

# **Thoracolumbar injuries : short segment posterior instrumentation as standalone treatment – thoracolumbar fractures**

by  
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Master of Medicine in Orthopaedic Surgery at the University of  
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**Declaration:**

I, Johannes Hendrik Davis, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree at this or any other academic institution.

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## Abstract

### *Objective:*

This research paper reports on the radiographic outcome of unstable thoracolumbar injuries with short segment posterior instrumentation as standalone treatment; in order to review rate of instrumentation failure and identify possible contributing factors.

### *Background:*

Short segment posterior instrumentation is the treatment method of choice for unstable thoracolumbar injuries in the Acute Spinal Cord Injury Unit (Groote Schuur Hospital).

It is considered adequate treatment in fracture cases with an intact posterior longitudinal ligament, and Gaines score below 7 (Parker JW 2000); as well as fracture dislocations, and seatbelt-type injuries (without loss of bone column - bearing integrity). The available body of literature often states instrumentation failure rates of up to 50% (Alanay A 2001, Tezeren G 2005). The same high level of catastrophic hardware failure is not evident in the unit researched.

### *Methods:*

Sixty-five consecutive patients undergoing the aforementioned surgery were studied. Patients were divided into two main cohorts, namely the “Fracture group” (n=40) consisting of unstable burst fractures and unstable compression fractures; and the “Dislocation group” (n=25) consisting of fracture dislocations and seatbelt-type injuries.

The groups reflect similar goals in surgical treatment for the grouped injuries, with reduction in loss of sagittal profile and maintenance thereof being the main aim in the fracture group, appropriately treated with Schantz pin constructs; and maintenance in position only, the goal in the dislocation group, managed with pedicle screw constructs.

Data was reviewed in terms of complications, correction of deformity, and subsequent loss of correction with associated instrumentation failure. Secondly, factors influencing the aforementioned were sought, and stratified in terms of relevance.

*Results:*

Average follow up was 278 days for the fracture group and 177 days for the dislocation group (all patients included were deemed to have achieved radiological fusion – if fusion technique was employed). There was an average correction in kyphotic deformity of 10.25 degrees. Subsequent loss in sagittal profile averaged 2 degrees (injured level) and 5 degrees (thoracolumbar region) in the combined fracture and dislocation group.

The only factor showing a superior trend in loss of reduction achieved was the absence of bone graft (when non-fusion technique was employed).

Instrumentation complications occurred in two cases (bent connection rods in a Schantz pin construct with exaggerated loss in regional sagittal profile, and bent Schantz pins). These complications represent a 3.07% hardware failure in total. None of the failures were considered catastrophic.

*Conclusion:*

Short segment posterior instrumentation is a safe and effective option in the treatment of unstable thoracolumbar fractures as a standalone measure.

## Chapter 1:

### Introduction

The debate on appropriate management of injuries of the thoracolumbar junction still continues. This includes conservative- versus operative management, and in the latter case, which strategy will best serve adequate decompression of neural structures, restoration of vertebral body height, prevention of further - , or recurring deformity and sparing motion segments.

Proponents of the anterior approach argue the more thorough, direct decompression of neural structures combined with the ability to provide constructs with superior mechanical load bearing properties and related decreased risk for hardware failure.

(Kostuik JP 1988, Esses SI 1990, Gertzbein 1992, Jacobs RR 1984, McAfee PC 1985, Riska EB 1987, Shono Y 1994)

Higher theoretical complication risk exists due to the extent of the visceral approach. Avoidance of para-spinal muscle trauma, and lower wound and instrumentation related complications are reported however, with utilization of an anterior procedure. (Kirkpatrick JS 2003)

This modality proves especially valuable in burst fractures with incomplete neurology and intact posterior ligamentous structures with fusion rates of 93% and improvement of at least a Frankel grade in 94.6% of patients in a specific study (Kaneda K 1997).

In terms of correction in kyphotic deformity another study showed an average kyphotic deformity of 22.7 degrees corrected to an average of 7.4 degrees with only 2.1 degrees of loss in correction. This was achieved through anterior decompression and two-segment instrumentation reconstruction. (Sasso RC 2005)

Posterior approach and instrumentation offers direct - or indirect decompression of the neural structures, with the added relative ease of the approach. Effective indirect decompression can be achieved through postural reduction and longitudinal distraction with aid of ligamentotaxis on condition that the posterior longitudinal ligament is intact. Initial improvement of 23% has



been shown in mean canal cross sectional area on CT with eventual 87% of normal canal dimensions at five year follow up. (Wessberg P 2001)

Pedicle fixation also allows for short constructs with sparing of motion segments.

Short-segment constructs have however been implicated in failure of instrumentation (as high as 50%) and subsequent progressive deformity. (Alanay A 2001, Tezeren G 2005)

The cantilever bearing properties of short segment constructs set this method up for failure in instances with extensive bony loss of the anterior column. Current literature supports the use of this modality for flexion-distraction or Chance-type injuries.

*Posterior-only-stabilization is often criticized as running the risk for instrumentation failure and loss of correction.*

## Chapter 2:

### Thoracolumbar injuries – overview

#### *2.1. Epidemiology & Mechanism*

The thoracolumbar junction is the most common site of injury following trauma to the thoracic and lumbar spine (approximately 90% of all thoracic and lumbar injuries). These injuries are most prevalent in men between 15 and 35 years of age. Injuries range from minor isolated compression fractures of the vertebral body to circumferential osteo-ligamentous disruption with marked instability. 15-20% of thoracolumbar injuries are further complicated by neurological injury and impairment.

65% of thoracolumbar fractures occur as a result of motor vehicle trauma, or fall from height. Athletic participation and physical assault contributes the remaining 35%. Motorcycle crashes are associated with greater chance of severe and multiple level spinal column injuries compared to other modes of motorized transport. The incidence has further been shown to be 13% amongst military pilots, helicopter crashes and parachuting accidents contributing 73% of these injuries. In general, injuries to the thoracolumbar junction are sustained through high energy insults, as encountered with motor vehicle accidents or fall from height, and may represent a combination of flexion, extension, compression, distraction, torsion or shear.

#### *2.2. Anatomical consideration*

T10–L2 spinal levels represent the transition between a rigid thoracic column, and a more flexible lumbar column. The spinal weight bearing axis furthermore translates from kyphosis to lordosis at the T12-L1 intervertebral disc. The thoracic spine allows for minimal flexion and extension, yet permits lateral bending and torsional movement, through coronal orientated facets. The sternum, ribs and costovertebral articulations further stabilize the thoracic spine. The lumbar spine permits flexion and extension as the primary plane of motion through sagittally orientated facets.

The mismatch in tensile strength innate to the anterior longitudinal ligament (providing a strain resistance in excess of 450 Newton), and the weaker posterior longitudinal ligament (able to resist forces in the region of 66 Newton) further add to the injury susceptibility of this spinal segment.

These factors contribute to the recognizable fractures and injury patterns in this region.

### *2.3. Clinical evaluation*

Clinical evaluation provides invaluable information regarding the extent of injury with possible prediction of stability, and deserves brief mention in spite of not being a specific area of research in this research paper.

With consideration to the high energy often involved in the mechanism of injury ATLS (Advanced trauma life support) principles should always be adhered to with the management of the spinally injured patient. Initial resuscitation should be instigated, with appropriate management of life threatening injuries, whilst maintaining spinal column immobilization. Neurogenic shock with associated hypotension and bradycardia might further complicate the management of a patient with a thoracolumbar spinal injury, and requires appropriate management including judicious use of volume expanders and intravenous fluids as well as anticholinergic drugs.

Thorough secondary survey should specifically focus on possible associated injuries as predicted by the injury mechanism, including review for head injury, neck-, chest-, pelvic- and extremity injury.

Physical examination of the spine should reflect the presence or absence of midline tenderness or pain, lacerations, abrasions or contusions that may disclose the presence of further injury to the spinal column. Abnormal spacing or swelling between adjacent spinous processes may reveal ligamentous disruption and again predict gross instability.

The presence of abdominal or chest ecchymosis often accompanies seat-belt type injuries.

A complete and thorough neurological survey including review for the presence of the bulbocavernosus reflex as well as a digital rectal examination compliments the other clinical tell tale findings to present a complete clinical picture of the spinal injured patient. (Kenneth J Koval 2006)

The American Spinal Injury Association standard neurological classification of spinal cord injury (Bucholz RW 2006) serves as an efficient tool to ensure thorough clinical review and monitoring of progress. This tool is used as a standard in the facility where the research for this paper was conducted.

Patient Name \_\_\_\_\_  
 Examiner Name \_\_\_\_\_ Date/Time of Exam \_\_\_\_\_

**ASIA** AMERICAN SPINAL CORD ASSOCIATION      **STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY**      **ISCS**

**MOTOR**  
 KEY MUSCLES (scoring on a 5-point scale)

CS	R	L	Elbow flexors
C6			Wrist extensors
C7			Elbow extensors
C8			Finger flexors (distal phalanx of middle finger)
T1			Finger abductors (little finger)

UPPER LIMB TOTAL (MAXIMUM)     +  =   
 (25)    (25)    (50)

Comments: \_\_\_\_\_

**SENSORY**  
 KEY SENSORY POINTS

0 = absent  
 1 = impaired  
 2 = normal  
 NT = not testable

Light Touch    Pin Prick

	R	L	R	L
C2				
C3				
C4				
C5				
C6				
C7				
C8				
T1				
T2				
T3				
T4				
T5				
T6				
T7				
T8				
T9				
T10				
T11				
T12				
L1				
L2				
L3				
L4				
L5				
S1				
S2				
S3				
S4-5				

LOWER LIMB TOTAL (MAXIMUM)     +  =   
 (25)    (25)    (50)

TOTALS:     +  =   
 (50)    (50)    (100)

Any anal sensation (N/A)               

Pin Prick Score (max: 750)               

Light Touch Score (max: 750)               

NEUROLOGICAL LEVEL:               

COMPLETE OR INCOMPLETE?       

ASIA IMPAIRMENT SCALE:       

ZONE OF PARTIAL PRESERVATION:       

SENSORY MOTOR:               

*This form may be copied freely but should not be altered without permission from the American Spinal Injury Association.*      REV 2008

ASIA Neurological score

## 2.4. Radiological evaluation

### 2.4.1. Plain radiographs:

Plain radiographs present an indispensable tool in the evaluation of the patient, in whom a spinal injury is suspected.

Current literature further advocates the screening of the entire spinal column with plain film radiographs once a thoracolumbar injury is detected. The rate of concomitant or non-contiguous injuries can be as high as 12 % (Jeffrey M. Spivak 2006). Antero-posterior (AP) and lateral x-rays should be obtained.

The lateral view provides specific measurements allowing quantification of derangement in the sagittal profile; through measurement of the Cobb angle (Cobb method). This parameter has been shown to be more consistent in terms of kyphosis, then the posterior vertebral body tangent method. (Jeffrey M. Spivak 2006)

The percentage of vertebral body height loss is a useful calculation obtainable from the lateral plain film radiograph. Loss in excess of 50% is suggestive of posterior

ligamentous complex disruption (not clinically validated). Retropulsion of bony fragments is often demonstrated on lateral views.

The AP view allows review of the rotational and coronal alignment of the spine. Relative distances between spinous processes reflect rotation, whilst coronal translation implies severe injury with instability. An increase in interpedicular distance suggests separation of posterolateral vertebral body fragments, a trademark finding in burst fractures.

#### **2.4.2. Computed Tomography:**

Computed Tomography contributes a vast amount of information towards the extent of bony structure compromise, in specific, the columns involved (as described by Denis in 1983) and the degree thereof.

Thin cut (2 mm) CT Slices with multiple planar reconstruction of the injured and the adjacent uninjured levels demonstrate fracture lines with great detail, and allows for distinction between different fracture types. Burst fractures can be verified through fracture lines extending into the posterior aspect of the involved vertebral body, with associated canal compromise best appreciated on axial images. Posterior column fractures can also be shown clearly and concomitant lamina fractures often accompany a dural tear and nerve root entrapment.

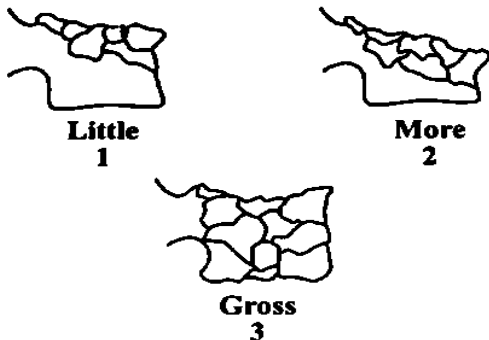
Facet dislocation is demonstrated on computed tomography, as a naked facet.

