

**“A STUDY OF THE MANAGEMENT OF UNSTABLE
THORACOLUMBAR SPINAL FRACTURES WITH PEDICLE
SCREW INSTRUMENTATION”**



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MASTER OF SURGERY

*IN
ORTHOPAEDICS*

Submitted by

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Dr. DIDDLESHRAVAN KUMAR

LIST OF ABBREVIATIONS

TL	Thoracolumbar
VB	Vertebral body
AP	Antero-posterior
mm	Millimeter
cm	Centimeter
ASIA	American spinal injury association
TLSO	Thoracolumbar Spinal Orthosis
SCI	Spinal cord injury

ABSTRACT

Background: The thoracolumbar junction is the most common area of injury to the axial skeleton. Forces along the long stiff kyphotic thoracic spine switch abruptly into the mobile lordotic lumbar spine at the thoracolumbar junction. Goals of treatment are to obtain a painless, balanced, stable spine with optimum neurological function and maximum spine mobility. The present prospective study has evaluated the effectiveness of pedicle screw instrumentation in various fractures around the TL spine to overcome the complications encountered in the conservative line of management of these fractures.

Materials & Methodology: 20 cases of fractures around the TL spine were operated with posterior pedicle screw fixation one or two level above and below the fracture. The cases were followed up for a mean of 6 months with radiological and neurological evaluation.

Results: The average age groups of the patients studied were 19 to 50 years majority were males, fall from height being the predominant mode of injury involving the T12 and L1 vertebral body. The unstable burst fractures the most common type of fracture, radiological parameters sagittal angle and index were recorded pre and post-operatively. The neurological grading was done using the Frankel's score. Follow-up was done for a minimum of 6 months where sagittal angle reduction achieved was 10.85° at final follow-up from 24.75° pre-operative. The sagittal index achieved at final follow-up was 71.8% compared to the pre-operative mean of 50.6%. The neurological improvement was regarded to be fair enough for the type of injury sustained and fixation achieved.

Conclusion: We found that the application of posterior instrumentation resulted in a reasonable correction of the deformity with a significant reduction in recumbency-associated complications; the limiting factor being the small study group and short follow-up period.

Keywords: thoracolumbar, pedicle screw and rod instrumentation.

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INTRODUCTION

The thoracolumbar junction is the most common area of injury to the axial skeleton. Forces along the long stiff kyphotic thoracic spine switch abruptly into the mobile lordotic lumbar spine at the thoracolumbar junction. Biomechanically, this transition zone is susceptible to injury and is the most commonly injured portion of the spine, motor vehicle accidents are the leading cause of injury followed by falls and sports related injuries.¹ Males are at four times higher risk than females. Other organ system injury is encountered in up to 50% of thoracolumbar trauma patients.² High energy injuries such as those causing thoracic level paraplegia, have a mortality rate of 7%.³

Various classifications have been proposed for the treatment of thoracolumbar spine injuries. These classifications all vary in their complexity and ability to help differentiate between the specific treatment options.

The goals of treatment are to obtain a painless, balanced, stable spine with optimum neurological function and maximum spine mobility. Significant controversy exists about the best method of treatment to achieve these goals.

Non-operative treatment includes postural reduction, bed rest, ambulatory bracing and observation. When considering today's cost conscious hospital environment along with medical complications of prolonged bed rest, an early goal of non-operative treatment is a mobile patient with or without a brace. It is mainly indicated for stable injuries without the potential for progressive deformity or neurological injury.

Operative treatment for thoracolumbar fractures is controversial. Surgery is typically employed in patients with unstable, three-column injuries and significant neurological deficits.

The development of reliable and biochemically stable implants for stabilization has evolved over many years beginning from Harrington rod system, interspinous process wiring, serrated spinous process plates, short compression rods, springs, laminar wiring and to the recent addition of pedicle screw implantation.

The advantages of surgical treatment with pedicle screw and rod fixation systems in spine injuries are shorter hospital stay, more complete rehabilitation, fewer complications of prolonged immobilization and reduced morbidity and mortality. Hence there is a need for study to delineate the benefits of this procedure on the functional outcome of the patients.

Twenty cases of unstable thoracolumbar fractures stabilized with pedicle screw and rod fixation system have been performed in our institution to prove how cost effective these fixations are to the patients.

AIMS AND OBJECTIVES

1. To evaluate the restoration of the alignment of the spine and spinal canal.
2. To aid in early mobilization.
3. To evaluate the improvement of neurological level if any following the procedure.

REVIEW OF LITERATURE

Various modalities of treatment have evolved over centuries in the treatment of spinal column injury, with the earliest methods found in the Edwin Smith papyrus, which dates as far back as 1550 BC.⁴ Early therapies called for the prescription of rest and application of dressings to wounds. Unfortunately, a spinal injury remained a relatively morbid injury largely due to lack of knowledge about the anatomy of the spine. Spinal anatomy became better defined in the ancient Greek era. Although human dissection was prohibited in Greek society, knowledge was obtained through the observation of athletes in the gymnasium, the examination of cadavers in the battlefield, and the dissection of animals.⁵

The physician and philosopher Hippocrates (460–377 BC) was considered the father of spinal surgery. In his treatise *On the Nature of Bones*, Hippocrates provided a detailed description of the different segments of the spine. He described three levels of spinal vertebrae: those supra-clavicular in location, those with costal articulations, and those located between the chest and pelvis. The first documented schematic for the treatment of non paralytic spinal injury is found in the treatises of Hippocrates.⁵ Treatment consisted of fracture reduction followed by immobilization. A variety of devices were created to achieve traction and reduction; these included the Hippocratic ladder, the Hippocratic board, and the traction bed. Similar devices appeared in ancient Arabic and Chinese literature as well. Hippocrates speculated on the use of trans-abdominal repair for anterior spinal dislocation in his writings, although he stated that it could only be performed postmortem.⁶

Surgical intervention in a living patient was first proposed by Paul of Aegina who lived in the seventh century. Paul recommended that a fracture associated with paralysis should be treated by removal of bone fragments that cause a neurological deficit. It has been documented that, in addition to using traction devices, Paul used a red hot iron during spinal interventions.⁵ In the 15th century treatise *Cerrahiyetul Haniye*, the Turkish physician Serefeddin Sabuncuoglu also described traction methods and the use of cauterization in the treatment of spinal injury.⁷ His treatise contains illustrations of instruments needed for the surgical procedures as well as the traction devices that were used. In the 1700s Sir Percival Pott surgically opened and drained paravertebral abscesses caused by tuberculous spondylitis, a condition that now is referred to as Pott disease.⁴

Fitz Lange (1909) described the use of steel rods or celluloid bars tied to spinous processes with either wire or silk. Dr. Don King (1940) used screws through the facet for spinal stabilization. A natural extension of screw fixation by H.H. Boucher (1959) was to aim the screws more medially to enter the pedicle and exit through the base of transverse process.^{8,9} Paul Randall Harrington (1950-1960) his contributions of rod and hooks for posterior spinal stabilization in cases of idiopathic scoliosis correction. Edward Luque (1970) developed rod-sublaminar wire systems which were inexpensive and was suitable to support posterior spine especially in flexion, extension and rotation.¹⁰ Roy-Camille developed the pedicle screw fixation systems in 1960's. He has described his own technique for the identification and entry of pedicle. In 1986, they studied 123 cases with

thoracolumbar spine fractures. They stabilized spine injuries with pedicle screw-plate system. 40% patients showed neurological improvement. The radiological correction of deformity was excellent. Patients with complete paraplegia at thoracic level did not show any improvement in neurological status. They felt pedicle screw-plates are good implants for stabilization.¹¹ Dr. Arthur D Steffee although he did not originally device the pedicle screw he has modified it and he has invented variable screw placement plate. He also has devised his own method for pedicle screw entry.¹²

Olerud S (1988) in a prospective study of 17 patients followed up with thoracolumbar fractures, best long term functional results are obtained with correction and maintenance of spinal alignment and preservation of motion segments. These goals can be achieved in majority of patients through the use of posterior spinal instrumentation.¹³

An et al., (1989) studied patients treated for low lumbar burst fractures with a number of available treatment modalities. Patients treated with short segment rigid pedicle fixation had less low back pain and higher healing rates than those treated with longer instrumentation constructs.¹⁴

Babu ML (1990) treated 63 cases of thoracolumbar fractures operatively. 85% patients showed neurological improvement. Good stability was achieved in operated patients. They concluded that operative management gives good results even in situation where sophisticated instrumentation is not available.¹⁵

Vanden Berghe.L, Mehdiian, Lee.J.C, Weatherley.C.R. (1993) in their bio-mechanical analysis of various methods of fixation concluded that pedicular screw

fixation provided the greatest overall stability and is the best system for fixation for thoraco lumbar fracture fixation¹⁶

Lewis J ,McKibbin B(1994) have concluded after comparison of management of unstable thoracolumbar fractures using conservative and operative means of fixation that open reduction and internal fixation are indicated in the interests of long term spinal function.¹⁷

Stamburg (1997) observed that short rigid instrumentation (transpedicular) is the best in accomplishing shorter fusion, maintaining vertebral height and restoring sagittal alignment. Internal fixation using pedicle screw system has become widely accepted as the method of choice in the surgical treatment of thoracolumbar fractures managed by posterior fusion and instrumentation.¹⁸

Manish Chadha ,Raj Bahadur (1998) in their study of 20 patients with thoracolumbar fractures treated with Steffe pedicle system with average follow up of 30 months concluded that reasonable deformity correction and fair chance of neurological recovery and significant reduction of recumbency can be expected even when surgery is delayed.¹⁹

Yousry Eid, Mohd. H El-Shafie, Hani A Morsy, M Agdy,(1999) concluded that pedicle screw fixation for unstable thoracolumbar fractures gives satisfactory results, provided that adequate restoration of the neural canal is achieved either directly or indirectly. The addition of posterior fusion of stabilized segments would improve the overall results,specially for the more unstable injuries with fracture dislocations.²⁰

Yassin Elgoul(2000) in their study of 24 pts with unstable burst fractures with partial neurological deficits with average follow up of 19.3 months concluded that

pedicle screw fixation is a highly reliable method for reduction and stabilization of unstable thoracolumbar fractures.²¹

M.DNasser,M.DAbdel Gawad(2001) in their study of 37 pts with average follow up of 6 months concluded that transpedicular screw-rod system has advantage of providing secure spinal stabilization.²²

Liljenqst,Hackenberg.L,Link. (2001) in their bio-mechanical analysis that pedicle screws are superior in comparision to hooks with superior pullout strength in spine fixation²³.

Andress (2002) analyzed 50 patients retrospectively who had an unstable burst compression injury at T12-L1 (type A3 according to Magerl) without neurological deficit. All fractures were stabilized by an internal fixator either with or without transpedicular grafting. Clinical results did not correlate with radiographic results, and neither the time until follow-up nor the type of fracture nor the use of transpedicular screw fixation with bone grafting affected clinical or radiographic results significantly.²⁴

James MD, (2002) in their study concluded transpedicular screw fixation in thoracolumbar spinal injuries to be reliable and the safe method, offers superior three column stabilization of the vertebral column and produces early pain-free fusion results.²⁵

Afzal S, Mir MR, Halwai MA, Shabir A(2002) have concluded that pedicle screw instrumentation is a favoured system for spinal fracture stabilization, provides stable and rigid fixation, thus aligning the spine anatomically and less extensive construct providing immediate mobilization, reducing hospital stay, high patient satisfaction with a rapid return of best possible function surgically.²⁶

Kaya RA (2004) in their study concluded although anterior vertebrectomy and fusion is generally recommended for burst fractures causing canal compromise, in these patients neural canal decompression can also be achieved by a modified transpedicular approach less invasively.²⁷

Mark R (2004) in a study concluded that posterior stabilization can be effective with chance fracture and flexion distraction injuries that have marked kyphosis and in translational or shear injuries. Advances in understanding both biomechanics and type of fixation have influenced that development of reliable systems that stabilize these fractures and permit early mobilization.²⁸

Yoon-Soo Lee, Joo-Kyung Sung, (2004) in their study of long term follow-up results of short- segment pedicle screw fixation for thoracolumbar burst fractures concluded that pedicle screw fixation is efficient and safe method.²⁹

Dipankar Sen, DK Patro (2005) concluded that even though the infrastructure for spinal Injury management in developing countries is inadequate in many aspects, still it is possible to achieve results comparable with standard literature by adequate decompression and stabilization followed by appropriate rehabilitation according to the social and cultural demands of the patients.³⁰

Jan Seibenga (2006) in a study of 34 cases of thoracolumbar fractures analyzed surgical treatment with 18 patients for a mean follow-up of 4.3 yrs with functional outcome scores and concluded that patients with burst fractures without neurological deficit should be treated with segmental posterior stabilization.³¹

Alexandre Sadao, Iutaka et al (2006) in their study of 19 patients of unstable thoraco lumbar fractures with average follow up of 10 months concluded that with appropriate technique pedicle screws are efficient in thoracolumbar fixation³²

Iutaka AS, Narazaki DK, Santiago Lopez AS et al. (2006) have concluded that CT is a very good analysis method for pedicular positioning. They also concluded that the treatment of unstable thoracolumbar spine fractures using pedicle screws is efficient and appropriately technically accurate.³³

Mohammad F. Butt (2007) in a study of 50 patients with thoracolumbar fractures proved that the advantage of an operative procedure for treating these injuries is the immediate stabilization of the injured spine and an indirect or direct decompression of neural structures, operative stabilization enables early mobilization without a heavy and uncomfortable cast and clearly shortens the hospital stay. The indication for an operative stabilization in patients with unstable spine injuries and complete paraplegia is the prospect of early rehabilitation and a reduced burden to the care giver.³⁴

Myung-Sang Moon (2007) in a study of 15 Denis burst and 2 Denis type D compression fractures between T12-L3 they concluded that short segment posterior pedicle fixation with contoured rods is an effective reduction and stabilization method and offered better consolidation of vertebral body without collapse and maintain the motion segment function.³⁵

Murat Altay (2007) in a study of 63 patients of thoracolumbar fractures 32 patients were treated by short segment posterior fixation and 31 patients with long segment posterior fixation. Clinical outcomes and radiological parameters (sagittal index and canal compromise) were compared according to demographic features and Magerl

subgroups statistically. They recommended that especially in patients who need more mobility with LSC point 7 or less with Magerl type A3.1 and A3.2 fractures without neurological deficit, short segment posterior fixation achieves adequate fixation without implant failure and correction loss.³⁶

Mohd Arif, Mohd Inam, Abdul Satar, Mohd Satar, Mohd Shabir(2009) in their study of 76 patients with thoraco-lumbar spine fractures concluded that posterior fixation by pedicular screws gives rigid fixation with excellent result which enables patients to resume daily activities early.³⁷

ANATOMY OF THE THORACOLUMBAR SPINE

In adults the vertebral column is typically composed of 33 vertebrae, lower 5 are fused to form the sacrum; 4 vertebrae usually comprise the coccyx, the first usually being separate and the following 3 fused. The remaining 24 remain separate bones: 7 in the neck, 12 in the thoracic region and 5 in the lumbar region.

THE THORACIC SPINE

The vertebral bodies of the thoracic spine increase in size from T1 to T12. The unique structures of the vertebral body in the thoracic spine are the facets, which are present on the upper and lower portions of the lateral surface of the body and articulate with the ribs forming the costovertebral joints. The superior facet lies cranially with articular surface on the dorsal aspect the inferior facet lies caudally with articular surface towards the ventral aspect. The facet joint of the thoracic spine is different from the rest with a coronal orientation. The transverse process of the T11 and T12 do not have the costal facet for articulation with the tubercle of the rib.

THORACIC VERTEBRA

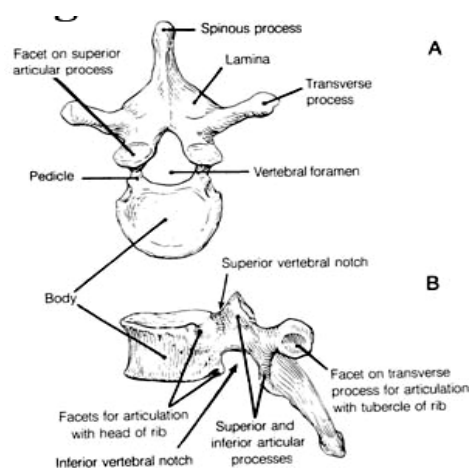


FIGURE 1: ANATOMY OF THE THORACIC VERTEBRA

The thoracic pedicle projects posterior to the upper portion of the vertebral body and has a greater superior-inferior diameter than the medio-lateral diameter. The mean pedicle widths and heights for T1 to T12 vary from 4 to 10 mm and 8 to 17 mm respectively. The projection point of the pedicle axis is located medial to the lateral edge of the superior and superior to the midline of the transverse process.

