A ONE YEAR STUDY OF EFFICACY OF PEDICULAR SCREW AND ROD FIXATION SYSTEM IN STABILISATION OF THORACIC & LUMBAR LESIONS OF THE SPINE, AT KLE HOSPITAL & MRC BELGAUM

Submitted by :

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DISSERTATION

Submitted to the

KLE UNIVERSITY, BELGAUM.

In partial fulfillment

of the requirements for the award of the degree of

MASTER OF SURGERY
IN
ORTHOPAEDICS

Under the Guidance of

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ACKNOWLEDGEMENT

I take this opportunity to express my most humble and sincere gratitude to my teacher and Guide **Dr. B. B. Putti,** **M.S. Ortho,A.O.Fellow** *Professor and Head Department of Orthopaedics, J.N. Medical College, Belgaum for his fatherly guidance, valuable suggestions and constant encouragement, great care and attention to detail throughout the study which facilitated the completion of my dissertation.*

I am deeply obliged to, **Dr. S. M. ANTIN,** **D. Ortho, MS Ortho**, *Professor, Department of Orthopaedics, J.N. Medical College, Belgaum for his valuable advice and extensive encouragement for completion of his dissertation.*

It is with great respect that I express my thanks to **Dr. V. G. Murkibhavi,** **D. Ortho, M.S. Ortho, A. O. Fellow**, *Professor, Dept. of Orthopaedics, J. N. M. C Belgaum for his kind co-operation and guidance.*

I wish to thank profusely **Dr. R. B. Uppin,** **M.S. Ortho, A. O. Fellow.** *Professor,* **Dr. K. S. Patil** **M.S.Ortho, D.Ortho,D.A.**, *Professor,* **Dr. S. V. Udapudi,** **M.S.Ortho** *Professor, for their valuable help, suggestions, encouragement and co-operation throughout.*

I wish to thank **Dr Somnath Sanikop** **MS Ortho Mch**, **Dr. Ravi S. Jatti,** **MS, Ortho,** **Dr. Ravindra Gurav,** **M.S. Ortho** **Dr. S. H. Motimath,** **M.S. Ortho,** **Dr.Sanjeev Patil,** **M.S. Ortho, A. O. Fellow,** **Dr. Praksh C. Wali,** **M.S. Ortho** **and Dr Mahantesh Patil** **MS Ortho Mch,** *for their co-operation*.

I am also thankful to **Dr. Amit B. Putti** **M.S. Ortho, Mch,** *for his friendly advice.*

I am grateful to **Dr. V. D. Patil,** **M.D. Peadiatrics**, *Principal J. N. Medical College, Belgaum for extending his help towards the completion of this dissertation.*

I also thank ***Dr. M. V. Jali,*** *MD & CEO, K.L.E'S Hospital and MRC and District Surgeon, District Hospital, Belgaum, for allowing me to utilize the clinical material for this dissertation.*

I wish to offer my thanks to Department of Medical Education for their valuable information and support.

No amount of words can measure up to the deep sense of gratitude and thankfulness that I feel towards my parents **Dr Parshwanath & Mrs Kavita Magdum** & wife **Dr Shonali** *for their valuable help, everlasting support, motivation and endless co-operation without which I would not be what I am today.*

I offer my sincere thanks to all my friends and post graduate colleagues Dr Chetan MD, Dr Rajesh Tale, Dr Vishwanath LD, Dr Amit, Dr VKC Reddy, Dr Chetan K, Dr Vishal Khasliwal, Dr Adarsh, Dr PankajP , Dr Vinay Raddi , Dr Veman Suakar, Dr Abhinav Thakur, Dr.Prasanna, Dr Dinesh , Dr. Fardin , Dr. Vinay P & Dr Pankaj Kumar for their companionship and support.

I would like to acknowledge the tireless work of ***Mr. Mahesh Desai*** *of* **Malta Computers** *for excellent data processing and completion of this manuscript.*

From the bottom of my heart I convey my heartfelt gratitude to all my patients without whose co-operation this study would have been incomplete.

Dr. Vikrant Magdum

ABBREVIATIONS

AP	Anterior posterior
ASIA	American Spinal Injury Association
B/B	Bladder and bowel
CSIC	Clear self intermittent catheterization
Lat.	Lateral
MRI	Magnetic resonance imaging
VSP	Variable Screw Placement
CT scan	Computed tomography

ABSTRACT

OBJECTIVES :

The spinal disorders are one of the leading and grave problems in orthopaedic practice, more so in modern era where the individual are more at risks due to their day-to-day activities.

There are number of instrumentation available for fixation of thoracic and lumbar lesions. There are reported results of pedicular screw and rod fixation in thoracic and lumbar lesions of spine and its clinical outcome.

METHOD :

This longitudinal prospective study of pedicular screw and rod fixation in thoracic and lumbar fractures was done in 21 cases during the period of September 2006 to September 2007 in KLES Dr. Prabhakar Kore Hospital and MRC, Belgaum. All patients were treated surgically by Pedicular screw and rod instrumentation. The Denis pain and work scale was used post operatively to assess the clinical outcome.

Initial preoperative clinical and radiological assessment was done. ASIA (American Spinal injury association) grading, saggital angle, saggital index, slip percentage and slip angle were used pre and post operatively to assess the outcome.

Prophylatic antibiotics were given for 5 days. Follow up of patients was done both clinically and radiological at 1st, 2nd, 3rd, 4th, 5th and 6th month and assess for any complication. At end of 6 months of follow up Denis pain and work scale was used to assess the clinical outcome.

RESULTS AND CONCLUSION :

Posterior stabilization by pedicular screw and rod is an effective method of achieving spinal stabilization in thoracic and lumbar lesions. It is an effective method of restoring spinal angulation and maintaining the spinal correlation post operatively and at follow up.

The Pedicular screw fixation is associated with less number of complications. It helps fairly in improving the neurological status and the clinical outcome has been satisfactory in terms of Denis work and pain score.

The disadvantage of pedicular screw fixation is that it has steep learning curve and high technical expertise is required to minimize complications.