Quality coronal and sagittal reconstructions can further aid the diagnosis of distraction or translational injuries.

CT imaging is also used to quantify canal compromise through various methods (no clear superiority or reproducibility of one method over another has been demonstrated to date).

Further reference is made to the “load sharing classification” (Gaines score) of specific fractures in this dissertation (used as a patient inclusion criteria in the study). The load sharing classification is a CT imaging-based form of classification that portrays the bearing capacity of the anterior bony column (McCormack T 1994, Parker JW 2000) with a score of seven or greater representing extensive loss of bearing abilities, and thus predicting greater risk for failure of cantilever bearing instrumentation.

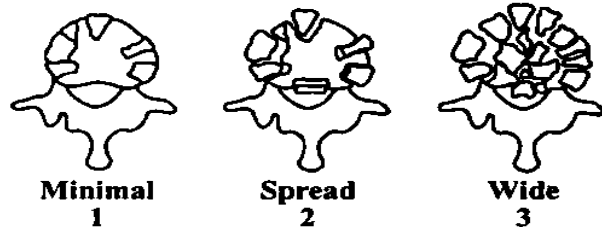
## Comminution/Involvement



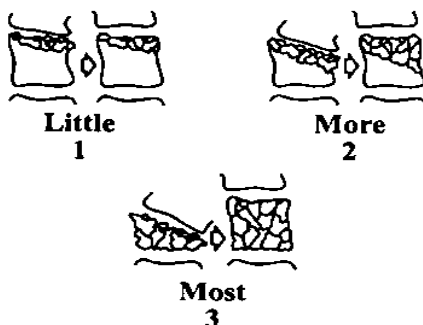
- 1 Little = < 30% Comminution on sagittal plane section CT
- 2 More = 30% - 60% Comminution
- 3 Gross = > 60% Comminution

## Apposition of Fragments

- 1 Minimal = Minimal displacement on axial CT cut.
- 2 Spread = At least 2mm displacement of < 50% cross section of body.
- 3 Wide = At least 2mm displacement of > 50% cross section of body.



## Deformity Correction



- 1 Little = Kyphotic correction  $\leq 3^\circ$  on lateral plain films.
- 2 More = Kyphotic correction  $4^\circ - 9^\circ$ .
- 3 Most = Kyphotic correction  $\geq 10^\circ$ .

Load sharing classification (Gaines score)

### 2.4.3. Magnetic Resonance Imaging:

MRI presents the superior imaging modality in terms of demonstrating neural integrity as well as intervertebral disk pathology or ligamentous insufficiency. Spinal cord -, cauda equine - and nerve root compression, is readily visualized.

T2 weighted imaging shows a bright flare within the spinal cord in the presence of oedema, this "cord signal" may be the harbinger of poor neurological prognosis.

MRI imaging further contributes with information regarding the position and station of involved intervertebral disks in the injured spinal column providing the necessary information to aid in the decision of open surgical treatment modalities versus closed manipulative techniques and conservative management (not restricted to thoracolumbar injuries).

MRI also provides the ability to evaluate the structural integrity of the posterior longitudinal ligament. It has been shown that an intact posterior longitudinal ligament on MRI is associated with superior canal clearance utilizing indirect methods through posterior distraction instrumentation, compared to cases with a disrupted posterior longitudinal ligament. (Oner FC 2002)

Posterior ligamentous complex (PLC) integrity has also been shown to be an important determinant of the recurrence of kyphosis in surgically treated patients at final follow up, and is therefore a further important determinant demonstrated on MRI, when considering the most appropriate treatment modality for a specific injury pattern. (Oner FC 2002)

### *2.5. Classification*

A myriad of classification systems have been proposed over the years attempting to relate mechanistic-, anatomic- or biomechanical features of specific injury patterns to prognostic factors.

The early column concept of spinal biomechanics was first described by Holdsworth (1960). It was initially conceptualized as a two column model with a solid anterior - and composite posterior column. This system did not contribute towards decision making and treatment algorithms, and was modified by Denis (1983) to include a third - middle column. Stability of the spinal column was dependent upon the structural integrity of at least two of the three columns. The anterior column consists of an anterior longitudinal ligament, the anterior half of the vertebral body, the anterior annulus fibrosis and the anterior disc; the middle column consists of the posterior half of the vertebral body, posterior annulus, posterior disc and posterior longitudinal ligament. The posterior column comprise the posterior arch and is made up out of the spinous processes, laminae, facets, the pedicles and the posterior ligamentous structures namely – Ligamentum flavum, interspinous ligaments, and the supraspinous ligaments. (Denis F 1983)

### 2.5.1. Denis Classification:

Denis stratified thoracolumbar injuries into major and minor injuries. Minor injuries include: Articular process fractures (1%), Transverse process fractures (14%), Spinous process fractures (2%), and Pars inter-articularis fractures (1%).

Major injury patterns consist of:

1) Compression fractures (48%)

- With the middle column as described in the “three column concept” intact.

Four subtypes exist namely:

- a. Type A – with superior- and inferior endplates of the affected vertebral body fractured.
- b. Type B – with fracture of the superior endplate.
- c. Type C - with fracture of the inferior endplate.
- d. Type D – with both endplates intact.

2) Burst fractures (14%)

- With failure of anterior and middle columns under axial load. Five subtypes exist:

- a. Type A – with superior- and inferior endplates of the affected vertebral body fractured.
- b. Type B – with fracture of the superior endplate.
- c. Type C – with fracture of the inferior endplate.
- d. Type D – burst rotation.
- e. Type E – burst lateral flexion.

3) Flexion distraction injuries (5%)

- With compression failure of the anterior column, and tension failure of the posterior and middle columns. Four subtypes are described:

- a. Type A – one level bony injury.
- b. Type B – one level ligamentous injury.
- c. Type C – two level injury with bony middle column.
- d. Type D – two level injury with ligamentous middle column.

4) Fracture dislocations (16%)

- With failure of all three columns in tension, compression, rotation or shear.

- a. Type A – Flexion rotation.
  - i. Posterior and middle columns fail in tension and rotation.
  - ii. Anterior column fails in compression and rotation.



- b. Type B – Shear.
  - i. All three columns fail in a shearing mechanism.
- c. Type C – Flexion distraction.
  - i. Tension failure of the middle and posterior columns.
  - ii. Anterior tear of the annulus fibrosus and stripping of the anterior longitudinal ligament.

Inter – and intra-observer reliability has been shown to be moderate only (79% and 56% respectively). (Wood KB 2005)

### **2.5.2. McAfee classification:**

This classification evolved from the Denis three column concept, in an attempt to predict the mechanism of failure of the middle column with greater accuracy. This classification system was derived from the review of CT scans as well as plain film radiographs of a hundred consecutive thoracolumbar injuries. This radiographic review revealed that the middle column could fail by axial compression, axial distraction or translation.

The McAfee classification distinguishes between injuries resultant from distractive forces, and those from a primarily compressive force. This understanding, can aid in decision making during surgical reduction and fixation.

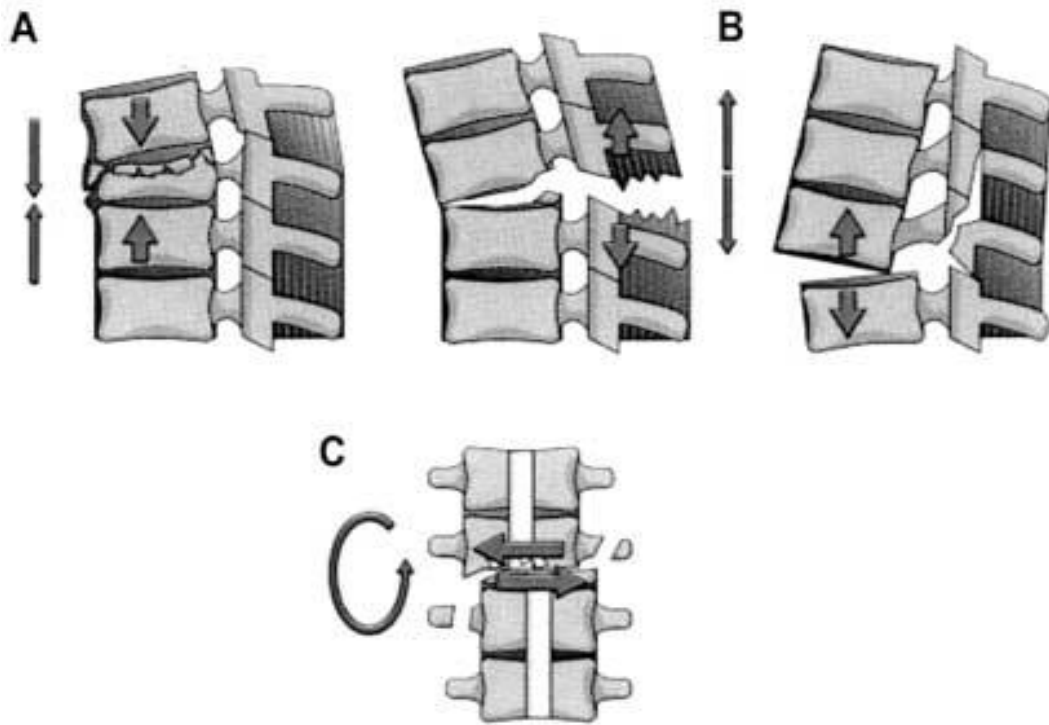
This classification has however been criticized as inadequate in describing all fracture patterns, and has not yet been validated in terms of prognostic value. (Mirza SK 2002)

### **2.5.3. Magerl classification (AO classification)**

This classification endures widespread use and is based on the analysis of more than 1400 thoracolumbar fractures.

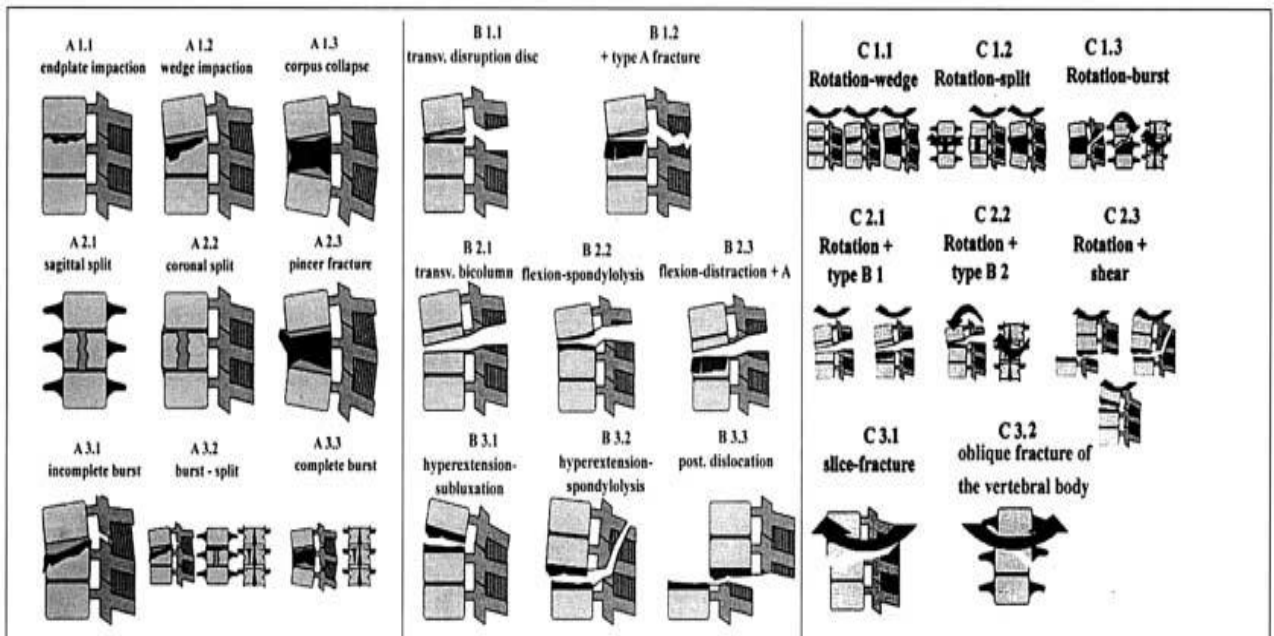
This classification divides injuries into:

1. Type A – Compression type injuries
2. Type B – Distraction type injuries
3. Type C – Rotation injuries.



AO Classification (Magerl)

Further sub classification is based on the disruption pattern or morphology of the spinal elements; primarily differentiating bony disruption and ligamentous injuries.



