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ORIGINAL RESEARCH

Posterior Segmental Stabilization of Adult Thoracolumbar Junction Fractures: Single-Surgeon, Single-Center Experience

Oğuz ALTUNYUVA[1], Nur BALÇIN[1], Hanside Setenay ÜNAL[2], Ali İmran ÖZMARASALI[3]

[1] Bursa Çekirge State Hospital, Neurosurgery Clinic, Bursa, Türkiye.
[2] Hakkari Yüksekova State Hospital, Neurosurgery Clinic, Hakkari, Türkiye.
[3] Bursa City Hospital, Department of Neurosurgery, Bursa, Türkiye.

ABSTRACT

Thoracolumbar junction fractures (TLJF) are critical spinal injuries frequently associated with neurological deficits and internal organ trauma. This retrospective study evaluated 21 adult patients with TLJF who underwent posterior segmental instrumentation between May 2022 and September 2024. Demographic features, trauma mechanisms, neurological status, fracture classifications, and surgical outcomes were analyzed. Laminectomy was performed in 14 patients with significant canal compromise, while short-segment posterior instrumentation was preferred in cases with intact posterior elements. During follow-up, most patients showed significant pain reduction and neurological improvement. Early surgical decompression and stabilization in neurologically compromised patients were associated with better clinical outcomes. Posterior segmental instrumentation remains a reliable treatment method, though long-term studies comparing short- and long-segment stabilization are needed.

Keywords: Thoracolumbar fracture. Thoracolumbar Junction. Posterior Segmental Instrumentation. Adult Spinal Trauma.

Erişkin Torakolomber Bileşke Kırıklarında Posterior Segmental Stabilizasyon: Tek Cerrahın Tek Merkezli Deneyimi

ÖZET

Torakolomber bileşke kırıkları (TLBK), sıklıkla nörolojik defisitler ve iç organ yaralanmaları ile birlikte görülen kritik omurga travmalarıdır. Bu retrospektif çalışmada, Mayıs 2022 - Eylül 2024 tarihleri arasında posterior segmental enstrümantasyon cerrahisi uygulanan 21 erişkin hasta değerlendirildi. Demografik özellikler, travma mekanizmaları, nörolojik durum, kırık sınıflamaları ve cerrahi sonuçlar analiz edildi. Belirgin kanal basısı olan 14 hastada laminektomi uygulanırken, posterior elemanları sağlam olan olgularda kısa segment enstrümantasyon tercih edildi. Takip sürecinde çoğu hastada anlamlı ağrı azalması ve nörolojik iyileşme gözlendi. Nörolojik defisitli hastalarda erken dönemde yapılan cerrahi dekompresyon ve stabilizasyon daha iyi klinik sonuçlarla ilişkili bulundu. Posterior segmental enstrümantasyon güvenilir bir tedavi seçeneği olup kısa ve uzun segment tekniklerinin karşılaştırıldığı uzun dönem çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Torakolomber fraktür. Torakolomber Bileşke. Posterior Segmental Enstrümantasyon. Yetişkin Omurga Travması.

Thoracolumbar junction fractures (TLJF) involve fractures of the T10-L2 vertebrae[1]. This region represents a transition zone from the relatively stable thoracic spine, supported by the rib cage, to the more mobile lumbar spine. TLJFs, commonly resulting from high-energy trauma, account for 10-20% of all spinal fractures[2,3]. Neurological deficits are observed in approximately 15% of TLJF cases, often warranting urgent surgical intervention[4]. While the majority of fractures at this level are compression fractures, they can also present as burst fractures, flexion-distraction injuries, or fracture-dislocations[5]. Due to their anatomical location, these fractures may also be associated with internal organ injuries, posing a risk of high mortality. Therefore, understanding the mechanism of fracture, distinguishing between stable and unstable fractures, and selecting the appropriate surgical technique are critical factors in the management of TLJF.

