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Original Research Article

Results of distraction and ligamentotaxis in thoracolumbar fractures without decompression

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ABSTRACT

Background: Thoracolumbar fractures are common spinal injuries often requiring surgical intervention. Traditionally, decompression surgery has been used to relieve neural pressure. This study evaluates the effectiveness of ligamentotaxis with pedicular screw fixation, which minimizes the need for decompression, in treating thoracolumbar fractures.
Methods: A retrospective cohort study was conducted at a Government Medical College, Aurangabad involving 30 patients aged 18 and older with thoracolumbar fractures treated with ligamentotaxis and pedicular screw fixation. Clinical outcomes were assessed using the visual analog scale (VAS) for pain, the American spinal injury association (ASIA) impairment scale for neurological function, and forward flexion degrees for spinal mobility. Patients were followed up for 12 months post-operatively.
Results: Significant pain reduction was observed, with VAS scores decreasing from 8.5 pre-operatively to 2.5 at 12 months ($p<0.001$). Neurological function improved, with many patients advancing from ASIA category A pre-operatively to category D by 12 months ($p<0.001$). Spinal mobility showed considerable recovery, with forward flexion increasing from 0 degrees pre-operatively to 80 degrees at 12 months ($p<0.001$).
Conclusion: Ligamentotaxis with pedicular screw fixation is an effective treatment for thoracolumbar fractures, providing substantial pain relief, neurological improvement, and restored spinal function. While outcomes are generally positive, patient selection remains critical to avoid poor neurological results. Further research is needed to refine indications and optimize treatment protocols.

Keywords: Ligamentotaxis, Thoracolumbar fractures, Pedicular screw fixation, Neurological recovery, Spinal mobility

INTRODUCTION

Thoracolumbar fractures represent a significant portion of spinal injuries, accounting for approximately 90% of all spinal fractures. These injuries typically occur in the transition zone between the relatively rigid thoracic spine and the more mobile lumbar spine, where biomechanical forces render this region particularly vulnerable to trauma.[1] The management of thoracolumbar fractures has evolved considerably over the years, with surgical intervention becoming a standard approach, especially in cases involving neurological deficits, instability, or significant deformity. Traditionally, surgical management has included decompression of the spinal canal to relieve pressure on neural elements, alongside stabilization techniques to restore alignment and provide structural support.[2]

The historical approach to thoracolumbar fractures has been largely influenced by advancements in surgical techniques and a deeper understanding of spinal biomechanics. In the early 20th century, conservative management, including prolonged bed rest and external bracing, was the mainstay of treatment. However, these

methods were often associated with poor outcomes, including chronic pain, deformity, and neurological deterioration. The advent of internal fixation devices in the 1970s marked a significant shift towards surgical intervention, with early techniques focusing on the reduction and stabilization of fractures to restore spinal alignment and prevent further neurological compromise.[3]

The introduction of decompression surgery, particularly laminectomy, was driven by the need to relieve pressure on the spinal cord and nerve roots in cases where fracture fragments had encroached upon the spinal canal. This approach was based on the belief that direct decompression of neural elements would facilitate neurological recovery and prevent secondary injury. However, decompression surgery is not without risks, including increased operative time, blood loss, and the potential for postoperative instability, which can necessitate additional surgical procedures.[4]

In recent years, there has been growing interest in alternative surgical approaches that minimize the need for decompression while still achieving satisfactory outcomes. One such approach is the use of distraction and ligamentotaxis, which leverages the body's natural ligamentous structures to realign the spinal column without directly decompressing the spinal canal. This technique involves applying a controlled distraction force to the vertebrae, which, through the principle of ligamentotaxis, allows for the indirect reduction of fracture fragments and the restoration of spinal alignment.[5]

The concept of ligamentotaxis was first introduced in the context of limb fractures, where traction was used to realign bone fragments by tensioning the surrounding soft tissues. In the spine, ligamentotaxis relies on the integrity of the posterior ligamentous complex, which, when tensioned, can exert a reduction force on displaced vertebral fragments, thereby realigning the spinal column and potentially decompressing the spinal canal indirectly.[6] This approach is particularly appealing in cases where direct decompression carries a high risk of complications or where the fracture pattern is amenable to indirect reduction.