AO Classification - Expansion

The Magerl classification is considered the most comprehensive of the classification systems. Inter- and intra-observer reliability has been shown to be problematic (82% and 67% respectively). (Wood KB 2005)

#### **2.5.4. Thoracolumbar Injury Classification and Severity Score (TLICSS)**

TLICSS represent the most recent evolution in attempts to create a comprehensive and integrated morphological and mechanistic classification with prognostic and treatment directed predictive value.

Treatment route dictated by predicted instability is a central theme to this classification, but the method for determining instability remains contentious.

The TLICSS classification utilizes three primary criteria to determine stability – fracture morphology, neurologic injury and status of the posterior ligamentous complex (PLC).

Fracture morphology is determined by plain film radiographs and CT imaging. It is divided into three classes of compression (with burst as sub-category), translation or rotation, and distraction. These classes represent the different mechanisms of injury. The presence of neurologic injury signifies a higher energy mechanism, and dictates appropriate management (especially in the instance of incomplete neurological deficit). Posterior ligamentous complex injury, with disruption, as illustrated on T-2 weighted MRI (particularly fat suppressed images) also weights the score of this system in favor of surgical intervention.

Surgical intervention is warranted for a TLICSS score greater or equal to 5 and conservative management is advocated for a score of 3 or less.

The reliability scores for the TLICSS system have been promising with surgeon opinion in agreement with the TLICSS score in 96.4% of cases. (Vacarro AR 2006)

This system is however not fully validated by a prospective randomized study.

TLICSS		
1. <u>Injury mechanism: (use worst level)</u>		
Compression		
Simple	1 Point	
Lateral angulation > 15°	1 Point	
Burst	1 Point	
Translational / rotational		
	3 Points	
Distraction		
	4 Points	
2. <u>Posterior ligamentous complex disruption:</u>		
Intact	0 Points	
Suspected-/ indeterminate injury	2 Points	
Injured	3 Points	
3. <u>Neurologic status:</u>		
Nerve root involvement	2 Points	
Conus medullaris / cord involvement	Incomplete	3 Points
	Complete	2 Points
Cauda equine involvement	3 Points	
<p>The score is equal to the total of the three components, a score equal to or less than 3 dictates conservative management. A score of 5 or greater is indicative of a need for operative treatment, with a score of 4 allowing for either conservative- or surgical management.</p>		

## Chapter 3: Treatment considerations

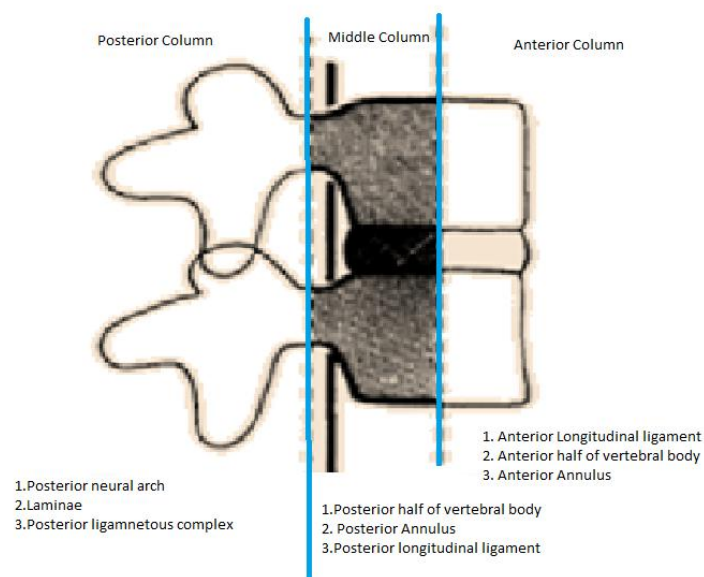
### *3.1. The concept of stability*

The spine is considered to be unstable following injury that renders the spine incapable of maintaining mechanical and neurological integrity under normal physiological loads. The resultant outcome, if no additional intervention is made, can include: further and progressive neurological damage, Progressive and unacceptable deformity and chronic pain with disability.

#### *3.1.1. Denis' Three-column Concept:*

Instability according to Denis exists with the disruption of any two, or more of the three columns as described in his three-column concept (described under classification systems). (Denis F 1983)

Thoracolumbar stability can usually be attributed to the middle column with an injury typically being seen as stable in the presence of an intact middle column.



**Denis' Three Column Concept**

Denis further describes three degrees of instability:

1. First degree (Mechanical instability with potential for late kyphosis)
  - a. Severe compression fractures
  - b. Seat-belt type injuries
2. Second degree (Neurologic instability with potential for late neurologic injury)
  - a. Burst fractures without neurologic deficit
3. Third degree (mechanical and neurologic instability)
  - a. Fracture-dislocations
  - b. Severe burst fractures with neurologic deficit

### 3.1.2. McAfee

McAfee noted that burst fractures can be unstable: with acute progression in neurologic impairment and deformity, or late onset of pain, neurological deficit and deformity.

He described specific factors in burst fractures indicative of instability.

1. > 50% canal compromise.
2. 15°-25° of kyphosis.
3. > 40% loss of anterior body height.

### 3.1.3. White & Panjabi

Specific scoring criteria were described by White and Panjabi for the assessment of clinical instability in spinal injury.

In the thoracolumbar spine an instability score of 5 or more indicates instability.

Element	Points
Anterior elements unable to function	2
Posterior elements unable to function	2
Disruption of costovertebral articulation	1
Radiographic criteria	
Sagittal displacement > 2.5mm	2
Relative sagittal plane angulation > 5°	2
Spinal cord or cauda equine damage	2
Dangerous loading anticipated	1

**White & Panjabi stability assessment**

No standard algorithm for the determination of stability exists, and the above mentioned scoring systems and concepts only serve to aid the decision in appropriate course of management. The TLICSS system as described in chapter 2 may also be a helpful tool, although it still requires validation. (Vacarro AR 2006)

## *3.2. Treatment*

### **3.2.1. Conservative management:**

Most thoracolumbar fractures can be managed successfully through conservative measures utilizing prolonged bed rest, casting methods, or bracing. The difficulty is often in predicting which fractures can be safely treated in this manner based on clinical and radiological findings. Prolonged recumbency further contributes to pulmonary compromise and decubitus ulcers; and special mitigating precautions should be implemented along with thromboprophylaxis.

To date no infallible treatment protocols or recommendations have been described, in spite of numerous publications on the matter. It is generally assumed that stable thoracolumbar fractures including Denis' minor injury types, compression fractures, stable burst fractures and injuries with a TLICSS score equal to – or less than 3 requires consideration for conservative management. Conservative management is used in conjunct with analgesia and is anecdotally recommended for a minimum of ten to twelve weeks to allow bony union. Regular follow up with radiographic review to assess healing and maintenance of spinal profile is recommended.

Healing is denoted by a progressive decrease in pain, return to functional activity and radiographic evidence of healing.

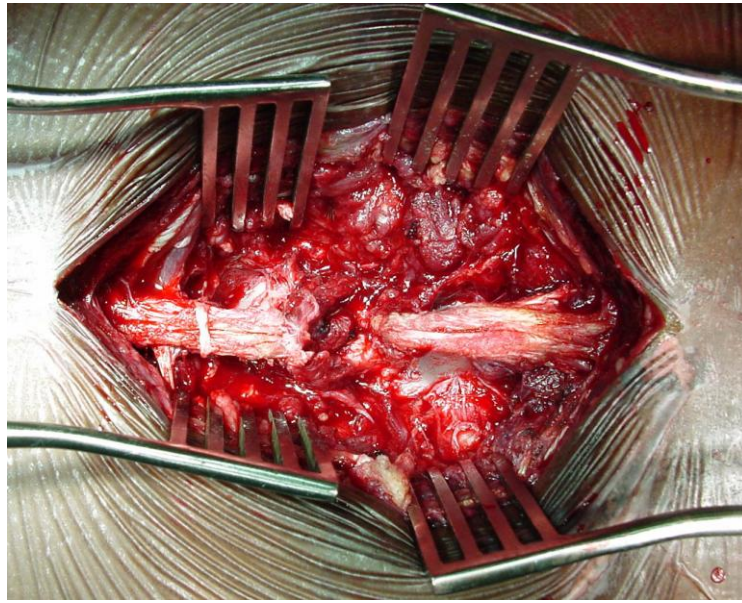
Failure of conservative management is defined as progression in spinal deformity, progressive neurological impairment, persistence of pain or intolerance to casting or bracing.

### **3.2.2. Surgical management:**

Surgical treatment is strongly recommended in patients with incomplete neurological impairment with canal compromise, fracture dislocations, multiple non-contiguous injuries or failed conservative measures. Injury to both middle and anterior columns as described by Denis in conjunction with disruption of the posterior ligamentous

complex (evident on MRI) is progressively being described as definite indication for surgical treatment of thoracolumbar injuries.

Relative indications for surgical stabilization of thoracolumbar fractures include: marked obesity precluding bracing or casting and poly-trauma, requiring multiple surgeries or manipulation of the patient to allow nursing care.



**Disrupted posterior ligamentous complex**

Goals of surgical management include:

1. Shorten duration of incapacitation and hospitalization.
2. Optimization of function.
3. Facilitation of nursing care.
4. Prevention of deformity, instability and pain.
5. Optimizing neural decompression while providing a stable internal fixation over the least number of spinal motion segments.

Surgical intervention can broadly be categorized as anterior-, posterior-, or combined anterior and posterior procedures. Literature comparing the different procedures is limited; with vague boundaries in terms of specific indications for the respective interventions.

The type of procedure is often influenced by surgeon's experience and preference, as well as neurological status and fracture pattern.



### 3.2.2.1. Anterior surgery:

Injury to the conus medullaris or cauda equine often accompanies fractures to the thoracolumbar region. The neurological impairment is generally caused by impingement through retropulsion of vertebral body fragments, or kyphotic alignment. In general anterior surgery serves to decompress the neural elements (especially in the instance of incomplete neurological deficit) through a partial - or full corpectomy. Anterior surgery further facilitates the placement of an anterior bearing strut; ranging from cadaveric allograft (Femur, Humerus or Fibula), autograft or cage construct, that contributes to bearing of the trunk cephalad to the level of injury. A neurological improvement of up to one modified Frankel grade has been reported in anterior only management of thoracolumbar injuries, along with a 15.3° improvement in kyphotic deformity and a subsequent loss of 2.1° in sagittal profile and a 95% fusion rate. (Sasso RC 2005)

### 3.2.2.2. Posterior surgery:

Posterior surgery can be used to stabilize unstable injuries through instrumentation and in the presence of an intact posterior longitudinal ligament allows for indirect clearance of retro pulsed bony fragment in the vertebral canal with aid of ligamentotaxis.

Segmental hook and rod constructs have largely been replaced by pedicle screw and rod constructs allowing for shorter segment instrumentation and the associated sparing of adjacent motion segments. Pedicle screw constructs allow for true three dimensional fixation (transcending all three columns).

Multiple reports of catastrophic failure have been published (Alanay A 2001, Tezeren G 2005). The advent of Titanium pedicle screw constructs with superior yield strength seems however to have profoundly decreased the mechanical failure of these constructs, certainly within the confines of biomechanical models in laboratories. (Bonfield W 1997)

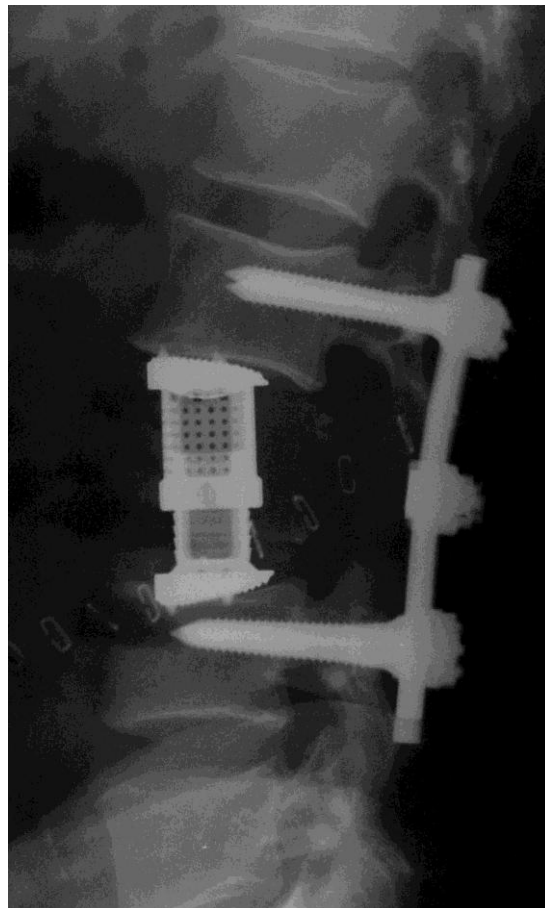
Appleyard et al from the Murray Maxwell Biomechanics Research Laboratory proved titanium pedicle based implants to be superior in terms of stiffness, bending strength as well as fatigue strength, with a further marked decreased flexibility compared to stainless steel constructs of similar dimensions.