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Dr. Oguz ALTUNYUVA
Neurosurgeon
Bursa Cekirge State Hospital, Neurosurgery Clinic
E-Mail: dr.oguzaltunyuva@gmail.com

AUTHORS' ORCID INFORMATION
Oguz ALTUNYUVA: 0000-0002-3450-0471
Nur BALCIN: 0000-0003-3928-8606
Hanside Setenay UNAL: 0000-0003-3546-3200
Ali Imran OZMARASALI: 0000-0002-7529-2808

In our study, we retrospectively analyzed patients with TLJF who underwent posterior instrumentation surgery using posterior segmental instrumentation techniques and aimed to discuss the findings in the context of current literature.

Material and Method

A total of 21 cases operated on by a single surgeon (OA) between May 2022 and September 2024 were retrospectively reviewed. This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by ethics committee.

A total of 21 cases, retrospectively reviewed, were from the adult age group (>18 years). Medical records were analyzed for age, gender, comorbidities, trauma mechanism, internal organ injury, additional pathologies, time to surgery, fracture location, neurological symptoms and findings, postoperative follow-up processes, and outpatient control records. Conventional X-ray and thoracolumbar computed tomography (CT) were performed in the diagnostic process of all cases, and preoperative thoracolumbar magnetic resonance imaging (MRI) was conducted for patients requiring further evaluation based on the mTLICS fracture classification protocol. Postoperatively, CT scans were used to assess decompression adequacy and the positioning of stabilization materials in all cases. During the initial outpatient follow-up, X-rays were taken to recheck the instrumentation materials. The modified TLICS (mTLICS) scoring system was used for surgical decision-making. Visual analog scale (VAS) scores were examined to assess pain levels during preoperative and postoperative follow-up. In cases with neurological deficits, the Frankel Classification (ASIA scale) was used to evaluate neurological status during both preoperative and postoperative follow-up. Cases without surgical indications following acute trauma (mTLICS<5) but requiring late-stage surgery due to kyphotic deformity or increased compression during follow-up were excluded from the study.

Patients with an mTLICS score of 5 or higher underwent posterior segmental instrumentation surgery. Laminectomy was performed in cases with free fragments in the canal, neurological deficits, severe kyphotic angulation, and spinal canal stenosis (Figure 1). Patients with stable general condition, neurological symptoms, and no significant internal organ injury were operated on within the first 3 hours following trauma. Preoperative antibiotic prophylaxis was administered to all cases. Patients were monitored in the clinical or intensive care unit for 4 to 14 days and were mobilized as early as possible in the postoperative period. All patients with neurological deficits were referred to the physical therapy and rehabilitation clinic, where physiotherapy treatment was provided based on recommendations. During the postoperative period, patients used a thoracolumbar steel-reinforced brace for 4 to 12 weeks.

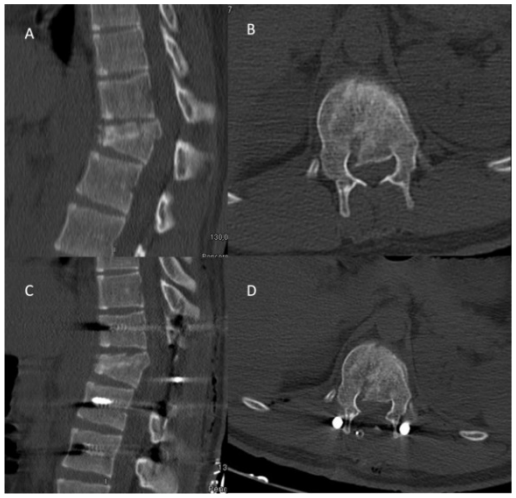

Figure 1.
Preoperative and postoperative thoracolumbar CT images of an 18-year-old patient with neurological deficit brought to our emergency department due to a T12 burst fracture after a motorcycle accident. A: Preoperative T12 burst fracture showing anterior kyphotic angulation and irregularity in the posterior wall of the vertebral body. B: Axial view showing spinal canal narrowing caused by the indentation of the posterior vertebral body at the T12 level. C: Postoperative sagittal view following T11-L1-2 stabilization and laminectomy. D: Postoperative decompression appearance of the spinal canal after laminectomy.