Key words : Pedicular screw and rod instrumentation ; thoracic and lumbar instability

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INTRODUCTION

The spinal disorders are one of the leading problems in orthopaedic practice, more so in modern era where the individuals are more at risk due to their day today activities. [1]

Thoracolumbar spinal segment is the 2nd most commonly involved segment after the cervical segment in spinal injuries, contributing about 30 to 60% of all spinal injuries. Thoracolumbar injuries in trauma are concentrated at the thoracolumbar junction region, 60% occurring between T12 and L2.[2] 15 to 20% patients with fracture of thoracolumbar level have associated neurological injury. [3]

Degenerative causes of instability like spondylolysthesis occur more commonly in lower lumbar region . L4-L5 level is affected 6 to 8 times more commonly than any other adjacent level.[4] Other common causes of instability include infections and tumour . Tumours more commonly affect anterior to dural sac, which cause pathological fracture and retropulsion of soft and bony tissue causing dural compression.[5]

The treatment options for spinal instability of thoracic and lumbar spine have long been controversial. Many authors, advised non-operative treatment, but later report emphasized the advantage of Open reduction internal fixation (ORIF) with posterior instrumentation.[6, 7]

Most authors agree that neurological improvement is independent of treatment modality.[1] But surgical decompression and stabilization points at advantage of improving neurological deficits. Lately consensus is evolving around the world for stabilization of spine, with fusion and instrumentation of unstable spine.[7]

Historically, thoracic and lumbar instability have been treated with bed rest for variable period of time.[8] This mode of treatment is accompanied with complication due to recumbency. In case of spinal fractures it is very labor intensive, cost of therapy in terms of hospital hours used, bed occupancy and care by trained personnel is very high. In a country like ours, where there is acute shortage of hospital facilities and trained manpower, conservative management, more often than not, end up as benign neglect, so there is an urgent need for exploring possibilities of surgical stabilization, early mobilizations and rehabilitation of patients.

Internal fixation and stabilisation of spinal lesion allows early mobilization of all patients, regardless of neurological deficit, while protecting the neurological structures from further injury and enhancing their recovery.[9]

Surgical treatment can be anterior, posterior or anterioposterior. As most orthopaedic and spinal surgeons are more experienced in posterior approach and at the same time this approach requires less operative time with less blood loss, hence a safe alternative.[10]

Historically, Harrington hook rod construct or its modifications have been extensively studied.[11] Their main disadvantage is that it spans 5-6 spinal segments.[12] Hence, newer options, especially pedicle screw rod constructs which provide short segment immobilization have gained popularity.[13]

The goals of surgery are to achieve stability, to correct deformity, early mobilization, to expedite post operative recovery and to decrease pseudoarthrosis. The pedicle screw and rod construct helps to achieve all these.[14]

In pedicular screw system the fixation achieved is more rigid as the screw is passed through the “force nucleus” of the vertebrae.[15] This is the post through which five anatomical structures - the superior facet, the inferior facet, the lamina, the pedicle and the transverse process, channel all posterior forces that are transmitted to the body.[16]

In this study, we have stabilized cases of thoracic & lumbar unstable spinal lesions with pedicular screw and rod fixation. Pedicle screw system have gained much popularity in recent times. We have evaluated all patients for maintenance of spinal correction and neurological improvement after posterior instrumentation in thoracic and lumbar spinal lesions and clinical outcome in terms of spinal scoring system called as Denis work and pain scale.

OBJECTIVES

1. To study efficacy of pedicular screw and rod fixation system in achieving ‘stabilization’ in thoracic and lumbar lesions of spine.
2. To study clinical outcome by using spinal scoring system. (Denis Work and Pain Scale).

REVIEW OF LITERATURE

Historical Background

The earliest documented spinal surgery however is found in the Edwin Smith surgical Papyrus which was written about 3000 – 2500 B. C.[17]

In 1891, Hadra of Galueston was credited with the first application of spinal instrumentation where he first used wire to stabilize a cervical fracture dislocation. [18]

In 1911 Hibbs introduced the concept of non-instrumentation by inducing osseous fusion for stabilization of a deformed spine. Although the procedure initially provided stabilization it relied heavily on the use of casts and did not ultimately provide deformity correction.[19]

Lange from Munich was the first person to implant a metal rod to attempt to increase spinal stability.[20] King reported the first extensive use of internal fixation for the posterior thoracolumbar spine in the 1940s.[21,22] He placed screws across the facet joints to facilitate fusion.

It was not until 1950 and 1960 that the 1st successful instrumentation was introduced in Houston by Dr Harrington.[11] For years Harrington instrumentation was the gold standard against which all other instrumentation system were tested. This system allowed the surgeon to manipulate the spinal deformity in the coronal plane but includes excess motion segments in the fusion mass with loss of optimum surgical contouring. It has till now undergone 47 modifications.[21]

In 1944, **King**[22] first developed the concept of using pedicle as a means of spinal fixation and it wasn't until 1959 that Boucher reported on the actual success of obtaining a posterior fusion by passing screws through the lamina and pedicle into the vertebral body.[23] Transpedicular fixation of the lumbar vertebrae can be considered for patients who require rigid internal mechanical fixation of the spine while fusion is taking place. Spondylolisthesis, post-decompression or post-laminectomy instability, degenerative scoliosis, degenerative spinal instability, nonunion from previous failed surgery, extensive fractures, and tumors involving the lumbar spine can be treated with pedicle screws.[6]

There are several distinct advantages to using pedicle screws for spinal fixation. Pedicle screws are effective for rigidly fixing the spine; they can be used on vertebrae after a laminectomy has been performed, unlike hook rods systems; and they reduce the number of levels instrumented compared to hook/rod systems.[24] Further advantages are that the screw-bone interface is stronger mechanically than the hook-bone interface or wire-bone interface [23] screws provide an excellent way of attaching instrumentation to the sacrum [23] and normal spinal curvatures can be maintained. And finally, very few spinal segments must be fused or fixated.[25]

Transpedicular systems initially used plates to attach the screws and spinal elements together. Screw plate systems are semirigid, cannot easily correct spinal deformities, and can be difficult to apply if contouring is needed. The plate can also reduce the surface area of bone available for bone graft placement. Screw and rod systems were subsequently developed to overcome these limitations.[26]

In 1986, Arthur D Steffee introduced the variable screw placement system as a means of transpedicular fixation of unstable spine.[15, 20]

There was much controversy regarding the conservative versus operative treatment of the thoracic and lumbar instability. There are various studies which have proved beyond doubt that the surgical treatment is much better than the conservative treatment in many cases of thoracic and lumbar fractures.[6, 7]

In a study conducted on 100 patients of thoracolumbar fractures who were treated by surgery it was concluded that reduction and internal fixation of the injured spine allows mobilization of all patients regardless of neurological deficit, while protecting the neurological structures from further injury and enhancing their recovery. [7]

A study conducted at Unfaukrankenhause Berlin , Germany on thoraco-lumbar fracture treated with posterior pedicular screw and rod fixation with bone grafting, suggests that pedicular screw and rod thoroughly decompresses spinal canal with reliable fixation and early load bearing and suitable for unstable thoraco-lumbar fractures.[27]

A study was conducted on second degree spondylolysthesis for a period of 3 yrs. Patients underwent decompression , pedicular screw and rod and bone grafting. The study concluded that Mossmiami fixation system is simple and efficient method of treating spondylolysthesis.[28]

