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Thoracolumbar spine trauma: review of the evidence.

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Thoracolumbar Spine Trauma: Review of the Evidence

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Abstract

Aim: Provide a comprehensive review of literature regarding the classification systems and surgical management of thoracolumbar spine trauma.

Methods: A Pubmed search of 'thoracolumbar', 'spine', 'fracture' was used on January 05, 2013. Exclusionary criteria included non-Human studies, case reports, and non-clinical papers.

Results:1520 manuscripts were initially returned for the combined search string. 150 were carefully reviewed, and 48 manuscripts were included in the review.

Discussion: Traumatic Spinal Cord Injury (SCI) has a high prevalence in North America. The thoracolumbar junction is a point of high kinetic energy transfer and often results in thoracolumbar fractures. New classification systems for thoracolumbar spine fractures are being developed in an attempt to standardize evaluation, diagnosis, and treatment as well as reporting in the literature. Earlier classifications such as the Denis '3-column model' emphasized anatomic divisions to guide surgical planning. More modern classification systems such as the Thoracolumbar injury classification system (TLICS) emphasize initial neurologic status and structural integrity of the posterior ligamentous complex as a guide for surgical decision making and have demonstrated a high intra- and interobserver reliability. Other systems such as the Load-Sharing Classification aid as a useful tool in planning the extent of instrumentation and fusion.

Conclusion: There is still much controversy over the surgical management of various thoracolumbar fractures. Level I data exists supporting the nonsurgical management of thoracolumbar burst fractures without neurologic compromise. However, for the majority of

fracture types in this region, more randomized controlled trials are necessary to establish standards of care.

Key Words:
Thoracolumbar, Fracture, Burst Fracture, Spinal Cord Injury

Introduction

Traumatic Spinal Cord Injury occurs at a rate of 12 to 50 per million per year in the United States with the peak incidence in the young aged 15-29. The most common mechanisms of SCI are motor vehicle accidents and falls.[42] The actual rate of SCIs are not agreed upon, and case reports vary from 0 -93%.[25] A large portion of traumatic spine injuries involve the thoracolumbar junction (T10-L2) due to the transfer of kinetic energy from a stiff thoracic spine to the more mobile lumbar spine. Some reports place thoracolumbar fractures as high as 90% of all spine fractures.[11]

Morbidity

The clinician should have a high suspicion for additional trauma, given that thoracolumbar injuries are often a result of high velocity impact mechanisms such as motor vehicle collisions. A retrospective review of thoracolumbar trauma found in 151 patients, a 25% incidence of spinal cord injury and almost a 30% incidence of intraabdominal injury.[6] Concomitant spine fractures occur readily with a high incidence of up to fifteen percent, which should prompt routine CT scanning of the entire neuroaxis upon admission. A surgical trauma evaluation should occur for every patient with a thoracolumbar spine fracture, as these types of injuries require a high kinetic injury.

Early Use of Classification System

Classification systems have seen an early introduction in fracture management for a variety of reasons. In a large percentage of fractures involving a load-bearing mechanism on the anterior and middle columns, much debate today still exists today over the stability, given the success clinicans have had with the bracing of compression fractures and even some burst fractures.[7, 44, 45, 47] However, occasionally a delayed presentation is seen, manifesting as persistent pain, new neurological deficit, and even glacial instability and worsening deformity. Further use of these classification systems for assessment have been to establish a risk for instability and even prognosis.

Classification

To date, a predominant classification system for thoracolumbar trauma is not in use. One of the most widely recognized classification systems seen early in use is the Denis Classification. The spine is segmented into three columns, where the anterior column consists of the anterior longitudinal ligament (ALL), anulus fibrosis, and anterior half of the vertebral body. The middle column, consists of the posterior half of the vertebral body along with the posterior longitudinal ligament (PLL) and the posterior annulus fibrosis. In the posterior column, one finds the bony neural arch, which joins at the posterior spinous processes, and underneath the ligamentum flavum provides additional protection to the thecal sac.