Results

Of the cases, 15 (71.4%) were male, and 6 (28.6%) were female. The mean age was 46.3±18.8 years. Hypertension (HT) was the most common comorbidity in the medical history of the patients. Regarding trauma mechanisms, the most frequent cause was falling from height in 7 cases (33.3%), followed by motor vehicle accidents (MVA) in 6 cases (28.6%), with 3 cases each of suicide attempts and motorcycle accidents, and 2 cases (9.5%) of pedestrian traffic accidents. Fourteen cases (66.7%) presented with neurological deficits. Four cases (19%) had spinal fractures in regions other than the thoracolumbar junction. The most commonly fractured vertebrae were T12, L1, T11, and L2, respectively. One case required surgery for fractures at both T11 and T12 vertebral levels. Two cases had isolated abdominal organ injuries, while three cases had both thoracic and abdominal organ injuries. Orthopedic fractures requiring follow-up or treatment were identified in 10 cases (47.6%). Cranial injuries that did not require surgical intervention were detected in 2 cases (9.5%). The mean follow-up duration was 12.1±13.9 months (Table I, II).

Table I. Demographic Data and Findings

Variable	n=21(%)
Gender	
Male	15 (71.4)
Female	6 (28.6)
Mean Age (years)	46.3±18.8
Comorbidities	
Hypertension (HT)	7 (33.3)
Diabetes Mellitus (DM)	5 (23.8)
Cardiac Disease	5 (23.8)
Osteoporosis	4 (19)
Mechanism of Trauma	
Fall from Height	7 (33.3)
High-Energy Traffic Accident (HETA)	6 (28.6)
Low-Energy Traffic Accident (LETA)	2 (9.5)
Motorcycle Accident	3 (14.9)
Suicide Attempt	3 (14.9)
Neurological Deficit	14 (66.7)
Fracture Location	
T11	3 (14.3)
T12	9 (42.9)
L1	9 (42.9)
L2	1 (4.8)
Associated Injuries	
Abdominal Injury	5 (23.8)
Thoracic Injury	3 (14.3)
Extremity/Orthopedic Injury	10 (47.6)
Spinal Fractures Excluding TLBF	4 (19)
Cranial Trauma	2 (9.5)
Mean Follow-up Duration (months)	12.1±13.9

Among the 14 cases with preoperative neurological deficits, 12 showed improvement in ASIA scores at the 3-month outpatient follow-up, while neurological deficits remained permanent in 2 cases. The average VAS score reported by patients for lumbar pain was 9.57±0.67 preoperatively, which decreased to 1.86±2.24 at the 3-month postoperative follow-up (Table III). During the follow-up period, only one case (4.8%) required reoperation due to screw malposition. Surgical site infection developed in one case (4.8%) and was treated with antibiotic therapy. One case underwent postoperative orthopedic surgery for a pelvic fracture, and another required an emergency preoperative splenectomy due to intra-abdominal bleeding. No mortality was observed during the follow-up period.

Discussion and Conclusion

Due to its anatomical and biomechanical transitional nature, TLJF is the most common fracture type in the adult population. The term thoracolumbar transition zone was first introduced in 1982 by Pierre Stagnara et al.[1], encompassing the T10-L2 vertebral segments. Although many classifications have been proposed for fractures in this region (Table IV), the first classification was described by Watson-Jones[6]. Numerous other classification systems have been introduced since, but no universally accepted classification exists among neurosurgeons, primarily