THE LUMBAR SPINE.

The vertebral body is larger, heavier and wider transversely and has a kidney shape. The spinal canal is triangular most notable at L5. The angled lateral borders of the spinal canal are called lateral recess and constitute the bony canal of the spinal nerve root.

The pedicles arise from the upper portion of the body which are short and have a medial inclination. The width of the pedicle gradually increase from L1-L5, but the height varies between individuals. The pedicle length measured between the dorsal and ventral cortex of the vertebra average 40-50 mm. The medial inclination of the lumbar pedicle increases consistently from L1-L5. The projection point is above the midline of the transverse process at the levels above L4. At L4, the projection point is close to the midline of the transverse process. At L5, this point is located inferior to the midline of the transverse process.

LUMBAR VERTEBRA

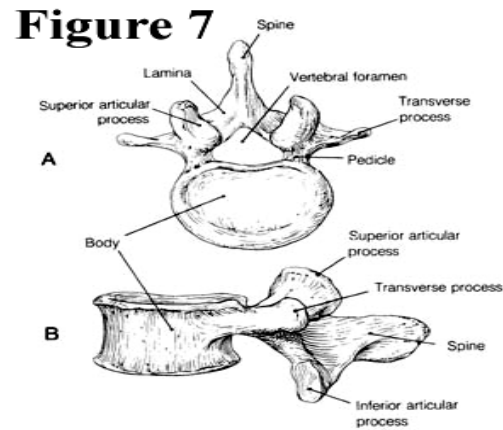


FIGURE 2: ANATOMY OF LUMBAR VERTEBRA

The lamina is thicker and oriented in a more vertical direction in the sagittal plane in comparison to the cervical and thoracic spines. The lamina may be divided into cephalad which has a smooth inner surface and caudal which has a rough inner surface and serves for the attachment of ligamentum flavum. The portion of the lamina between the superior and inferior articular processes and just below the level of the pedicle is the isthmus or pars interarticularis.

The superior and inferior articular facets are oriented sagittally. The superior articular surface is concave and faces posterior-medially, the inferior articular surface is convex and faces antero-laterally.

ARTICULATIONS AND LIGAMENTS

Adjacent vertebrae are connected by three types of intervertebral articulations. Synovial joints are formed between the inferior articular facets of one vertebra above and the superior articular facets of the vertebrae below. These joints are extensively reinforced by different ligaments. These ligaments connect the tips of the spinous processes (*supraspinous ligaments*), the base of the spinous processes (*interspinous ligaments*), and the transverse processes (*intertransverse ligaments*). In addition the laminae of adjacent vertebrae are bound together by ligamentum flavum.

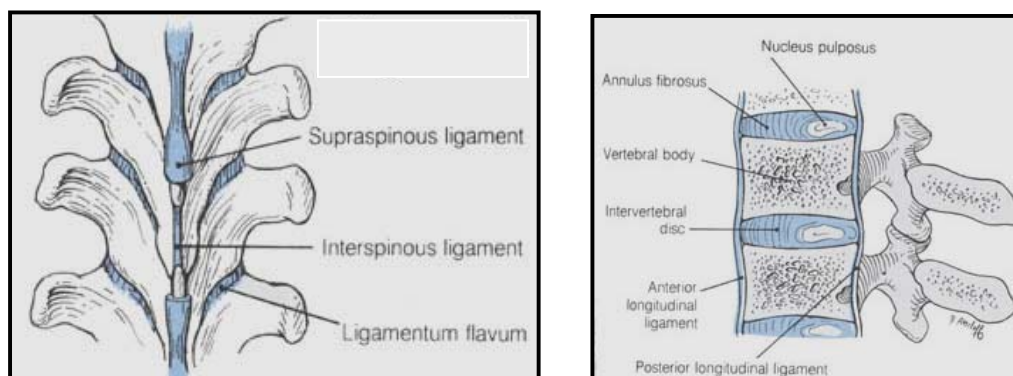


FIGURE 3: THE SPINAL LIGAMENTS THE INTERVERTEBRAL DISC

Ligamentum flavum are present between the lamina of adjacent vertebra. It is mainly composed of yellow elastic fibers. It is thick in the lumbar spine compared to the rest of the spinal column.

The supraspinous and interspinous ligaments are posterior ligaments of the spinal column connecting the spinous process. The interspinous extends from the lower margins of the spinous process above and to the upper margin of lower spinous process. The supraspinous ligaments extend from the occipital bone to sacrum.

The anterior longitudinal ligament is a strong band extending from the skull down to the sacrum attaches to the whole anterior aspect of the vertebral bodies and intervertebral discs. Limitation of the extension of the spinal column is the main function.

The posterior longitudinal ligament extends from the occipital bone to the sacrum, attaches to the posterior aspects of body and discs. They are narrow over the middle of the vertebra and broad over the discs in the thoracic and lumbar region. The role of posterior longitudinal ligament is in stabilization of the spinal column during flexion.

SPINAL MUSCLES

The muscles that directly control the movement of the vertebral column may be divided into categories according to their position as prevertebral and postvertebral.

Prevertebral muscles constitute the external oblique, internal oblique, the transversus abdominus and the rectus abdominus.

Post vertebral muscles are further divided into 3 groups.

Superficial muscles – erector spinae comprise of iliocostalis, the longissimus and the spinalis.

The deep back muscles are divided into two groups, the erector spinae and the transversospinalis. The erector spinae or sacrospinalis muscle group extend from the pelvis to the back of the skull. In the lumbar region, muscle fibers arise from the robust lumbar aponeurosis and in the lower thoracic regions the erector spinae divides into three longitudinal columns of muscle. The most lateral, the *iliocostalis*, attaches to the angles of the lower ribs (*iliocostalis lumborum*), but is continued cranially as a series of long fiber bundles, each spanning about six ribs (*iliocostalis thoracic*), and into the neck, attaching to transverse processes (*iliocostalis cervicis*) . The next most medial muscle is

the *longissimus*. It attaches to lumbar and inferior thoracic transverse processes (*longissimus dorsi*) and in the thoracic region to the adjacent ribs (*longissimus thoracis*). Upper thoracic bundles arising medial to these fibers attach to cervical transverse processes (*longissimus cervicis*) or the skull (*longissimus capitis*). The most medial part of the erector spinae is the *spinalis*. From the lumbar aponeurosis, fibers of *spinalis* attach to the lumbar and thoracic spinous processes.

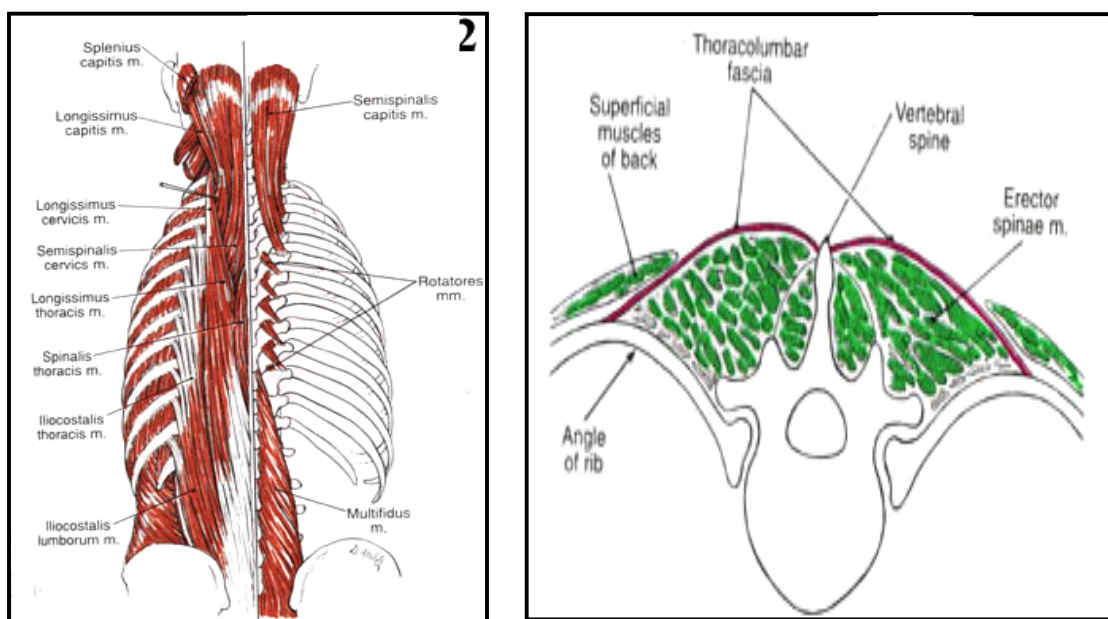


FIGURE 4: THE DEEP MUSCLES OF THE BACK

Deep to the erector spinae are a series of muscles connecting the transverse and spinous processes. There are three layers of these transversospinalis muscles. The more superficial span more vertebrae than the deeper muscles. The most superficial is the *semispinalis*. These cross several segments and are named according to their attachments (thoracic, cervicis, and capitis). Deep to semispinalis and spanning fewer segments is the

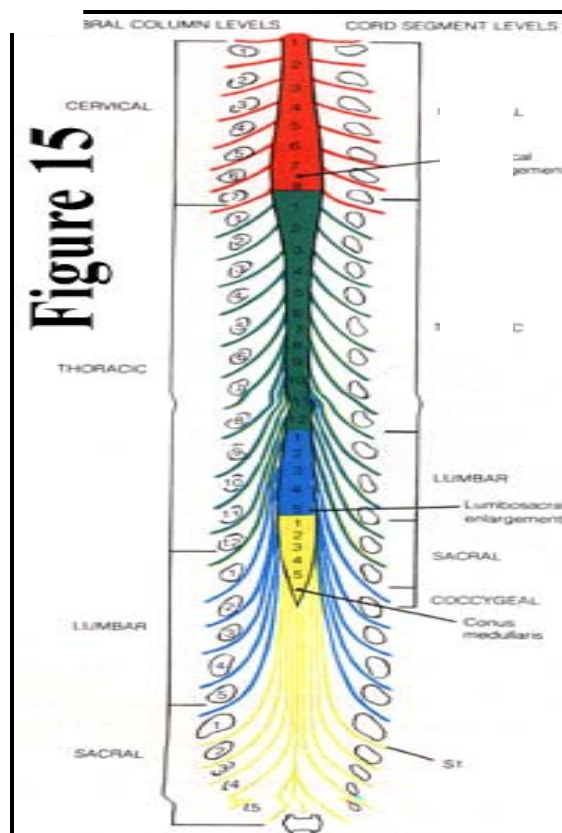
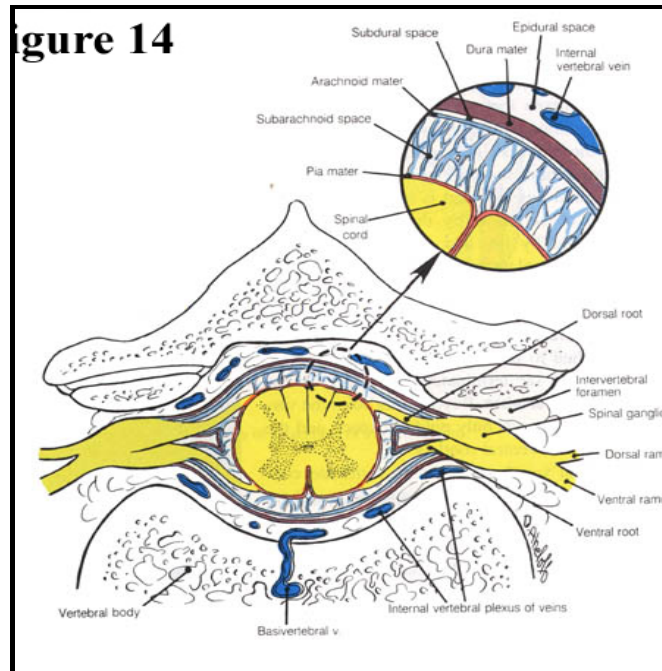
multifidus. It extends from C2 to L5. The deepest muscles in this group are the *rotatores*. The *rotatores longus* crosses two segments and the *rotatores brevis* only one. The functions of these muscles are like those of the erectors spinae, not well known. That they cross but a few intervertebral joints suggests a role for the transversospinalis group in the precise control of vertebral position.

Spinal Cord.

The spinal cord extends from the base of the skull and usually ends at L1-L2 intervertebral disc space. The average cord length in males is 45 cm, 42 cm in females. The cord is widest in its lateral diameter than in the AP plane. The cord diameter is 24.5/14.7 mm in cervical, 17.2/16.8 mm in thoracic and 23.4/17.4 mm in lumbar region. From L1-L2 intervertebral space it continues as conus medullaris from the apex of which a prolongation of the diameter, the filum terminale descends to be attached to posterior surface of coccyx. The conus medullaris contains the myelomeres of the 5 sacral nerve roots.

All of the roots of the spinal nerves from L2 to the lowest coccygeal nerve pass caudal to the conus medullaris to exit at their respective intervertebral foramina. This mass of spinal roots within the spinal canal (in the subarachnoid space) is known as the *cauda equina*.

Figure 14



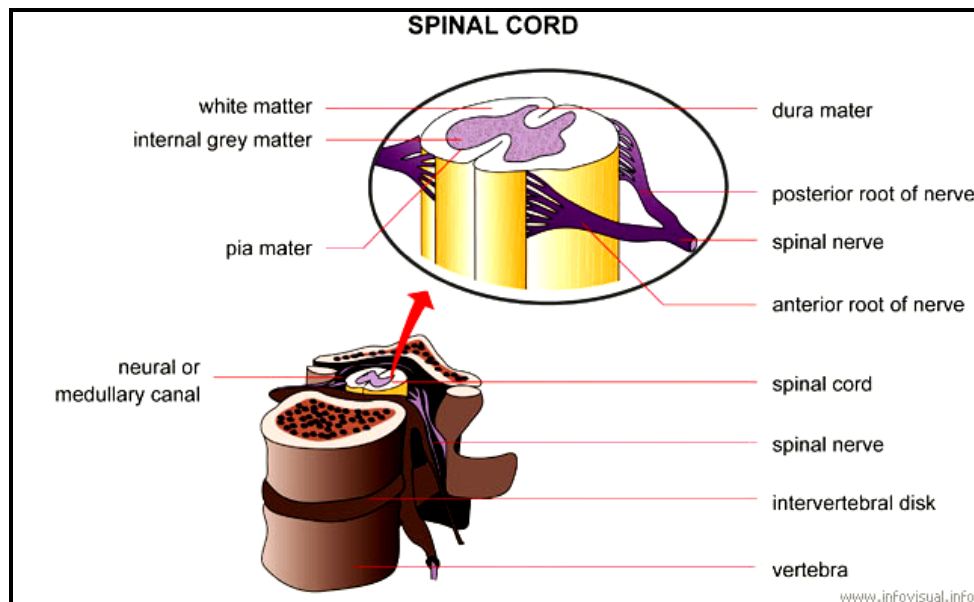


FIGURE 5: THE SPINAL CORD

The exact effects of a spinal cord injury vary according to the type and level injury, and can be organized into two types:

In a *complete injury*, there is no function below the "neurological" level, defined as the lowest level that has intact neurological function. If a person has some level below which there is no motor and sensory function, the injury is said to be "complete". Recent evidence suggests that less than 5% of people with "complete" spinal cord injury recover locomotion.

In *incomplete injury* some sensation or movement below the level of the injury is retained. The lowest spinal cord level is S4-5, representing the anal sphincter and peri-anal sensation. So, if a person is able to contract the anal sphincter voluntarily or is able

to feel peri-anal pinprick or touch, the injury is said to be "incomplete". Recent evidence suggests that over 95% of people with "incomplete" spinal cord injury recover some locomotor ability.

In addition to a loss of sensation and motor function below the point of injury, individuals with spinal cord injuries will often experience other complications of spinal cord injury:

- ✓ Bowel and bladder function is regulated by the sacral region of the spine, dysfunction of the bowel and bladder is common, including infections of the bladder, and anal incontinence.
- ✓ Sexual function is also associated with the sacral region, and is often affected.
- ✓ Inability or reduced ability to regulate heart rate, blood pressure, sweating and hence body temperature.
- ✓ Spasticity (increased reflexes and stiffness of the limbs).
- ✓ Neuropathic pain.
- ✓ Autonomic dysreflexia or abnormal increases in blood pressure, sweating, and other autonomic responses to pain or sensory disturbances.
- ✓ Atrophy of muscle.
- ✓ Superior Mesenteric Artery Syndrome
- ✓ Osteoporosis (loss of calcium) and bone degeneration.
- ✓ Gallbladder and renal stones.