At their Right's Day Orthopaedic of Guangzhan, China study on lumbar disc herniation associated with spinal instability was done. They were treated with fenestration discectomy , bone grafting and pedicular screw and rod for lumbar fusion. The study suggested that pedicular screw rod fixation system improves prognosis in instability associated with degenerative lumbar disc herniation.[29]

In a study at Stanford Uni School of Medicine, CA 94305 , with pyogenic vertebral osteomyelitis underwent spinal instrumentation forspinal instability. Following instrumentation the infection appeared to be controlled and patients were mobilized directly after instrumentation.[30]

In a study, 43 patients with pyogenic (37 patients) and tuberculous (6 patients) osteomyelitis of the thoracic and lumbar spine (24 men and 18 women) who underwent combined posterior debridement and internal fixation with transpedicular screw-rod systems. Of the 26 patients with preoperative neurological deficit 88% had significant improvement. They conclude that, most patients with thoracic and lumbar osteomyelitis can be successfully treated by combined debridement and internal fixation using only a posterior approach.[31]

Dept. of Orthopaedics, catholic University Of Rome, spinal tumours were operated and stabilised, mostly with pedicular screw and rod system. Post-operatively. 63.5% patients showed satisfactory outcome, 46% patients showed good neurological improvement [32]

In a study of 147 patients of thoracolumbar fractures in 1977 treated by conservative means with a follow up period of more than eight years, suggested that recumbent treatment does not give favourable results as it had been previously thought.[33]

In a prospective study of 104 cases of thoracolumbar burst fractures it was concluded that prophylactic stabilization and fusion of acute burst fractures have significant advantage over conservative treatment. [34]

In another study of 123 patients by pedicle screw plates it was concluded that pedicle screw plates allow a satisfactory and stable reduction in the thoracolumbar fractures of the spine.[35]

In a 10 year retrospective study of 234 patients who underwent pedicle screw fixation for various spinal pathology it was concluded that fusion with pedicle screw showed relatively good functional capacity relative to baseline, a low rate of radiological failure, satisfaction of patients with their progress and minimal surgical and hardware related complications.[36]

A prospective comparative study of 67 patients with burst fractures or fracture dislocations of thoracolumbar spine all treated with either Harrington or transpedicular fixation concluded that transpedicular devices are more reliable in achieving a near anatomical reconstruction of fractured site and rate of complications was low. [37]

One study of 22 patients with neurological deficits surgically treated by pedicle screw fixation showed a low improvement in neurological deficits (14%) but reported good correction of kyphosis and maintenance of correction at follow up.[38]

In a comparative study of 90 patients of thoracolumbar spine fractures, 45 treated by conservative means and 45 cases treated by posterior spinal fixation using variable screw placement system it was concluded that 40% patient showed an improvement in their neurological status as compared to only 20% in conservatively treated group. There was significantly less number of complications in operated group.[39]

66 cases of grade 1 and 2 spondylolysthesis patients were treated with posterior decompression and transpedicular fixation. On conclusion, grade 1 & 2 cases treated with pedicular screw and rodshowed satisfactory results.[40]

Bridwell et al[44] reported a study on 44 patients who underwent fusion after decompression for degenerative stenosis with spondylolisthesis. They compared a decompression group, decompression and uninstrumented fusion group, and fusion with instrumentation group. The instrumentation group showed a much higher fusion rate, better functional outcome, and improved restoration of sagittal alignment compared with the uninstrumented group [41]

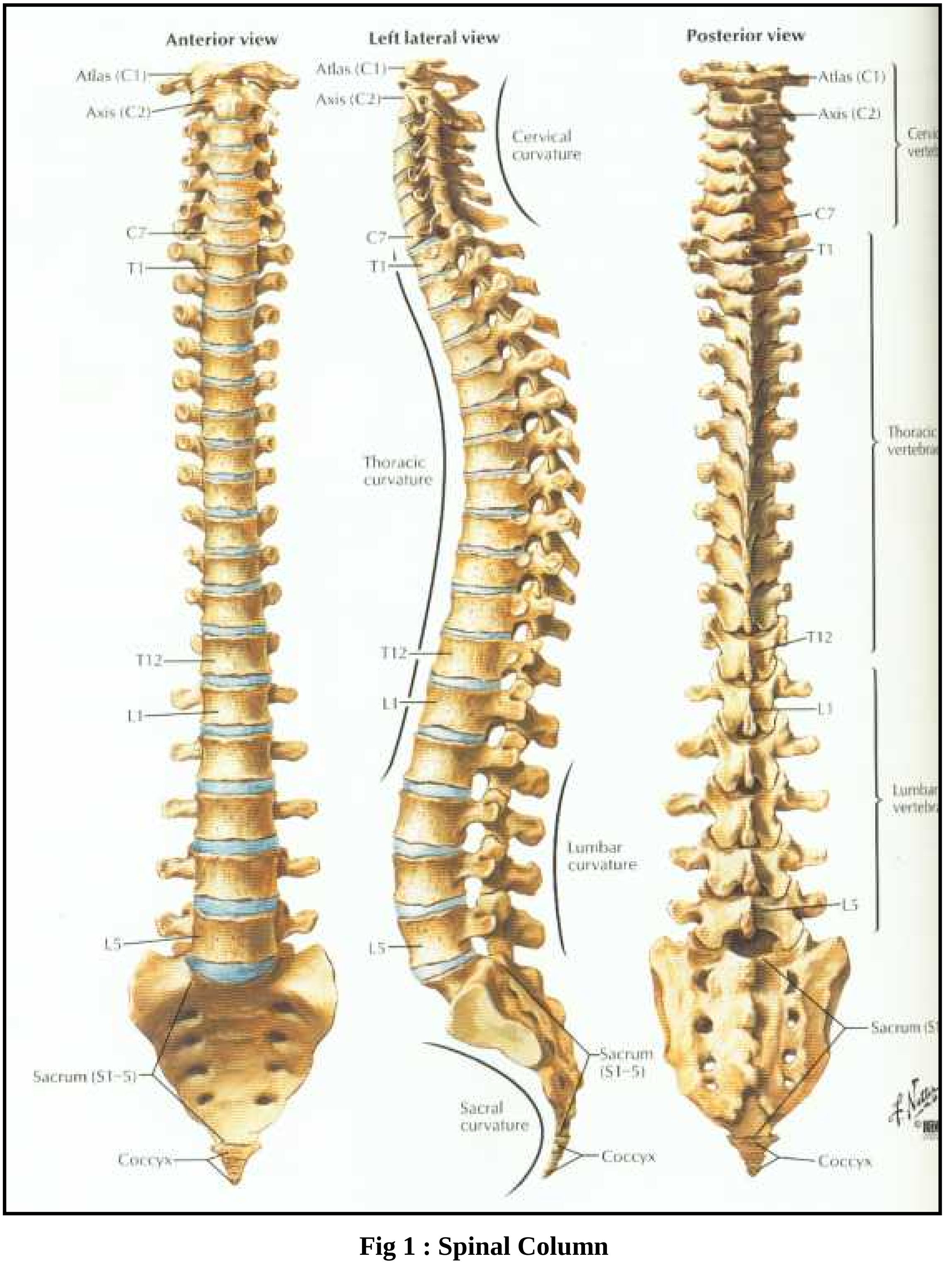


Fig 1 : Spinal Column

ANATOMY OF THORACIC AND LUMBAR SPINE

The human spine also known as vertebral column is made of individual units called vertebra. The name vertebral column is derived from its appearance when viewed from the front it really looks like a column.[42] (Fig 1)