One system designed specifically to aid in the decision making process for anterior versus posterior approach to surgical treatment of thoracolumbar fractures is the Load Sharing

Classification (LSC) designed by McCormack and colleagues.[28] In a preoperative analysis of 28 patients, a 9 point scale was used to evaluate extent of fracture of the vertebral body, apposition of the anterior column fracture, and extent of kyphosis. Higher scores are suggestive of the need for anterior column support or long-segment posterior fixation.[1] These three factors, when present with a maximal score, were determined to have the highest need for posterior pedicle screw stabilization. Further work has demonstrated its reliability and validity.[3, 7, 10, 14, 18]

One fairly recent system for evaluating trauma proposed by the Spine Trauma Study Group (STSG) to the thoracolumbar junction was described by Vaccaro et al. to address two key factors, posterior ligamentous stability and neurologic injury, which are not addressed in the load-sharing classification.[34] These two factors arguably have a higher prognostic significance in addition to guiding surgical management. Called the thoracolumbar injury classification and severity score (TLICS), points are assigned based on fracture morphology, posterior ligamentous complex competency, and the neurologic status of the patient. Disruption of the posterior ligamentous complex is heavily weighted in the TLICS system, as the authors advocate for the need for surgery with a disrupted posterior ligamentous complex. Its inter- and intraoberserver reliability has been demonstrated.[21] Patel et al. prospectively analyzed two consecutive groups of 25 patients 7 months apart to assess interobserver reliability, finding improvement in reliability with use.[32] The increased reliability highlights the weaknesses of prior systems, such as the AO and Denis classifications.

Treatment Guided by Classification

Treatment of thoracolumbar burst fractures is controversial, due to the limited availability for randomized prospective studies. Classification systems are being developed to aid in selecting appropriate surgical candidates.

Nonoperative Management

A large majority of thoracolumbar fractures are burst fractures, classically described as a stable injury.[12] The majority of level I evidence favors the conservative management of thoracolumbar burst fractures. Wood et al[44-46], in a randomized (RCT) prospective trial comparing anterior or posterior instrumentation and fusion to nonoperative treatment with a brace or body cast, found no clinically significant difference between the two arms. The results of Wood were repeated by Gnanenthiran et al[15] finding in a prospective RCT equivalent pain and functional outcome scores at 4 years. In this trial, they find a slightly improved radiographic result, via a reduced kyphotic deformity in the surgical arm, but with no clinical correlate. Later classifications would come out as well as expert consensus that will emphasize posterior ligamentous integrity and neurologic status over fracture morphology.[41]

In a recent study of AO type A3 fracture (burst type), Bailey and Colleagues[2] randomized 69 patients to thoracolumbosacral (TLSO) bracing versus or no bracing. Inclusion criteria were patients with kyphosis of less than 35 degrees, as well as no neurologic compromise, or signs of injury to the posterior ligamentous complex on MRI. They found no significant difference in deformity on follow-up as well as functional recovery on follow-up.

Other data is simply contradictory to the conclusions of Bailey. Siebenga et al[38] evaluted 34 patients, comparing short-segment posterior pedicle screw instrumentation to bracing alone. They found that surgical stabilization not only improved the deformity, but bracing resulted in a trend towards worsening kyphosis. Also, all composite scores of functional outcomes used, VAS pain, VAS spine, and questionnaires used, all found significantly better outcomes in the surgical group, including those returning to work.

Operative Treatment

A preponderance of literature is found describing the use of posterior pedicle screw instrumentation for surgical stabilization of thoracolumbar fractures.[26]

Surgical Decision Making

Denis one-column injuries[13, 23] most commonly refer to injuries of the anterior longitudinal ligament and anterior one half of the vertebral body, without evidence of disruption of the posterior ligamentous complex (PLC). Compression fractures fall into this category, and the use of bracing has been often accepted as adequate treatment.[44, 45,33]