SYNDROME	LESION	CLINICAL PRESENTATION
<i>Anterior cord</i>	Anterior gray matter, descending corticospinal motor tract and spinothalamic injury, with preservation of dorsal columns	Variable motor and pain and temperature sensory loss with preservation of proprioception and deep pressure
Central cord	Incomplete cervical white matter injury	Sacral sparing and greater weakness in the upper limbs than the lower limbs
Brown-sequard	Injury to one half of the cord and preservation of contralateral half	Ipsilateral motor and proprioception loss contralateral pain and temperature sensory loss
Conus medullaris	Injury to sacral cord and lumbar nerve roots within the spinal canal	Areflexic bladder, bowel and lower limbs May have preserved bulbocavernosus and micturition reflexes
Cauda equina	Injury to lumbosacral nerve roots within the spinal canal	Areflexic bladder, bowel and lower limbs
Root injury	Avulsion of compression injury to single or multiple nerve roots	Dermatomal sensory loss myotomal motor loss and absent deep tendon reflexes

TABLE 1: SYNDROMES ASSOCIATED WITH SPINAL CORD INJURY

THE PEDICLE

The pedicle has been shown to be the strongest portion of the vertebral body and is considered to be the “force nucleus” of the vertebral body. It is a hollow bone containing thick cortical bone with very less cancellous bone in the center. A correctly placed pedicle screw can dynamically resist loads in all planes and can provide a fulcrum for the correction of rotational and sagittal deformities of individual vertebral bodies. Therefore, multiple planes of correction and stability can be attained while the number of segments that must be fused is minimized. The pedicle screw is not designed to enter the spinal canal, thereby decreasing the risk of neural impingement, which is a potential risk with wire and hook-based systems since the acceptance of pedicle screw in the 1980’s multiple systems incorporating the pedicle screw of vertebral fixation with numerous minor technical variation have been developed. Some systems have relied on pedicle screws as the sole means of vertebral fixation, but others have promoted the use of pedicle screws in combination with hooks and sub laminar wires.

ANATOMY AND BIOMECHANICS.^{37, 38}

Transverse / axial pedicle angulation or inclination: the pedicular axis angulation in the axial or transverse plane is at the T-12 vertebral body, where the pedicles actually diverge slightly in an antero-lateral direction (-0.6°). In general, the angle of pedicle inclination increases gradually as one travels from the thoracic spine (range $0-10^{\circ}$) down to the lumbar spine. The greatest around 27° at the L-5 vertebral level.

Pedicle diameter: Krag et al., found that from T-9 to L-1 the medial-lateral pedicular diameter was very consistent with a mean width of 7.01 mm at L-1. From L-1

down the pedicular diameter increased gradually to value of approximately 15.5 mm at L-5. The sagittal pedicle height decreasing minimally as one goes caudally or cranially. He also recommended computed tomography as an effective and relatively accurate imaging modality to measure pedicle diameter and expected screw length preoperatively.

Pedicle length and cord diameter: The pedicle-screw length at a particular vertebral level. Pedicle length is relatively consistent between T-9 and T-12, ranging from 15 mm and 25 mm. The mean pedicle length measured at 0 and 15° from postero-lateral and antero-medial in sagittal plane is consistent from T-9 to L-5 and is approximately 42 mm at 0° and 50 mm at 15° angulations.^{39,40,41}

Pedicle identification techniques:

Various methods describing the ideal pedicle starting point and screw direction orientation have been reported. The straight-ahead technique as described by Roy-Camille begins screw insertion at the intersection of a horizontal line bisecting the facet joint.¹¹ The screw is then inserted straight ahead, parallel to the vertebral endplates. The Magerl technique uses the same horizontal landmark for screw insertion as the Roy-Camille technique but uses a longitudinal guideline that is just lateral to the angle of the superior articular facet.⁴² The screw is then angled lateral to medial while remaining parallel to the vertebral endplates. The up-and-in technique of Levine and Edward uses the same longitudinal reference line as described by Magerl, but with a horizontal reference line that crosses the lower third of the transverse process. The screws are then placed in a caudal-to-cephalad direction toward, but not into the vertebral endplate. The screws are also angled slightly medially as in the Magerl technique.

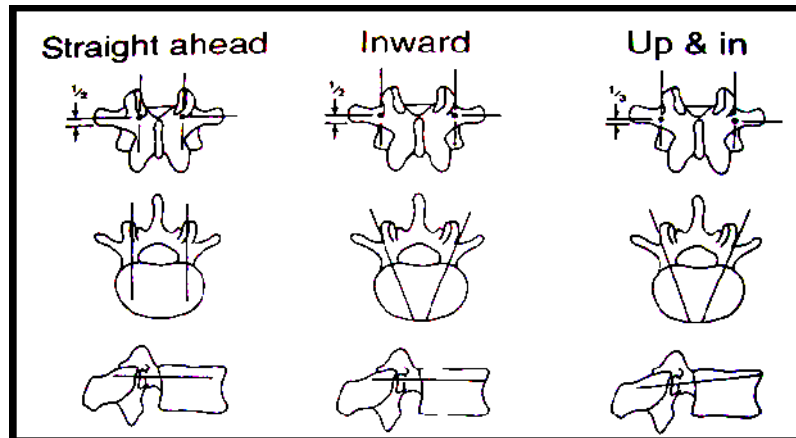


FIGURE 6: METHODS OF ENTRY AND FIXATION OF SCREWS IN THE VB

BIOMECHANICS

Forces applied to the spine can always be broken down into component vectors. A vector is defined here as a force oriented in a fixed and well defined direction in 3-D space. A force vector act on a lever (moment arm), causing a bending moment. The bending moment applied to a point in space causes rotation or a tendency to rotate, about an axis. This axis is the instantaneous axis of rotation (IAR). In order to establish an easily defined and reproducible coordinate system, the standard Cartesian coordinate system has been applied to the spine. In this system there are three axes: the x, y and z axes. About these axes rotational and translational movements can occur. This results in 12 potential movements about the IAR; translational movements along each of the axes (one in each direction) and 2 rotational around each of the axes (one in each direction). The potential movements may also be considered in terms of degrees of freedom; thus six degrees of freedom exists about each IAR. The IAR is the axis about which each vertebral segment rotates at any given instant and is, by definition, the centre of the

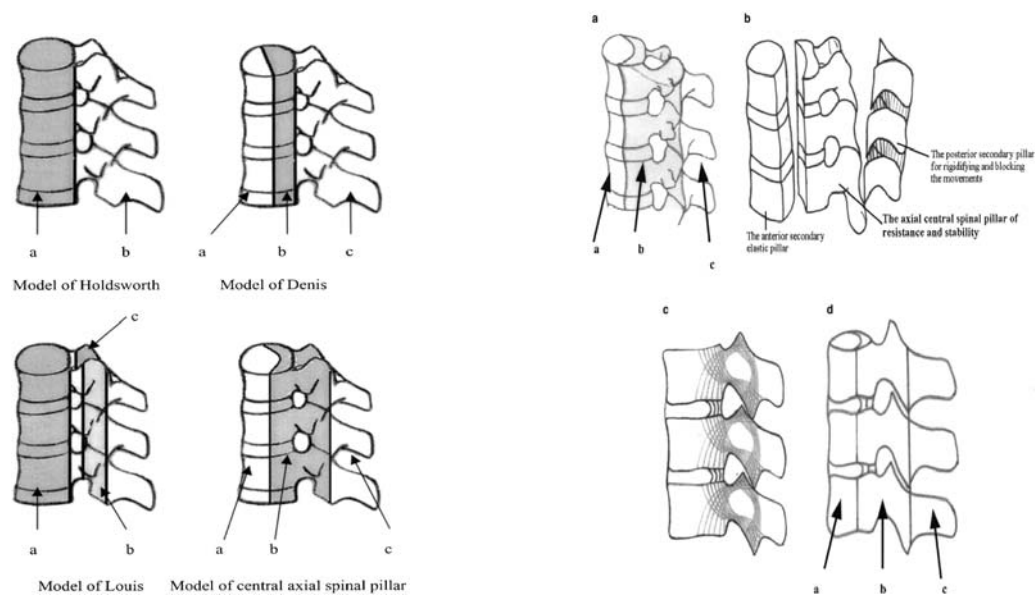
coordinate system for each motion segment, when a spinal segment moves. There is an axis passing through, or close to, the vertebral body that does not move; this is the axis about which the vertebral body rotates.

IAR acts like a fulcrum, if spinal flexion occurs, all points ventral to the IAR come closer to each other and all points dorsal to the IAR become farther apart. A1 and B1 designate ventral and dorsal points aligned with the vertebral endplates in neutral position. A2 and B2 represent ventral and dorsal points aligned with vertebral endplates following flexion.

Couples –is a pair of forces, applied to a structure, that are of equal magnitude and opposite direction, having lines of action that are parallel but that do not coincide. An axial load applied to a vertebral body at the point of the IAR results, by definition, in an equal (in magnitude) but opposite (in direction) reaction force. This pair of forces may result in deformation or failure of the vertebral body resulting in a burst fracture. If however, the load is applied in a plane at some distance from the IAR, a bending moment is created. This bending moment is matched with an equal but opposite reaction bending movement. This pair of forces may similarly result in deformation of the vertebral body, resulting in a wedge compression fracture. This type of deformation/failure may occur in any plane, depending on the point of application of the force vector.

The axial overlapping of the posterior third of the vertebral body continued by the pedicles and the articular processes forms the central axial spinal pillar for stability and resistance. This model appears as a complete concept of Denis and Louis models: the posterior third of vertebral body and intervertebral disc as in Denis's concept joins with the two columns of articular facets as in Louis's concept (Figure 7). The vertebral

segments situated in front of the central axial pillar form the anterior secondary pillar and the overlapping of the laminae, spinous processes, connecting ligaments, etc forms the posterior secondary pillar (Figure 7). The spinal instability appears because of the disruption of the biomechanical continuity of the central axial spinal pillar.



a – central axial spinal pillar, b, c – secondary pillar

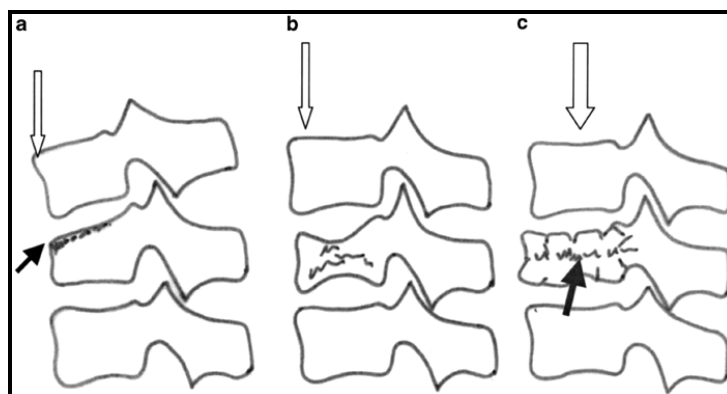
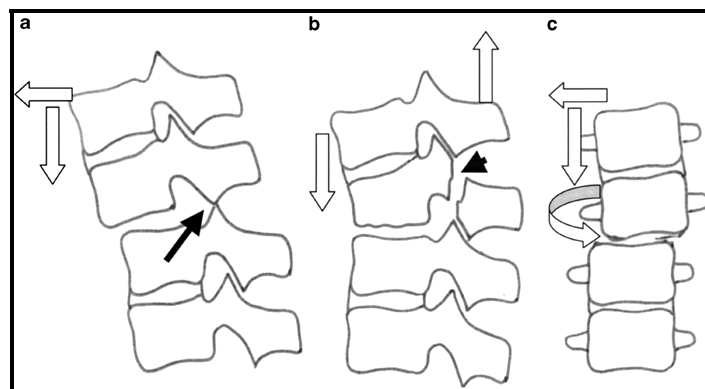
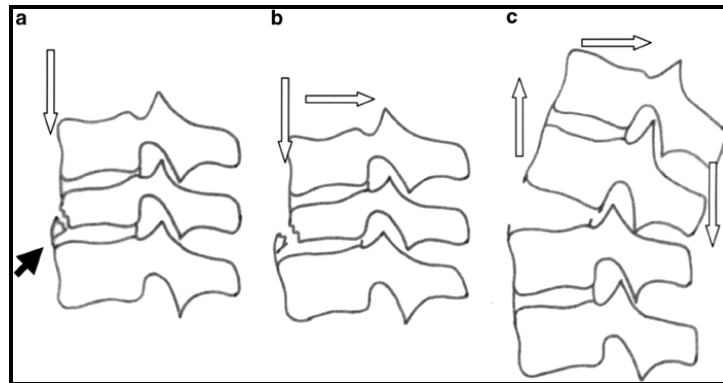


FIGURE 7: LOUIS'S CONCEPT OF VERTEBRAL COLUMN

- a. Axial deformation through eccentric compression resulting in a superior wedge fracture
- b. (**a** and **b**) situation with an unaffected central axial spinal pillar and without spinal instability
- c. Axial deformation through centric compression and burst fracture with partial lesion of the central axial spinal pillar and latent spinal instability



- a. Combined mechanisms through axial deformation with eccentric compression (eccentric distraction) and anterior translation resulting a dislocation and spinal instability;
- b. Axial deformation through eccentric distraction resulting an inferior wedge fracture and fracture of the pars interarticularis;
- c. Combined mechanisms through axial eccentric compression (lateral bending), lateral translation and possible axial rotation



- a. Axial deformation through eccentric compression resulting in a partial anterior inferior body fracture but integrity of the central axial spinal pillar;
- b. A combined mechanism through eccentric compression, posterior translation and with lesion of the axial spinal pillar and spinal instability;
- c. Axial deformation with eccentric distraction and posterior translation, lesion of axial spinal pillar is evident and spinal instability exists

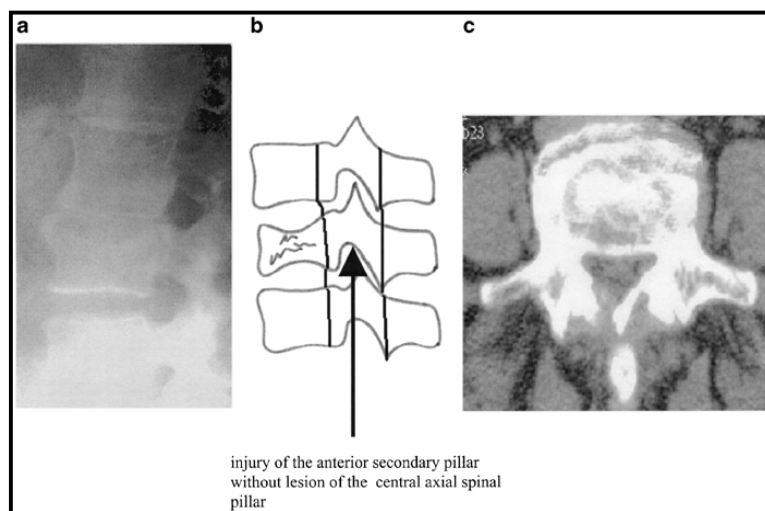
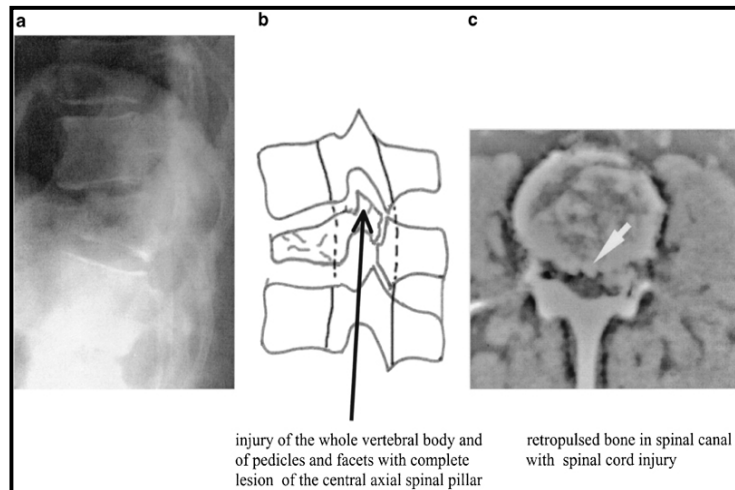


FIGURE 8: ANATOMY AND BIOMECHANICS OF VARIOUS FRACTURES

INJURY TO THE ANTERIOR SECONDARY PILLAR WITHOUT LESION TO CENTRAL SPINAL PILLAR



INJURY TO THE VERTEBRAL BODY WITH SPINAL INSTABILITY, A RETROPULSED FRAGMENT IN THE CANAL

RADIOGRAPHIC EVALUATION

PLAIN RADIOGRAPHS

The standard antero-posterior and lateral views provide objective evidence to document the level of injury, demonstrate bony and soft tissue injuries and also provide information required to assess the stability of the injury.