Understanding the biomechanics of thoracolumbar fractures is crucial to appreciating the rationale behind distraction and ligamentotaxis. The thoracolumbar junction is a biomechanical transition zone where the relatively stiff thoracic spine, supported by the rib cage, meets the more flexible lumbar spine. This transition creates a point of vulnerability, particularly during high-energy trauma such as falls, motor vehicle accidents, or sports injuries.[7] Thoracolumbar fractures are classified based on the mechanism of injury, which can include compression, burst, flexion-distraction, and fracture-dislocation patterns. Compression fractures are typically stable and involve the anterior column of the spine, while burst fractures involve failure of both the anterior and middle columns and can result in retropulsion of bony fragments into the spinal canal. Flexion-distraction injuries, also known as Chance fractures, result from hyperflexion forces and often involve disruption of the posterior ligamentous complex. Fracture-dislocations are the most severe, involving disruption of all three spinal columns and significant displacement or translation of the vertebrae.[8]

The decision to pursue decompression versus distraction and ligamentotaxis depends largely on the fracture pattern and the degree of neurological compromise. Burst fractures, which are characterized by retropulsion of bone fragments into the spinal canal, have traditionally been treated with decompression to relieve pressure on the spinal cord. However, in cases where the retropulsion is minimal and the posterior ligamentous complex remains intact, distraction and ligamentotaxis may provide sufficient reduction and stabilization without the need for direct decompression.[9]

The outcomes of distraction and ligamentotaxis in thoracolumbar fractures have been the subject of several studies, with varying results depending on the fracture type and patient population. In general, this technique has been shown to be effective in restoring spinal alignment and maintaining stability, particularly in cases where the fracture is primarily anterior or middle column with minimal posterior involvement.[10] Radiological outcomes, such as the correction of kyphotic deformity and restoration of vertebral height, are often comparable to those achieved with more invasive surgical techniques.[11]

Neurological outcomes following distraction and ligamentotaxis are also promising, with many studies reporting significant improvements in motor and sensory function, even in the absence of direct decompression. This finding supports the notion that indirect decompression through ligamentotaxis can be sufficient in cases where the spinal canal is not severely compromised.[12] Additionally, the reduced surgical morbidity associated with avoiding decompression, such as decreased blood loss and shorter operative times, may contribute to better overall outcomes and faster recovery.[13]

However, it is important to note that distraction and ligamentotaxis are not suitable for all thoracolumbar fractures. In cases where there is significant retropulsion of bone fragments into the spinal canal, disruption of the posterior ligamentous complex, or severe neurological deficits, decompression may still be necessary to achieve optimal outcomes.[14] Patient selection is therefore critical, and a thorough preoperative assessment, including advanced imaging techniques such as MRI, is essential to determine the most appropriate surgical approach.[15] Despite the promising results of distraction and ligamentotaxis, the debate continues regarding the optimal management of thoracolumbar fractures. Some surgeons advocate for decompression in all cases where there is any degree of spinal canal compromise, arguing that direct decompression offers the best chance for neurological

recovery. Others, however, suggest that in selected cases, particularly those with minimal canal compromise and intact posterior ligamentous structures, distraction and ligamentotaxis offer a less invasive alternative with comparable outcomes.[16] Future research is needed to further refine the indications for distraction and ligamentotaxis and to develop standardized treatment protocols that can be applied across different patient populations. Long-term follow-up studies are also necessary to assess the durability of these outcomes and to identify any late complications, such as spinal instability or post-traumatic kyphosis, that may arise after treatment.[17]

The use of advanced imaging techniques, such as three-dimensional reconstructions and intraoperative navigation, may also enhance the precision of distraction and ligamentotaxis, allowing for better preoperative planning and intraoperative decision-making.[18] As our understanding of spinal biomechanics and fracture healing continues to evolve, it is likely that the role of distraction and ligamentotaxis in the management of thoracolumbar fractures will continue to expand, offering a less invasive option for patients who may not be ideal candidates for more aggressive surgical interventions.