One recent classification, the TLICS,[34] evaluated fracture morphology, integrity of the PLC, and neurologic status in an attempt to help guide surgical management and offer prognostic significance. Integrity of the PLC is heavily weighted and is supportive of surgical intervention. In a distraction injury, surgery is usually indicated as well.[34]

Anterior versus Posterior Approach

Intuitively, one can argue that the approach can be designed to address the location of the pathology. In actuality, an anterior column injury in the thoracolumbar junction can often be addressed from either an anterior, lateral, or posterolateral approach. McAfee argued an anterior, retroperitoneal approach, early on, for thoracolumbar fractures with retropulsed fragments into the canal.[27] Schnee and Ansell proposed an anterior approach for purposes of direct neural decompression, in the case of greater than 40% vertebral body loss of height (LOH), or 15 degrees or greater of kyphosis. In the absence of posterior pedicle screw stabilization, an anterior plate was utilized by their practice, and others, with relative success.[29] In twenty-five patients, they found no statistically significant difference in pain and functional results.[37]

In a systematic review of posterior approach alone versus combined circumferential decompression and fusion Po and colleagues found a significantly higher correction of kyphosis in the anterior-posterior decompression and fusion. Yet, there was a statistically higher blood loss, hospital length of stay, operative time, and cost, while there was a trend towards higher morbidity.[31] Given the obvious benefits of decompression of anterior pathology, one prospective trial attempted to address this problem. Lin and colleagues randomized 64 patients to an anterior approach group and a posterior decompression, as well as a partial corpectomy and stabilization from a posterolateral approach.[24] They found no statistically significant results in Frankel score, ASIA motor score, and post-operative radiographic results. The pulmonary complications and morbidity was significantly higher in the anterior approach group. These results go against the thought that circumferential decompression is needed through a combined approach to provide optimal visualization of the dura and anterior compression. With pedicle screw instrumentation, a posterior approach allows for three-column fixation as well as decompression of anteriorly compressive pathologies.

Wood et al.[46], in a randomized controlled trial of anterior verus posterior decompression and fusion of thoracolumbar burst fractures , evaluated 38 patients without neurological deficits and found no difference in blood loss, hospital stay and radiographic markers of fusion and deformity. Clinical markers of quality of life at the 2 year follow up were no different. A trend towards higher complications posteriorly were noted.

When comparing anterior versus posterior decompression and fusion studies, some methodology is uniquely different and conclusions should be taken under consideration before translating their results to your clinical practice. For example, Stancic et al[39] compares 25 patients treated for burst fracture, anteriorly with decompression and plating, versus posteriorly with deformity reduction, so called *ligamentotaxis*, and either fixation with pedicles screws and rods, or variably with rod and hook fixation. Additionally, autograft was inconsistently used in either groups. One consideration of the use of autograft has always been its contribution to comparison of postoperative pain between two groups, since it is another form of bias.

Another example is be Sasso et al[36] who compared 53 patients with unstable burst fractures who underwent either an anterior corpectomy, strut graft and plating, versus posterior pedicle screw fixation and hook placement. They found a significant difference in the postoperative kyphosis on follow-up, 8.1 degrees versus 1.8 degrees in the posterior and anterior groups respectively.

Short versus Long Segment Construct

When fracture morphology is not carefully considered, short segment fixation, defined as fixation one level above and below the level of pathology of a thoracolumbar junction fracture, has a significant failure rate.[48] This can be seen in the form of screw pullout, loss of correction, or construct breakage. Kramer et al, followed 11 patients prospectively, all who were treated with short-segment bilateral transpedicular instrumentation and fusion with iliac crest autograft for all thoracolumbar fracture morphologies. On 33 month mean follow-up, they found a 34%

rate of screw failure, with an associated loss of vertebral body height. Despite this, there were no differences in post-operative Frankel Grade.[22] Carl et al,[5] in a series of 38 patients treated with pedicle screw instrumentation posteriorly, found a rate of 24% screw failure at a 22month follow-up, despite a patient satisfaction rate of 97%.[5] Likewise, McLain et al.[30] in a series of 52 patients treated with Cotrel-Debousset posterior instrumentation experienced a twenty percent failure rate by follow-up time, when utilizing a short-segment construct. The load-sharing classification was developed in an attempt to address those thoracolumbar fractures with higher likelihood of requiring additional anterior column support and/or long-segment constructs. Sapkas et al.[35] defined short segment as one level above and below the fracture site, while long-segment construct defined as two levels above and below. They found a significantly higher failure rate in the short-segment group, and worse radiographic outcomes (measured as Beck index and Cobb angle changes over follow-up period). Clinically, there were no significant differences, as measured by serial low-back outcomes scores.[35]