Basic knowledge of the spinal column's osseoligamentous and neurological structures is essential to understand and evaluate trauma to spine. It helps the surgeon to assess the relative stability of the injury, the risk of an associated neurological deficit, and the specific treatment needed. [43]

The anatomical structures can be broadly classified into two.

A. Spinal column

B. Spinal cord

Embryology (Fig 2)

The development of human spine starts with the onset of the triploblastic stage of the embryo and ends in the third decade of life. [44]

The vertebral column

The vertebral column is formed from the sclerotomes of the somites.

Fate of Somites

We have seen that the paraxial mesoderm becomes segmented to form a number of somites, that lie on either side of the developing neural tube. A cross-section through a somite shows that it is a triangular structure and has a cavity. The somite is divisible into three parts.

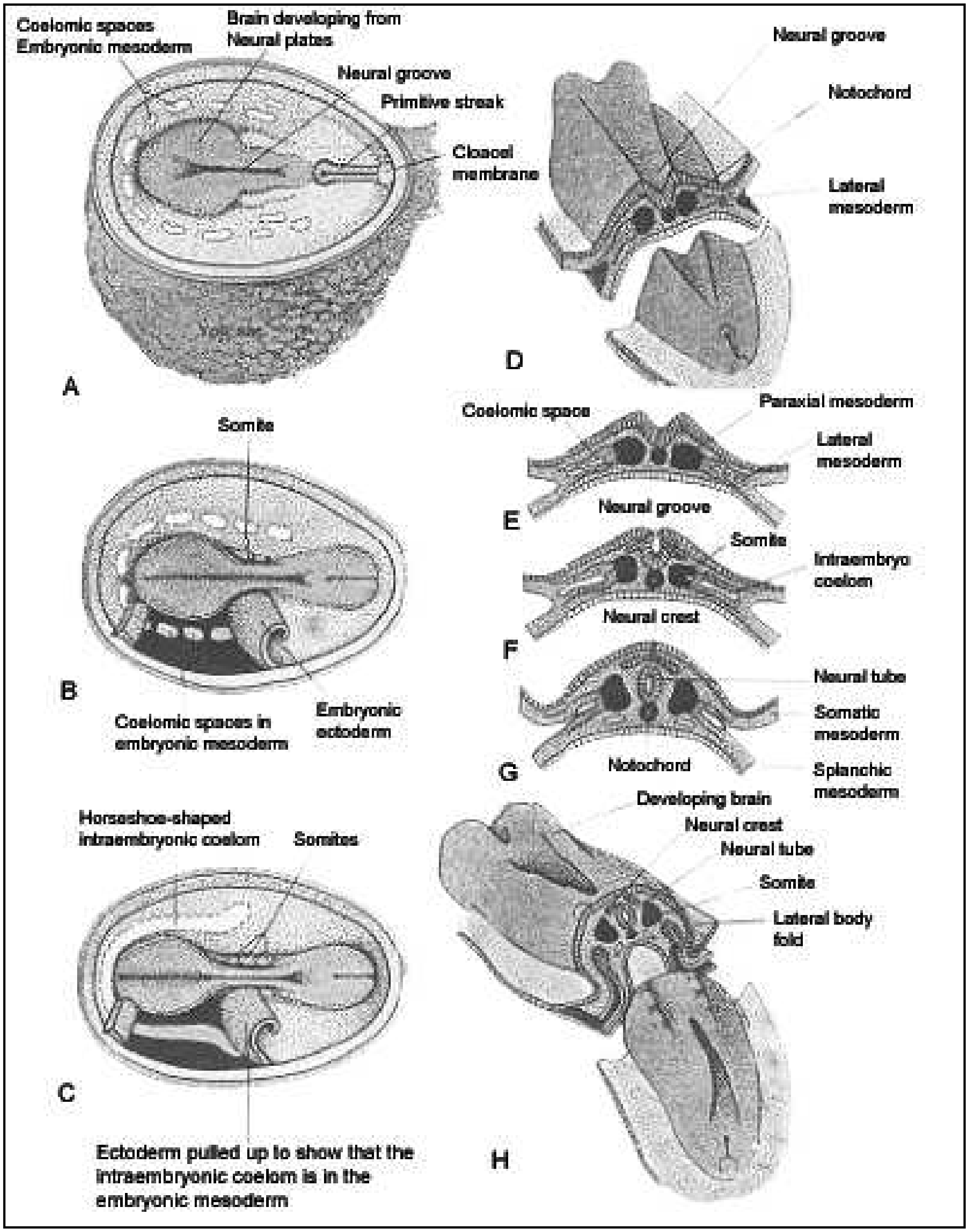


Figure 2 : Spinal Embryology

a. The venteromedial part is called the sclerotome. The cells of the sclerotome migrate medially. They surround the neural tube and give rise to the vertebral column and ribs.

b. The lateral part is called the dermatome. The cells of this part also migrate, and come to line the deep surface of the ectoderm covering the entire body. These cells give rise to the dermis of the skin and to subcutaneous tissue.

c. The intermediate part is the myotome. It gives rise to striated muscle as described in the following section.

In the cervical, thoracic, lumbar and sacral regions one spinal nerve innervates each myotome. The number of somites formed in these regions, therefore, corresponds to the number of spinal nerves. In the coccygeal region, the number of somites exceed the number of spinal nerves but many of them subsequently degenerate.

The cells of each sclerotome get converted into loose mesenchyme. This mesenchyme migrates medially and surrounds the notochord. The mesenchyme then extends backward on either side of the neural tube and surrounds it. Extensions of this mesenchyme also take place laterally in the position to be subsequently occupied by the transverse processes, and ventrally in the body wall, in the position to be occupied by the ribs.