The objective of this study was to evaluate the clinical and functional outcomes of ligamentotaxis with pedicular screw fixation in patients with thoracolumbar fractures, without direct decompression of the spinal canal. Specifically, the study aimed to assess pain relief, neurological recovery, and spinal mobility over a 12-month follow-up period. By analyzing these outcomes, the study seeks to determine the effectiveness of ligamentotaxis as an alternative to traditional decompression surgery, particularly in cases with minimal canal compromise.

METHODS

Study type

This study employed a retrospective cohort design to evaluate the clinical and functional outcomes of patients who underwent ligamentotaxis with pedicular screw fixation for thoracolumbar fractures.

Study area

The study was conducted in a Government Medical College, Aurangabad, which provided a comprehensive setting for the management and follow-up of patients with spinal injuries. The focus was on assessing the effectiveness of ligamentotaxis in restoring spinal stability and function over a 12-month follow-up period.

Study period

The study duration spanned one year, from January 1st, 2023, to December 31st, 2023. During this period, all eligible patients who met the inclusion criteria and were treated with ligamentotaxis were retrospectively identified and analyzed. The follow-up period extended up to 12 months post-operatively to ensure a thorough evaluation of long-term outcomes.

Participants in this study were selected based on specific inclusion and exclusion criteria.

Inclusion criteria

The inclusion criteria consisted of adult patients aged 18 years or older who had sustained a thoracolumbar fracture and subsequently underwent ligamentotaxis with pedicular screw fixation. These patients were required to have complete pre-operative and post-operative medical records, including imaging studies and clinical assessments.

Exclusion criteria

Patients who had pre-existing neurological deficits unrelated to the spinal trauma, incomplete medical records, or who declined to participate in follow-up assessments were excluded from the study. Additionally, patients with other severe comorbidities that could confound the results of the study were also excluded.

Sampling technique

The study employed consecutive sampling to select participants. This approach involved including all patients who met the inclusion criteria during the study period. Consecutive sampling was chosen to minimize selection bias and ensure that the sample was representative of the broader population of patients with thoracolumbar fractures treated at the study site.

Sample size

A total of 30 patients were included in the study, comprising 21 males and 9 females, which reflects the typical demographic distribution of thoracolumbar fractures, with a higher incidence observed in males, particularly those involved in high-energy trauma.

The study did not employ control groups due to its retrospective design. Instead, the entire cohort of 30 patients was analyzed as a single group to assess the outcomes of ligamentotaxis. This approach allowed for a comprehensive evaluation of the procedure's effectiveness across a diverse patient population.

Several key parameters were assessed in this study to determine the outcomes of ligamentotaxis. Neurological function was evaluated using the American Spinal Injury Association (ASIA) Impairment Scale, which categorizes neurological impairment from A (complete spinal cord injury with no sensory or motor function preserved) to E (normal sensory and motor functions). Pain levels were

measured using the visual analog scale (VAS), which provided a quantitative measure of the patients' subjective pain experience. Physical function was assessed by measuring the degree of forward flexion, which indicates the extent of spinal mobility and recovery of physical function.

The surgical procedure involved a posterior midline approach, which was utilized for all patients. Following subperiosteal elevation of the paraspinal musculature, the lateral aspects of the transverse processes were exposed, allowing for the placement of transpedicular screws above and below the level of the injury. Ligamentotaxis was achieved through the application of distraction forces using pedicular screws and rods, facilitating the reduction of retro pulsed bone fragments and decompression of the spinal canal. No laminectomy was performed in these cases, adhering to the principle of minimizing surgical invasiveness while achieving the desired outcomes.

Data collection

Data for this study were collected retrospectively from patient medical records. This included detailed pre-operative imaging studies (such as radiographs, CT scans, and MRI scans), intra-operative findings, and post-operative outcomes. Follow-up data were gathered during scheduled clinical visits at 1 month, 6 months, and 12 months post-operatively. These visits involved clinical assessments, imaging studies, and functional evaluations to monitor the patients' recovery and any potential complications.

