

SHORT SEGMENT FIXATION OF THORACOLUMBAR FRACTURES WITH PEDICLE FIXATION AT THE LEVEL OF THE FRACTURE

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ABSTRACT

Thoracolumbar fractures are very frequent injuries, for both anatomical and biomechanical reasons. The most appropriate surgical treatment is still debatable. However, the main objectives are generally the restoration of segmental stability, correction of the deformity, decompression and protection of the neurological structures, and obtainment of rapid clinical-functional improvements.

The purpose of this study was to evaluate the efficacy and safety of thoracolumbar fracture fixation performed with short segment posterior fixation and insertion of undersized screws inside the fractured vertebra.

A prospective study was conducted among 80 patients that were treated after sustaining a thoracolumbar fracture from January 2010 to December 2017. The site of the fracture was dorsal in 35 cases, lumbar in 40 cases and multifocal in 5 cases.

58 patients were male and 22 female, with a mean age at diagnosis of 49.8 years.

42 patients were treated surgically using the studied technique(10 dorsal fractures and 32 lumbar).

38 patients were treated conservatively. At the clinical and instrumental follow-up, during a post-op period from a minimum of 6 months to a maximum of 18 months, the consolidation of the fracture was successfully achieved in all cases. In no case was there any worsening of the neurological situation or instrumental failure.

In the presence of vertebral fractures of the thoracolumbar tract without neurological damage, the posterior surgical treatment with short segment construct and insertion of undersized screw inside the fractured vertebra without arthrodesis (fusion), permits consolidation of the fracture and allows a rapid functional recovery, with minimal incidence of complications.

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1. Introduction

Thoracolumbar fractures are very frequent injuries, for both anatomical and biomechanical reasons[1]. To date, the most appropriate surgical treatment is still debatable. However, the main objectives are generally the restoration of segmental stability, correction of the deformity, and decompression and protection of neurological structures in order to obtain rapid clinical-functional improvements.

The posterior approach, which includes various surgical techniques, allows the appropriate treatment of most thoracolumbar injuries, also including those indirectly involving the anterior spinal region, without excluding the possibility of a second surgical intervention with an anterior somatic reconstruction.

The studied surgical technique of short segment posterior fixation and insertion of undersized screws without fusion involves the use of two pedicle screws in both the vertebra overlying the fracture and the one

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below the level of the fracture, as well as the introduction of two undersized screws inside the fractured vertebra. The use of these screws inserted at this level arises from the need to achieve greater stability of the segmental fixation without interfering with the biological healing process. In fact, some authors have reported that the insertion of short screws at the fracture level has ensured greater fixation stability and reduced the risk of implant failures [2,7-9]. The biggest clinical issue raised was the potential negative influence on fracture healing by the insertion of screws inside the two vertebra. In the selected cases, all treated with posterior instrumentation, posterolateral arthrodesis (fusion) was never performed. The purpose of this study was to evaluate the efficacy and safety of thoracolumbar fracture stabilization performed with short segment posterior fixation and insertion of undersized screws inside the fractured vertebra without arthrodesis (fusion).

2. Material and methods

A prospective data collection was performed from January 2006 to December 2017.

The types of fractures requiring surgery, based on the American Orthopedic (AO) classification system, consisted of 40 type A1 and 44 type A2 fractures (Table 1).

Description of population	Conservative	Surgery
Number of Patients	42	42
Average Age of Patients	49.8	49.7
Range of Age of Patients	19-64	18-64
Gender Ratio (M:F)	2.5(30:12)	2.5(30:12)
Work of Population (%)	Agricultural Activity: 12(28.57%) Industrial Sector: 22(52.38%) Tertiary Industry: 8(19.05%)	Agricultural Activity: 12(28.57%) Industrial Sector: 22(52.38%) Tertiary Industry: 8(19.05%)
Type of Accident: Number (%)	Fall from Height: 12(28.57%) Traffic Accident: 18(42.86%) Accident Agriculture: 12(28.57%)	Fall from Height: 12(28.57%) Traffic Accident: 18(42.86%) Accident Agriculture: 12(28.57%)
Type of Fractures According AO-Margel Classification: Number of A1(%) - Number of A2(%)	A1= 20(47.62%) A2= 22(52.38%)	A1= 20(47.62%) A2= 22(52.38%)
Level of Vertebral Body Fractured: Number (%)	T10= 3(7.14%) T11= 3(7.14%) T12= 4(9.52%) L1=14(33.33%) L2=14(30.95%) L3=4(11.92%)	T10= 3(7.14%) T11= 3(7.14%) T12= 4(9.52%) L1=14(33.33%) L2=14(30.95%) L3=4(11.92%)
Type of treatment	Conservative Three points brace	Open Short Poster Stabilization with undersized screws inside the fractured vertebral body, without arthrodesis