For some time the mesenchyme derived from each somite can be seen as a distinct segment. The mesenchymal cells of each segment are at first uniformly distributed. However, the cells soon become condensed in a region that runs transversely across the middle of the segment. This condensed region is called the perichordal disc. Above and below it are less condensed parts. The mesenchymal basis of the body (or centrum) of each vertebra is formed by fusion of the adjoining, less condensed parts of two segments. The perichordal disc becomes the intervertebral disc.

The neural arch, the transverse processes and the costal elements are formed in the same way as the body. The interspinous and intertransverse ligaments are formed in the same manner as the intervertebral disc.

The notochord disappears in the region of the vertebral bodies. In the region of the intervertebral discs, the notochord becomes expanded and forms the nucleus pulposus.

From the above account we may note that :

1. The vertebra is an intersegmental structure made up from portions of two somites. The position of the centre of the somite is represented by the intervertebral disc.
2. The transverse processes and ribs are also intersegmental. They separate the muscles derived from two adjoining myotomes.
3. Spinal nerves are segmental structures. They, therefore, emerge from between the two adjacent vertebrae and lie between two adjacent ribs.
4. The blood vessels supplying structures derived from the myotome (e.g. intercostals vessels) are intersegmental like the vertebrae. Therefore, the intercostals and lumbar arteries lie opposite the vertebral bodies.

The mesenchymal basis of the vertebrae is converted into cartilage by the appearance of several centres of chondrification. Three primary centres of ossification appear for each vertebra; one for each neural arch and one for the greater part of the body (centrum). At birth the centrum and the two halves of the neural arch are joined by cartilage. Note that the posterolateral parts of the body are formed from the neural arch. The lines of junction between the parts of the body derived from the centrum and neural arches form the neurocentral joints. [45]

A. SPINAL COLUMN :

Spinal column consists of vertebral bodies and intervening discs, posterior elements (pedicles, superior and inferior articular processes, laminae, transverse processes and spinous processes) . Ligaments interconnect these.

1. **VERTEBRAL BODIES AND DISCS**: (Fig 3)

Thoracic spine consists of 12 vertebrae and lumbar spine 5. There is an intervetebral disc between adjoining vertebrae. Discs are firmly attached to the bodies. The anterior and posterior longitudinal ligaments give added stability. The above structures constitute the anterior and middle columns of Denis. These two columns bear 80% of the load applied to the spine in upright position.

2. **POSTERIOR ELEMENTS**:

These consist of pedicles, superior and inferior articular processes laminae, transverse process and spinous processes. These osseous structures are connected by supraspinous, interspinous and intertransverse ligaments; ligamentum flavum and facet capsules. All these osseoligamentous structures form the posterior column of Denis. Thoracic spine gets added stability by rib cage. Special emphasis is placed on the posterior elements, as they are very important in posterior stabilization of spine.

3. **LIGAMENTS OF THE SPINE** (Fig 3)

Ligaments are uniaxial structures; they are most effective in carrying loads along the direction in which the fibers run. They readily resist tensile forces but buckle when subjected to compression.[45]

The ligaments connecting the vertebrae also form a column and can be divided as continuous and segmental.

→ Continuous ligaments

- Anterior longitudinal ligament
- Posterior longitudinal ligament
- Supraspinous ligament

→ Segmental ligaments

- Ligamentum flavum
- Interspinous ligament
- Intertransverse ligament

a. **Anterior longitudinal ligament** : It is a fibrous structure arising from the anterior aspect of the basiocciput and is attached to the atlas and anterior surfaces of all vertebrae, down to and including a part of the sacrum. Firmly attached to the edges of the vertebral bodies, it is affixed not so firmly to the fibers of the intervertebral disc, at which level it narrows. It is well developed in the thoracolumbar region and thicker

b. **Posterior longitudinal ligament** : It arises from the posterior aspect of the basiocciput and runs over the posterior surfaces of all the vertebral bodies down to the coccyx. It too, is thicker in the thoracic region. In the lumbar region, it is less developed as compared to its anterior counterpart. In contradiction to its anterior counterpart, it is wider at the disc level and narrower at the vertebral body level.

c. **Intertransverse ligament** : These pass between the transverse processes in the thoracic region and are characterized by rounded cords, intimately connected with the deep muscles of the back.

d. **Supraspinous ligaments** : This is much thicker and broader in the lumbar region and is not of much significance in the thoracic region. It originates in the ligamentum nuchae and continues along the tips of spinous processes as a round slender strand to the sacrum.

e. **Ligamentum flavum** : The ligamenta flava extend from anterioinferior border of the lamina above to the posterosuperior border of the lamina below. Also called the yellow ligament (because of their high content of elastin fibres) they are thicker in the thoracic region.

f. **Interspinous ligaments** : They connect adjacent spinous processes and their attachments extend from root to apex of each process. They are narrow and elongated in thoracic region and broad and thick in the lumbar region.

The load bearing structures of the vertebral column are, anteriorly the body and posteriorly the two facet anticulations.

4. **PEDICLES**

Pedicles are the strongest part of the vertebra and integrity of the pedicle is an important factor in the selection of the screw and its placement.[46]

Pedicles serve as the load transmitting struts between the neural arch and the vertebral body. They are the strongest part of the vertebra. Anteriorly they attach to superior portion of the lateral aspect of the posterior surface of the body. Posteriorly they are attached at the pars interarticularis.[35] It consists of outer cortical bone and inner cancellous medulla.

Zindrick et al [47] have described the pedicle measurements. They studied the morphometric characteristics of thoracic and lumbar pedicles in 2905 pedicles from D1 to L5 with computed tomography and individual vertebral specimen roentgenograms. A study of length and width of lumbar pedicles by Singel TC et al [48] has shown that there is increase in width of lumbar pedicles proceeding from L1 to L5 and width being maximum at L5 level to enable the weight transmission. The others who have studied the pedicle dimensions include Krag et al, [49] Rama Devi et al, [46] Scillant etc. Morphometric values are important during the screw placement in pedicles.

The important morphometric characteristics that are important from surgical point of view are :

(1) Pedicle isthmus width

a. **Transverse :** The narrowest dimension in transverse plane was chosen as the transverse width. The widest pedicle was seen at L5 level with a mean width of 18.0 mm. The narrowest was seen at the T5 level with a 4.5 mm mean width. Narrowest width in the lumbar spine was seen at L1 with a mean of 8.7 mm.

b. **Sagital :** The narrowest dimension in sagittal plane was chosen as the sagittal isthmus width. The widest was seen at T11 with a mean value of 17.4 mm. The narrowest was seen at T1 with a mean of 9.9 mm. In the lumbar spine, the narrowest width was seen at L5 with a mean of 14.0 mm. The widest was at L1 with a mean value of 15.4 mm.