Table II. Surgical Procedures and Patient Features

Case No	Age	Gender	Trauma Type	Fracture Site	Neurological Status (Deficit: + / No Deficit:-)	mTLICS Score*	Associated Injury	Stabilization Level	Laminectomy (Yes: + / No: -)	Surgical Timing (hours)
1	49	M	HETA	L1	+	10	Abdominal, Thoracic	T11-12-L2-3	+	8-24
2	68	F	Fall	T12	+	8	None	T10-11-L1-2	+	<3
3	26	M	HETA	T12	+	6	Cranial	T10-11-L1-2	+	<3
4	31	M	Suicide	L1	+	10	Abdominal, Thoracic, Cranial	T11-12-L2-3	+	48-72
5	41	M	Fall	T12	-	5	None	T11-12-L1	-	24-48
6	30	F	Suicide	L2	+	7	Abdominal	T12-L1-3-4	+	<3
7	33	M	LETA	L1	+	6	Cranial	T11-12-L2-3	+	<3
8	74	F	Fall	T11	+	6	None	T9-10-12-L1	+	<3
9	62	M	HETA	L1	-	5	None	T12-L1-2	-	24-48
10	68	F	Fall	T12	-	5	None	T11-12-L1	-	24-48
11	50	M	HETA	L1	-	5	None	T12-L1-2	-	24-48
12	41	M	Suicide	T11-12	+	10	Abdominal, Thoracic	T9-10-11-L1-2-3	+	48-72
13	52	F	Fall	L1	+	7	None	T11-12-L2-3	+	<3
14	18	M	Motorcycle Accident	T12	+	6	None	T11-L1-2	+	<3
15	18	M	Motorcycle Accident	L1	-	5	None	T12-L1-2	-	24-48
16	70	M	Fall	T12	+	7	None	T10-11-L1-2	+	<3
17	62	M	HETA	T12	-	5	None	T10-11-L1-2	-	48-72
18	21	M	Motorcycle Accident	L1	+	8	None	T11-12-L2-3	+	<3
19	45	M	LETA	L1	-	6	Abdominal	T12-L1-2	-	24-48
20	75	M	Fall	T11	+	7	None	T10-12-L1-2	+	<3
21	39	F	HETA	T12	+	6	None	T10-11-L1-2	+	<3

*In cases where translational/rotational or distraction fractures were detected on thoracolumbar CT scans and a neurological deficit was present, surgical indication was established based on CT findings alone. MRI was not performed to avoid time and resource loss, and the PLK evaluation score in the mTLICS system was calculated as "3."

HETA: High-Energy Traffic Accidents

LETA: Low-Energy Traffic Accidents

'+': Yes, '-': No

due to a lack of reliability and clinical applicability in the classifications[7]. Historically, multiple classification systems have been described, including those by Böhler, Ferguson-Allen, Nicoll, Holdsworth, and Kelly-Whitesides[7-11]. Dennis and McAfee contributed significantly by introducing the three-column model, forming the foundation of modern classification systems[12,13]. The McCormack classification, introduced in 1994, focused on the severity of anterior column fractures rather than ligament damage for guiding treatment approaches[14]. The same year, the Magerl classification detailed 53 subgroups covering all fracture types, making it the most comprehensive system[15]. The Vaccaro classification (TLICS) included both posterior longitudinal ligament injuries and neurological status, aiming to optimize follow-up and treatment strategies through a comprehensive radiological and clinical approach[16]. The TLICS system was later succeeded by the biomechanical AO Spine TLBF classification (TLAOSIS) and the currently most widely used modified TLICS (Table V)[17,18]. In a study conducted by Withrow et al. involving 476 patients, mTLICS, TLICS, and TLAOSIS classifications were compared within the same patient group, revealing that all three classifications were effective for diagnosis and treatment. However, mTLICS demonstrated higher accuracy and specificity than TLAOSIS, while TLAOSIS showed greater sensitivity than mTLICS. The authors emphasized the need for prospective studies to validate and further support the adoption of mTLICS.

Table III. Surgical Outcomes

n=21	Preoperative	Postoperative (3rd Month)
Neurological Improvement		
ASIA-A	2	2
ASIA-B	3	0
ASIA-C	3	1
ASIA-D	6	1
ASIA-E	7	17
Mean VAS Score Change	9.57±0.67	1.86±2.24

Although some publications in the literature suggest non-surgical management for TLBF with accompanying neurological deficits[19], the general consensus supports performing surgery as soon as possible in such cases. For stable TLBF cases, the treatment approach is conservative, whereas for unstable cases, surgical intervention is recommended. However, complications associated with conservative treatment and potential loss of workforce highlight the ongoing uncertainty regarding the optimal treatment approach[20]. The most used and up-to-date classification, the Modified TLICS, recommends conservative management for cases scoring between 1 and 4, while those scoring 5 or higher are treated surgically. The Modified TLICS classification, compared to the previously introduced TLICS, offers a more comprehensive description of fracture types, neurological status, and posterior ligamentous complex involvement. It also clarifies the ambiguous score of 4 points, often referred to as the "gray zone," thereby standardizing treatment protocols.