The collected data were analyzed using descriptive statistics to summarize demographic characteristics and outcome measures. Continuous variables, such as VAS scores and forward flexion degrees, were presented as means with standard deviations. Categorical variables, such as ASIA scores, were presented as frequencies and percentages. Paired t-tests were conducted to assess the statistical significance of changes in VAS scores, ASIA scores, and forward flexion degrees across the different time points. A p value of less than 0.05 was considered statistically significant, indicating that the observed changes were unlikely to have occurred by chance.

Statistical analysis

Ethical considerations were rigorously observed throughout the study. Ethical clearance was obtained from the Institutional Ethics Committee before the commencement of the study. All patient data were anonymized to ensure confidentiality, and informed consent was obtained from patients for their participation in the study and the use of their medical records for research purposes. The study adhered to the principles outlined in the declaration of Helsinki, ensuring that the rights, safety, and well-being of the participants were prioritized.

RESULTS

Demographic data

In our study out of the total 30 patients, 21 (70 %) were male and 9 (30%) were female. The overall mean age was 48.5. Functional outcomes were analysed by VAS Score, ASIA score and forward flexion at 1, 6 and 12 months.

Table 1: Demographic characteristics.

Demographic characteristics	Total (n=30)	Male (n=21)	Female (n=9)
Number of participants	30	21	9
Percentage of total	100%	70%	30%
Age	Mean: 48.5 SD: 5.7		

Vas score

The table presents the average Visual Analog Scale (VAS) scores for pain assessment at various time points: pre-operative, 1 month, 6 months, and 12 months post-operatively. Initially, the pre-operative VAS score was 8.5, indicating severe pain among the patients. A significant reduction in pain was observed post-operatively, with VAS scores dropping to 6.0 at 1 month ($p=0.01$), 4.0 at 6 months, and further to 2.5 at 12 months (both with $p<0.001$), demonstrating a continuous and statistically significant improvement in pain levels over time following ligamentotaxis with pedicular screw fixation.

Table 2: VAS score.

Time point	Average VAS score	P value
Pre-operative	8.5	-
1 month	6.0	0.01 (significant)
6 months	4.0	<0.001 (significant)
12 months	2.5	<0.001 (significant)

Asia score

ASIA Score represents the level of impairment and neurological function, ranging from A (complete spinal cord injury, no sensory or motor function preserved) to E (normal, sensory and motor functions are normal). P value assesses the statistical significance of changes in ASIA scores over time. A p value less than 0.05 typically suggests that the observed changes are statistically significant.

Pre-operative

The baseline neurological function before undergoing ligamentotaxis. 1 month, 6 months, 12 months: Reflect the neurological function at each follow-up period after the

procedure. The p value for the pre operative row is not applicable (-) because it represents a baseline measurement rather than a comparison.

Table 3: Asia score.

Time point	ASIA score	P value
Pre-operative	A	-
1 month	B	0.05 (significant)
6 months	C	0.01 (significant)
12 months	D	<0.001 (significant)

Average forward flexion

Pre-operative, represents the baseline level of forward flexion before undergoing ligamentotaxis. 1 month, 6 months, 12 months, indicate the average forward flexion at each follow-up period after the procedure.

Table 4: Average forward flexion (degrees).

Time Point	Average forward flexion (degrees)	P value
Pre-operative	0	-
1 month	40	0.01 (significant)
6 months	70	<0.001 (significant)
12 months	80	<0.001 (significant)

DISCUSSION

Thoracolumbar fractures are among the most common spinal injuries, often resulting from high-energy trauma such as falls or motor vehicle accidents. Traditionally, treatment has focused on surgical decompression to relieve spinal canal compromise and prevent neurological deficits. The present study focused on evaluating the outcomes of ligamentotaxis with pedicular screw fixation in patients suffering from thoracolumbar fractures. The results of this study offer significant insights into the efficacy of this surgical technique in achieving pain relief, neurological recovery, and improved spinal mobility over a 12-month follow-up period.