(2) Pedicle angle : **(**Fig 4)

a. **Transverse pedicle angle** : This is obtained by measuring the angle between a line perpendicular to the transverse isthmus and a line parallel to the vertebral midline in the transverse plane. The largest angle from the midline was seen at L5 with the mean pedicle angle of 29.8°. The shallowest angle was seen at T12 and this was 4.2°. In the lumbar spine the shallowest angle was 10.9° at L1. The largest angle of the thoracic spine was at T1 with a mean value of 26.6°.

b. **Sagittal pedicle angle** : This is obtained by measuring the angle between a line perpendicular to the sagittal isthmus and the anterior vertebral body border in the sagittal plane. The largest cephalad angluation was seen at T2 with mean value of 17.5°. The L5 angled caudally – 1.8°.

(3) Depth to Anterior cortex : This is the distance from the most posterior aspect of the transverse process to the anterior cortex, taken either in the line of the transverse pedicle angle or in a line parallel to the vertebral body. The shortest distance to the anterior cortex was seen at L_2 and L_3 i.e. 51.9 mm.

Zindrick et al [47] also studied the size of pedicles in mature and immature spine. They found that transverse pedicle width at L_5 and L_4 levels reached 8mm or more in children 6 to 8 yrs of age. But the transverse width at L_3 did not reach 8mm till the age of 9-11 yrs. The distance to the anterior cortex increased dramatically from the youngest age group until adulthood at all levels.

RELATIONSHIP TO IMPORTANT STRUCTURES: [50]

Pedicles are closely related to important structure on all sides. Knowing these structures helps the surgeon to avoid penetrating pedicle cortex during surgery. They are.

i. Medial to pedicles are epidural space, nerve root and dural sac.

ii. Caudally exiting nerve root from the same level.

iii. Laterally and superiorly nerve root from the level above lies closely. At sacral level great vessels and their branches lie lateral to sacral ala.

iv. Anteriorly: At L3 and L4 levels, common iliac artery and veins lie directly anterior. In the sacral region variable sacral artery can lie directly anteriorly.

SURGICAL LANDMARKS TO THE PEDICLE

Many proponents of the pedicular screw systems have studied the entry point for the pedicular centre. The most widely used methods are.

a. **Roy Camille**[35]: The pedicle centre lies at the intersection of vertical line through the facet joint and horizontal line through the middle of the insertion of the transverse process.

b. **Weinstein**[51]: At the lateral and inferior corner of the superior articular facet.

c. **Steffee**[15]: Recommended entry point at what he called as the "force nucleus" of the vertebra. It lies at the convergence of the ridge on the superior articular facet, the ridge on the pars interarticularis and the ridge on the transverse process.

d. **Zindrick**[52]: described a " pedicle approach zone". This is a funnel shaped area, which should be decorticated before entering the pedicle.

5. SUPERIOR AND INFERIOR ARTICULAR PROCESSES AND FACET JOINTS:

Superior articular processes project upwards from the junction of laminae and pedicles. It articulates with inferior articular process of the vertebra above to from the facet joint. It is a synovial joint. The direction of the joint surfaces determine the direction of the movement possible between adjacent vertebrae.

6. LAMINAE:

These are broad plates of bone lying behind and medial to the pedicles. They fuse behind the median plane into the spinous process. They from posterior boundary of vertebral fractures.

7. SPINOUS PROCESS:

These pass backwards and downwards from the junction of the two laminae. These give attachment to ligaments and muscles which are very important in functioning and maintenance of stability of the spine.

8.TRANSVERSE PROCESSES:

These are 2 in number. They project laterally from the junction of pedicle and lamina. In the thoracic spine they articulate with ribs.

9. STRUCTURES AFFECTING STABILITY TO THE SPINE :

These are the bony architecture, the ligaments and the muscles

1. Bony structures

In the thoracic region, the rib cage stabilizes the spine. The anatomy and orientation of the articular facets lock the vertebrae well and give rotational stability.

2. Ligaments

The continuous ligaments, the segmental ligaments and capsule of facet joints all make the column stable

3. Musculature

The paraspinal muscles absorb the tensile forces and add to the tensile strength of the posterior elements.

10. **TRABECULAR PATTERN OF THE VERTEBRAE** (Fig. 5)

This has an important bearing on mechanisms of types of injury. If a vertebral body were to be cut in a coronal plane, it would be seen to consist of bony trabeculae oriented in a horizontal and vertical fashion.

If the vertebral body were to be sectioned in a sagittal plane passing through the articular processes, a special pattern of obliquely running trabeculae would be seen.

The superior trabeculae begin from the superior end plate and run posteriorly and fan out into 2 tails, one each passing to the spinous process and superior articular process. The inferior trabeculae similarly pass from the inferior end plate to the inferior articular process and the spinous process.

This arrangement of the trabeculae and hence the overlapping in the posterior half of the vertebral body makes it highly resistant to compressive forces. But this leaves a weak triangular area in the anterior half of the body which is more susceptible to axial forces.

This triangle of minimum resistance fails under 600 kg of axial functional load whereas, posterior half can sustain 800 kg of axial loading.

B. SPINAL CORD: (Fig. 6)

It fills about 50% of the canal in the thoracolumbar segments. The remainder of the canal is filled with CSF, epidural fat and meninges. The spatial relationships of grey and white matter structures remain consistent throughout the length of the cord, but the proportions change based on the level.

The vertebral level and the spinal cord level do not correspond to each other. From T1 to T6 the spinal cord level lies 2 levels above the vertebral body level. T7 to T9 it is 3 levels above. Two T10 to T12 vertebral levels correspond to lumbar myclomeres. The conus medullaris containing the sacral and coccygeal mycomeres is dorsal to L_1 and L_{1-2} disc.

Spinal cord ends at L1 L2 disc. It ends as conus medullaris. Below this cauda equina continues (motor and sensory roots of lumbosacral mylomeres). Till L1, cord trauma, root injury or both may cause the neurological deficits. Below L1, it is entirely caused by root damage.