### 3.2.2.3. Combined Anterior- and Posterior procedures:

Specific indications and quantified benefits of combined anterior and posterior procedures remain indistinct. Various biomechanical studies in has shown superior construct yield strength in combined constructs, over anterior only and posterior only constructs. The theoretic advantage in the combined approach is found in the ability to maximally clear the vertebral canal, followed by a construct superior in strength and maintenance in sagittal profile.

The additional surgical approach, compared to an anterior- or posterior only intervention does further contribute to its inherent morbidity and risks.

Again the posterior ligamentous complex and its integrity, is paramount to the decision on a stand-alone procedure versus a combined anterior- and posterior procedure, in a posterior ligamentous complex deficient spine. (Vaccaro 1999)



**Combined Anterior- and Posterior procedure**

## Chapter 4:

### Specifics of treatment as dictated by injury type

#### *4.1. Burst - and compression fractures*

##### **4.1.1. Non-surgical treatment:**

Compression fractures can typically be treated non-surgically. Posterior ligamentous complex - integrity is considered a prerequisite for non-surgical treatment.

Plain film radiographic findings suggestive of posterior ligamentous complex disorder include:

1. Anterior vertebral body height loss greater than 50 %
2. Gapping of interspinous process space
3. Kyphosis in excess of 30°

Presence of these radiographic findings should prompt further investigation with MRI, and or consideration for surgical treatment.

Milder injuries with minimal height loss (less than 10° compression) and thoracic injuries with additional support from the ribcage often allows for mobilization without any external immobilization. More extensive injuries, yet stable injuries require external support.

The Jewett device (or similar hyperextension braces) counteracts flexion moments but doesn't offer stability in terms of lateral flexion and rotation, it therefore serves to restrict progression in kyphosis; of particular value in wedge compression injuries.

These orthotic aids should be utilized for six to eight weeks to maintain alignment and allow healing in an acceptable position. Adequate control of the injured level in orthotic aid, should be confirmed through standing (weight bearing) plain film radiographs, after initial fitting, and regularly followed up with further radiographic imaging to confirm maintenance in sagittal profile and balance until bone healing occurs.

Burst fractures can be attributed to higher energy mechanisms compared to compression fractures.

As with compression fractures an intact posterior ligamentous complex is considered paramount in case of non-surgical treatment for burst fractures. Again as with

compression fractures; plain film radiographic findings highly suggestive of posterior ligamentous complex disorder include:

1. Anterior vertebral body height loss greater than 50 %.
2. Gapping of interspinous process space.
3. Kyphosis in excess of 30°.

Custom made-to-fit clam-shell devices such as the thoracolumbosacral orthosis (TLSO) provide support in the sagittal and the coronal planes, and further counteract rotational moments at the site of injury as required in burst-type injuries. It provides the same type of stability as a Risser-like body cast, but is often better tolerated.

Log-rolling precautions and strict bed rest are required until the intended brace is securely fitted. Prior to full ambulation, weight bearing radiographs should again confirm adequate control of the injured spinal segment. The kyphotic angle as well as vertebral body height should be adjudicated and compared to initial radiographs with any alteration in dimensions being scrutinized for posterior ligamentous complex disruption. Again, follow up radiographs should be obtained regularly, and the patient well informed about the additional symptoms that might divulge neurological compromise such as cauda equine syndrome, or conus medullaris compression.

Failed conservative measures denoted by: progressive alteration in alignment or instability, progressive or new symptoms in keep with neurological compromise and failure of union with persistent pain beyond the expected healing period should prompt alteration of treatment to surgical intervention.

Outcomes of conservative management:

In compression fractures, a 69% incidence of non-specific back ache has been shown in evaluation of eighty-five patients with a minimum of three years follow up. It was further found that the degree of kyphosis correlated with pain intensity, but no critical threshold value was clearly demonstrated. Vertebral body height loss was not correlative, and neither physio-therapy, nor bracing influenced the outcomes. (Folman Y 2003)

The eleven to fifty-five year outcome results in forty-two neurologically intact patients, with stable thoracolumbar burst fractures, treated non-surgically, showed an average kyphosis of 26° in flexion and 17° in extension. Kyphosis did not correlate with the

degree of functionality or pain at final review. 88% of patients returned to their pre-injury occupation, with low pain scores averaging 3.5 reported; as per visual analog scale. None of the patients had any neurological deterioration. (Weinstein JN 1988)

Another study of thirty-eight patients with stable thoracolumbar burst fractures without neurological compromise, treated non-surgically reported an average increase in kyphosis from 20° to 24° (at average follow up of four years). Early ambulation was allowed and only nine patients made use of an orthotic aid. No correlation between kyphosis, canal compromise and clinical outcome could be demonstrated. (Shen WJ 1999)

The value of non-surgical treatment with the additional use of an orthosis was shown in a study reporting on the results of 60 consecutive patients with stable thoracolumbar burst fractures, without neurological compromise. Average follow up at forty-two months showed a final kyphosis of 8° increased from an initial 6°. Satisfactory functional outcome was found in 91%, with 83% of patients returning to their pre-injury level of activities. (Aligizakis A 2002)

Non-surgical measures are only rarely used in patients with neurological impairment following a thoracolumbar injury. This is most often the case in patients not fit for surgical management. An early review of results in eighty-nine patients with neurological impairment showed neurologic recovery in 35% of non-operatively treated patients, and 38% of operatively treated patients. The latter group did however contain a much larger group of patients with incomplete neurological injury (Burke DC 1976)

In patients with thoracolumbar burst fractures associated with a complete (Frankel A) neurological injury no recovery was found regardless of the method of treatment (surgical or non-surgical). Neurological injury could further be correlated with the degree of kyphosis at presentation. (Dendrinos GK 1995)

#### **4.1.2. Surgical treatment:**

Surgical treatment entails stabilization with, or without decompression of the neurological structures.

Lower incidence of pneumonia, shorter intensive care unit stay and lower hospital charges have been associated with surgical stabilization of thoracolumbar injuries within three days following injury. (Croce MA 2001)

The goals of surgical management of burst and compression fractures include:

1. Establishment and maintenance of normal spinal alignment.
2. Stability until solid bony fusion can be achieved.
3. In the presence of neurological deficit with canal compromise, decompression allows for maximizing the spinal canal volume allowing the liberation of entrapped neural elements.

These goals can be achieved through either anterior or posterior procedures.

#### 4.1.2.1. Compression fractures:

Rarely compression fractures deemed unstable, with disruption of the posterior ligamentous complex requires surgical stabilization. This can be readily achieved through posterior instrumented fusion using pedicle screw- or hook constructs facilitating solid bony fusion and correction of kyphosis.

#### 4.1.2.2. Burst fractures:

The surgical management of burst fractures remains a topic marred by differing opinions and controversy. This is particularly true in instances with no discernable neurological compromise and anterior-, posterior-, or combined procedures are widely advocated by proponents of the various procedures.

In patients with neurological impairment (especially incomplete lesions) most authors agree that decompression of the neural structures is beneficial; again the method best suited to achieve this goal, remains a matter of great controversy. Both direct- and indirect procedures to achieve this goal, are accepted in widespread practice.

Indications for surgical management include:

1. Mechanical instability with progressive- or risk for progressive deformity.
2. Neurological compromise (especially incomplete- or progressive neurological compromise).
3. Radiographic and clinical indicators pointing to a likely disruption of the posterior ligamentous complex:
  - a. Kyphosis of 30° or greater.
  - b. Loss of anterior vertebral body height in excess of 50%.
4. Continued pain after three to six months and documented non-union on bone-scan or MRI scan.

#### 4.1.2.2.1. Posterior procedures:

Mechanical stabilization of the unstable spine through a posterior procedure is effected through various instrument constructs. This includes hook-, or pedicle screw constructs (with various pedicle screw designs) including Schantz pins or so-called “internal fixator” devices. Pedicle screw constructs provide the theoretical advantage of three column stability over hook constructs, and also allow for short segment instrumentation. Hook and rod constructs have largely fallen into disuse due to the extended constructs required for adequate stability; it remains a useful option however.

Sub laminar wire constructs have played only a small role in the stabilization of unstable burst fractures.

Anterior and posterior procedures have been shown to result in equivalent clinical outcomes, but posterior-only procedures are associated with a shorter duration of surgery and less blood loss in comparison to anterior procedures.

#### Indirect decompression:

Simple laminectomy as a decompressive procedure in thoracolumbar injuries has largely fallen out of favour because of the further posterior destabilization and progressive subsequent kyphotic deformity resulting.

Indirect decompression in concept relies on longitudinal distraction along the axis of the fractured segment. With aid of ligamentotaxis the intact posterior longitudinal ligament and or posterior annulus serve as reduction agents to the displaced and retropulsed vertebral body fragments. 23% improvement in the mean cross sectional dimension of the vertebral canal has been shown, immediately following indirect-reduction; with further improvement through remodelling of canal dimensions to 87% of normal at five years. Patients with incomplete neurological injury further showed an average improvement of 1.8 Frankel grades. No relation could be shown between extent of canal compromise and neurological injury or recovery. (11)

Integrity of the posterior longitudinal ligament seems to be influential in the degree of correction achieved through ligamentotaxis, and it has been inferred that canal compromise in excess of 50% as reviewed on plain film radiography or CT scan imaging may be indicative of posterior longitudinal ligament disruption, warranting a direct decompression procedure.

Various authors have further commented on the efficacy of indirect reduction of thoracolumbar burst fractures related to timing of the surgery following injury. Canal clearance of 33% has been shown with surgical intervention within one week compared to 24% within the second week and 0% within the third week following injury. (Court-Brown Charles 2006)

Posterior approach with direct decompression of neural structures:

Techniques allowing for a posterior approach with posterolateral access to the vertebral canal and neural structures have been developed; in conjunction with pedicle screw stabilization and fusion.

This method allows for direct decompression of neural structures and clearance of the spinal canal.

Significant reduction in canal abutment has been shown on CT imaging, following decompression with a posterior only approach.

The posterolateral technique for decompression of the spinal canal is effective at the thoracolumbar junction and in the lumbar spine, but the unyielding spinal cord limits the success of this technique in the spinal segments cephalad to the thoracolumbar junction.