AP view of plain radiographs demonstrates changes in interpedicular distance. Interpedicular distance generally increases along the spinal column from cranial-caudal but comparison with the adjacent levels are more reliable and signify lateral displacement of vertebral body fragments typical of burst fractures. Interspinous distance alterations indicate posterior ligamentous complex disruption. Relative coronal and sagittal plane translation >2.5 mm suggests gross disco-ligamentous failure and instability.⁴³

Lateral view demonstrates sagittal plane alignment performed using the Cobb's method, which involves the angle created by intact superior and inferior endplates of adjacent uninjured segments. Vertebral body height can also be assessed using the anterior and posterior heights. Segmental kyphosis $>30^{\circ}$ suggested a critical threshold beyond which posterior ligamentous complex disruption is likely, and a loss of $>50\%$ of vertebral body height another indicator for instability.^{44, 45}

CT SCAN

It is valuable in the evaluation of spinal injuries. In subtle injuries it allows the diagnosis of fractures which may not be visualized on plain radiographs. It is superior to MRI for diagnosis of small fractures of posterior elements.

Its main contribution is in the evaluation of the pattern of trauma. With the use of sagittal and coronal reconstruction and 3D-CT, it becomes easy to describe the trauma pattern in detail. The extent of compromise of the spinal canal is well depicted. CT is virtually diagnostic in burst fractures which are among the commonest injuries to affect the spine, classically at D12-L1.

A retropulsed posterior fragment is invariably present compromising the spinal canal with bilateral pedicular fractures and compression on the body.

The disadvantage of CT in spinal trauma lies in the fact that it cannot show the cord directly. Cord contusion and other aspects of cord injury which are important prognostic factors in spinal trauma can only be depicted on MRI.

MRI SCAN

It has become the primary modality for imaging the spine in preference to CT in cases of spinal trauma with neurological deficits. It can reliably image the vertebral body, paravertebral soft tissues, intervertebral discs, the cord, thecal sac and the nerve roots.

MRI can depict cord contusion and edema and also detect extra-axial lesions such as epidural hematoma. The distinction of various types of cord injuries is important for further management and prognosis.

The advantages are multiplanar imaging, inherently better soft tissue resolution, hence it can directly image the spinal cord and lack of ionizing radiation.

MRI has a limitation in imaging dense cortical bone in cases of trauma without neurological compromise; a CT scan would probably be a better modality for evaluating fractures.

CLASSIFICATION OF THORACOLUMBAR FRACTURES.

Various classification schemes have been proposed to describe thoracolumbar fractures and dislocation. Advancements in imaging technology have increased our understanding of their patho- mechanics and have improved their classification. The ideal classification system should allow reliable clinical application; provide a consistent prognosis and ultimately optimization of treatment decisions.

In 1943, Watson-Jones identified comminuted wedge fractures as a subset of thoracolumbar injuries; these are now commonly referred to as burst fractures.⁴⁶ In 1949 Nicoll created the first well-known classification system which focused in the morphological differences between various patterns. In 1953, Holdsworth classified thoracolumbar fractures into 5 groups according to the mechanism of injury.⁴⁷

Pure flexion – stable wedge fracture

Flexion and rotation – unstable fracture dislocation

Extension- dislocation reduces spontaneously and is stable in flexion.

Vertebral compression – burst fracture

Shearing

This classification does not consider the unstable burst fracture.

In 1968, Kelly and Whiteside's described the thoracolumbar spine as consisting of two weight bearing column – the hollow column of the spinal canal and the solid column of the vertebral bodies.⁴⁸ In 1983, Denis developed the three-column theory of spinal instability upon which he later based a classification system of thoracolumbar spine injuries.⁴⁹ (fig)

Anterior column constitutes – anterior longitudinal ligament, the anterior half of vertebral body and the anterior portion of the annulus fibrosis.

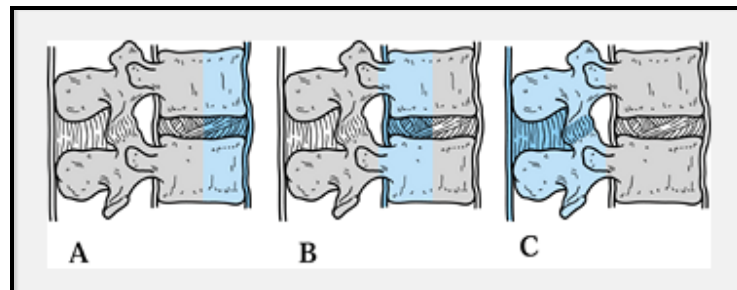


FIGURE 9: DENIS THREE COLUMN THEORY

Middle column – posterior longitudinal ligament, the posterior half vertebral body and the posterior aspect of the annulus fibrosus.

Posterior column – includes the neural arch, the ligamentum flavum, the facet capsules and the interspinous ligaments.

DENIS CLASSIFICATION:

TYPE		MECHANISM
1.	Compression	Flexion
	Anterior	Anterior flexion
	Lateral	Lateral flexion
2.	Burst	
	A	Axial load(sup to inf end plate)
	B	Axial load plus flexion(superior end plate)
	C	Axial load plus flexion(inferior end plate)

D	Axial load plus rotation
E	Axial load plus lateral flexion

- | | | |
|----|----------------------|---------------------|
| 3. | Seat belt | Flexion distraction |
| 4. | Fracture dislocation | Flexion distraction |
| | Flexion rotation | Flexion rotation |
| | Shear | Shear |
| | Flexion distraction | Flexion distraction |

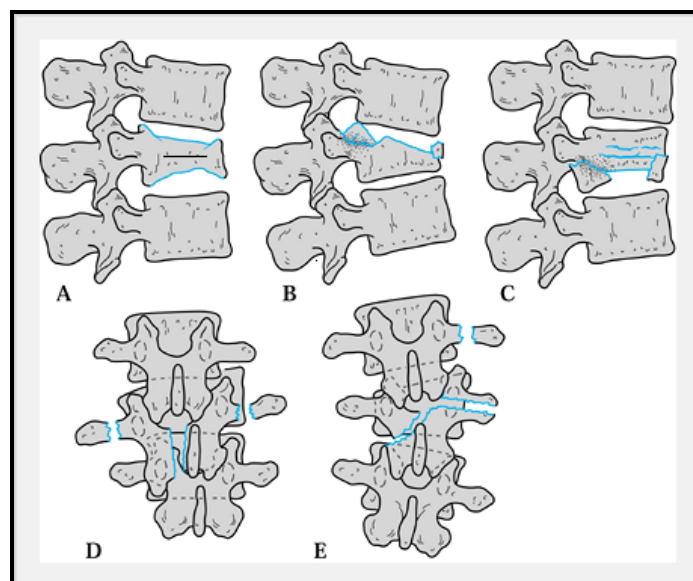


FIGURE 10: DENIS BURST FRACTURE CLASSIFICATION

Due to shortcomings in the Denis' three-column classification system McAfee et al⁵⁰ they proposed that the mechanism of failure of middle column, by axial compression, axial distraction or translation could be determined which would influence the stability.

Wedge Compression Fractures – cause isolated failure of anterior column results from forward flexion, rarely associated with neurological deficits.

Stable Burst Fractures – only anterior and middle.

Unstable Burst Fractures – anterior and middle column fail in compression, the posterior column is also disrupted due to compression, lateral flexion or rotation.

Chance Fractures – horizontal avulsion fractures of the vertebral body caused by flexion around as axis anterior to the anterior longitudinal ligament.

Flexion Distraction Injuries – anterior column fails on compression, middle and posterior column in tension, flexion axis is posterior to the anterior longitudinal ligament.

Translation Injuries – all three columns have failed in shear, there is malignment of the neural canal in the transverse plane.

AO CLASSIFICATION SYSTEM

It divides injuries into three basic groups based o the primary mechanism of failure. These groups are compression (type A), distraction (type B), and torsional and rotational forces (type C). Further subgroups were developed to characterize the fracture location and morphology, as well as to distinguish between osseous or ligamentous disruption and the direction of displacement.⁵¹

TYPE A INJURIES: GROUPS, SUBGROUPS AND SPECIFICATIONS:

Type A. Vertebral body compression

A1. Impaction fractures

A1. 1. Endplate impaction

A1. 2. Wedge impaction fractures

1. Superior wedge impaction fracture

2. Lateral wedge impaction fracture

3. Inferior wedge impaction fracture

A1. 3. Vertebral body collapse

A2. Split fractures

A2. 1. Sagittal split fracture

A2. 2. Coronal split fracture

A2. 3. Pincer fracture

A3. Burst fracture

A3. 1. Incomplete burst fracture

Superior incomplete burst fracture

Lateral incomplete burst fracture

Inferior incomplete burst fracture

A3. 2. Burst-split fracture

Superior incomplete burst fracture

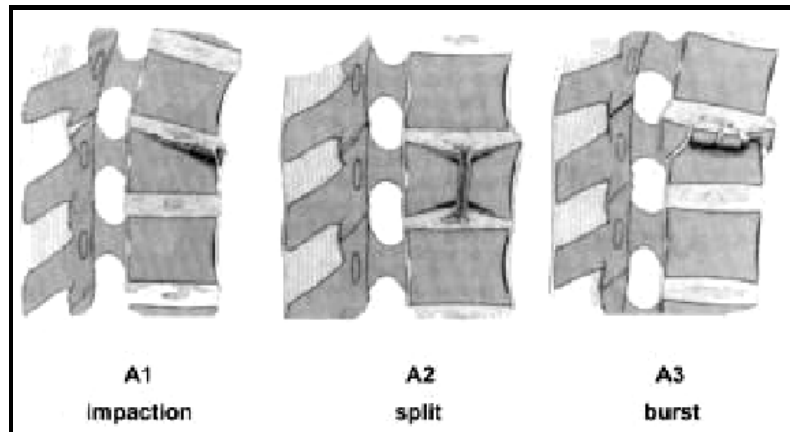
Lateral incomplete burst fracture

Inferior incomplete burst fracture

A3. 3. Complete burst fracture

Pincer burst fracture

Complete flexion burst fracture



**FIGURE 11: AO CLASSIFICATION SHOWING COMPRESSION FRACTURE
TYPES**

Type B injuries: groups. Subgroups and specifications:

Type **B**. Anterior and posterior element injury with distraction

B1. Posterior disruption predominantly ligamentous (flexion distraction injury).

B1. 1. With transverse disruption of the disc

1. Flexion-subluxation
2. Anterior dislocation
3. Flexion-subluxation/anterior dislocation with fracture of the articular process + type A fracture

B1. 2. With type A fracture of the vertebral body

Flexion-subluxation + type A fracture

Flexion-subluxation/anterior dislocation with fracture of the articular process + type A fracture

B2. Posterior disruption predominantly osseous (flexion distraction injury)

B2. 1. Transverse bicolmn fracture-Anterior dislocation + type A fracture

B2. 2. With transverse disruption of the disc

Disruption through the pedicle and disc

Disruption through the pars interarticularis and disc (Flexion-spondylolysis).

B2. 3. With type A fracture of the vertebral body

Fracture through the pedicle + type A fracture

Fracture through the pars interarticularis (Flexion-spondylolysis) + type A fracture

B3. Anterior disruption through the disc (hyperextension-shear injury)

B3. 1. Hyperextension-subluxations

Without injury of the posterior column

With injury of the posterior column

B3. 2. Hyperextension-subluxations

B3. 3. Posterior dislocation

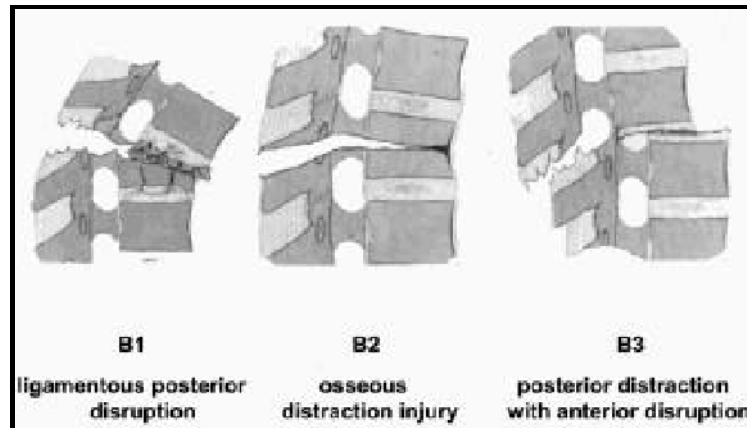


Figure 12: Anterior and posterior element injury with distraction

Type C injuries: groups. Subgroups and specification

Type C. Anterior and posterior element injury with rotation

C1. Type A injury with rotation (compression injury with rotation)

C1. 1. Rotational wedge fracture

C1. 2. Rotational split fractures

Rotational sagittal split fracture

Rotational coronal split fracture

Rotational pincer fracture

Vertebral body separation

C1. 3. Rotational burst fracture

Incomplete rotational burst fracture

Rotational burst-split fracture

Complete Rotational burst fracture

C2. Type B injury with rotation

C2. 1.-B1 injuries with rotation (flexion-distraction injuries with rotation)

Rotational flexion subluxation

Rotational flexion subluxation with unilateral articular process fracture

Unilateral dislocation

Rotational anterior dislocation without/with fracture of articular process

Rotational flexion subluxation without/with unilateral articular process fracture + type A fracture

Unilateral dislocation + type A fracture

Rotational anterior dislocation without/with fracture of articular process = type A fracture

C2. 2.-B2 injuries with rotation (flexion distraction injuries with rotation)

Rotational transverse bicolmn fracture

Unilateral flexion spondylolysis with disruption of the disc

Unilateral flexion spondylolysis + type A fracture

C2. 2.-B3 injuries with rotation (hyperextension-shear injuries with rotation)

Rotation hyperextension – subluxation without/with fracture of posterior vertebral element.

Unilateral hyperextension – spondylolysis.

Posterior dislocation with rotation.

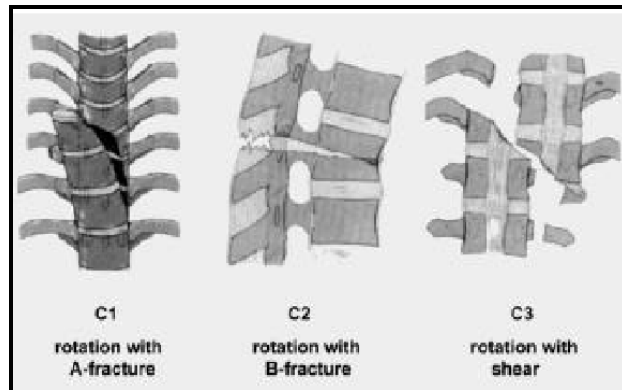


FIGURE 13: ANTERIOR AND POSTERIOR ELEMENT INJURY WITH ROTATION

C3. Rotation-shear injuries

C3.1. Slice fracture

C3.2. Oblique fracture

NEUROLOGICAL EVALUATION

All patients are observed for spontaneous activity during resuscitation; complete spine examination and neurological assessment follow resuscitation. The chest, abdominal, cervical spine, pelvis and other musculoskeletal injuries are ruled out before detailed spine and neurological examination. Once the patient is haemo-dynamically stabilized and all other trauma series examination is excluded detailed examination of spine beginning with inspection and palpation with log-rolling maneuver. Deformity and tenderness are checked and palpated for.

The neurological examination follows the American Spinal Injury Association Scale due to its easy reproducibility. Strength is assessment of five specific muscles in the upper and lower limb and pin-prick discrimination assessed in 28 specific sensory locations on each side of the body. The upper limb elbow flexors (C5), wrist extensors

(C6), elbow extensors (C7), finger flexors (C8) and finger abductors (T1). The hip flexors (L2), knee extensors (L3), ankle dorsiflexors (L4), long toe extensors (L5) and plantar flexors (S1) in the lower limb are evaluated. These muscles are chosen because of the consistency of their innervations and their appropriateness in determining the level of injury. They are then graded according to the standard grading charts.

TABLE 2: MUSCLE POWER GRADING

MOTOR	
GRADE	<i>DESCRIPTION</i>
SCORE	
0	No visible or palpable contraction
1	Any visible or palpable contraction
2	Able to move full range of joint motion with gravity eliminated
3	Able to move full range of joint motion against gravity
4	Able to move full range of joint motion against some resistance
5	Normal according to examiner if inhibiting factors were not present

SENSORY GRADES

0 – ABSENT to unable to distinguish

1 – IMPAIRED to able to distinguish but intensity is abnormal

2 – NORMAL

NT – not testable

ASIA Impairment Scale – modified form Frankel's

A - Indicates a "complete" spinal cord injury where no motor or sensory function is preserved in the sacral segments S4-S5. Since the S4-S5 segment is the lower segmental, absence of motor and sensory function indicates "complete" spinal cord injury.

B - Indicates an "incomplete" spinal cord injury where sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5. This is typically a transient phase and if the person recovers any motor function below the neurological level, that person essentially becomes a motor incomplete, i.e. ASIA C or D.