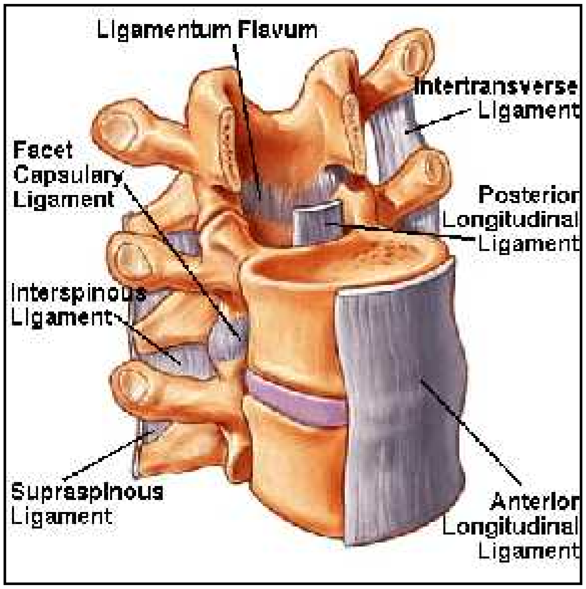


Figure 3 :
Spine Units and Ligaments

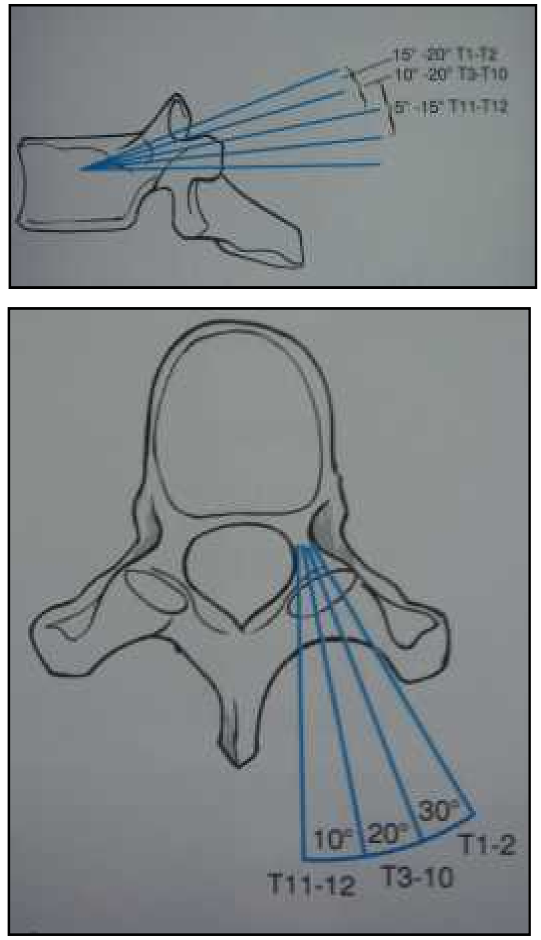


Figure 4 : Pedicale Angle

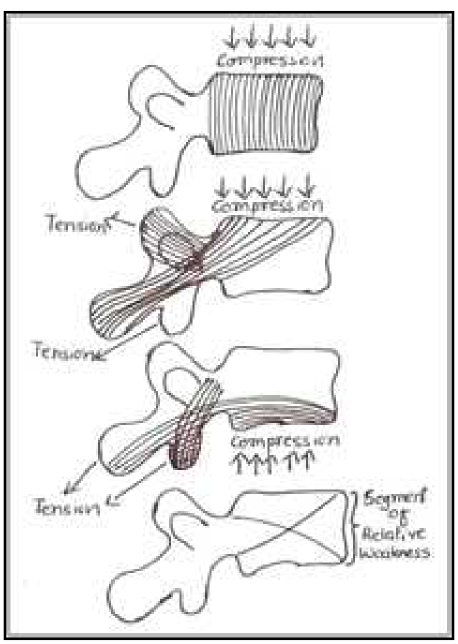


Figure 5 : Vertebral trebecular

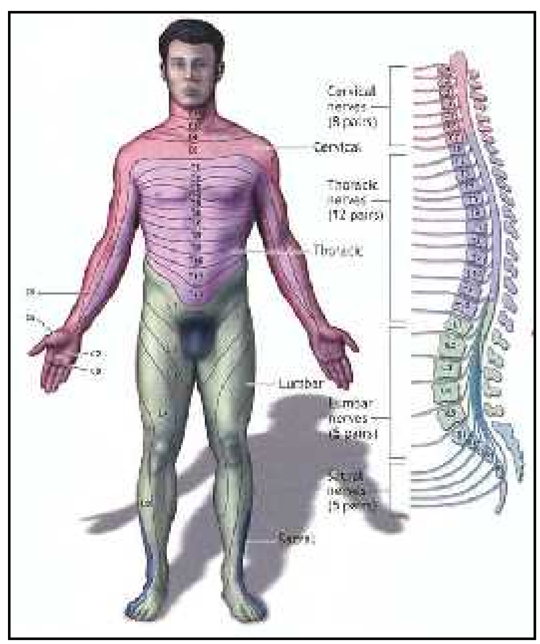


Fig 6 : Spinal Cord

BIO MECHANICS

Bio-mechanics should be considered in terms of Kinematics i.e., the physiologic motion allowed with the constraints of anatomy and the forces acting on the Spine.

Any motion of the spine may be resolved into 6 components using a three dimensional co-ordinate system (Fig 7). The three pure types of translation along a single axis are anteroposterior translation along saggital plane (along Z axis). Mediolateral translation in the frontal plane (along x axis), and craniocaudal translation along longitudinal plane (along Y axis), (Fig 7).

Angular motion can also be described by the coordinate system. The three pure types of angulations are flexion extension in the saggital plane (x is the axis of rotation), lateral flexion in the frontal plane (z is the axis of the rotation) and rotations about the craniocaudal axis (y is the axis of rotation). The six cardinal motions (three linear and 3 angular) can be coupled.

Motions of translation are relatively restricted in the thoracolumbar spine, especially anteroposterior or mediolateral translation. Consequently physiologic motion of the spine is achieved chiefly by angulation.

Thoracic spine is much stiffer than the lumbar spine in saggital plane. This restricts lateral flexion-extension. This is due to restraining effects of the rib cage, and the relatively thinner discs of the thoracic spine, which restrict the arc of motion.[52] Rotation about the craniocaudal axis is greater in the thoracic spine.[53] In the lumbar spine, rotation is limited by the orientation of the facets and the anterior portion of the annulus to only 10 degrees for the entire lumbar spine versus about 75 degrees of rotation of each side in the thoracic spine.[54]

Forces: (Fig. 7)

The forces acting on the spinal column include internal (i.e. muscle) forces and external forces resulting from contact with the environment (e.g. gravity, acceleration or missile) Kelly and **Whitesides**[55] observed that the vertebral bodies and discs primarily function to support compressive loads, whereas the processes, with their profusion of connecting ligaments seem best adapted to withstand tensile forces.

Jacobs et **al**[56] analyzed the normal physiological forces acting on the spine. Thoracolumbar junction transmits a compressive load of approximately 400 Newton's owing to the weight of the body above that point. Because the centre of gravity is located anterior to the spine, this eccentric position results in a flexion. Bending forwards to 90 degrees at the hips, results in 400 N shear force between the two vertebrae in addition the flexion bending movement increases the shear force dramatically to 120NM. Treatment should restore the ability of the vertebral column to withstand these physiological stresses.