This procedure involves hemi-laminectomy and removal of a pedicle. This technique further allows posterolateral decompression of the dura along its anterior dimension. The posterolateral approach does not necessarily improve neurologic function. However, compared to posterior instrumentation with indirect reduction, it does help ensure canal reduction and alignment, which may aid recovery and hasten rehabilitation. (Garfin SR 1985)

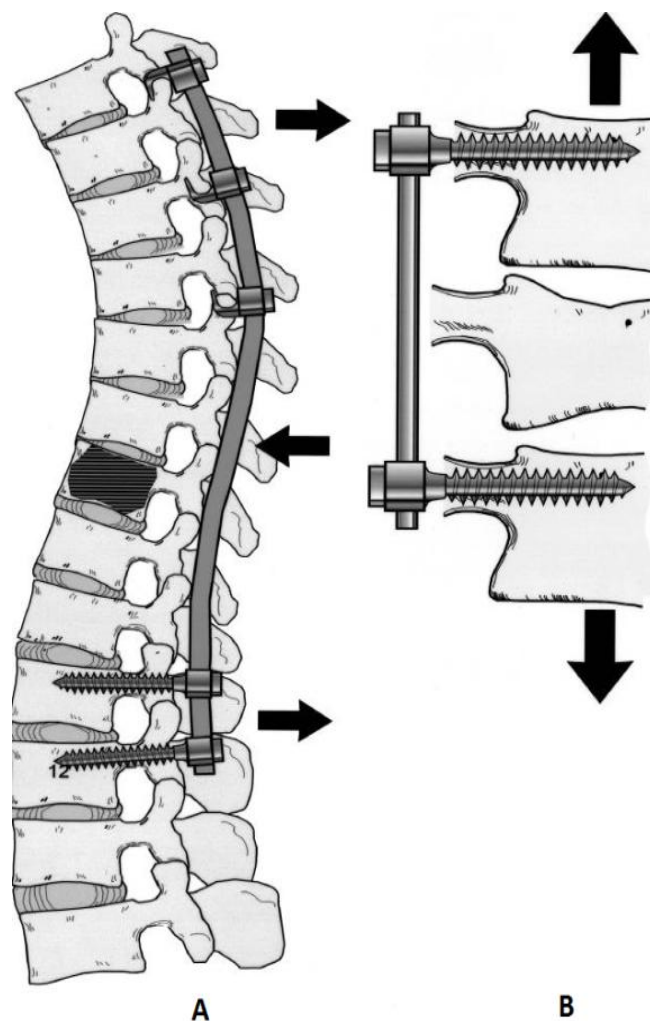
Short segment vs. Long segment fusion:

The number of levels that should be included in a posterior only construct, in order to achieve a robust fixation along with a biomechanical option able to withstand repeated cycling in the absence of a normal anterior supporting column, remains an unresolved and controversial topic. The stabilizing and bearing forces in longer constructs make use of three anchor points, with the area of contact between lamina and rod between the terminal fixation points acting as the third anchor ("A" in figure below). In short segment constructs, bearing occurs in a cantilever fashion, with the



instrumentation withstanding the full complement of deforming forces (“B” in figure below). (McLain 2006)

A specific study has shown a loss in sagittal profile of  $10^\circ$  in 55% of cases instrumented with short segment constructs compared to none in the extended construct group, this did not transcend into a clinical difference or difference in patient satisfaction. (Tezeren G 2005)



**Cantilever bearing**

Transpedicular bone graft:

Transpedicular bone grafting was introduced in an attempt to provide anterior column bearing abilities and reconstitution of the burst vertebral body height. This technique did however not show diminished rates of instrumentation failure. (Alanay A 2001)

Fusion vs. non-fusion technique:

In an attempt to conserve motion following a thoracolumbar junction injury, non-fusion techniques have been advocated; with instrumentation merely supporting the injured level to allow bony healing, with subsequent removal to allow reinstatement of maximum motion.

Retrospective review of twenty-eight patients treated with a non-fusion technique for unstable burst fractures, revealed no difference in outcome compared to patients with concomitant posterolateral fusion. Instrumentation failure was reported at 14%, similar to reported failure rates in patients treated with fusion. (Sanderson PL 1999)

A superior trend in progression of kyphotic deformity following non-fusion technique in thoracolumbar injuries has been demonstrated. (Davis JH 2009)

#### 4.1.2.2.2. Anterior procedures:

Anterior surgery allows for direct decompression and removal of retro pulsed bony fragments from the vertebral canal. It is considered the most efficacious method of canal clearance, when decompression of the vertebral canal is required with good visualization and access to the fractured vertebral body and adjacent caudal and cephalad disks, allowing for complete clearance.

The extensive clearance of anterior structures serves to further destabilize the spine. This necessitates the re-establishment of the bearing integrity of the anterior vertebral column through various techniques.

The ideal reconstructive device or material used in re-establishment of the anterior column; should provide a mechanical stability and spinal alignment maintenance while facilitating stable fusion. Structural autograft has been established as the gold standard in anterior column reconstruction. Tricortical iliac crest-, fibula- or rib grafts are most commonly used. (Eck KR 2000) (Molinari RW 1999) (Singh K 2002)

Complications associated with the use of autograft centre mostly around donor site morbidity and lack of intrinsic stability. (Sasso RC 2005) (Lee SW 2000)

Allograft struts and more recently; titanium mesh, or expandable cages filled with cancellous autograft provide further options to the treating physician.

Excellent arthrodesis rates in treatment of spinal fractures have been reported with utilization of allograft, leading to question the use of expensive cage implants in fractures requiring corpectomy and anterior fusion. (McKenna PJ 2005)

Slightly lower incorporation of allograft was reported compared to autograft, with little clinical significance in terms of outcome and maintenance of sagittal profile. (Finkelstein JA 2004)

Successful allograft anterior column reconstruction has been reported extensively in the available body of literature; with specific reference to the management of spinal tuberculosis infection. (Singh K 2002, Hodgson AR 1960)

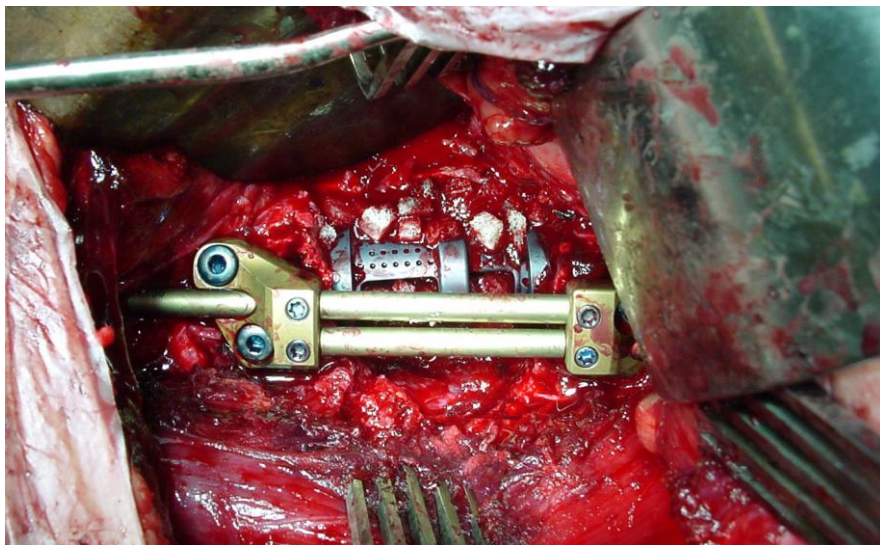
Further successes have also been reported with anterior column reconstruction utilizing Titanium mesh cages filled with autograft bone. (Bhat AL 1999, Federico C 1999)

Problems encountered with mesh cages included poor remodelling and biological incorporation of the central region, of the large quantity of bone graft used to fill the voluminous void within the titanium mesh cage.

The sharp edges resting on the adjacent vertebral end-plates have also been shown to cause subsidence into the adjacent vertebra, with pseudo-arthrosis and loosening as result. (Grob D 2005, McKenna PJ 2005)

Expandable titanium cages provide a further option for anterior column reconstruction with additional benefit in the inherent adjustable fit, which allows for precise tension and bearing capability to be created, independent from bony healing.

Good results have been published with anterior column reconstruction in tumor surgery, (Ernstberger T 2005) and in conjunction with posterior instrumentation it offers an effective yet expensive option for fracture treatment. (Vieweg 2007, Lange U 2007)



**Expandable Titanium cage with anterior instrumentation**

Time delay to anterior decompression:

It has been suggested that delay in anterior decompression has a detrimental effect on the potential for neurological recovery. An extensive meta-analysis of the available body of literature revealed some statistically significant advantage to early surgery (within 24 hours) in the neurologically incomplete injured patient. No definite advantage could be demonstrated to subgroups within the 24 hour time frame. (La Rosa G 2004)

It has further been shown that decompression of the conus medullaris in an incomplete patient showed neurological improvement in a statistically significant number of patients, up to two years following initial insult, with an overall bowel- and bladder control improvement in up to 50 % of patients, with fractures at the T12 level or caudal to this level. (Transfeld E 1990)

#### *4.1.2.2.3. Combined Anterior and Posterior procedures:*

Canal compromise in conjunction with dislocation of the spine may sometimes warrant a combination of anterior and posterior procedures.

These injuries result from an axial compression mechanism (burst- or compression fractures) combined with posterior distraction, rotation and or translation.

A strong indication for a combined anterior – and posterior procedure would include thoracolumbar injuries with incomplete neurological injury, canal compromise (retropulsion) as well as severe injury to the posterior bony elements.

Superior biomechanical stability and structural rigidity has been shown with combined anterior – and posterior procedures, with superior radiological outcomes. (Wilke HJ 2001, Been HD 1999)

Theoretic advantages have not been validated in randomized prospective trials.

#### *4.1.2.2.4. Minimal invasive options:*

Minimal invasive options for treatment of thoracolumbar burst fractures have been developed. Reports on the efficacy and results of these methods are sparse. Calculable rates of vascular injury and neurologic deterioration have been reported with anterior decompression using a thoracoscopic approach in order to perform a corpectomy supplemented with anterior column reconstruction and instrumentation.

Such complications are considered rare in open surgery; and the steep learning curve as well as extensive surgical duration must be considered with minimal invasive surgery. It is however deemed a safe and successful modality of treatment. (Khoo L 2002)

#### *4.2. Flexion distraction and Chance injuries (Seat-belt type injuries)*

Pure dislocation at the thoracolumbar segment is a rare occurrence. The mechanism associated with this type of injury consists of a flexion-, combined with a distraction moment; as typically found with an improperly worn, high-riding lap belt in a head-on collision. This creates a concentration of force at a rotational point anterior to the thoracolumbar junction, with enhancement of distractive forces along the posterior aspect of the spinal segment.

In contrast, with flexion-compression type injuries, this concentration of force is found at a fulcrum about the spinal canal, with compression on the structures anterior to this point and distraction posterior.

By convention, the variable patterns of vertebral body - and posterior element fracture, associated with a flexion-distraction mechanism are distinguished from fracture dislocations through the absence of translation.

Flexion-distraction type injuries are divided into: purely ligamentous injuries, osteoligamentous injuries or purely osseous injuries as reflected in the classifications. Two-thirds of patients with flexion-distraction type injuries sustain an injury to the neural elements through distraction.

Injury to the hollow viscus, often accompanies this type of spinal injury through a massive increase in pressures within the abdomen associated with the compression mechanism. Ecchymosis along the abdominal wall is suggestive of this occurrence.

These types of injuries are only very rarely treated non-surgically.

In purely osseous flexion distraction injuries, hyperextension casting or bracing may be considered for the duration of three - to four months (until radiographic and clinical union is established).

The vast majority of flexion-distraction injuries are treated through surgical measures.

The anterior longitudinal ligament is usually intact, as dictated through the injury mechanism. Anterior surgery with resulting further destabilization is therefore usually not considered. Posterior compressive instrumentation and fusion is the most commonly used treatment modality.

Over-compression should be avoided because of the risk of expulsion of loose disk fragments into the spinal canal, from a ruptured intervertebral disk.

Short-segment pedicle screw -, or hook constructs will usually suffice in the re-establishment of the posterior tension band, with resulting stability in this type of injury. (Court-Brown Charles 2006) (Spivak JM 2006)

#### *4.3. Fracture dislocations:*

Fracture dislocations at the thoracolumbar junction are usually complicated by a complete neurological deficit. These injuries are attributed to high energy mechanisms and are often associated with the multiply injured patient.

Surgery is indicated to stabilize the spine and facilitate mobilization, pulmonary care, rehabilitation, patient transfers and nursing care.

The mechanism of injury can be variable, and include flexion, extension, distraction and shear.

Reduction of the fracture dislocation is achieved through patient positioning on the operating table or through direct manipulation during surgery.

In the neurologically intact or incompletely injured patient, this reduction must be performed with the utmost care, to avoid further neurological damage.

A posterior approach and instrumented fusion will suffice in the vast majority of patients with fracture dislocations, with a combined anterior and posterior approach reserved for the instances with extensive vertebral body comminution, compression or displacement of vertebral fragments into the spinal canal.

Anterior stand-alone procedures are best avoided due to inadequate stability, and good stability has been reported in short-segment posterior-only instrumented fusions facilitated through pedicle screw constructs. (Spivak JM 2006)

#### *4.3. Gunshot wounds*

In general, fractures sustained through low velocity gunshot wounds to the spinal column are considered to be stable fractures.

Surgical debridement is required for high energy rifle or military assault weapon wounds, and surgical stabilization of the spine may be indicated.

Neural injury is often secondary to the blast or soft tissue pulse effect associated with the shock wave from bullet impact with decompression rarely indicated.

An exception to this doctrine would be a gunshot wound with bullet fragments in the spinal canal between T12 and L5, with impaired neurological function.

Bullet extraction may also be indicated for late neurological deficits secondary to bullet migration or lead toxicity.