C - Indicates an "incomplete" spinal cord injury where motor function is preserved below the neurological level and more than half of key muscles below the neurological level have a muscle grade of less than 3.

D - Indicates an "incomplete" spinal cord injury where motor function is preserved below the neurological level and at least half of the key muscles below the neurological level have a muscle grade of 3 or more.

E - Indicates "normal" where motor and sensory scores are normal. Note that it is possible to have spinal cord injury and neurological deficit with completely normal motor and sensory scores.

TABLE 3: DEEP TENDON REFLEXES ARE GRADED AS BELOW

REFLEX	GRADE
Absence	0
Diminished	1
Normal	2
Hyperactive	3
Clonus	4

Methylprednisolone bolus 30 mg/kg, then infusion 5.4 mg/kg/h. Infusion for 24 hours if bolus given within 3 hours of injury. Infusion for 48 hours if bolus given within 3 to 8 hours after injury. No benefit is reported if methylprednisolone started more than 8 hours after injury

TREATMENT OF THORACOLUMBAR FRACTURES

COMPRESSION FRACTURES.

They are considered as stable fractures and therefore treated non-operatively. The parameters for treatment are normal neurological function, vertebral body height loss and kyphosis. Patients with <10% loss of vertebral height do not need any brace or external support for mobilization. Fractures with <30 to 40% height loss and <20 to 25 degree kyphosis can be treated with Jewett hyperextension brace for 6-8 wks where follow up is done with radiographs with brace at regular intervals to monitor fracture healing and alignment. A loss of height >50% or more than 30 degree of Kyphosis in non-osteoporotic bone strongly suggest possibility of PLC disruption, which places the risk of

increasing deformity or neurological deficit where operative management with posterior stabilization is required.⁵²

BURST FRACTURES.

Stable burst fractures defined as fractures that have no PLC injury without neurological deficit. The other criteria are <25 to 30 degree of kyphotic deformity, < 50% height loss, absence of interspinous widening and less than 50% canal compromise.

Aligizakis et al studied the results of non operative treatment using orthosis of TLSO in 60 patients with thoracolumbar burst fractures without neurological deficit. The average follow-up was 42 months. After treatment, 91% of patients had a satisfactory functional outcome, and 83% had little or no pain. The average initial kyphosis was only 6 degree which worsened to 8 degrees at final follow-up. The authors prefer to keep the patient flat and on log-roll precaution until custom-molded TLSO are in place. The then under went a trial of standing radiographs before ambulation is permitted. Clinical follow-up is with radiographs at 2 wks, 1 month, 2 months and 3 months, before the brace is discontinued and alignment confirmed for mobilization.⁵³

OPERATIVE TREATMENT

Indications:

- ✓ Unstable burst fracture with or without neurological deficit.
- ✓ Rapidly increasing kyphotic deformity and deficit.
- ✓ Presence of posterior ligament complex injury.
- ✓ Multiple injuries to other musculoskeletal parts.

POSTERIOR APPROACH.

The role of posterior surgery for unstable burst fractures is primarily for realignment and stabilization. Although hook-rod and sub laminar wire constructs have been used in the past, pedicle screw instrumentation is now the most frequently used method for stabilization. In contrast to hook and wires, pedicle screw constructs provide better three point fixation and allows short segment fixation.⁵⁴

Advantages:

Avoids morbidity of anterior exposure in patients who are already endangered with pulmonary or abdominal injuries.

It involves shorter operative time and decreased blood loss, and functional outcomes are similar anterior surgery.⁵⁵

Disadvantages:

It cannot reconstitute anterior column support, hence leads to higher incidence of progressive kyphosis and instrumentation failure when treating highly comminuted fractures.⁵⁶

ANTERIOR APPROACH.

This is indicated for decompression of neural elements, stabilization of anterior column. As it provides direct visualization of the anterior thecal sac and is the most reliable method of spinal canal decompression. Reconstruction of the anterior column is the prime concern in highly comminuted fractures which is not sufficiently stabilized with posterior constructs alone.

Kaneda et al., have reported the largest series of stabilization for unstable burst fractures. They studied 150 patients treated with single stage anterior decompression, strut grafting and instrumentation using a rod-sleeve-staple device. The average canal clearance was nearly 100%, whereas the fusion rates 93%. One hundred and forty two patients improved at least one Frankel grade.

COMBINED APPROACH.

Indicated in posterior ligamentous disruption and severe osteopenia. Advantages include high degree of canal clearance, immediate circumferential stabilization and good anterior and posterior fusion rates. Disadvantages are morbidity of two separate procedures.

CHANCE FRACTURE OR SEAT BELT INJURIES.

The middle and posterior column are involved;. Features include disruption and separation of posterior elements, either the ligamentous or osseous, little anterior wedging of body, anterior or lateral displacement, commonly L1,L2,L3 involved, neurological deficit is rare, intra-abdominal injury is common. Diagnosis with plain radiographs demonstrates a horizontal fracture through the posterior arch and pedicles extending into the body. Fracture may extend through one or two levels, increase height of posterior vertebral body, horizontal split of transverse process and pedicles, increased interspinous distance. Treatment of mainly osseous injuries is bracing while mainly ligamentous injury are treated with posterior fusion.

FRACTURE DISLOCATIONS.

They constitute 19% of major spinal fractures. Three subtypes according to the mechanism of injury.

1. Flexion-rotation – Anterior Longitudinal Ligament is usually preserved, 40% have spinal cord injury.
2. Flexion-distraction - Similar to seat-belt injury except failure of the ALL leads to forward displacement of the superior vertebral body on the inferior, 25% have complete spinal cord injury.
3. Shear - Almost all have complete SCI, upper body may displace anteriorly or posteriorly depending on the force vector. If the upper body is driven anteriorly, there is much greater chance of articular fractures.

Anterior and cranial displacement of the superior vertebral body with failure of all three columns. A pathognomonic x-ray finding is dislocation seen on AP or lateral films. CT may show occlusion of the canal as a result the offset of one vertebra on top of the other, i.e. the "double body" sign on axial views. There may be jumped facets. Indirect signs are multiple rib fractures, and multiple transverse process fractures. In the thorax, these may be stable, but at the TL junction they are universally unstable and require fusion.

THORACOLUMBAR INSTRUMENTATION

ANTERIOR INSTRUMENTATION:

- Kaneda device, Z plate, Zeilke

POSTERIOR IMPLANTS:

- HOOKS & RODS – Harrington, Edwards, Jacob's

- SEGMENTAL – Luque, Drummond, Hartshill
- PEDICLE IMPLANTS – Steffe, Luque, Moss Miami, AO fixateur internal
- COMBINED – Cotrel-Dubousset

Posterior instrumentation of the thoracic & lumbar spine dates back over past 80 yrs when spinous process wiring & posterior inter laminar fusion techniques was first reported. Harrington rods were introduced as the beginning of modern spinal instrumentation. An understanding of the pathology & biomechanics of the spinal disorder is paramount in choosing the appropriate method of implantation

HARRINGTON INSTRUMENTATION

Dr. Paul Harrington of Houston 1950, designed a rod for the correction of scoliosis in poliomyelitis

Introduced the term “distraction & fusion” to supplement maintenance of fixation

Also used for axial loading & flexion-compression fractures

Procedure

Exposure of the spine, preparation of the facet above and lamina below

Up going hook are placed under the prepared facet proximally, down going hook for the distally prepared lamina

Ratchets fitted through the hook above and the rounded region through the distal hook. Compression or distraction applied

DISADVANTAGES

- ✓ Straight back syndrome
- ✓ Hook cut out
- ✓ Over distraction, failure of fixation

- ✓ Implant failure
- ✓ Iatrogenic neurological complications
- ✓ Cannot be used when posterior column fails
- ✓ Flat back syndrome

MODIFICATIONS

Dr. John Moe's modification:

- ❖ Squaring of the distal hook & distal end of the rod allows better rotational stability, prevents loss of lumbar lordosis
- ❖ Used double hooks in the proximal lamina which reduced individual hook stress between 2 hooks

Edwards modular instrumentation:

- ❖ Combined axial control & versatility (Harrington) and segmental screw fixation (Raman & Roy) into one
- ❖ Hooks from C-shape to L- shape, increased lamina-hook contact

Jacob's locking hook instrumentation:

- ❖ Both ends of rod threaded instead of notches which provided linear distraction
- ❖ Hooks are fixed with locking nuts
- ❖ Rod can be contoured to the shape of the spine

SEGMENTAL INSTRUMENTATION

- ❖ It allows corrective forces to be distributed over multiple sites of attachment providing rigid internal fixation & resistance to rotational forces
- ❖ Segments to be immobilized were reduced
- ❖ Best suited for deformity correction & translation injuries

LUQUE INSTRUMENTATION

- ❖ Introduced to overcome the axial & sagittal plane translations in previous invention
- ❖ Minimally effective in compression & distraction
- ❖ Used in conjunction with Harrington, Cotrel – Dubousset and other instrumentation

Disadvantages : neurological deficits

SUBLAMINAR WIRING

- ❖ Introduced to overcome the axial and sagittal plane translations in the previous inventions.
- ❖ Used in conjunction with Harrington, Luque L- rods, Cotrel-Dubousset and other instrumentations.
- ❖ Minimal effectiveness in compression or distraction, mainstay is in control of rotation and providing many points of fixation to distribute the correction force over many levels.
- ❖ Use of 18G wire.

HARTSHILL INSTRUMENTATION

- ❖ It gives more rigid internal fixation and resistance to rotational forces than traditional Harrington system.
- ❖ It consists of solid Hartshill rectangle, segmentally wired at each level with 16 or 18 gauze wires.

Indications:

Thoracolumbar spine fractures and dislocations suited for translational injuries with complete neurological injury.

Disadvantages:

Axial loading is not resisted, increased risk of cord injury, not suited for upper thoracic spine as the canal is very narrow

DRUMMOND SPINOUS PROCESS WIRING

- ❖ Safe & easier but biomechanically inferior to sub laminar wiring
- ❖ Spinous process purchase site
- ❖ A stainless steel button 8 mm in diameter & 0.8 mm thick made of stainless steel & a 18G wire
- ❖ **Indications:** idiopathic / neuromuscular scoliosis

TRANSPEDICULAR SCREW FIXATION

- ❖ Most significant recent development in posterior spinal fixation
- ❖ 1st reported 1940, Boucher used in 1959 for posterior lumbar fusion, 1969 Harrington used with rods for L5-S1 lysis, accepted in 1980
- ❖ Pedicle – “the force nucleus”
- ❖ Multiple planes of correction & stability is attained with no. of segments to be fused minimized
- ❖ Intact lamina not required, distraction not required, it does not enter the spinal canal hence decreased risk of neural impingement.

INDICATIONS

- ✓ Degenerative spondylolisthesis
- ✓ Trauma (unstable fractures with or without neurological deficits)
- ✓ Large defect after excision of large lumbar spine tumor
- ✓ Scoliosis and Kyphosis correction
- ✓ Degenerative disc disease with instability

IMPLANT DESIGN

These consist of stainless steel 4.5 to 7 mm screws which are cancellous screws. They are usually mono or polyaxial with larger core diameter. They are either self tapping or non self tapping. They are assembled with 5 mm rods which are connected longitudinally to the screw heads which have slots to allow these rods and then tightened with an inner and outer screw to secure the rod fixed. Transverse rods with connector assembly are also available for add on stability. Steffee plates are used instead of the rods, in our study all cases were stabilized with the pedicle screw and rods system.

Advantages

- ✓ Increased rigidity & stability and accelerates fusion rates.
- ✓ Short segment immobilized.
- ✓ Low percentage of implant failure.
- ✓ Maintains normal curvature of the spine.

Disadvantages

- ✓ HIGHER MORBIDITY – joint damage, neurological damage, vascular injury.
- ✓ High stress concentration of adjacent level.
- ✓ Technically difficult.

FACTORS AFFECTING SCREW PULLOUT STRENGTH

- ✓ Use of longest & largest screw.
- ✓ Quality of bone – BMD < 0.45 gm/cm².
- ✓ Depth of screw placement – 80 % depth.
- ✓ Direction of the screw – inward direction allows for a longer screw to be placed, interlocking affect, and lateral starting point avoids contact with superior facet joint.
- ✓ Tapping – not recommended in osteoporotic bones.
- ✓ Use of PMMA to improve strength of pullout.

PROCEDURE

Posterior approach is chosen in this study hence this procedure is explained in detail. Patient positioned prone over the bolsters under the chest and pelvis so as to allow the abdomen to hang free to reduce intra-operative bleeding, image intensifier is used to obtain images for the level identification and fracture reduction.

Sterile drapes are spread, epinephrine 1:500,000 is infiltrated in the paraspinal muscle region to achieve hemostasis. Incision is made over the spinous process of the level above and below the injured vertebra.

Para spinal muscles separated subperiosteally either by an electrocautery or by blunt dissection with a Cobb's elevator. Continue to widen the dissection to the tips of the transverse process. Identify the pedicle of the normal vertebra above and below confirm over an image intensifier.

Insert a blunt awl into the pedicle, advance it through the pedicle; monitor the path under the image intensifier, confirm the continuity of the pedicle wall with a small ball tipped probe. Probe it in all four quadrants to ensure that a solid tube of bone exists.

Tap the pedicle and the vertebral body to at least one half of the depth of the vertebral body using a tap for the screw diameter chosen from preoperative pedicle measurements. Insert the pedicle screw; continue the above process for the rest of the pedicles of the vertebral bodies to be instrumented. Confirm the screw placement on the image intensifier.

When screws have been placed then select the proper length of rod and contour it and cut it slightly longer than needed to accommodate distraction. Insert the rod and reduce the fracture.

Laminectomy is performed, dura identified cleared of any bony pieces, decompression achieved, bone grafts are placed in the postero-lateral aspect after thorough wash.

Fascia is closed tightly; subcutaneous layer is closed over a drain. Skin closed using a subcuticular stitch.

METHODOLOGY

From June 2008 to September 2010, 20 patients from the Department of Orthopaedics, R.L.J Hospital and research Centre were operated for unstable thoracolumbar fractures with pedicle screw fixation and posterior decompression and were followed up for 3 to 12 months (mean – 7.5 months).

Initial assessment: detailed history pertaining to mode of injury and time of injury were taken, clinical examination which included general examination for head, cervical spine, chest, abdominal injury is completed. Then after the patient is stabilized, examination of the spine with neurological evaluation for motor power, sensory, reflexes and bowel-bladder is done to evaluate the level of spine injury and extent of cord damage. This follows the American Spinal Injury Association of neurological evaluation. Methylprednisolone is administered in cases who presented within 6 hours from injury.

A radiograph of the injured spine in two views is done to classify the fracture type using the MacAfee's system of classification. In cases with associated injuries additional radiographs were included to rule out fractures. MRI scan was reserved for affordable patients.

There were 18 unstable burst fractures, 1 flexion distraction and 1 translation injuries in our series. One case was associated with distal end radius fracture. Patients with one of the following were considered to have an indication for surgical stabilization of the spine:

- Presence of neurological involvement caused by the fracture.
- All neurologically stable or unstable patients with instability criteria of kyphotic deformity (sagittal angle) more than 20° , loss of vertebral body height (sagittal index) of more than 50%.

