant was withdrawn and the causes, as well as the follow-up time until withdrawal.

To stabilize these injuries, we used the CD Horizon Longitude™ (Medtronic Sofamor Danek) multi-level percutaneous fixation system. The inserted polyaxial pedicle screws' diameter was between 4.5 and 7.5 mm, depending on the pedicle width as determined by computerized tomography (CT) before the surgery. The pedicle screws were inserted upon anatomical reference points using intraoperative radiography. Safety and precision in pedicle screw placement were assessed by analyzing the CT axial planes 6 months after surgery, with 3 mm sections using the classification described by Zdichavsky et al.[21,22] (Figure 4).

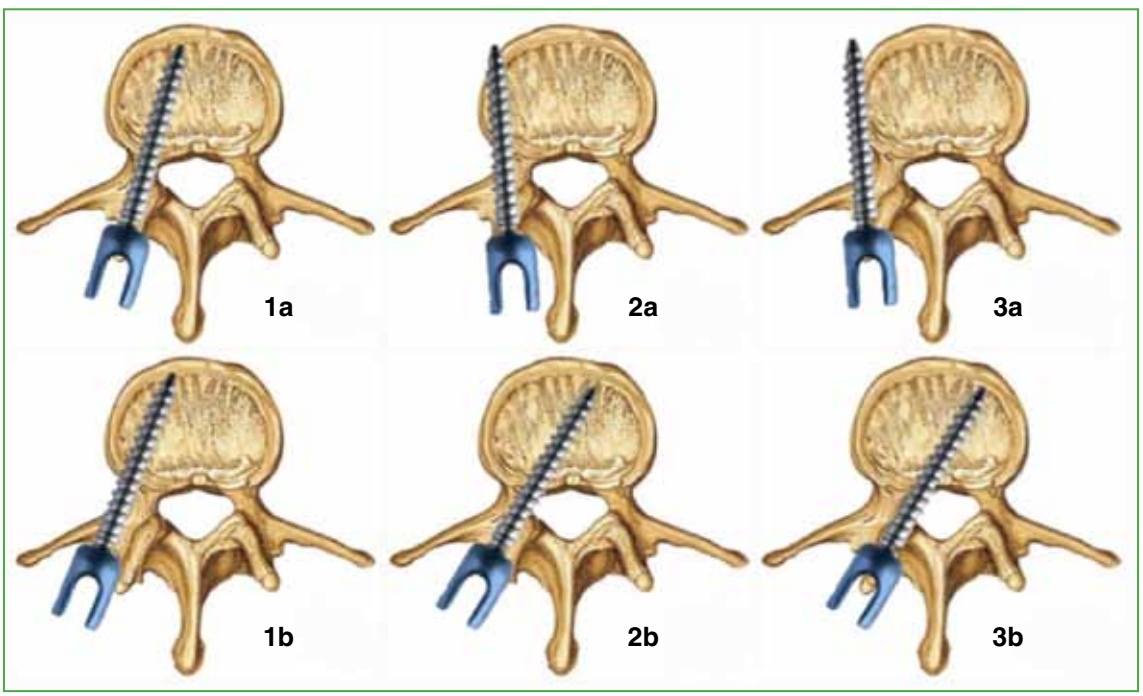

Figure 4. Classification by Zdichavsky et al. to assess the position of the screws. The best positioning options are the 1A and 1B types. In 2A or 2B position, stability must be assessed, but no revision is required in general. In bad 3A and 3B positions, depending on stability or potential neurological irritation, the possibility of a screw revision must be considered.

The minimally invasive procedures consisted in one or two-level lateral interbody fusions[23], with or without implants. For the anterior arthrodesis, a local graft harvested from the iliac crest or rib was used.

The surgery indication was specifically evaluated for each patient; all of them were treated by means of percutaneous stabilization with pedicle screws. Furthermore, any patient who met the following criteria was deemed as a candidate for adjunct anterior arthrodesis: 1) A3 or A4 or B2 fractures, as per the Magerl/AO classification, with a preoperative segmental kyphosis value higher than 20° or compromised ligaments in the posterior tension band or 2) fractures with a >4 score in the TLICSS scale.

The patients were evaluated with radiographs, CT and MRI upon entering the Institution and with radiographs or CT in the last follow-up. The lumbopelvic parameters were scanned before and after the surgery, as well as the measurements related to the fracture: pelvic incidence, pelvic inclination, sacral inclination, lumbar lordosis, thoracic kyphosis. The height of the impacted vertebral body and the pre and postoperative segmental kyphosis were determined by CT, taking as parameter the sagittal plane of the vertebral body's anterior side and the superior and inferior vertebral discs of the involved vertebra, respectively[24] (Figure 5).