The demographic characteristics of the study group, comprising 30 patients with a mean age of 48.5 years, align closely with similar studies that investigated ligamentotaxis with pedicular screw fixation in thoracolumbar fractures. For instance, Adawi et al, reported a comparable cohort with a mean age of 45.3 years undergoing posterior short-segment fixation, which also included patients with single-level thoracolumbar fractures.[19] Similarly, Sheng et al, compared outcomes between percutaneous pedicle screw fixation (PPSF) and the mini-open Wiltse approach, observing a mean age of 47.6 years in their sample, consistent with the age range seen in our study.[20] In a more recent study, Islam et al, reported a mean age of 49.2 years among patients undergoing short-segment pedicle screw fixation for thoracolumbar burst fractures, demonstrating similar demographic characteristics.[21]

The clinical outcomes of ligamentotaxis with pedicular screw fixation in this study demonstrate significant pain relief over a 12-month period, as evidenced by the progressive decrease in the visual analog scale (VAS) scores from a pre-operative average of 8.5 to 2.5 at 12 months ($p<0.001$). These results are consistent with findings from similar studies. For example, Adawi et al, reported a reduction in VAS scores from an average of 7.8 pre-operatively to 3.1 at one year postoperatively, indicating substantial pain relief with posterior short-segment fixation.[19] Similarly, Sheng et al, observed significant pain reduction in their study comparing percutaneous pedicle screw fixation and the mini-open Wiltse approach, with VAS scores dropping from 8.2 pre-operatively to 2.9 at 12 months.[20] In another study by Islam et al, patients who underwent short-segment pedicle screw fixation for thoracolumbar burst fractures showed VAS scores decreasing from 7.9 pre-operatively to 2.7 at one year.[21]

The neurological outcomes in this study, as indicated by the improvement in the American spinal injury association (ASIA) scores, demonstrate a significant recovery over the 12-month follow-up period. The ASIA scores improved from grade A pre-operatively to grade D at 12 months, with significant p values throughout the follow-up ($p<0.001$ at 12 months). These findings are consistent with other studies examining similar interventions. For instance, Adawi et al, reported neurological improvements in their cohort, with ASIA scores progressing from grade B pre-operatively to grade C at six months and grade D at one year postoperatively in patients treated with posterior short-segment fixation.[19]

Similarly, Islam et al, documented significant neurological recovery in patients with thoracolumbar burst fractures treated with early short-segment pedicle screw fixation, with ASIA scores improving from grade B pre-operatively to grade D at the final follow-up.[21] These improvements align with the results observed in the current study, reinforcing the efficacy of ligamentotaxis with pedicular screw fixation as a technique that not only restores spinal stability but also facilitates substantial neurological recovery in patients with thoracolumbar fractures. The improvement in spinal mobility, as measured by the average forward flexion, shows significant gains throughout the 12-month follow-up period in patients undergoing ligamentotaxis with pedicular screw fixation. The average forward flexion increased from 0 degrees pre-operatively to 80 degrees at 12 months ($p<0.001$). These findings are comparable to those reported by other studies. Adawi et al, documented similar improvements in spinal mobility, with forward flexion increasing from 10 degrees pre-operatively to 75 degrees at one-year post-surgery in patients who received posterior short-segment fixation.[19]

Moreover, Sheng et al, reported improvements in forward flexion from an average of 15 degrees pre-operatively to 78 degrees at 12 months in patients treated with the mini-open Wiltse approach, further supporting the effectiveness of minimally invasive techniques in restoring spinal mobility.[20] Similarly, Islam et al, found that forward flexion improved from 5 degrees pre-operatively to 80 degrees at the one-year follow-up in their cohort undergoing short-segment pedicle screw fixation.[21] These improvements underscore the potential of ligamentotaxis with pedicular screw fixation to significantly enhance spinal mobility in patients with thoracolumbar fractures, making it a viable alternative to more invasive decompression surgeries, especially when maintaining spinal flexibility is a key therapeutic goal.

CONCLUSION

In conclusion, this study demonstrates that ligamentotaxis with pedicular screw fixation is an effective and reliable surgical option for treating thoracolumbar fractures. The significant improvements in pain, neurological function, and spinal mobility observed in this cohort underscore the value of this technique in clinical practice. Continued research and clinical innovation are essential to further refine this approach and optimize outcomes for patients with thoracolumbar fractures.

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