Table IV. Historical Evolution of TLBF Classifications

Classification	Year	Mechanism	Fracture Categories (Subgroups)
Böhler	1930	Anatomical-Mechanical	6
Watson-Jones	1938	Morphological-Stability	3 (7)
Nicoll	1949	Anatomical-Morphological	4 (7)
Holdsworth	1963	Two-Column Theory	6
Kelly-Whitesides	1968	Two-Column Theory	8
Denis	1983	Three-Column Theory	5 (16)
McAfee	1983	Three-Column Theory	6
McCormack	1994	Load Sharing	9
Magerl	1994	Morphological	3 (53)
Vaccaro (TLICS)	2005	Load Distribution	3
Vaccaro AOSpine	2013	Morphological-Neurological Status	3 (53)
AOSpine TLAOSIS	2016	Morphological-Neurological Status	3 (17)
Modified TLICS	2016	Morphological-Neurological Status	3

Table V. Modified TLICS Scoring System

Morphology	Score
Compression fracture with ≤50% height loss	1
Compression fracture with >50% height loss	2
Burst fracture with >50% height loss and >50% spinal stenosis	2
Burst fracture with >50% height loss or >50% spinal stenosis	3
Translational/rotational injury	3
Distraction injury	4
Neurological Status	
Intact	0
Nerve root injury	2
Incomplete cord/conus medullaris injury	3
Complete cord/conus medullaris injury	2
Cauda equina syndrome	3
Posterior Ligamentous Complex (PLC)	
Intact	0
Focal edema or MRI evidence of PLC soft tissue widening	1
Bone widening in facet joint or spinous process	2
PLC disruption	3
Conservative Treatment	**1-4**
Surgical Treatment	**5-10**

Conservative treatment methods include orthosis application along with DVT prophylaxis, physiotherapy, potential pressure ulcer management, and analgesia[21]. While orthosis application may reduce pain and accelerate fun ctional recovery, it

does not influence vertebral height or kyphotic angulation[22,23]. Although there is no consensus in the literature regarding the application of surgical versus conservative methods[24-26], the general approach is that stable fractures without neurological deficits, minor vertebral fractures, cases with less than 50% vertebral body height loss, sagittal index below 20, minimal kyphotic angulation, intact posterior ligamentous complex, fractures with less than 2 mm of bone fragment protrusion into the canal, and patients with surgical contraindications (e.g., burn at the intervention site, severe head trauma, hemodynamic instability, active sepsis) should be managed conservatively[21,27,28]. During conservative treatment, upright X-ray imaging should be used to monitor patients, particularly for malposition detection, while CT and MRI should support the follow-up process when necessary[28].

Surgical approaches include posterior, anterior, combined techniques, and vertebroplasty/ kyphoplasty[29]. The anterior approach is typically preferred in cases with burst fractures where sufficient decompression cannot be achieved posteriorly and provides effective fusion[20,30,31]. However, due to the requirement for significant surgical expertise, the need for prolonged thoracolumbar orthosis usage, and increased complication risks, it is less commonly chosen[32]. A similar situation is observed with the combined anterior-posterior approach[33].

With current technological advancements, posterior approaches can achieve effective decompression through procedures such as laminectomy, ligamentotaxis, posterior corpectomy, and excision of canal-compressing fragments[29,30,34]. There is an ongoing debate in the literature regarding short- and long-segment instrumentation[29]. Long-segment stabilization provides greater stability and better sagittal balance with reduced mobility in the remaining segments, while short-segment stabilization results in less movement restriction in the thoracolumbar junction[30,35].