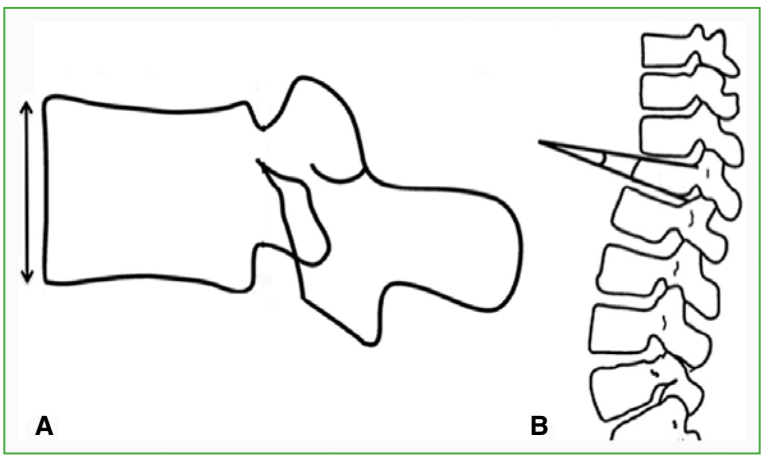

Figure 5. Scheme representing the anatomical landmarks used to take the tomographic measures of pre and postoperative vertebral body height (**A**) and segmental vertebral kyphosis (**B**).

The fracture's healing was evaluated by CT in the last follow-up consultation, considering it satisfactory if there could be observed an osseous bridging in the interbody arthrodesis, together with the reorganization of the bone matrix in the fractured vertebra at the time of the percutaneous intervention exclusively.

In order to compare a patient's pre and postoperative measurements, a paired t-test with the Stata 13 program was used.

RESULTS

Between January 2012 and December 2017, 15 patients diagnosed with traumatic thoracolumbar fracture underwent surgery (Table 1): eight of them with the percutaneous technique and seven combining the percutaneous and minimally invasive techniques through lateral interbody fusions. In five of these seven patients, an interbody device with autologous bone graft was used to grant anterior support to the spine. In the other two, only an autologous bone graft was used.

The average age was 59 years (22-86 range). Ten of them were male. The average follow-up was 32.9 months (7-71 range) (Table 2).

Six patients suffered low-energy trauma (fall from standing height); nine patients, high-energy trauma (a crushing by a freight elevator, four high-level falls and four motor vehicle accidents) (Table 3).

Table 1. List of treated patients

Age/ Sex	Fracture level	AO Classification	TLICS	Percutaneous surgery time (min)	Minimally invasive surgery time (min)	Associated procedures	Fixed levels	Instrumentation	Number of screws	Complications	Treatment	Follow-up (months)	Postoperative VAS	ODI POP
54/M	T12	A3/B2	6	150	240	T11-L1 Noninstrumented anterior arthrodesis	4	T10-L2	8	Intercostal pain	Removal of the material	71	6	46
64/M	L1	A3	2	130			2	T12-L2	6	Wound infection	Surgical debridement	47	1	10
58/F	L1	A4/B2	7	180	180	T12-L2 Anterior arthrodesis	4	T11-L3	8	Wound infection	Surgical debridement	44	2	12
67/F	T12	A3	2	90			4	T10-L2	8			42	3	24
61/F	L1	A3	2	110			2	T12-L2	4			41	0	12
60/F	L1	A4	2	110	140	T12-L2 Anterior arthrodesis	4	T11-L3	8			36	3	12
81/M	T10	B3	7	140			2	T9-T11	6			36	1	16
72/M	L4	A4	5	80	110	L3-L5 Anterior arthrodesis	2	L3-L5	4			35	1	4
34/M	L2	A3	2	110	200	L1-L2 Noninstrumented anterior arthrodesis	2	L1-L3	4			33	3	14
59/M	T12	A3	2	105			2	T11-L1	6			34	4	22
86/F	T11	B3	4	150			3	T10-L1	8			23	4	16
60/M	L1	A3	2	140			4	T11-L3	10			24	2	6
57/M	L3	A4	6	80	90	L2-L4 Anterior arthrodesis	2	L2-l4	5			13	0	20
49/M	L1	A3	2	80			2	T12-L2	6			8	3	2
22/M	L2	A3/B2	7	165	105	L1-L2 Anterior arthrodesis	2	L1L3	5			7	1	4

M: Male; F = Female; T = thoracic; L = lumbar; VAS = *Visual Analog Scale*, ODI = *Oswestry Disability Index*.