Table 1 - Study sample description

The reason for adopting the described surgical technique was based on the following inclusion criteria: reduction of vertebral height between 30-50%, retropulsed fragments into the spinal canal less than 50% of the sagittal diameter, intact neurological status or at least presence of incomplete lesion, absence of inverted fracture fragments in the spinal canal, absence of concomitant lesions in the adjacent discs.

The surgical steps required for the execution of this surgical technique are similar to those used in the classical posterior stabilization with short segment construct using pedicle screws and fixation bars. The main difference is the introduction of two undersized pedicle screws in the fractured vertebral body. The technique of screw introduction does not differ from the one used for the over and underlying vertebral bodies; the difference is represented by the shorter length of the screws in order to avoid interference with the biological process of callus formation. All cases required the introduction of 6 screws (as pointed out in the clinical cases reported as example) (Figure 1) in each patient with a single vertebra fracture, or 8 screws (Figure 2) in the case of a two-level fracture.



Figure 1 - Fractures of L1 Vertebral body without neurological deficit. CT and XR before the surgery and XR after the surgery.



Figure 2 - Fractures of L1 and L2 vertebral bodies. XR before the surgery and XR after the surgery. We did a long stabilization with 8 screws (4 undersized in L1 and L2 vertebral bodies). The CT shows the convergence of 2 screws.

Treatment in all cases used the Xia 2 surgical instruments from the Stryker Company. This study is based on the analysis of clinical-functional and instrumental results with a follow-up of at least 6 months (maximum 18 months), including radiographic and CT evaluation to study fracture healing, proper placement of the implants, correction of the deformity, and decompression of the neurological structures.

Results were evaluated using two of the assessment scales most widely used in international literature: Short-Form Health Survey (SF -36) and Oswestry Low Back Pain Disability Questionnaire.

The first is composed of 36 points designed to quantify 8 different aspects of the health status of the patient: perception of general health status, level of physical activity, limitation due to physical health, bodily pain, general mental health, limitation due to emotional problems, vitality degree and social activities. The score of each scale is calculated from 0 to 100. The second rating scale evaluates the pain related disability index. The questionnaire includes ten items represented by pain intensity, personal care, lifting, walking, sitting down, standing position, sleep, social life, traveling, changes in work and daily life, all pain related. These 10 items describe the disability level. Each one of them includes a score from 0 to 5 to indicate the impact of pain (0 = no effect, 50 = maximum impact). The total score is the sum of the scores obtained.

Patients' notes and electronic hospital records were also used to perform our data collection. Data were recorded using Microsoft Excel. This was followed by data analysis with statistical calculation.

The study was conducted in accordance with the principles of the Declaration of Helsinki and its amendments and informed consent was given by all included patients.

This type of paper does not need Ethical Approval Committee.

3. Results

84 patients (60 males, 24 females, ratio: 2.5) who sustained thoracolumbar fractures were included in this study. They were treated at a single specialist center. The mean age at diagnosis was 49.8 years (range from 19 to 64 years). The site of the fracture was dorsal in 35 cases, lumbar in 40 cases and multifocal in 9 cases.

42 patients (10 dorsal fractures and 32 lumbar fractures) were treated surgically using the studied technique, while the remaining received conservative treatment.