Often, when radiographic outcomes are significantly different, but less than ten degrees in Cobb angle, no clinical difference is felt by the patient.[16] The aforementioned data showing a higher failure rate of short segment fixation is by no means definitive, given the older instrumentation systems that are no longer in use. Again, while radiographic correction was definitively worse in the short-segment construct, the clinical outcomes were not much different.

Fracture Specific Considerations

Burst Fracture

Despite the lack of supporting level I evidence in the literature, operative stabilization via instrumentation and fusion remains to be a common treatment for thoracolumbar burst fractures.

A Cochrane, systematic review comparing operative to non-operative management of thoracolumbar burst fractures found no statistically significant difference in pain, functional outcome, rates of return to work, radiographic findings, and hospital length of stay. In fact, the average costs and complication rates were higher.[47]

One well known prospective study was by Wood and colleagues[46] who compared anterior and posterior approach to thoracolumbar burst fractures in a randomized controlled trial finding equivalent functional outcome scores at 2 year follow-up, but a significantly higher complication rate from the posterior approach. Despite the appreciable body of literature supporting nonoperative management, an argument can be made for posterior stabilization, arguing that this form of internal bracing is more appealing to the patient than body casting for an extended duration. Other social considerations may lead to the surgical option, as there could be a high rate of noncompliance with a rigid orthosis.

Other considerations for burst fracture correction include the decision to incoporate the affected level with transpedicular pedicle screw instrumentation. Guven et al.[17] in a prospective randomized study, randomized 36 patients to surgery without fracture level incorporation and 36 patients and 36 patients with fracture level incorporation.

Flexion-Distraction Injuries

Further considerations include fractures of the thoracolumbar junction that affect all three columns, such as the so-called bony *Chance* fractures. These injuries are often associated with neurological deficits. In more serious injuries, larger kinetic forces are involved, resulting in three-column injuries, such as distraction patterns, or rotational injuries. Posterior pedicle screw fixation makes the most sense in this case, with or without anterior column restoration. Tezer et al[40] underwent a retrospective review of 48 patients who underwent posterior stabilization alone for flexion-distraction injuries at the thoracolumbar junction. They achieved a solid fusion in all case with maintenance of the restored sagittal alignment on follow-up, with successful reduction of the canal in all patients. Similar success was noted by Inamasu et al.[19] with the posterior approach alone for flexion-distraction injuries treated with purely pedicle screw instrumentation and arthrodesis.

MIS vs. Open Surgery

With recent advances in industrial inventions in the last 10 years, more recent publications are found with minimally invasive options for fusion of the thoracolumbar spine. For example, Jiang et al[20], in a randomized trial, compared percutaneous pedicle screw fixation to an open paraspinal approach for pedicle screw placement, finding shorter hospital Length of stay (LOS), less blood loss, and less pain at a three month follow-up in the minimally invasive surgery (MIS) arm. This went at the cost of significantly decreased postoperative reduction of the kyphotic deformity. Intuitively, MIS treatment spares more muscle and is less painful, has a decreased blood loss as a result, and requires less narcotics. The advantages purported in the literature is lacking in Level I publications, and predominantly retrospective data.[4]