Table 2. Demographic data

N	15
Age (years)	59 (22-86 range)
Sex Female Male	 10 5
Follow-up (months)	32.9 (7-71 range)

Table 3. Results

Trauma Low-energy High-energy	 6 9
Magerl/AO classification A3 A4 B2 B3	 7 3 2 3
TLICS classification <4 4 >4	 8 1 6
Percutaneous surgery time (min)	121 (80-180 range)
Minimally invasive procedures time (min)	160 (90-290 range)
Hospital stay	13 (3-45 range)

Twelve fractures (80%) were at the thoracolumbar transitional level: one in T11, three in T12, six in L1 and two in L2. The rest were located in T10, L3 and L4.

According to the AO classification, seven fractures were A3; three, A4; two, B3 and three, B2 (2 with A3 anterior component and one with A4).

The TLICSS values were: eight fractures ≤3, one 4 and six, ≥5.

The average time for percutaneous surgery was 121 min. (DE 32 min., 80-180 range). The average duration for minimally invasive lateral procedures was 160 min. (DE 57 min., 90-240 range).

Nine patients had two levels fixed, one patient had three levels fixed and, in five patients, four levels were percutaneously stabilized.

96 screws were placed with the percutaneous technique in the 15 patients. According to Zdichavsky et al.[21, 22], 75 screws were placed in 1A position; 13, in 1B position (best placement options); two, in 2A; four, in 2B (wherein it is frequently necessary to assess stability, due to pedicle wall violation) and two, in 3B (screw revision is possible in case of neurological symptoms or instability, due to its being in extrapedicular position). No new operation to reposition any screw was needed.

The average hospital stay was 13 days (3-45 range); the average waiting time between hospitalization and surgery was 3.7 days (0-11 range); and the average rehabilitation time from surgery until medical discharge was 9.3 (3-41 range). Three patients were hospitalized within 90 days after surgery; two of them, due to infection of the percutaneous surgical wound, requiring surgical debridement without removing the instruments. The other patient had to be rehospitalized due to an underlying decompensated heart failure.

There were three registered complications (26%): the two wound infections (13%) discussed, and a patient who felt intercostal pain after 16 months of follow-up and required to have the material removed (Table 1).

All of them had a Frankel score of E at admission, except for a 72-year-old patient who suffered an A4 fracture of L4 with a 40% compromise of the spinal canal after a standing height fall, with a Frankel score of D which evolved to E during the postoperative period. This patient was treated with a two-level percutaneous stabilization with four screws from L3 to L5 and a lateral hemicorpectomy of L4 and interbody fusion with a device filled with an autologous bone graft through a minimally invasive technique.

All of the fractures had healed as of the radiographical analysis at the end of the follow-up period, after 32.9 months (7-71 range).

Two of the 15 patients had their implants withdrawn: one of them, after 16 months due to radicular pain; the other, after 5 months due to skin discomfort.

The postoperative functional results at the end of follow-up and the radiographical parameters assessed are detailed in Tables 4 and 5, respectively.

Table 4. Functional assessment

	Average	Range
Postoperative VAS	2.27	0-6
Postoperative ODI	14.57	2-46

VAS = *Visual Analog Scale*, ODI = *Oswestry Disability Index.*

Table 5. Radiographic parameters

	Preoperative	SD	Postoperative	SD	p
Pelvic incidence (º)	54.3	8.8	-		
Pelvic inclination (º)	21.2	10.7	18	6.9	
Sacral inclination (º)	37.1	11.1	35.4	6.5	
Lumbar lordosis (º)	45	16.2	50.9	13.7	
Thoracic kyphosis(º)	38	14	43	10.2	
Segmental kyphosis (º)	15.9	8.3	10.5	7.9	0.01
Vertebral body height (mm)	18	3.7	21.2	5	0.02

SD = standard deviation.

DISCUSSION

The current trends towards minimally invasive surgery techniques represent a turning point in spinal surgery. Percutaneous instrumentation with pedicle screws for thoracolumbar trauma was first communicated in 2004 by Assaker[25], without any fault in the construction or misplacement or slackening of the screws. Later studies have shown the benefits associated with this technique in comparison with conventional posterior approaches; among them: shorter surgery and hospital stay times, reduced blood loss, lower wound infection rates, improved functional results, and a better assessment of pain[9, 21, 23].