There is a low infection rate associated with these injuries, and prophylactic broad-based antibiotic cover for a forty-eight hour period will usually suffice.

Trans-intestinal gunshot wounds traversing colon, intestine or stomach before entering the spine carry a significantly higher infection rate. Antibiotic cover is required for a duration of seven to fourteen days.

Steroid administration in gunshot wounds has been associated with higher rates of non-spinal complications.

## Chapter 5:

### Short segment posterior only instrumentation of thoracolumbar fractures: A study of outcomes

#### *5.1. Material and methods*

##### *Patient demographics*

Patients, who sustained traumatic junctional fractures of the thoracolumbar spine treated with stand-alone short segment posterior instrumentation, for the period December 2001 to July 2007, were retrospectively enrolled in the study.

##### *Injury stratification*

In order to reflect bony loss of the anterior two columns, injuries were divided into:

1. Fracture group (N=40) consisting of:

Unstable burst fractures

- Includes:*
1. Neurological fallout
  2. Loss of body height > 50 %
  3. Angulation > 30 °
  4. Scoliosis more than 10 degrees

And unstable compression fractures

- Includes:*
1. Loss of body height > 50 %
  2. Angulation > 30 °

2. Dislocation group (N=25) consisting of:

Fracture dislocations

Seat-belt type injuries

(With no relevant loss in bony bearing structure of the anterior columns).

##### *Surgical technique*

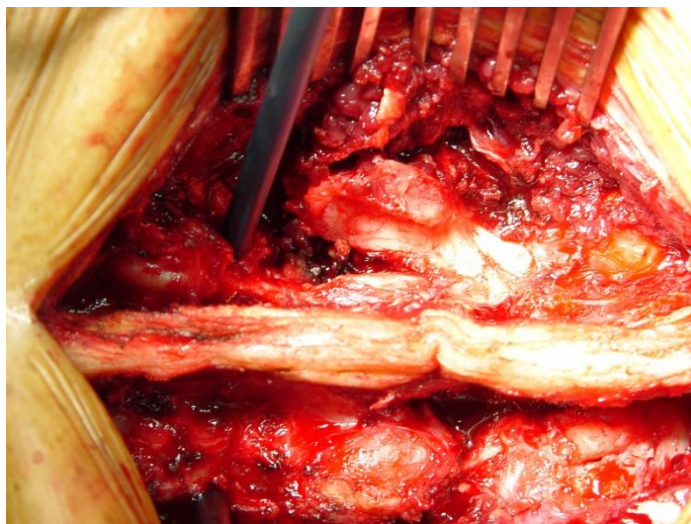
A standard midline posterior approach was utilized over the injured region, with subperiosteal dissection to expose the posterior components to the tips of the transverse processes. Mechanical stability was established through posterior instrumentation, as dictated by injury requirements.



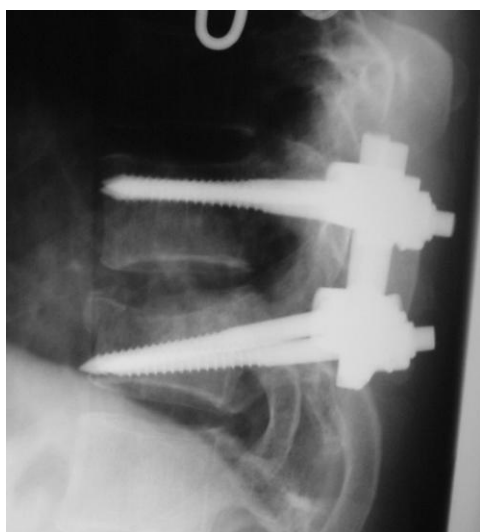
Instrumentation used included either Schantz pins (6mm) or pedicle screw constructs. Schantz pin constructs were typically utilized with reduction in vertebral body height as goal (Fracture group), and pedicle screw constructs in the dislocation group in order to achieve and maintain stability, without restoration in vertebral body height.

All constructs were short segment constructs restricted to adjacent – or “above and below” levels dependant on the surgeons perceived adequacy of bony purchase in the pedicles.

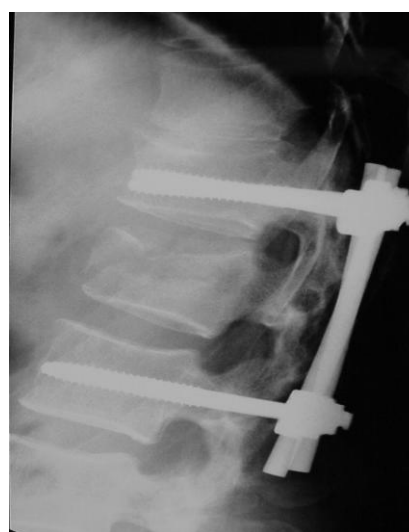
Posterolateral intertransverse fusion was performed in most cases (56), with nine cases managed with a non-fusion technique, and the eventual removal of instrumentation in an attempt to preserve motion.



**Midline posterior sub-periosteal approach**



**Adjacent level instrumentation**

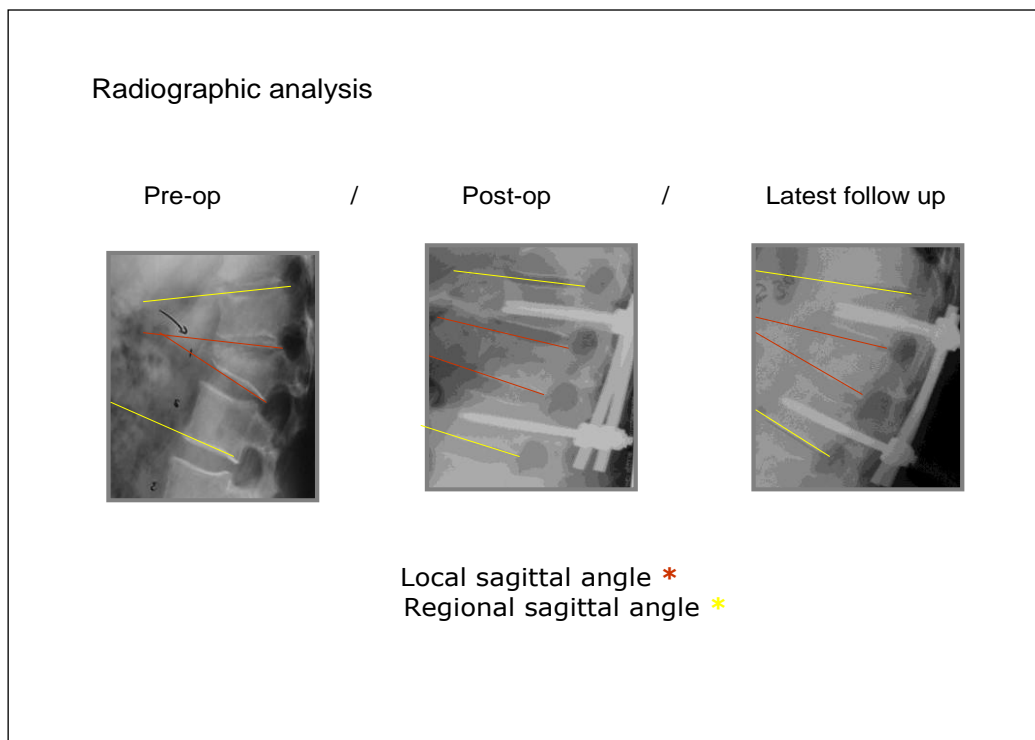


**Above - and below level instrumentation**

### *Quantification and survey*

Plain film XR review was performed at three separate instances in time, reflecting the initial post injury position, the immediate post surgery position, and the position at latest follow up.

Measurements were taken at each interval to reflect a local sagittal angle (angle between superior and inferior end-plates of the fractured vertebra, or level of injury), and a regional sagittal angle (angle measured between superior end-plate of most cephalad instrumented vertebra, and the inferior end-plate of the caudad most, instrumented vertebra). These angles were then compared to portray trends in reduction in the fracture group; and the maintenance of sagittal profile in both the fracture and the fracture dislocation groups.



### **Radiographic Analysis**

Patients were further broadly categorized into three groups of follow up, namely -less than three months,- three months to one year,- and more than one year). Average loss in position could be established for each individual time sub-group, reflecting the continuity of loss in position, vs. loss related to a specific time interval.

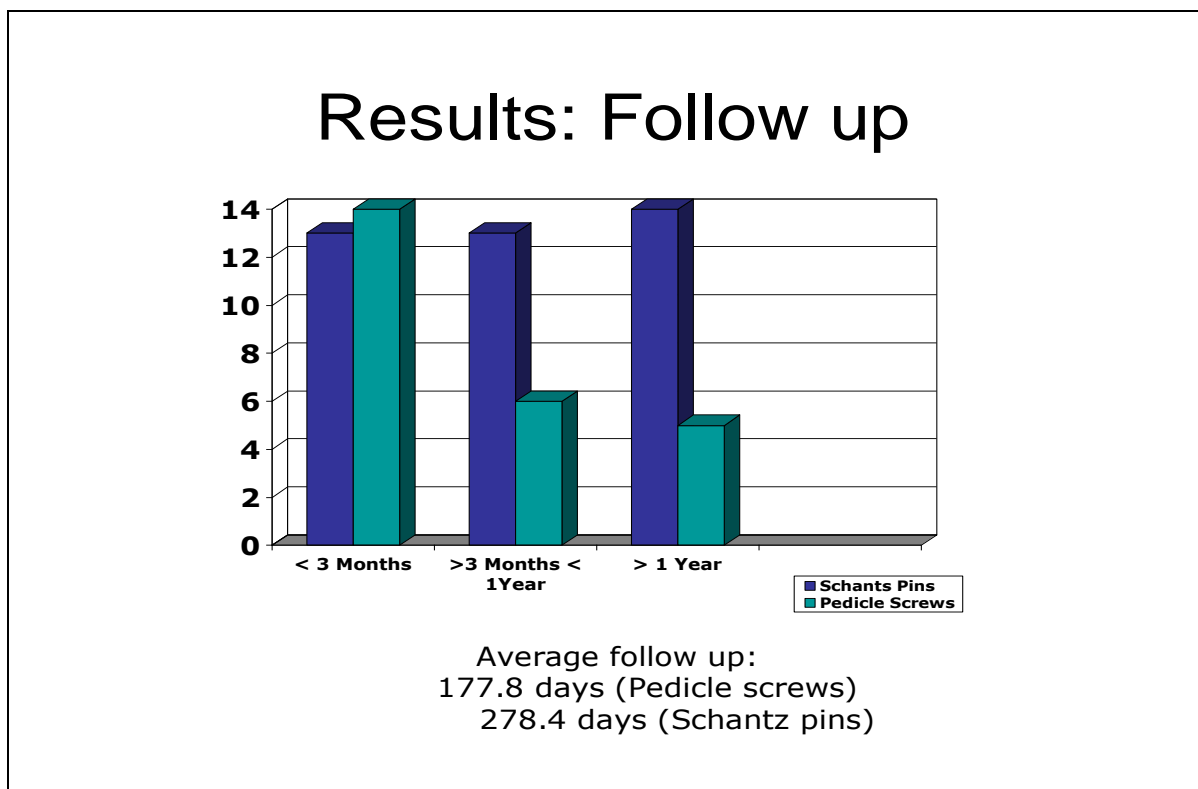
All patients had bony union of the fusion mass; or union of the involved fracture reported, at time of final follow up in order to be included in the study.

Factors identified as possible contributors to correction, and or, loss of correction included:

1. Use of bone graft (no distinction between Allograft or Autograft)
2. Instrumentation position (Adjacent levels, or above- and below)
3. Engagement of anterior cortex of vertebral body with instrumentation
4. Post-operative bracing
5. Time duration from injury to surgery  
(Special interest in subset of patients managed surgically within 72 hours from injury)
6. Instrumentation type

#### *Patient demographics*

The study included 65 patients (50 males and 15 females), with a mean age of 36 years (17-62±12.3). Aetiology presented as falls 19.5% (30 patients), and motor vehicle accidents 54% (35 patients). Of the mentioned motor vehicle accidents, 46% presented as pedestrians (16 patients), and 54% as vehicle occupants (19 patients). The average duration of follow up was 278 days in the fracture group (Schantz pin constructs), and 177 days in the fracture dislocation group (pedicle screw constructs).