Arthrodesis

Ongoing debate exists as the role of fusion, in addition to instrumentation in the setting of thoracolumbar fractures. Dai et al, randomized 73 patients to posterior instrumentation with or without arthrodesis for Denis Type B (superior endplate) fractures.[9] Load-sharing scores of greater than 6 were a key exclusion criteria due to the high need for anterior column support. Patients in the fusion group all had posterolateral fusions with iliac crest autograft. At up to 7 year follow-up, no significant difference was noted between the two groups with regard to radiographic deformity, quality of life, and functional outcome measures.[9]

Similarly, Wang et al, in a prospective RCT of 58 patients with thoracolumbar burst fractures found no significant difference in functional low back outcome scores at follow-up as well as no statistically difference in sagittal alignment. The vertebral height and immediate instability was more common in the fusion group, likely due to the disruption of the posterior column in preparation for fusion.[43]

Dai et al.[8] in a prospective randomized trial, evaluated 65 patients with thoracolumbar fractures with a LSS of greater than 6 and a thoracolumbar burst fracture. They compared anterior only approaches with the use of either autraft, versus titanium cage placement packed with local bone and allograft. They found no significant difference between the clinical and radiographic markers used at any of the endpoints. All patients had achieved fusion as well. Evidence such as this, as well as the growing availability of commercial products aiding in fusion, have led to decreased use of autograft, predominantly harvested from the iliac crest.

Conclusion

There is much controversy as to how to properly manage thoracolumbar junction pathology. Newer classification systems such as the TLICS as well as the older load-sharing classification have helped the surgeon guide surgical management in a surgical disease where many options exist. More prospective, randomized trials are needed to guide clinical judgement, as the ‘expert consensus’ is still based on primarily retrospective data.

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Tables

Table 1. Thoracolumbar Spine Fractures: Clinical Summary Table

Table 2. Thoracolumbar Classification Systems

Table 1. Thoracolumbar Spine Fractures: Summary of the Evidence

Study	**Design**	**Comparison**	**Fracture type**	***N***	**Surgery**	**Conclusion**	**Level of evidence/Grade of Recomme-ndation**
Wood *et al.*, 2003 [6]	RCT	Surgery vs. Bracing	Burst fracture w/o deficits	47	Anterior or Posterior vs. orthosis	No significant difference	Ib/A
Wood et al., 2005 [19]	RCT	Anterior vs. Posterior	Burst fracture w/o deficits	38	Anterior or Posterior instrumentation and fusion	No clinically different outcomes, anterior trend toward fewer complications	Ib/A
Yi et al., 2006[7]	Meta-analysis	Surgery vs. Brace	Burst fracture w/o deficits	53	Posterior vs. Orthosis	No clinically significant difference	Ia/A
Gnanenthiran, 2012[20]	Meta-analysis	Surgery vs. Brace	Burst Fracture	79	Posterior vs. Orthosis	No clinically significant difference	Ia/A
Lin, 2011[26]	RCT	Anterior vs. posterior	Burst Fracture	64	Anterior vs. Posterior Subtotal Corpectomy, instrumentation, and fusion	Unchanged ASIA, Frankel, radiographic outcomes. Decreased pulmonary and overall	Ia/A

						complications in Posterior approach	
Dai *et al*., 2009[43]	RCT	Fusion vs. non-fusion	Denis type B burst	73	Posterolateral approach	No significant difference in clinical outcome (p<0.05)	Ib/A
Bailey *et al*. 2009 [22]	RCT	Orthosis vs. no orthosis	AO type 3 T11–L3	69	n/a	No significant difference in clinical outcome (p<0.05)	Ib/A
Dai *et al*., 2009 [38]	RCT	Anterior only	Burst fracture, LSS >6, and three column	65	Tricortical iliac crest allograft vs. titanium mesh cage	No pseudoarthrosis, (no significant difference between groups	Ib/A
Siebenga *et al*., 2006[22]	RCT	Posterior vs. orthosis	AO type A	34	Posterior vs. orthosis	Surgery: decreased deformity, higher FOS	Ib/A
Reinhold *et al*., 2010 ,[26]	RCT	Anterior vs. Posterior	Acute T1–L5	73 3	Anterior vs. posterior vs. anterior or posterior	Anterior/posterior: better radiographic deformity correction Posterior: better functional and subjective outcomes	IIa/B
Marco *et al*.[24]	Cohor t	Posterior surgery	Unstable burst	38	Kyphoplasty preceding short-segment transpedicular instrumentation	2-year improved ambulation, neurologic function	IIb/B
Stancic *et al*., 2001[31]	Cohor t	Anterior vs. posterior	Burst fracture	25	Anterior decompression or fixation vs. post-fixation	No significant difference in neurologic improvement and FOS, decreased morbidity with a posterior approach	IIb/B
Sapkas et	Retros	Short	Burst	50	Short versus Long	Unchanged Cobb	III/C