However, no differences were found regarding the postoperative anterior vertebral height and body angle between conventional open posterior surgery and percutaneous stabilization[9, 26].

Typical indications for the percutaneous approach include fractures with transient bone instability not requiring significant reduction or decompression. Type A fractures in the Magerl/AO classification, B1 fractures with compromised bones in the posterior tension band and fractures with a TLICSS <5 are also included[13, 25].

In our series, we treated seven A3 fractures as per the Magerl/AO classification, three A4, two B3 and three B2 (two with A3 anterior component and one with A4), corresponding to eight fractures with a TLCISS ≤3, one with 4 and six with ≥5. Although Vaccaro et al.[20] encourage a conservative treatment for thoracolumbar fractures with a TLICSS <4, this indication is highly controversial. Long-term clinical results for burst fractures (A3 and A4) seem to have no clinically relevant differences between both kinds of treatment, but radiological results are better for those who are operated[27]. Likewise, the surgical treatment of these injuries is related to short-term improvement in pain and to shorter recovery times in resuming work and everyday life activities[28]. In this study, a subgroup of eight patients with TLICSS <4 underwent surgery with their and their families' consent, choosing this method to avoid long periods of immobility, rest and pain, along with their potential consequences.

The combination of percutaneous fixation with minimally invasive anterior techniques of spinal reconstruction enables to preserve the potential advantages of this procedure. Such combination is indicated when the isolated posterior fixation is not mechanically sufficient (Load Sharing Classification of McCormack >6)[29], those A3, A4 or B2 fractures with a significant vertebral compression leading to a loss of vertebral body height and an anterior bone void or those with a TLICSS >4. Seven out of our fifteen patients were stabilized with an additional anterior procedure. Four fractures were classified as A4 and three, as A3, three of which had a B2 component. The average TLICSS was 4 (2-7).

One of the communicated advantages of minimally invasive techniques is the lower rate of surgical site infections. Ni et al.[30] informed of one superficial infection out of 36 patients with percutaneous fixation, which was treated just with antibiotics; Schmidt et al.[14] and Merom et al.[31] detected no infections in 76 and 10 patients, respectively; and Palmisani et al.[32] communicated only one infection which required the withdrawal of the instruments out of 64 patients. These studies[14, 30-32] inform of a low infection rate compared to those reported in conventional open procedures, which vary between 3.1% and 10%[33]. In our series, there were two injury infections in 15 patients (13%) (Table 2). Both of them required surgical debridement and intravenous antibiotic therapy. The isolated germs were *Staphylococcus epidermidis* in a 64-year-old man and *Enterococcus faecalis* in a 58-year-old woman. Both cases were solved without requiring instrument removal. Such complications occurred in the first cases, and we esteem that the lack of experience in the surgical treatment favored this situation. The smaller cuts are not necessarily better; the dermal borders suffer from repeated trauma during the procedure and are devitalized by distraction with the instruments, favoring colonization and infection. We should note that such a low amount of patients may have an impact on the results, by overestimating the rate of infection. The complication discussed did not occur in the rest of the series.These minimally invasive treatments also favor a shorter hospital stay[9, 30, 34], owing to a quicker rehabilitation. Merom et al.[31] refer that the patients who underwent percutaneous treatment could perambulate in one or two days, while those treated with a conventional posterior procedure did so after three or four days. In a 2015 systematic review, Phan et al.[9] communicate that the average hospital stay for minimally invasive procedures —out of 279 patients with thoracolumbar fractures— was 10.7 days. Our patients remained in hospital for an average 9 days after surgery (3-41 range); the longest case corresponds to a 60-year-old woman who had a lengthy hospitalization due to a high-energy accident with injuries in multiple organs. This value is comparable with the data from other series[9,34]. Likewise, three out of fifteen patients (20%) had unscheduled rehospitalizations within 90 postoperative days: two of them due to injury infections and one owing to a decompensated heart failure; they stayed for 40, 32 and 21 days at hospital, respectively, during the first three postoperative months. We have found no correlated data in similar studies.

As regards the radiographic analysis, it has been published that there are no statistically relevant differences regarding pre and postoperative kyphosis and pre and postoperative vertebral body height between those patients treated with a minimally invasive procedure and those treated with the conventional approach[9,26]. Pelegri et al.[35] and Ni et al.[30] report an average preoperative kyphosis of 16º and 18º, respectively, in their series of patients who underwent percutaneous treatment; these improved to 8º and 9º on average at the end of the follow-up, respectively. On the contrary, Palmisani et al.[32] inform an average correction loss of 4º in 57 Type A fractures treated with the percutaneous technique in short segments. They refer that such loss was greater with polyaxial, as compared to monoaxial, screws.