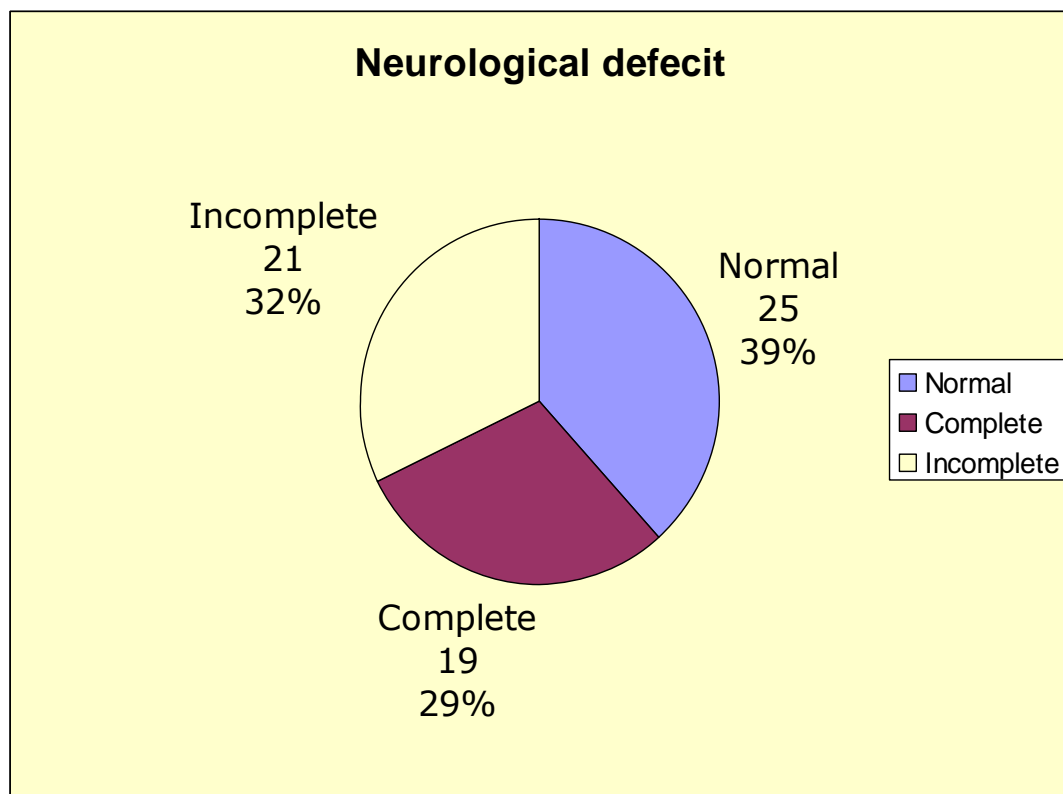
**Duration of follow-up**

40 Patients fell into the fracture category, and 25 patients into the dislocation category.

31 patients had no other injuries. Other associated injuries included: 22 other orthopaedic injuries, 5 patients with non-contiguous spinal injuries, 5 head injuries and 7 thoracic injuries.

Neurological compromise was present in 40 patients as charted on admission and again at discharge using the ASIA scoring system. A higher rate of neurological impairment in our patient population compared to 15-20% as described in the literature (Kenneth J Koval 2006), can be attributed to the fact that the spinal unit functions as a referral unit for neurologically impaired patients, with neurologically intact patients sometimes managed at the point of initial contact.

Four patients showed an improvement in ASIA motor score, but not to the extent of advancing a level in ASIA grading.



**Neurologic Deficit**

### *Peri-operative*

The average time delay from injury to - Acute spinal cord injury unit – admission was 4.9 days (0-53±9.9 days). Time delay from injury to time of surgical episode was 9.7 days on average (0-63±12.8 days). With surgery to discharge period spanning an average of 18.64 days (2-88±17.6 days). Average duration of surgery was 100 minutes (30-255±40 minutes).

Average blood loss during surgery was reported as 359 ml (50-2200±355 ml)

Bone graft was utilized in 56 cases (distinction was made between autograft and allograft), and post-operative bracing (TLSO) used in 6 patients only.

## **5.2. Results**

The fracture group (Schantz pin constructs) showed 10.25 degrees (0-26 ± 6.5 degrees) of reduction on average, (55% improvement in deformity) in terms of sagittal profile of the fractured vertebra. Regional sagittal profile improved by an average of 11.6 degrees (0-38 ± 8.9 degrees).

The subgroup of fractures treated surgically within 72-hours from injury incident showed a local sagittal profile improvement average of 9.3 degrees (0-20 ± 6.1 degrees). And a regional sagittal profile improvement 8.3 degrees (0-22 ± 7.5 degrees) on average.

Average progression in kyphosis of the local sagittal angle, and the regional sagittal angle were found to be 2 degrees (18% of reduction) and 5 degrees respectively (51% of reduction). This data was shown for the fracture group in combination with the dislocation group, with no statistical difference demonstrable between the two groups.

Regional loss of correction data was to an extent influenced by one specific case showing 10 degrees regression (following 2 degrees of initial correction) in regional sagittal angle, (in spite of a mean median data distribution of 20%). This case had a reported hardware failure namely a bent connection rod (Schantz pin construct).

### *Influencing parameters*

Bone graft was not performed, in 9 patients (Fracture group). This non-fusion technique displayed a superior trend in loss of sagittal profile. This trend was most

markedly demonstrated in the Regional sagittal angle. It was however not statistically significant (Local sagittal angle:  $p=0.40017$ ; Regional sagittal angle:  $p=0.05568$ ).

In patients with posterior fusions, no clear-cut difference could be shown in loss of position, between cases utilizing autograft in comparison to allograft ( $p=0.58$  Mann-Whitney U  $p=0.62$ ).

Levels of instrumentation related to the level of injury, as above- and below compared to adjacent levels of instrumentation, demonstrated no statistically significant influence (Local sagittal angle:  $p=0.01$  Mann-Whitney U  $p=0.82$ ; Regional sagittal angle:  $p=0.82$  Mann-Whitney U  $p=0.97$ )

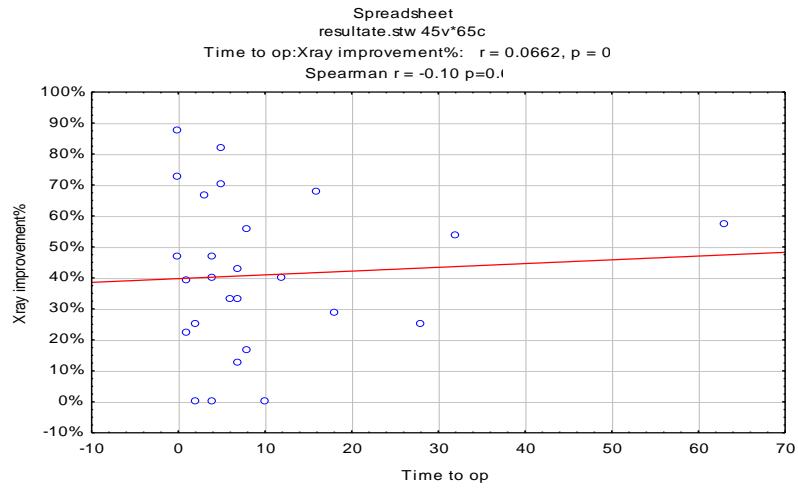
Engagement of the anterior cortex of the instrumented vertebral body, did not display a statistically significant influence compared to vertebrae with instrumentation not engaging the anterior cortex (Local sagittal angle:  $p=0.29$  Mann-Whitney U  $p=0.93$ ; Regional sagittal angle:  $p=0.51$  Mann-Whitney U  $p=0.26$ ).

No superiority could be demonstrated in terms of maintenance in position between Schantz pin constructs and pedicle screw constructs (Local sagittal angle:  $p=0.22$  Mann-Whitney U  $p=0.62$ ; Regional sagittal angle:  $p=0.52$  Mann-Whitney U  $p=0.59$ )

Due to the low number of patients managed with bracing post-operatively, no deductions of statistical value could be made.

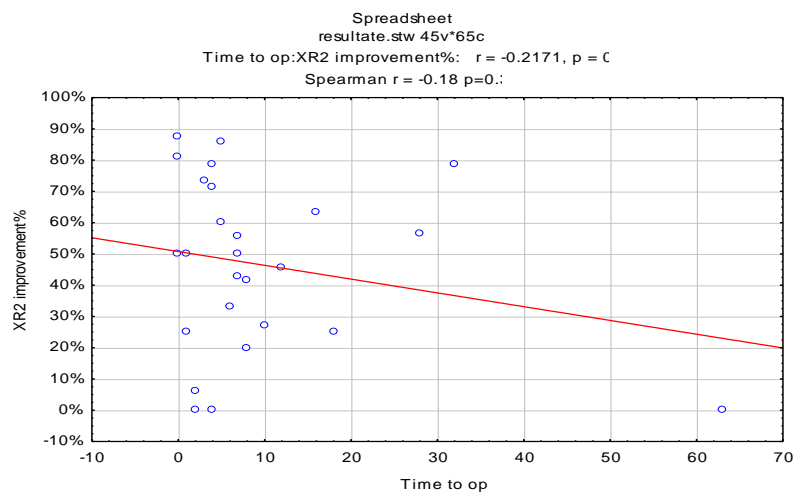
Time duration from time of injury to time of surgery made no significant difference in terms of degree of reduction, and in terms of loss in position

Time delay to surgery influence on reduction – Local sagittal angle



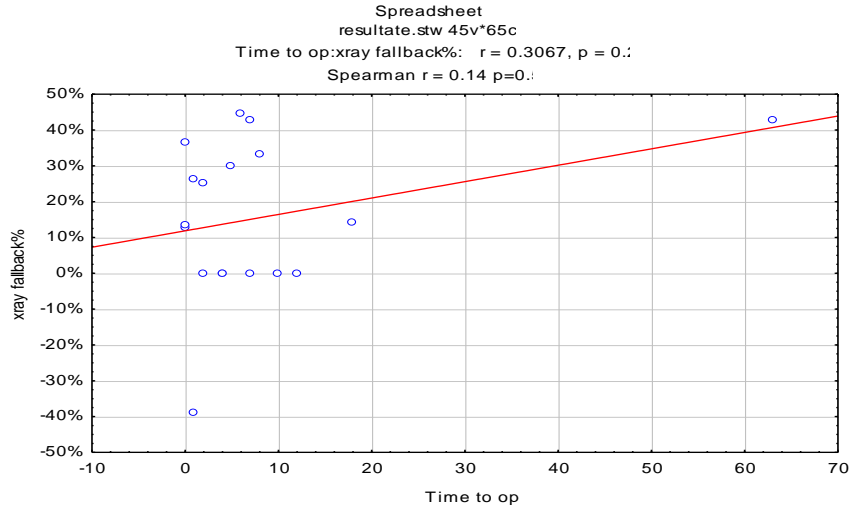
Time delay - influence on reduction (local)

Time delay to surgery influence on reduction – regional sagittal angle



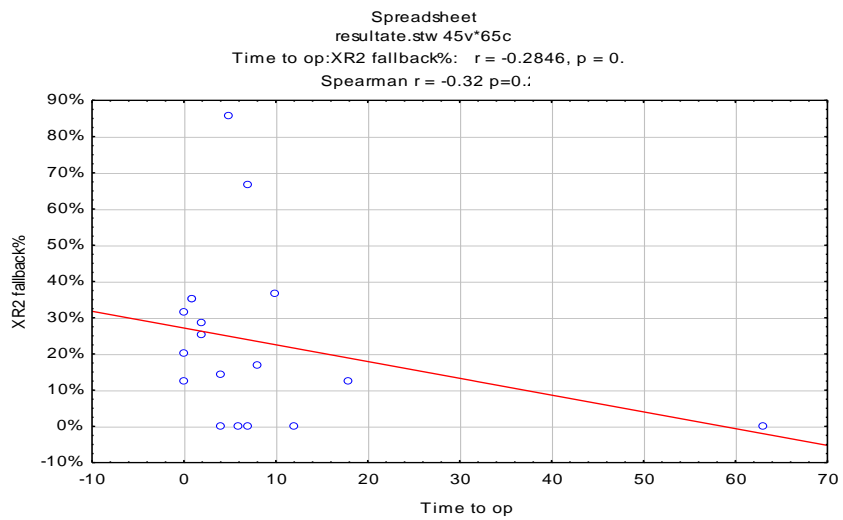
Time delay - influence on reduction (regional)