ASSESSMENT OF SAGITAL ANGLE

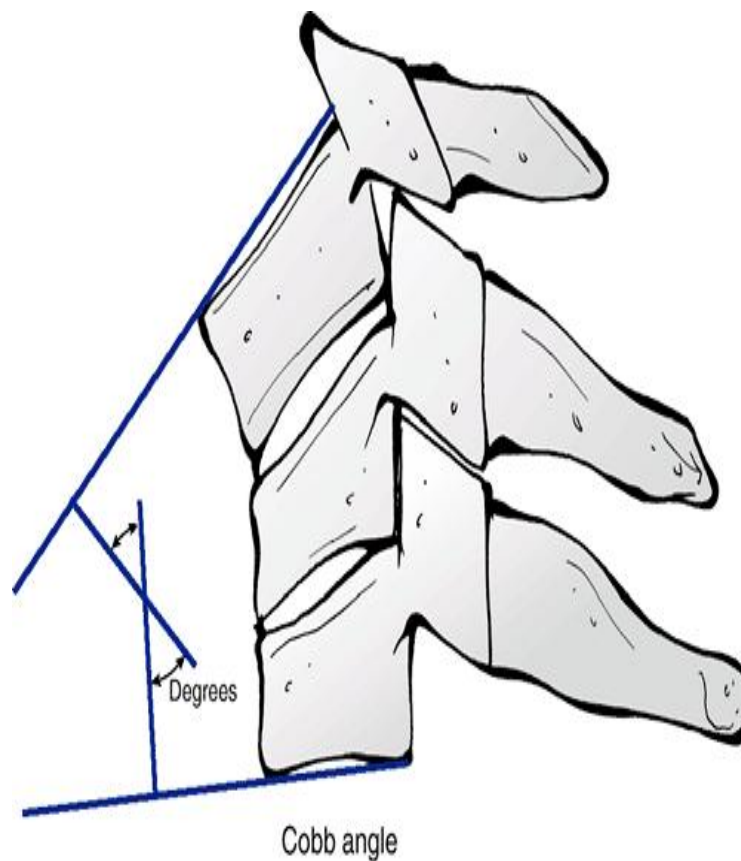
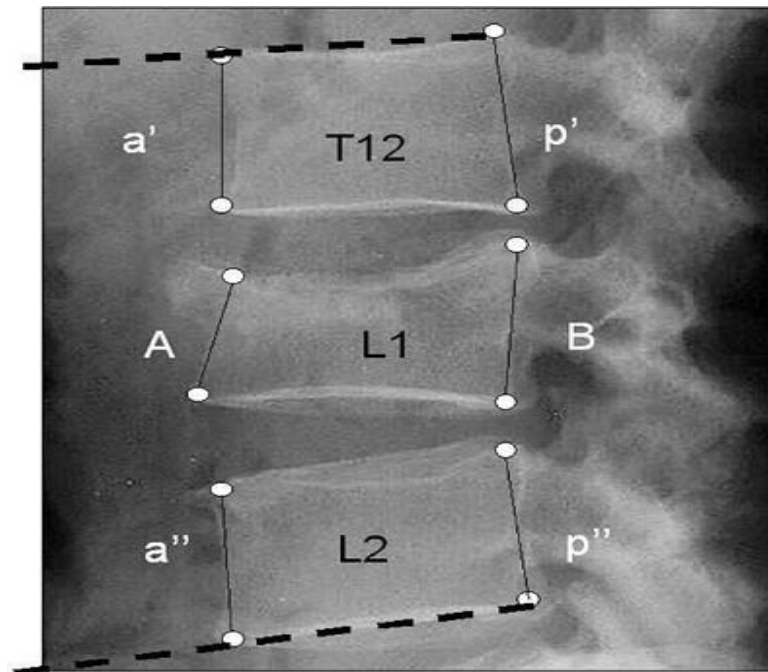


FIG 14 : ASSESSMENT OF SAGITAL ANGLE

FIG : 15 ASSESMENT OF SAGITTAL INDEX



$$\% \text{ Anterior Height Loss} = A / [(a' + a'') / 2] \times 100$$

$$\% \text{ Posterior Height Loss} = P / [(p' + p'') / 2] \times 100$$

Intra-operative: Patients were operated between 1 to 21 days of injury surgical interval with a mean of 4.5 days. For all cases posterior approach was used primarily stabilization was done using pedicle screw-rod system and followed by decompression of the cord with laminectomy of the injured segment and if required adjacent segments. The pedicle entry was established using the intersection method and confirmed by image intensifier. Bone grafts were placed in the postero-lateral aspect in all selected cases. The mean surgical interval was 3 hrs, ranging from 2 to 4 hrs.

PROCEDURE

- Posterior approach was chosen in this study hence this procedure is explained in detail.
- Patient positioned prone over the bolsters under the chest and pelvis so as to allow the abdomen to hang free to reduce intra-operative bleeding, image intensifier is used to obtain images for the level identification and fracture reduction.
- Sterile drapes are spread, epinephrine 1:500,000 is infiltrated in the paraspinal muscle region to achieve hemostasis. Incision is made over the spinous process of the level above and below the injured vertebra. Subcutaneous dissection achieved after adequate hemostasis.
- Paraspinal muscles separated subperiosteally either by an electrocautery or by blunt dissection with a Cobb's elevator. Continue to widen the dissection to the tips of the transverse process. Identify the pedicle of the normal vertebra above and below confirm over an image intensifier.
- Insert a blunt awl into the pedicle, advance it through the pedicle; monitor the path under the image intensifier, confirm the continuity of the pedicle wall with a small ball tipped probe. Probe it in all four quadrants to ensure that a solid tube of bone exists.
- Tap the pedicle and the vertebral body to at least one half of the depth of the vertebral body using a tap for the screw diameter chosen from preoperative pedicle measurements. Insert the pedicle screw; continue the above process for the rest of the pedicles of the vertebral bodies to be instrumented. Confirm the screw placement on the image intensifier.

- When screws have been placed then select the proper length of rod and contour it and cut it slightly longer than needed to accommodate distraction. Insert the rod and reduce the fracture.
- Laminectomy is performed, dura identified cleared of any bony pieces, decompression achieved, bone grafts are placed in the postero-lateral aspect after thorough wash.
- Fascia is closed tightly; subcutaneous layer is closed over a drain. Skin closed using a subcuticular stitch.

Post-operative: patients were administered intravenous antibiotics for 3-5 days, and then oral preparations were continued for another five days. They were allowed to lie on both right and left lateral positions in the immediate post-operative period. Drainage tubes were removed within 48 hrs of surgery. Check radiographs were taken for evaluation of fracture reduction; implant position, kyphotic angle and correction of vertebral height. All patients were started on a rehabilitation program with the passive mobilization of lower limb joints and to teach the patient attender regarding bed care and strengthening of muscles. Thoraco-lumbo-sacral orthosis were prepared for adequate bracing. Patients were made to sit on the third - fifth day with his braces on. Suture removal performed at 12th day. Bladder training was begun on the 7th day if patients obtained control catheter was removed and discharged, if not patients were taught self catheterization. Bowel evacuation was taught by tickling the perianal region or by digital evacuation.

Follow-up: patients were followed up at every month interval for 3 months and every 2 months for total of 6 months. At every follow-up symptomatic history pertaining to pain

relief, his level of activities and bowel-bladder function is taken. Clinical examination for deformity and neurological grading using the ASIA criteria is done. Radiographs are taken for evaluation of the fixation, sagittal angle and index calculation.

The cases with incomplete injuries were strictly restricted of activities for 4 weeks and all patients advised to continue TLSO brace for over 10 wks. Patients with complete injuries were confined to bed to prevent early re-collapse and mobilized depending on the radiographic evidence of fracture consolidation. They were mobilized using wheel-chair mobilization . Follow-up ranged from 3 to 12 months with an average of 7.5 months.

OBSERVATIONS AND RESULTS

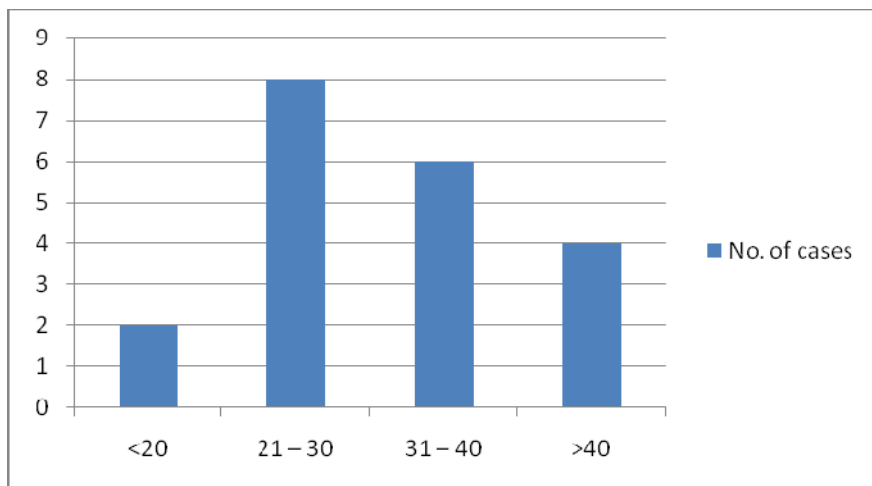
Age distribution:

A total of 20 cases were included of which 2 cases below 20 years of age, 8 were in the age group of 21 to 30, 6 of them in the group of 31 to 40 and 4 cases above 40 and The mean age calculated for the study was 32.5 yrs.

Table 4: Age distribution

AGE (yrs)	No. of cases	Percentage
<20	2	10
21 – 30	8	40
31 – 40	6	30
>40	4	20
TOTAL	20	100

Figure 16: Age distribution



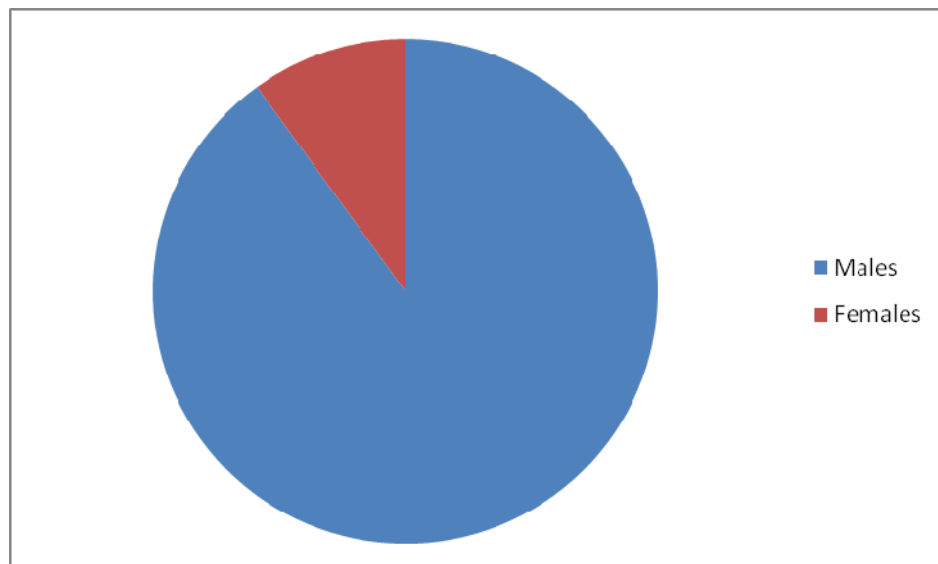
Gender Distribution:

In the study of the 20 cases 18 were males and only 2 were females. The results are as shown in table 5.

Table 5: Gender distribution

SEX	No. of cases	Percentage
Males	18	90
Females	2	10
TOTAL	20	100

Figure 17: Gender distribution



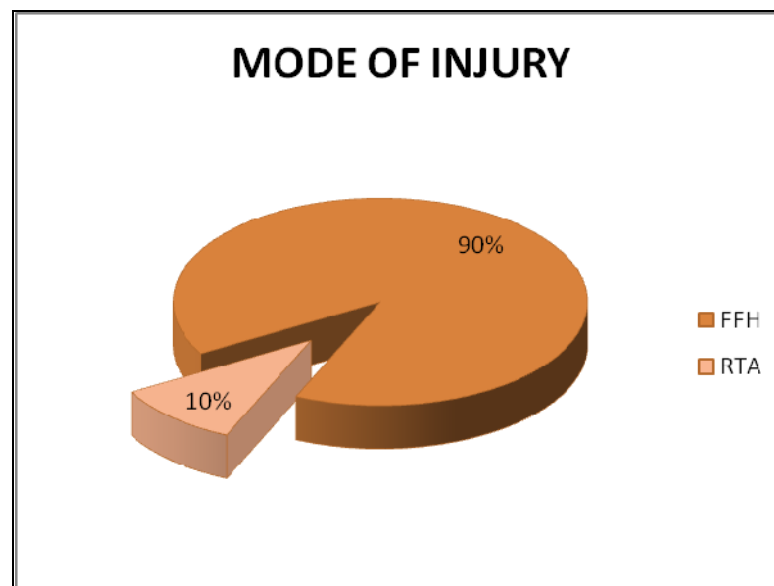
Mode of Injury:

The most common mode of injury in the study group was fall from a height followed by road traffic accident with only one case. The results are shown in table 6.

Table 6: Mode of injury distribution

MODE	No. of cases	Percentage
Fall from height	18	90
Road traffic accident	2	10
TOTAL	20	100

Figure 18: Mode of injury distribution



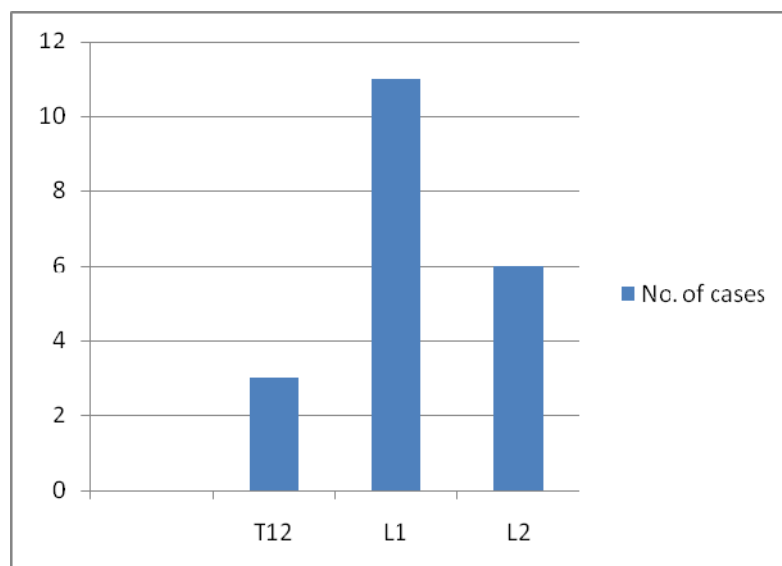
Level of Injury:

In our study we observed 3 cases with fracture at T-12 level followed by 11 cases at L-1 level, with sum total of 70% of fractures at T-12 and L-1 junction, 6 cases were at L-2 level which constitutes the remaining 30%.

Table 7: Level of injury distribution

LEVEL	No. of cases	Percentage
T12	3	15
L1	11	55
L2	6	30
TOTAL	20	100

Figure 19: Level of injury distribution



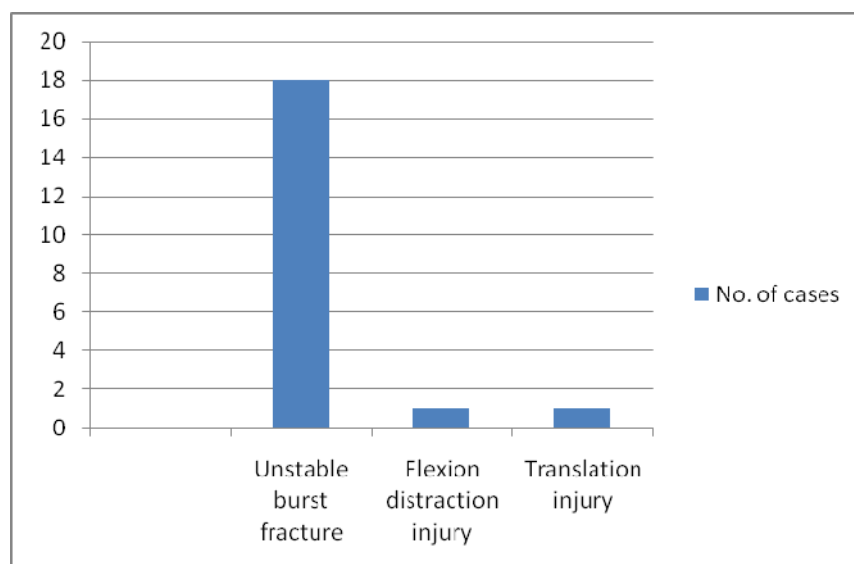
Type of Fracture:

The most common type of fracture observed in the study was unstable burst fracture with 18 cases followed by 1 case with flexion distraction injury and 1 case of translation injury.

Table 8: Type of fracture distribution

TYPE	No. of cases	Percentage
Unstable burst fracture	18	90
Flexion distraction injury	1	5
Translation injury	1	5
TOTAL	20	100

Figure 20: Type of fracture distribution



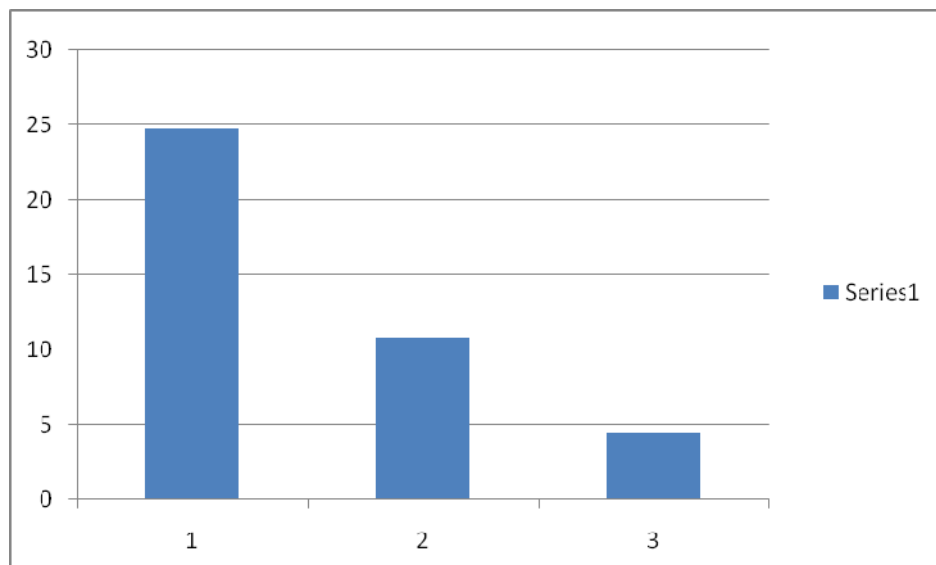
Sagittal Angle:

The radiological evaluation of sagittal angle and sagittal index was done pre-operatively, post operatively and at final follow-up. The results are as in table 9.