42 patients out of the total of 80 (10 dorsal fractures and 32 lumbar fractures) were treated surgically using the studied technique (ratio surgical/conservative treatment 0.52). It was not possible to follow-up 3 of the 42 surgically treated patients as the inclusion criteria of a minimum follow-up period of 6 months was not matched. The mean age at diagnosis was 49.8 years (range from 19 to 64 years). Etiology of the injury: fall from height (27.5%), traffic accident (43.6%), agriculture accident (28.9%). Type of fracture according to AO-Magerl Classification: 47.6% A1, 52.4% A2. Level of fractured vertebral body: 7.14% T10, 7.14% T11, 9.52% T12, 33.33% L1, 30.95% L2, 11.92% L3.

In all cases, it was observed that there was no significant blood loss intraoperatively and neither blood transfusions or blood products were required during the surgical procedures or the postoperative period. There was no need to use any rigid orthopedic braces during the postoperative care protocol. Sitting position and early mobilization were permitted on the second day post-op. Good consolidation of the fracture was achieved in all 39 cases (in absence of significant kyphotic deformity) at the clinical and radiological follow-up organized from a minimum of 6 months to a maximum of 18 months. No case showed worsening of the neurological situation or evidence of instrumental failure.

Good and excellent results were recorded in all cases from a clinical-functional point of view. Results obtained with the Short-Form Health Survey were recorded as follows: a mean score of 92 (87-96) in the postoperative period of at least 6 months' time. Results obtained in our

case histories with the Oswestry Low Back Pain Disability Questionnaire were recorded as follows: average score of 5 (from a minimum of 3 to a maximum of 9).

4. Discussion

Short-segment pedicle screw instrumentation constructs for the treatment of thoracolumbar fractures gained popularity in the 1980s[10-16]. The load-sharing classification (LSC) is a straightforward way to describe the extent of bony comminution, amount of fracture displacement, and amount of correction of kyphotic deformity in a spinal fracture[10-16]. There are no studies evaluating the relevance of fracture comminution/traumatic kyphosis on the long-term radiologic outcome of burst fractures treated by short-segment instrumentation with screw insertion in the fractured level[6].

There are several posterior surgical techniques currently employed to treat thoracolumbar fractures, and a large number of biomechanical studies suggest that reinforcement with a fracture-level screw combination can help to improve the biomechanical stability[17]. Li et al.[17] compared the von Mises stresses of the internal fixation devices among different short segment pedicle screw fixation techniques to treat 12 thoracic vertebral fractures, especially the mono-segment pedicle screw fixation and intermediate unilateral pedicle screw fixation techniques.

Comparing the stress between different spinal loadings, the maximal von Mises stress of the implants were observed in flexion in all implanted models. It was concluded that an additional pair of bilateral pedicle screws at the level of the fracture to SPSF may result in a stiffer construct and less von Mises stress for pedicle screws and rods. The largest maximal von Mises stress of the pedicle screws during all states of motion were observed in the mono-segment pedicle screw fixation technique[17]. Kose et al.[18] evaluated and compared the effect of short segment pedicle screw instrumentation and an intermediate screw (SSPI+IS) on the radiological outcome of type A thoracolumbar fractures, as judged by the load-sharing classification, canal area reduction percentage and remodelling. 39 patients who had undergone hyperlordotic SSPI+IS for an AO-Magerl Type-A thoracolumbar fracture were retrospectively evaluated. Their mean age was 35.1 (16 to 60) and the mean follow-up was 22.9 months (12 to 36). No patient needed revision for loss of correction or failure of instrumentation. Hyperlordotic reduction and short segment pedicle screw instrumentation with the adjunct of an intermediate screw is a safe and effective method of treating burst fractures of the thoracolumbar spinal tract. It provides excellent radiological results with a very low rate of failure, regardless of whether or not the fractures have a high or low load-sharing classification score[18]. Pellisè et al.[6] carried out a retrospective study analysis of 86 patients with non-osteoporotic thoracolumbar burst fractures managed with a six-screw construct in a single university hospital, with more than 2 years postoperative follow-up. They measured the clinical outcomes with radiologic parameters (regional kyphosis [RK], local kyphosis, and thoracolumbar kyphosis [TLK]) to evaluate the degree and loss of correction. It was concluded that the six-screw construct is effective for treating thoracolumbar junction burst fractures. The medium-to-long-term loss of correction is affected by the amount of bony comminution of the fracture, objectified through the LSC score[6]. Conventionally, short-segment fusion involves instrumentation

of one healthy vertebra above and below the injured vertebra, skipping the injured level. This short-segment construct places less surgical burden on the patient compared with long-segment constructs, but is less stable biomechanically, and thus has resulted in clinical failures. The addition of two screws placed in the fractured vertebral body represents an attempt to improve the construct stiffness without sacrificing the benefits of short-segment fusion[19].