Time delay to surgery influence on loss in position – Local sagittal angle



**Time delay - influence on loss in position (local)**

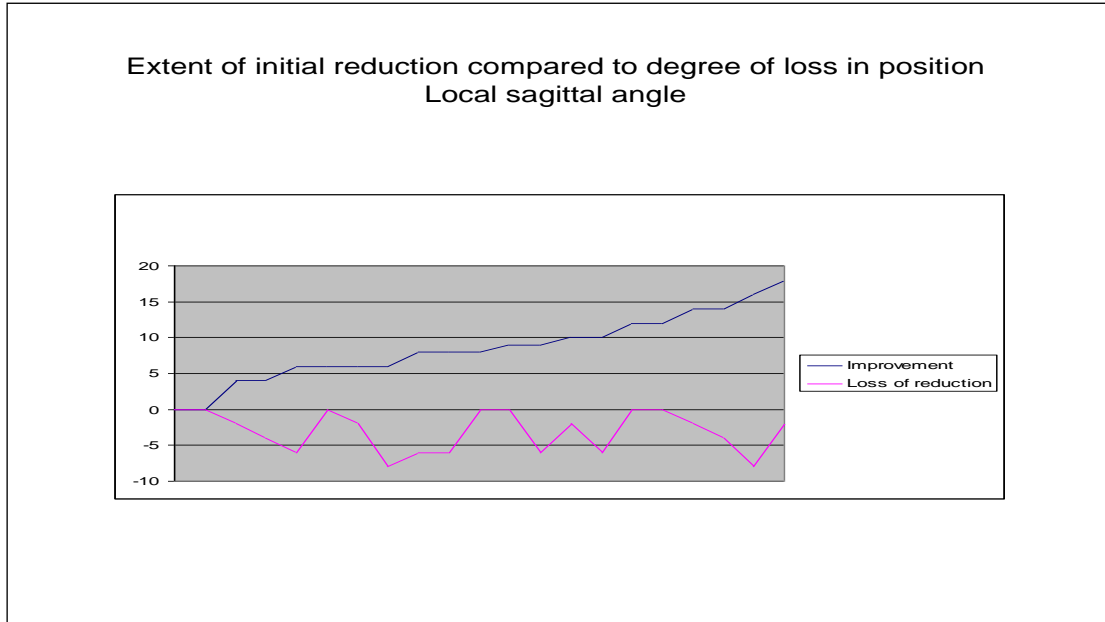
Time delay to surgery influence on loss in position – Regional sagittal angle



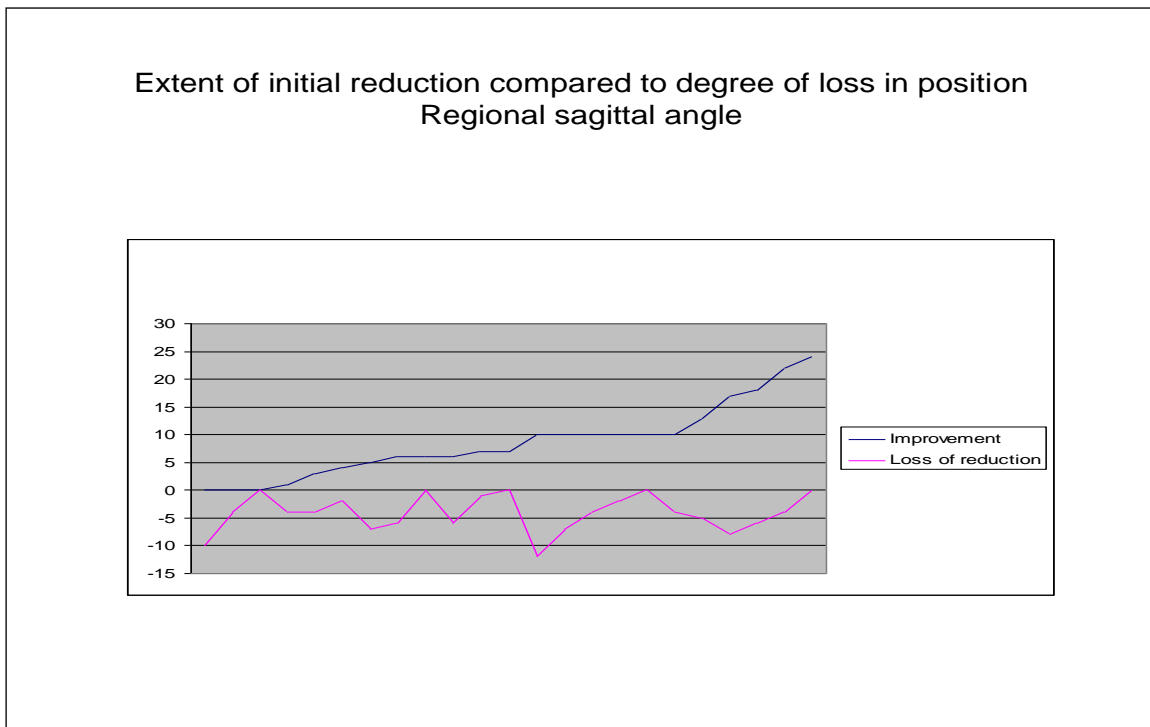
**Time delay - influence on loss in position (regional)**



The extent of reduction also did not reflect a clear relation to loss in position  
 (As shown in figures below)



**Reduction in relation to loss in position (local)**



**Reduction in relation to loss in position (regional)**

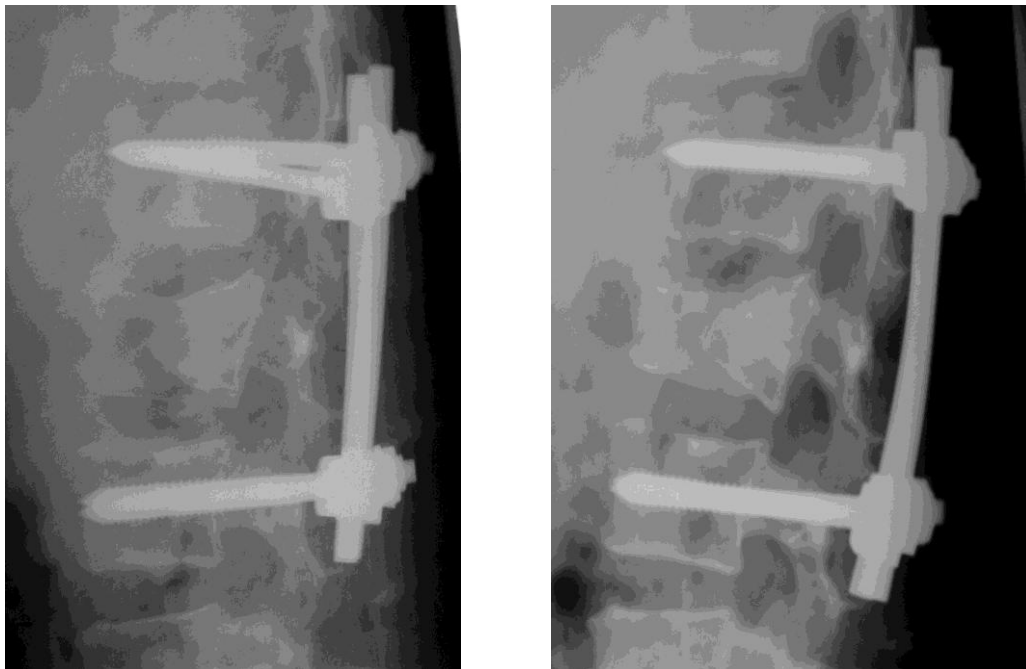
### *Complications*

Including the exaggerated loss in position of the aforementioned case, there were a total of two reported hardware failures. The additional case was reported as - bent Schantz pins, with no apparent breakage (214 days post-surgery). This entails a 3.07% hardware failure in total. No instances of catastrophic failure or breakage of instrumentation were reported.

A single case was reported to demonstrate misplaced pedicle screws inferior to the pedicle.

Another case developed infection at the bone graft harvest site; this was treated successfully with surgical debridement and antibiotics.

500% loss in position – bent connection rods



**Complication - Bent connection rods**

### *5.3. Discussion*

Short segment posterior instrumentation as stand-alone treatment offers a safe and effective modality in the management of thoracolumbar junctional injuries. Low peri-operative complications presented, and most patients endured a short term admission in the Acute Spinal Injury Unit prior to discharge to a rehabilitation facility or home.

Limited loss in reduction of sagittal profile did occur, this was however restricted to the earliest time sub-cohort, suggesting that that this occurrence coincided with post-operative rehabilitation and mobilization. No progression could be demonstrated between the three time sub-cohorts, with averages remaining at the position achieved at the end of the immediate post operative period, the period corresponding with attainment of bony fusion.

No difference could be demonstrated, in terms of loss in sagittal profile between the fracture group (Schantz pin constructs) and the dislocation group (Pedicicle screw constructs), This reinforced the idea that loss in sagittal profile following thoracolumbar fractures is not only attributable to the structural collapse of the bony support column, but that that the adjacent discs also contribute a fair extent of collapse (Oner CF 1998). This phenomenon was present in the dislocation group in the absence of end-plate fractures.

Non-fusion technique compared to fusion; was the only factor with bearing on the trend in loss of sagittal profile. Bone graft was not performed, in 9 patients (Fracture group). This was purposefully done, with removal of the utilized instrumentation, post union, in an attempt to preserve motion in the affected vertebrae. A superior trend was demonstrated in loss of sagittal profile. This trend was most markedly demonstrated in terms of Regional sagittal angle further suggesting that multiple intervertebral discs were likely involved in this process. This finding was in contrast with other authors. (Wang S 2006)

From Boden's extensive work on animal models we deem autograft as the gold standard in terms of promoting fusion. (Boden SD 2002)

The type of bone graft did however not seem to influence our data in terms of loss in sagittal profile, with fusions performed using Allograft only, compared to Autograft, showing no statistical difference in terms of loss in position. In the patient with a spinal injury, and especially so in instances with neurology, complications with the bone graft harvest site can likely be avoided, utilizing Allograft only, without significantly worse loss of position. This however warrants further study.

The levels of positioning (above-and-below vs. adjacent levels) of the instrumentation did not influence the maintenance of position in our data series. Aiming to preserve motion segments has been proven to be beneficial (Hassan D 2005), and utilizing adjacent level instrumentation did not prove detrimental in terms of maintenance in sagittal profile. Engagement of the anterior vertebral body cortex also did not prove to significantly alter the bearing capabilities of the constructs reinforcing the sentiment that pedicular fixation achieves fixation through purchase in the pedicle mostly.

The decision on levels of instrumentation is therefore based on the shortest possible construct to achieve fusion without sacrificing purchase.

#### ***5.4. Conclusion***

Schantz pin constructs compared well with pedicle screw constructs in the stand-alone treatment of unstable junctional fractures in terms of durability and maintenance of reduction. In spite of cantilever bearing properties short segment posterior instrumentation has been shown to offer an acceptable option for treatment in unstable thoracolumbar fractures and dislocations. The procedure has a relatively low complication rate with little blood loss, and low incidence of failure. It provides a cost effective option for prompt stability allowing early mobilization of a patient with a spinal injury.

The relative long average waiting period before surgery could be performed is a likely explanation for not being able to demonstrate a relationship between post injury time and reduction (average delay of 6.5 days).

Bone graft is strongly recommended for all procedures attempting stability in trauma related junctional instability.

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## Appendix 1: Data Sheet





## Appendix 2: Ethics committee approval



UNIVERSITY OF CAPE TOWN

**Health Sciences Faculty**  
**Research Ethics Committee**  
 Room E52-24 Groote Schuur Hospital Old Main Building  
 Observatory 7925  
 Telephone [021] 406 6492 • Facsimile [021] 406 6411  
 e-mail: Nosu.Tywabi@uct.ac.za

21 January 2008

**REC REF: 019/2008**

**Dr RN Dunn**  
 Orthopaedics Unit  
 Groote Schuur Hospital

Dear Dr Dunn

**PROJECT TITLE: SHORT SEGMENT POSTERIOR INSTRUMENTATION IN THORACOLUMBAR FRACTURES: A REVIEW OF OUTCOMES**

Thank you for submitting your study to the Research Ethics Committee for review.

It is a pleasure to inform you that the Ethics Committee has **formally approved** the above mentioned study.

Please notify Dr B Patel (in Hospital Management) that Groote Schuur Hospital medical records will be used for research purposes.

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

**Please quote the REC. REF in all your correspondence.**

Yours sincerely

**PROF M BLOCKMAN**  
**CHAIRPERSON, HSF HUMAN ETHICS**