In our study, all patients underwent posterior segmental instrumentation surgery. According to the literature, in cases involving the posterior column, free bone fragments within the canal, accompanying neurological deficits, and spinal canal stenosis exceeding 50%, decompression via laminectomy is recommended[36]. In 14 out of 21 cases, we performed laminectomy in addition to stabilization surgery. For cases without free bone fragments in the vertebral canal and intact posterior vertebral elements, we performed reduction in addition to posterior stabilization and applied short-segment stabilization. During short-segment stabilization, transpedicular screw fixation was performed at the fracture level when the pedicle was intact. Throughout our limited follow-up period, no kyphosis or instrumentation failure was observed. Although the study had a limited case series, our clinical observations indicated lower pain complaints during follow-up in patients who underwent short-segment stabilization surgery; however, larger-scale studies are required on this subject. We recommend short-segment stabilization, particularly in patients with intact posterior vertebral elements, no free bone fragments in the spinal canal, partial or suspected posterior ligamentous complex damage, and no neurological symptoms. Considering the transitional zone between the relatively stable thoracic region supported by the ribs and the more mobile lumbar region, long-segment stabilization in this area could limit spinal motion. However, given the potential for kyphosis progression, adjacent segment disorders, and osteoporotic-related screw malposition, long-term follow-up studies are necessary. For patients with significant anterior column insufficiency, the use of a thoracolumbar brace during the first 12 weeks after trauma is essential due to the risk of progressive kyphotic deformity. Although we consider the posterior ligamentous complex and posterior vertebral bony structures as mechanical support for short-segment instrumentation, close outpatient follow-up is recommended, especially concerning kyphosis risk.

Another point we aimed to emphasize in our study is the presence of additional trauma in patients. In 12 out of 21 cases, additional trauma was observed aside from the fracture. Abdominal and thoracoabdominal internal organ injuries were noted in 5 cases (23.8%), while orthopedic trauma was present in 10 cases (47.6%). Three cases (14.3%) with neurological deficits could not be operated on during the critical first 3-hour window due to unstable general condition, and surgery was postponed until stabilization. Thoracolumbar junction traumas can be associated with intra-abdominal organ injuries such as liver and spleen damage, as well as thoracic injuries[37-39]. Depending on the severity and mechanism of trauma, certain non-neurosurgical pathologies may be managed conservatively or with elective surgery, while severe pelvic fractures presenting with massive hematocrit drop, as observed in one of our postoperative cases, can occur. Additionally, fractures at different spinal levels were noted in 4 cases (19%), and cranial trauma not requiring surgical intervention was observed in 2 cases (9.5%). Considering the anatomical location and the mechanism and severity of trauma, we recommend that thoracolumbar junction injuries should always be assessed as polytrauma cases during initial emergency evaluations and perioperative clinical follow-ups, with necessary consultations from relevant trauma departments and periodic hemogram monitoring throughout clinical follow-up.

In cases of thoracolumbar junction fractures with neurological deficits, urgent treatment significantly improves patient recovery during follow-up[29,36,37,39]. Among the three cases in our series with unstable general conditions who missed the critical 3-hour window for acute surgical decompression despite having neurological deficits, two were assessed as ASIA-A preoperatively and remained ASIA-A postoperatively despite physiotherapy during outpatient follow-up. One case initially assessed as ASIA-C also remained ASIA-C throughout follow-up. Conversely, among the other 11 neurologically deficient cases who underwent acute surgical treatment, partial improvement was observed in one case, while the remaining cases achieved full neurological recovery (Table III). Our results, when evaluated alongside the literature, suggest that performing surgical decompression as soon as possible, especially in neurologically deficient patients with stable general conditions, can significantly improve neurological outcomes.

The main limitations of this study are its retrospective nature, small sample size, and limited follow-up duration. Future prospective studies with larger cohorts are required to validate these findings.

Due to the critical location of thoracolumbar junction fractures and the potential for accompanying internal organ injuries, they should be considered as possible multi-trauma cases. During the initial admission, additional imaging and consultations with relevant trauma departments should be conducted when necessary. While surgical intervention can be delayed in patients with stable neurological conditions, early surgical decompression and stabilization within the first 3 hours are crucial for patients presenting with neurological deterioration or deficits. Decision-making for surgical treatment should be guided by current classification systems such as the mTLICS and AO Spine TLAOSIS. Posterior segmental stabilization surgery, with its low complication risk and recent advancements in neurosurgical techniques, has shown successful outcomes. However, there remains no clear consensus in the literature regarding the choice between long- and short-segment instrumentation.

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