Table 9: Distribution of sagittal angle

PRE-OPERATIVE	POSTOPERATIVE	LOSS AT FINAL FOLLOW-UP
24.75 ⁰	10.85 ⁰	4.5 ⁰

Figure 21: Distribution of sagittal angle

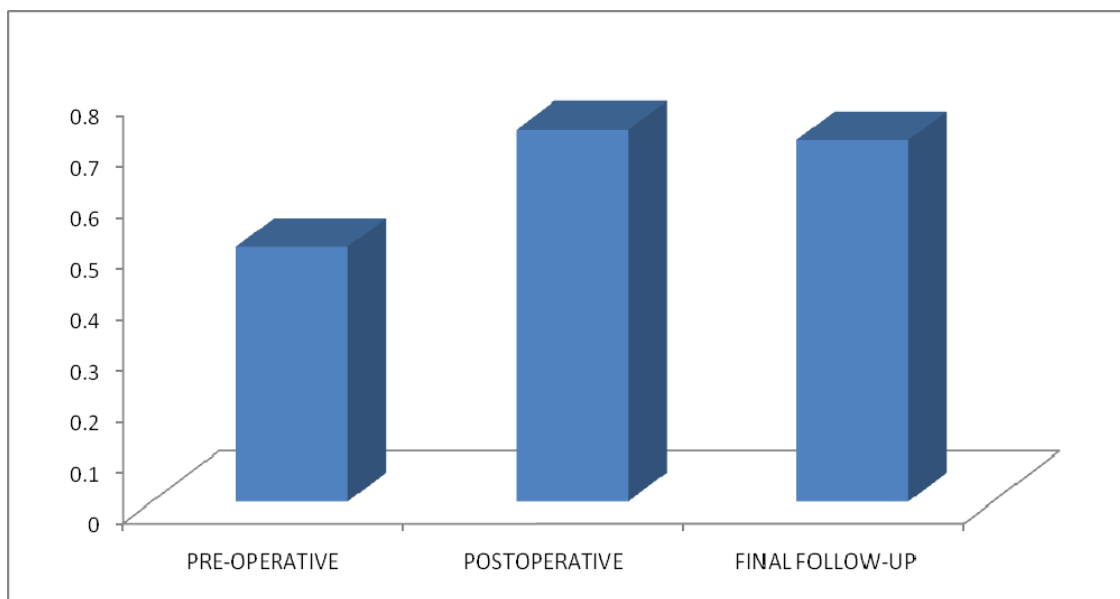


Sagittal Index:

Table 10: Distribution of sagittal index

PRE-OPERATIVE	POSTOPERATIVE	FINAL FOLLOW-UP
0.50	0.73	0.71

Figure 22: Distribution of sagittal index



Neurological evaluation:

Neurological evaluation was done according to American Spinal Injury Association scale in the pre-operative period and at all follow-ups. 50% cases showed improvement by one grade, 30% showed improvement by two grades, 15% showed no neurological improvement and only 5% showed 3 grade improvement.

Table 11: Distribution of neurological evaluation

Neurological grade	FOLLOW-UP				
PRE-OPERATIVE	A	B	C	D	E
A 4	3	1	-	-	-
B 2	-	-	-	1	1
C 14	-	-	-	9	5
D 0	-	-	-	-	-
E 0	-	-	-	-	-

Mean injury surgical interval:

Table 12: Mean distribution of injury surgery interval

No. of cases	Minimum (days)	Maximum (days)	Mean (days)
20	1	21	<u>4.53</u>

Mean surgical interval:

Table 13: Mean distribution of surgical interval

No. of cases	Minimum (hrs)	Maximum (hrs)	Mean (hrs)
20	2:00	4:00	<u>3:00</u>

Distribution of associated injuries

There was only one patient with an associated distal end radius fracture in our study(5%).

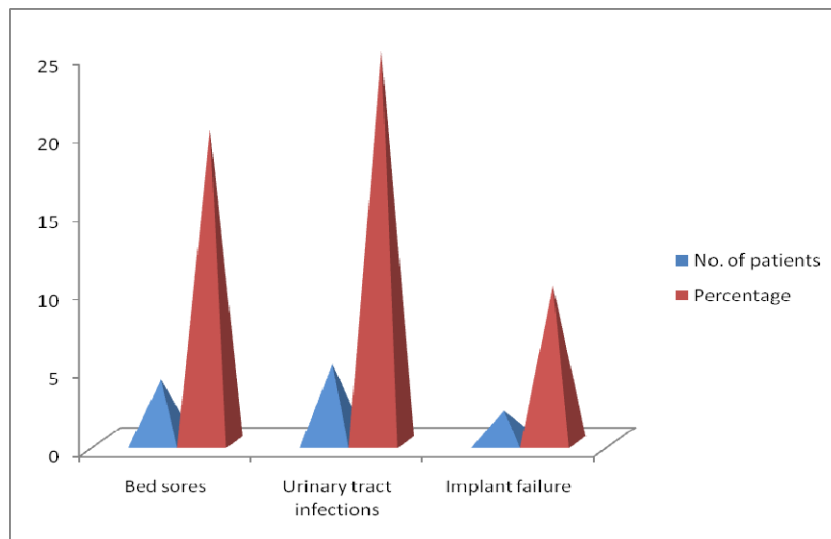
Complications:

The common complication associated in the study was bed sores and urinary tract infections(45%).

Table 14: Distribution of complications

Complications	No. of patients	Percentage
Bed sores	4	20
Urinary tract infections	5	25
Implant failure	2	10
TOTAL	11/20	55/100

Figure 23 Distribution of complications



DISCUSSION

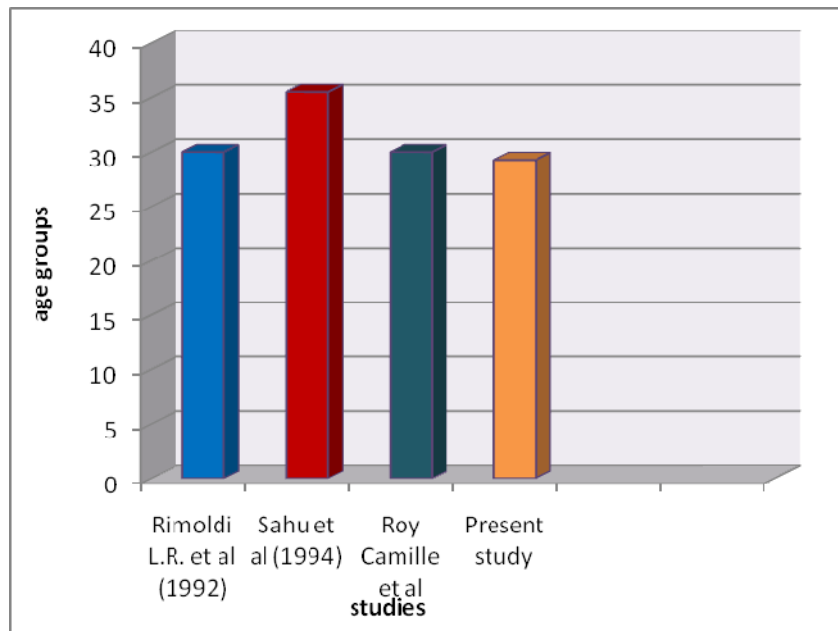
Age distribution:

In our study of 20 cases the highest percentage of patients were males and were in the age group of 19 to 50 yrs. These numbers when compared with studies done in developed countries and in developing countries showed consistent results. These results show that males in the working age group are predisposed to trauma.

Table 15: Age comparison

STUDIES	MEAN AGE (yrs)
Rimoldi L.R. et al (1992)	30
Sahu et al (1994)	35.5
Roy Camille et al ¹¹	30
Present study	32.5

Figure 24: Age group comparison



Gender incidence comparison:

Table 16: Gender comparison

Studies	Males (%)	Females (%)
Rimoldi L.R	78	22
Sahu et al	87	13
Yaser M Behairy ⁵⁷	64.7	35.2
Present study	90	10

Mode of injury comparison:

The mode of injury comparison with studies done in India also shows association of fall from height being the commonest mode of injury followed by road traffic accidents. Whereas studies done in western countries show road traffic accidents to be the most common mode of injury. The study group includes cases who were involved in climbing trees, and cases who were working at the construction sites hence making fall from height mode of injury more common in the study.

Table 17: Mode of injury comparison

Mode of injury	Dipankar Sen ⁵⁸	Yaser M Behairy ⁵⁷	Present study
Fall from height	64.7	47	90
Road traffic accident	35.2	52.9	10

FRACTURE ANATOMY

Level of fracture comparison:

The results of our study showed majority of fractures around T-12 and L-1 level which are consistent and comparable with the results of other studies which also shows T-12 – L-1 to be the most common level of fracture.

Table 18: Level of fracture comparison

Studies	T12 – L1
Sahu et al (1994)	82%
Roy Camille ¹¹	42%
Dipankar Sen ⁵⁸	82%
Mohammad F. Butt ³⁴	88%
Present study	70%

Type of fracture comparison: The type of fracture being the unstable burst fracture being the commonest in our study was also comparable with other studies showing similar results. This correlates with the mode of injury and the fracture type sustained by patients included in the study.

Table 19: Type of fracture comparison

Studies	UNSTABLE BURST FRACTURES
Gertzbein (1988)	68%
Viale (1993)	55%
Dipankar Sen ⁵⁸	58.8%
Present study	90%

RADIOGRAPHIC EVALUATION

Patients were radiologically evaluated with sagittal (kyphotic) angle and sagittal index (ratio of anterior and posterior height of vertebral body). Pre-operative, post-operative and final follow readings were comparable with various studies. This also proved that stability of fracture and fixation is better assessed with these two parameters.

Table 20: Sagittal angle comparison

	Pre-operative	Post-operative	Final follow-up
Roy Camille et al ¹¹	18 ⁰	5 ⁰	8 ⁰
Dipankar Sen ⁵⁸	16 ⁰	3.8 ⁰	5.8 ⁰
Mohammad F. Butt ³⁴	21.4 ⁰	12.8 ⁰	16.2 ⁰
Present study	24.75 ⁰	10.85 ⁰	4.5 ⁰

Table 21: Sagittal index comparison

	Pre-operative	Post-operative	Final follow-up
Yaser M Behairy ⁵⁷	0.51	0.85	0.84
Mohammad F. Butt ³⁴	0.44	0.72	1.02
Present study	0.50	0.73	0.71

NEUROLOGICAL EVALUATION

The neurological evaluation was according to ASIA scale in our study which showed significant improvement of one grade which is comparable with other studies showing 60 to 70% improvement at the final follow-up. Out of 20 cases studied 4 cases were with complete neurological injury and 16 cases with incomplete injury (B, C, D). 37.5% of these incomplete injuries showed two grade improvements, and 56.25% of them showed one grade of improvement. Of the complete neurological injury cases about 25% (1 case) showed one grade improvement. The limiting factor in the assessment was the mean of follow-up of 7.5 months compared to a long term follow-up of up to 2 years in various other studies.

ASSOCIATED INJURIES AND COMPLICATIONS

Associated injuries in various other studies were pelvic injuries, abdominal injuries and long bone fractures. In our study the only associated injury encountered was distal end radius fracture in one patient.

Bed sores and urinary tract infection and retention were most common post-operative complications encountered in this study.

CONCLUSION

Fracture and fracture dislocations of the thoracolumbar spine are the most commonly occurring types of osseous spine injury. In the developed countries road traffic accidents causing the major percentage and fall from height being the commonest mode of injury in the developing countries. The main aim of the treatment resides in early stabilization, direct or indirect decompression of the neural elements and early mobilization of the patient to prevent complications. This also avoids the burden on the family of the patients and the care givers and reduces the hospital stay compared with that of conservative means of treatment.

Unstable burst fractures were the most common fracture type encountered in the study which leads to deformity and neurological compromise. The radiological and neurological evaluations were the parameters taken into account to assess the instability and indication for surgery and recovery. There was marked improvement in the radiological parameters comparable to other studies done in both Western and Asian countries. The neurological improvement was observed to be fair enough in cases of incomplete neurological injury.

Short segment fixation using the posterior approach with pedicle screw-rod fixation devices with or without bone grafting achieves good stabilization and fair enough neurological recovery in patients with unstable thoracolumbar fractures. The limiting factors being a small study group and shorter follow-up period.

SUMMARY

- ❑ 20 cases of unstable thoracolumbar fractures with neurological injury were studied for radiological deformity correction and neurological recovery.
- ❑ Fall from height in working male patients of 19 to 50 years was noted.
- ❑ T-12 and L-1 vertebra were commonly involved, unstable burst fracture pattern was the most common type of injury encountered.
- ❑ Majority of the cases in the study had incomplete neurological injury.
- ❑ One Patient had associated fracture distal end of radius .
- ❑ Posterior approach was used for stabilization with pedicle screw-rod fixation and decompression done in all cases. Bone grafting used in majority of cases.
- ❑ Rehabilitation was started on the 3rd day with passive mobilization and bed care. They were made to sit on the 5th day. On discharge they were taught self catheterization and digital evacuation in needed cases until neurological recovery.
- ❑ Follow-up was done up to 6 months for neurological recovery and radiological stability.
- ❑ Pedicle screw-rod fixation devices provide better fixation for stability and a chance for neurological recovery. This helps in early mobilization and prevention of dreaded complications encountered in conservative line of management.
- ❑ It is still difficult to say that pedicle screw fixation devices are the ideal devices for fracture stabilization and allowed for neurological recovery as the follow-up period was not sufficient to prove this.