Norton et al.[19] studied the L1 axial load injury pattern on cadaveric spines. Relative motion in terms of vertical and axial rotations was not significantly different between the two groups. The L1-L2 rod strain was significantly increased in the six-screw construct compared with the four-screw construct ($p < .001$). They concluded that in a cadaveric L1 axial load fracture model, a six-screw construct with screws in the fractured level is more rigid than a four-screw construct that skips the injured vertebral body[19]. Liu C et al.[20] evaluated the curative effect of short-segment transpedicular fixation plus vertebra fracture fixation for thoracolumbar burst fractures in patients with osteoporosis. The clinical data of thoracolumbar burst fractures in 46 patients with osteoporosis, single segment fracture and neurological intactness, were analyzed retrospectively from January 2008 to January 2012. There were 20 males and 26 females with a mean age of 64.5 (56-78) years. The mechanisms of injury were fall ($n = 20$), traffic accident ($n = 12$), high falling injury ($n = 8$) and heavy pound injury ($n = 4$). The involved vertebrae included T11 ($n = 5$); T12 ($n = 17$); L1 ($n = 21$); L2 ($n = 3$). Pedicle screws were inserted into injured vertebra and the height of collapsed vertebra fractures was reduced with position and instrument. Visual analogue scale (VAS) and short form-36 scoring systems were used to evaluate pain level and quality of life. The height restoration and kyphotic correction rates of fracture level were measured radiologically. All patients underwent surgery safely without severe complications. Their conclusion was that the approach of short-segment transpedicular fixation plus vertebra fracture fixation is safe and effective to maintain proper reduction and reduce the rate of correction loss and instrument failure [20]. Moelmer et al.[21] reported in their retrospective study that health-related quality of life is affected several years after short segment posterior instrumentation of thoracolumbar fractures without neurological deficit.

The management of thoracolumbar fractures also includes percutaneous procedures and conservative management. Previous studies have tried to compare the management of Magerl's A1 and A2 thoracolumbar fracture in adults with percutaneous posterior stabilization and conservative management with 3 point spinal brace. Preliminary results showed that there are considerable advantages in functionality and pain for the treatment of these patients with percutaneous posterior stabilization as this allows the achievement of good and functional alignment of the spine at the end of the treatment. [22]

A prospective study comparing the use of dynamic corsets and 3-point braces in the treatment of osteoporotic thoracolumbar compression fractures showed that patients treated with dynamic orthosis had a greater reduction of pain and improvement in quality of life and respiratory function, with equally good and effective stabilization of the fracture and fewer complications. This means that the biofeedback activation of back muscles is probably a key factor in improving functional outcomes with dynamic orthosis [23].

Despite the fact that conservative treatments have achieved good results for certain types of thoracolumbar fractures, the involvement of three

columns, progressive neurological deficit, significant kyphosis and canal compromise with neurological deficit are accepted, well recognized indications for surgical stabilization through anterior, posterior or combined approaches [24,25].

5. Conclusions

Given the results recognized in the international literature and the ones obtained through our study, it appears that our results further confirm the advantages of the use of the study surgical technique for thoracolumbar fractures. This is evidenced by the very low complication rate, satisfactory and quick post-op rehabilitation, good consolidation of the fractures, and lastly, by the good/excellent clinical-functional results. The results of this study show that this technique is a safe option with good results and a low complication rate, equaling and even improving the results of the bibliography published to date. Furthermore, in its favor, this is a prospective study with a long-term follow-up and a population similar to the previously published studies. On the other hand, evaluating the limitations, the selection of patients is not randomized, leaving it up to the judgment of the surgical team as to which patients fulfilled the surgical criteria presented and which did not. Additionally, the associated injuries that may affect both the follow-up and the final results are not indicated.

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