In our series, the patients had an average segmental kyphosis of 16º (DE 8º) which was corrected and stabilized, on average, at 10º (DE 8º) at the end of the follow-up; this represents an average reduction and stabilization of 5º, which was statistically relevant (p = 0,01). Similarly, the height of the compromised vertebrae was, on average, 18 mm (DE 3.7) when deciding upon surgery; it grew and was kept at an average 21 mm (DE 5) in the last follow-up, which was also relevant (p = 0,02).

A differential analysis —between those patients who were prescribed with a complementary anterior procedure and those who were not— indicated that the patients with a double treatment had a higher preoperative kyphosis (+7º on average) and a lower anterior body height (+5 mm on average), in comparison with those who just underwent percutaneous stabilization. This matches the indication criteria for an anterior minimally invasive treatment associated with percutaneous stabilization. In the last follow-up, this difference was reduced to an average residual kyphosis of 2º (greater residual kyphosis in the percutaneous-only group, 11º vs 9º) and just 1 mm of average vertebral body height between both groups.

The precise placement of pedicle screws in open and percutaneous procedures has been studied and compared. These studies show that the percutaneous orientation of the pedicle screw with fluoroscopic guidance —if done with the adequate technique— leads to less pedicle wall violations in comparison to the open approach; the percutaneous procedure lacks tactile sensation, which heightens, even more, the technical challenge and difficulty associated with the steep learning curve[36].

In our series, the placement was excellent in 91.7% of the cases, 88 out of 96 pedicle screws were placed in 1A and 1B position according to Zdichavsky et al.[21, 22] (Figure 4), assessed through postoperative CT. 6,25% (6 screws: two 2A, four 2B) had a good position, and only two (2%) were placed in 3B position. No screw had to be repositioned.

Once the bone is consolidated, theoretically, the instruments can be eliminated, given that the discs are intact in this kind of fractures. Although there is no consensus, it seems reasonable to eliminate the instruments between 8 and 12 months after the fracture has become immobilized. Wild et al. eliminated the instruments in all of their patients and found a loss of correction during the year after extraction, but such loss became stable with time[26]. In the studies, there is scant commentary on the extraction of pedicle screws, either open or percutaneous, after the fracture has become consolidated. This question has not yet found an answer in long-term observational studies. In this series, two patients had to have the instruments removed due to local discomfort and radicular irritation, after 5 and 16 months, respectively; before the surgery, the fracture was confirmed to be consolidated. Our protocol does not include the scheduled extraction of the implant.

The role of percutaneous and minimally invasive spinal fixation does not replace open techniques but adds to therapeutic options. Those who advocate these techniques cite, among others, surgical time reduction, lesser blood loss and a lower alteration of the previously injured soft tissue. On the contrary, those who are opposed to the minimally invasive technique cite long learning curves for surgeons and potentially inadequate restoration of vertebral body height and local kyphosis. Knox et al.[37], Patel et al.[38] and Park et al.[39] commented upon the challenges they faced in the first cases treated in their assistance centers. They report a higher rate of complications due to incorrect screw placement, facet joint violation and the subsequent need for additional surgical procedures. In our experience, the infectious complications occurred in the second and third patients treated, and the only two misplaced screws (3B) occurred in the first case.

While this is a retrospective study on a small group of patients, it describes all of the percutaneous and minimally invasive procedures undergone in our Service for traumatic thoracolumbar fractures, representing our team's learning curve. Although the sample size lacks the power to create statistically relevant data, we have been able to pair the results of pre and postoperative measurements for segmental kyphosis and vertebral height, and also to obtain information which favors using these techniques. We highlight that half our patients were surgically treated in spite of the TLICSS being <4. This is a controversial point, because the available evidence[27] is not conclusive on the therapeutic reference pattern for burst fractures without neurological compromise.

We believe it is necessary to keep evaluating this series in the long term, paying much attention to the need of withdrawing the implant so as to define, on the basis of evidence, our working protocol with these minimally invasive techniques.

CONCLUSIONS

The treatment of traumatic thoracolumbar fractures by minimally invasive techniques was a safe procedure, with good clinical and radiological results by the end of follow-up. The rehabilitation and hospital stay times were comparable to those of other healthcare centers, although our complication rate was higher.

We are positive about using these techniques to treat selected thoracolumbar fractures and successfully reproducing the advantages reported by other authors.

Conflict of interests: Authors claim they do not have any conflict of interest.

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