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PROFORMA

NAME:

AGE:

SEX:

OCCUPATION:

ADDRESS:

UNIT:

IP No.:

Date of admission:

Date of surgery:

Date of discharge:

Chief complaints:

History of presenting injury:

Mechanism of injury:

Bladder function after injury:

Preliminary treatment:

Treatment:

Associated injuries:

Any significant past / present history:

GENERAL PHYSICAL EXAMINATION

Built and nourishment:

Pupils -

ENT bleed -

Pulse -

B.P. -

Respiratory rate -

SYSTEMIC EXAMINATION

C.V.S. –

C.N.S. –

R.S. –

P/A –

LOCAL EXAMINATION

INSPECTION:

Attitude:

Swelling:

Deformity:

External wounds:

PALPATION:

Swelling:

Tenderness:

Deformity:

Crepitus:

NEUROLOGICAL EXAMINATION (lower limbs):

MOTOR

RIGHT

LEFT

Bulk / nutrition –

Tone of the muscles –

Muscle power –

HIP:

Flexors –

Extensors –

Abductors –

Adductors –

KNEE:

Flexors –

Extensors –

ANKLE & FOOT:

Plantar & dorsiflexors –

Toe extensors –

Toe flexors –

SENSORY:

Light touch –

Tactile sensitivity –

Pressure –

Pain –

Temperature –

Position sense-

Vibration sense –

REFLEXES:

Knee jerk –

Ankle jerk –

Clonus –

Superficial reflex

Plantar –

Cremasteric –

Bulbocavernous –

Anal wink –

Abdominal – upper and lower

RADIOLOGY:

Type of fracture:

Level of injury:

Sagittal angle:

Sagittal index:

INVESTIGATIONS:

Hb%-

ESR-

BT-

CT-

Urine Routine- albumin, sugar, microscopy

Blood grouping-

ECG-

Chest X-ray –

HIV-

HBsAg-

CT scan report:

SURGERY:

Date of surgery-

Operative findings-

Level of fixation-

Blood loss / intra-operative complications-

Operative time-

POST-OPERATIVE

Antibiotic-

Analgesic-

Drain removal-

Mobilization-

Suture removal-

Discharge-

NEUROLOGICAL STATUS

Pre-operative grade-

At 3 wks-

3 months-

6 months-

RADIOLOGICAL STATUS

pre-operative

post-operative

FFU

Sagittal angle-

Sagittal index-

BLADDER FUNCTION

Signs of infection-

Filling sensation-

Type of bladder-

COMPLICATIONS

Bedsore-

Wound infection-

Respiratory tract infection

UTI-

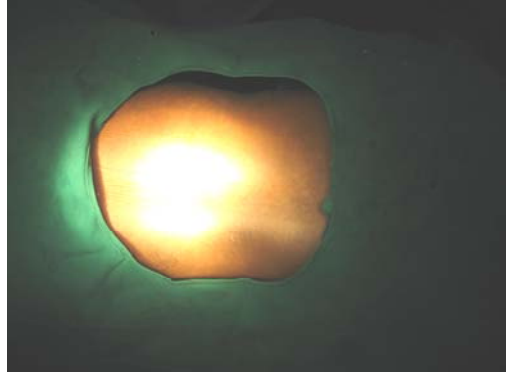
Paralytic ileus-

Implant failure-

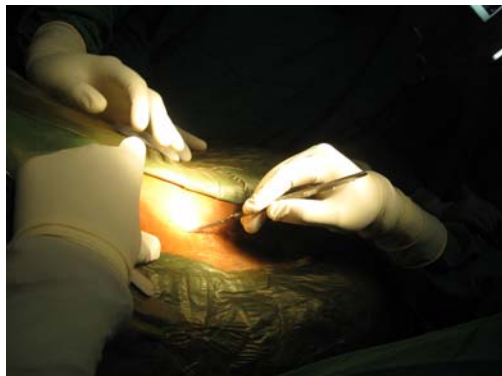
OPERATIVE PROCEDURE



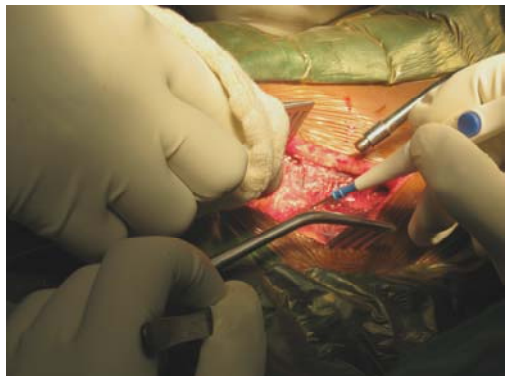
Positioning



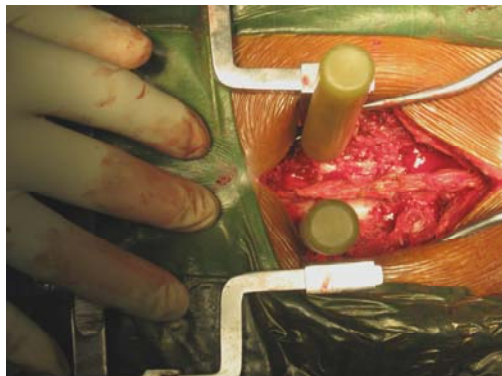
Draping



Skin incision



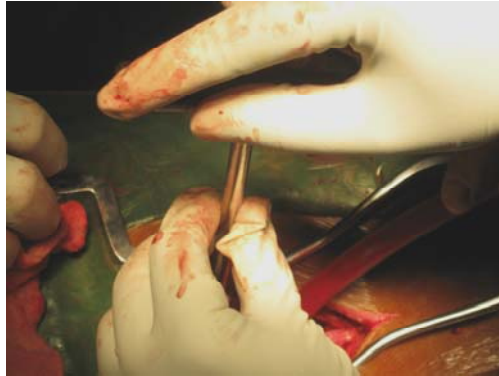
Paraspinal dissection



Pedicle probing



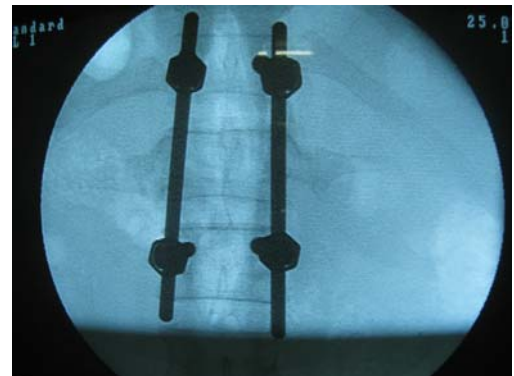
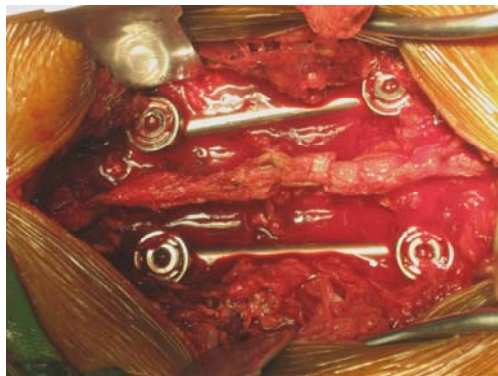
C-arm



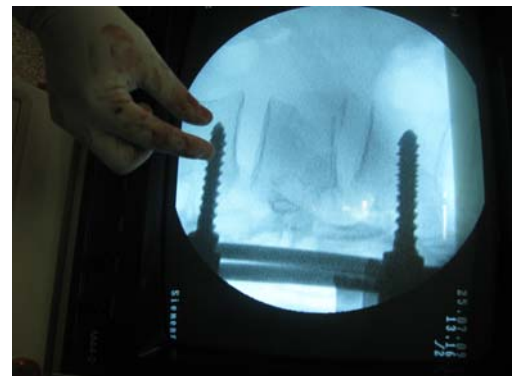
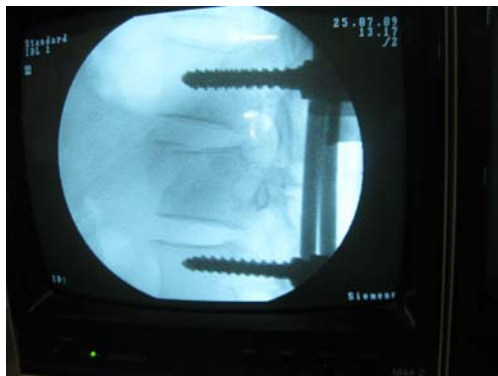
Tapping & screw fixation



C-arm

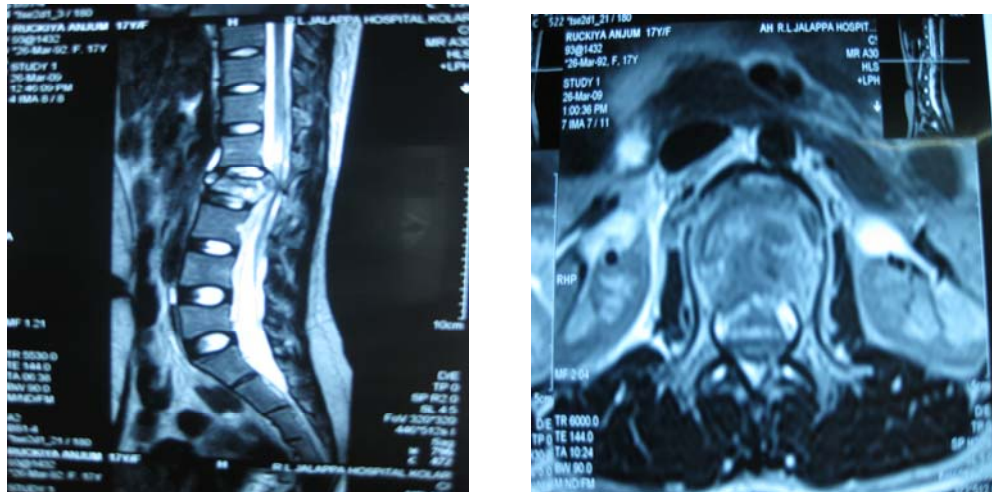


Final fixation

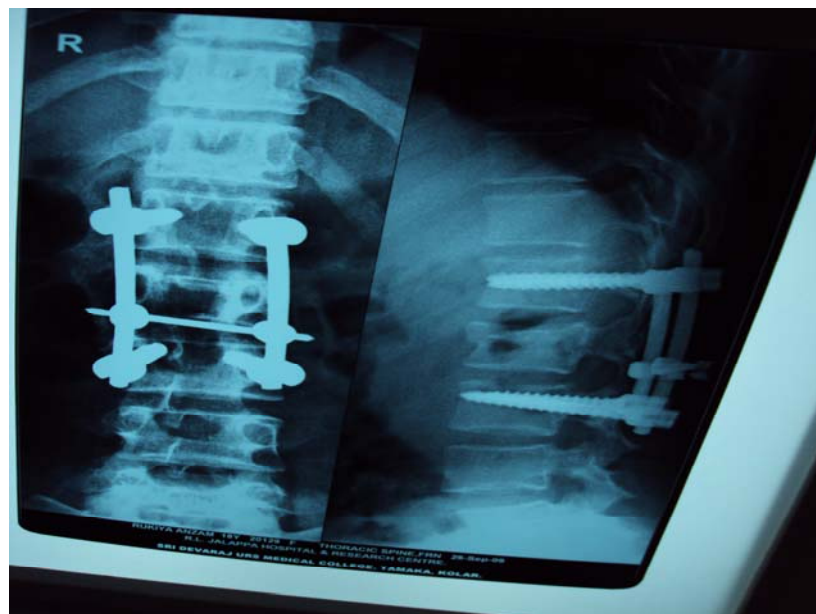


CASE -1 (RUCKAIYA)

Pre operative



Post operative



CLINICAL PHOTOS



CASE -2 (MANJUNATH)

Pre operative



Post operative



Implant failure – screw breakage

CLINICAL PHOTOS

Pre operative

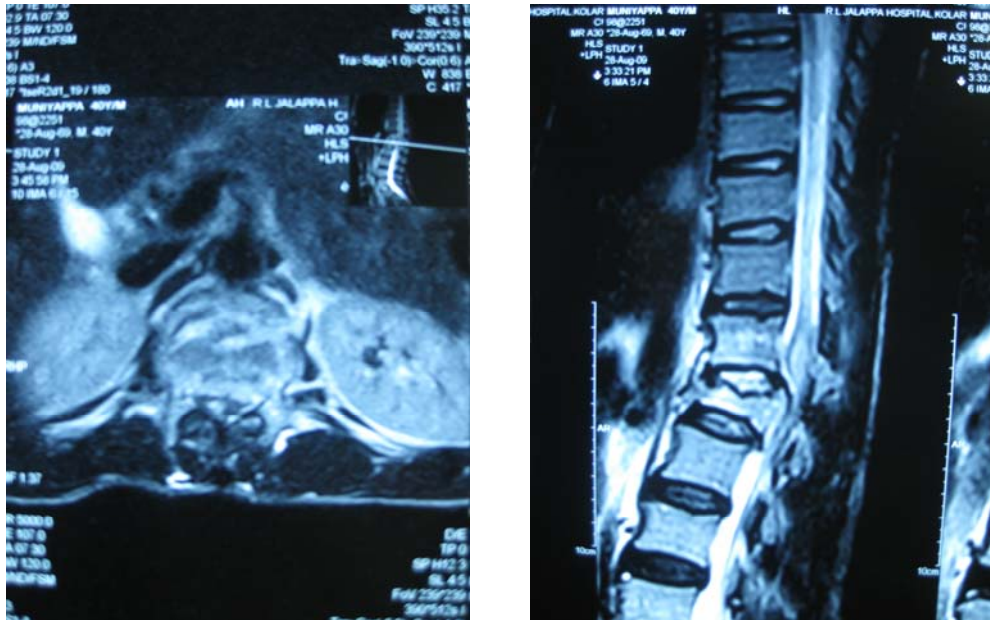


Post operative



CASE – 3 (MUNIYAPPA)

Pre operative



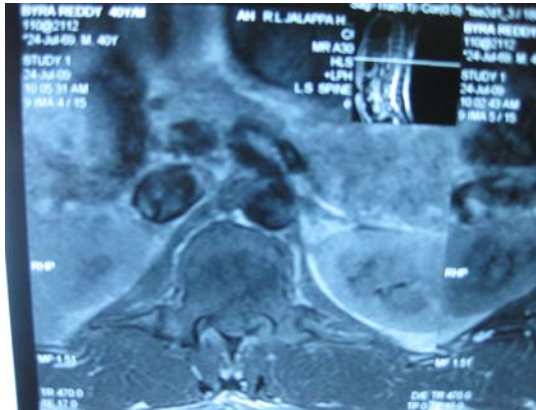
Post operative



CLINICAL PHOTOS



CASE – 17 (BYRAREDDY)



Pre operative



Post operative

CLINICAL PHOTOS



KEY TO MASTER CHART

Sl.No.:	Serial Number
IP. No.:	Inpatient Number
Mts :	Months
Pre-op:	Pre-operative
Post-op :	Post-operative
FFU :	Final Follow Up
FFH :	Fall From Height
RTA :	Road Traffic Accident
UBF :	Unstable Burst Fracture
TRS :	Translation injuries
FD :	Flexion Distraction injuries
LRTI :	Lower respiratory tract infection
UTI :	Urinary tract infections
URTI :	Upper respiratory tract infection
M :	Male
F :	Female
# :	Fracture

MASTER CHART																					
Sl. No	Name	Age/ sex	Ip. No	Mode of injury	Level of injury	Type of injury (McAfee)	Injury surgical interval (days)	Surgical interval (in hours)	Follow up (in mts)	Neurological evaluation (ASIA)			Sagittal angle (In Degrees)			Sagittal index			Associated injuries	Complication	No. of days of hospital stay
										Pre-Op	Post-Op	Follow up	Pre-Op	Post-Op	Loss at FFU	Pre-Op	Post-Op	Follow up			
1	RUKHIYA ANJUM	18/F	403602	FFH	L2	UBF	1	3	12	C	D	E	25	10	-	0.6	0.96	0.94	-	-	20
2	MANJUNATH	28/M	460238	FFH	L1	TS	3	4	12	C	D	E	20	10	10	0.6	0.85	0.75	-	Implant failure	16
3	MUNIYAPPA	40/M	533292	FFH	L1	UBF	3	3	12	C	C	D	25	12	08	0.42	0.40	0.66	-	Sacral sore,UTI	60
4	RADHA KRISHNA	18/M	584645	FFH	L2	UBF	21	2	6	C	C	D	10	8	2	0.8	0.8	0.8	-	-	15
5	NAGRAJ	22/M	367121	FFH	L1	UBF	4	3	12	C	D	E	24	9	10	0.6	0.71	0.66	-	Implant failure	15
6	MUNIRAJU	30/M	464155	FFH	L1	UBF	2	4	6	A	A	A	20	10	10	0.7	0.7	0.7	-	Bed sores, UTI	21
7	PRASHANTH	28/M	582852	FFH	T12	FD	3	3	6	A	A	B	40	20	20	0.4	0.80	0.80	-	UTI	21
8	MAMATHA	30/F	464592	FFH	L1	UBF	4	3	6	C	C	D	26	12	10	0.6	0.9	0.80	-	UTI	17
9	BABU	30/M	471769	FFH	L1	UBF	2	3	6	C	D	D	30	10	10	0.7	0.7	0.6	-	-	14
10	BOREGOWDA	35/M	564430	RTA	L1	UBF	3	4	8	C	D	E	20	10	0	0.4	0.7	0.65	-	-	20
11	HANUMAPPA	35/M	390948	FFH	L2	UBF	7	3	6	C	D	E	16	4	0	0.35	0.6	0.5	-	-	32
12	ESHWAR REDDY	45/M	428901	FFH	L1	UBF	3	3	8	B	C	D	30	12	2	0.3	0.8	0.8	-	-	22
13	SADASHIVIAIAH	40/M	396629	FFH	L1	UBF	1	3	6	B	D	E	30	10	2	0.3	0.6	0.6	-	Sacral sore	35
14	RAMU	21/M	454567	FFH	L2	UBF	2	3	9	A	A	B	26	10	2	0.4	0.8	0.8	distal end radius #	-	18
15	SHIVALINGIAH	40/M	576506	FFH	L1	UBF	6	3	9	C	C	D	20	8	4	0.6	0.8	0.8	-	-	22
16	VEERANNA	35/M	590801	FFH	L2	UBF	4	3	6	C	C	D	14	8	0	0.35	0.8	0.8	-	LRTI	20
17	BYRAREDDY	35/M	523845	FFH	T12	UBF	2	3	6	C	C	D	30	10	0	0.40	0.85	0.80	-	UTI	14
18	NARAYANSWAMY	45/M	546721	FFH	L1	UBF	14	4	6	C	C	C	35	15	0	0.4	0.80	0.80	-	-	14
19	CHOWDAPPA	50/M	630199	RTA	T12	UBF	4	3	4	A	A	A	14	9	0	0.40	0.50	0.50	-	Bed sore	14
20	NAGABHUSHAN	25/M	633626	FFH	T12	UBF	2	3	3	C	D	D	40	20	0	0.8	0.6	0.6	-	-	14