al., 2010[36]	pective	versus long segment	Fracture		segment	angle. Trend towards superior radiographic outcomes in long segment on follow-up	
Dai et al., 2008[8]	Retrospective Review	Bracing	Burst fracture	127	No surgical treatment, LSS evaluated	93% improvement, no deterioration in any case. Association with increased local kyphosis and LSS (P<0.05)	III/C
Altay et al., 2007[10]	Retrospective Review	Posterior	Burst Fracture	63	Short vs. Long-segment Fusion	Equivalent clinical outcomes except Magerl A3.3 complete burst (long-segment improved clinical outcome)	III/C
Sasso *et al.*, 2006 [32]	Retrospective review	Anterior only	Unstable three-column thoracolumbar fracture	40	Anterior decompression, graft, plating	Improved functional outcome, arthrodesis achieved	III/C
McDonough *et al.*, 2004[28]	Retrospective review	Anterior only	Unstable three-column thoracolumbar fracture	35	Anterior corpectomy, instrumented fusion	Improved neurologic function	III/C
Tezer *et al.*, 2005[41]	Retrospective review	Posterior only	Flexion–distraction (Chance)	48	Posterior short-segment instrumentation	Arthrodesis in all cases	III/C
Inamasu *et al.*,	Retrospectiv	Posterior	17 unstable	32	Stability, limited	Improved radiographic results,	III/C

2008[42]	e review	only	burst, 15 fracture–dislocation or flexion–distraction		recovery	improved neurologic outcomes in ASIA B–D	
McAfee *et al.*,1985[27]	Case series	Anterior only	Burst Fracture (stable or unstable)	48	Anterior decompression	Improved neurologic outcomes for incomplete injury	III/C
Vaccaro *et al.*, 2006[21]	Expert opinion	NA	Burst Fracture injuries	NA	NA	Guidelines for surgical management	IV/C

Table 2- Thoracolumbar Classification Systems

Classification system	Type	Description	Points
Magerl (AO Classification System)	A	Compression of vertebral body alone	–
	B	Distraction injury of anterior and posterior element	–
	C	Axial torque/multidirectional injury of anterior and posterior elements	–
Load Sharing Classification (LSC) (where <6 points may fare well with the posterior approach, 7 or greater is suggestive of anterior approach for anterior column restoration.)	1. Communition	A . <30 percent	1
		B. 30-60 percent	2
		C. >60 percent	3
	2. Fracture Apposition	A. <2mm displacement	1
		B. >2mm and <50% surface area	2
		C. >2mm and >50% surface area	3
	3. Sagittal	<3 degrees	1

	Deformity		
		4-9 degrees	2
		>10 degrees	3
Denis (Burst Fracture System)	A	No endplate fracture	–
	B	Superior endplate fracture	–
	C	Inferior endplate fracture	–
	D	Superior and inferior endplates fractured	–
Thoracolumbar Injury Classification Score (A Score greater than 4 or greater is suggestive of need for posterior column restoration).	1. Injury mechanism	Compression	1
		Translation	3
		Rotation	4
	2. Posterior ligamentous complex disruption	Intact	0
		Suspicion for/indeterminate	2
		Injured	4
	3.Neurologic status	Nerve root involvement	2
		Cord involvement (incomplete)	3
		Cord involvement (complete)	2
		Cauda equina involvement	2