Haher[57] and co-workers analyzed the load-carrying capacity at thoracolumbar junction. By disrupting the anterior column, they found that the load-carrying capacity of the thoracolumbar junction decreased by 30%. Ablating the anterior and middle columns decreased the load carrying capacity by 70%. Ablating posterior column decreased capacity by 65 %. By ablating annuls rotatory stability diminished by 80 %. This helps us evaluate the instability more accurately.

Degenerative spine disease usually presenting with low back pain , are associated with increased translation movements in sagital plane associated with rotation.[58] In cases of burst fractures of thoracolumbar spine in quite unstable in axial rotation.[59,60,61] Haher et al implicated that disruption of the anterior column results in rotational instability.[62]

Spinal stability and instability:

Various theories have been put forward to explain and understand the concept of spinal stability. According to White and Punjabi [63] the spine can be divided into anterior column and posterior columns .The dividing line being posterior longitudinal ligament. To achieve stability all elements in one column plus at least one element in the other column must be intact .

Denis [64] put forth his three column concept . He divided the spine into (Fig 8)

Anterior column	Anterior longitudinal ligament, anterior half of vertebral body and the anterior portion of the annulus fibrosis
Middle column	Posterior longitudinal ligament, posterior half of vertebral body and the posterior aspect of the annulus fibrosis
Posterior column	Neural arch, ligamentum flavum, the facet capsule and the interspinous ligament

For stability two columns must be stable.

John Evans came with **Flag pole** (Fig 9) concept of stability.[65.] The spine being the Flagpole and three wire anchoring the flagpole were anterior longitudinal ligament, anteriorly. Facet joint, laterally and supraspinous and infraspinous ligament, posteriorly to maintain stability the mentioned structures should be stable.

Stability of spine is that quality by which the vertebral structures maintain their cohesion in all physiological position of the body. On the other hand, instability is pathological process which can lead to displacement of vertebrae beyond their normal physiological limits.[65]

Definition : -

Stability : the ability of the spine under physiological loads to limit pattern of displacement so as to damage or irritate the spinal cord or the nerve roots and in addition to prevent incapacitating deformity or pain due to structural changes .[65]

Instability : inability of the spine to maintain its normal functional anatomy under physiological stress .[65]

The stability of spine functional unit is achieved by following [65]

1) Passive stabilization - is provided by shape and size of vertebral body and facet joints .
2) Dynamic stabilization – linking viscoelastic ligaments , joint capsule and annulus fibrosus .
3) Active stabilization – deep postural muscles.
4) Hydrodynamic stability - turgid nucleus pulposus .

When any of the restrains as described above fails or are damaged there is loss of equilibrium in the motion segment resulting in excessive movement and hence instability. The instability has two basic elements –[65]

1 Kinematic instability - focuses on the quality of motion like altered axis of rotation , coupling and paradoxical motion .

2 Quantity of motion - disruption of balancing forces leading to excessive movement or as a result of degeneration and osteophyte formation the spine is deformed and fixed . Instability can be divided into 2 broad types i.e., Neurological and mechanical.

a. Neurological instability: it is the inability of the spine to protect the spinal cord, cauda equina and nerve roots.

b. Mechanical instability: it is inability to withstand physiologic demands without pain deformity, abnormal motion or neural compression.

- Acute: instability during the first 3 months post injury.
- Chronic: Instability more than 3 months post injury.

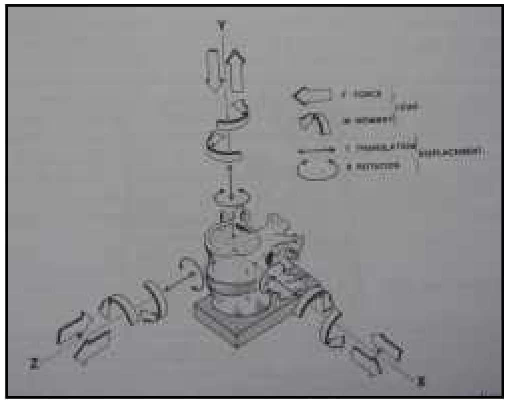


Fig 7 : Direction of forces

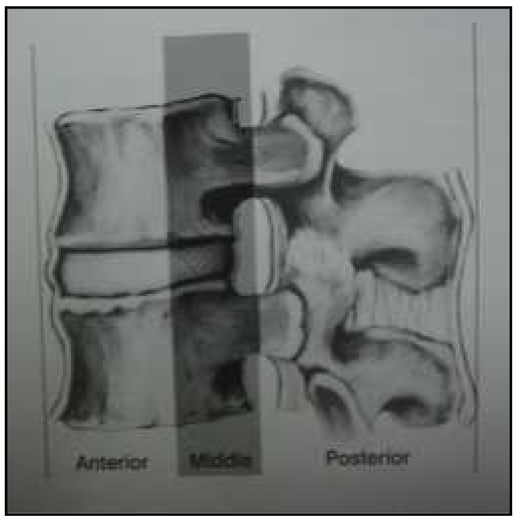


Fig 8: Dennis 3 column

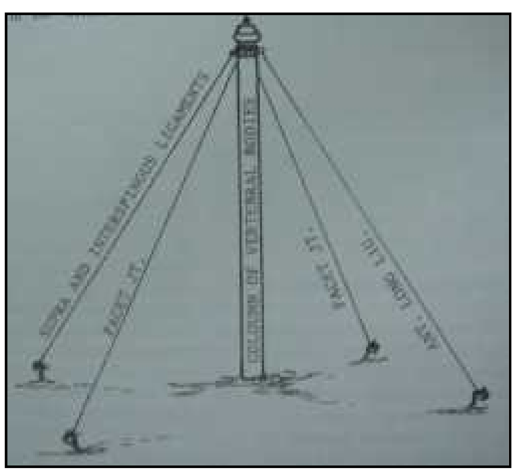


Fig 9: Flag pole concept of stability

RADIOLOGY

1. PLAIN RADIOGRAPHS:

In thoracic and lumbar spine at least anteroposterior and lateral views are required.[66] This is the primary modality of investigation. In all patients, supine anteroposterior and lateral views of the thoracic and lumbar spine are taken, this can point to further evaluation. Dynamic radiographs demonstrate presence of instability in spine. Presence of collapase, loss of pedicle, erosion of laminae, soft tissue mass with bony change give clue to possible aetiology. Congenital conditions like spina bifida, scralisation of lumbar vertebra, spondylolysthesis, spondylosis can be effectively detected on x-ray.

2. MYELOGRAPHY

With the advent of newer diagnostic tools myelography has lost its role due to its limitations and side effects. The main indication is a neurological deficit unexplained by the osseous lesion. It is helpful when MRI is contra indicated or is unavailable.

3.COMPUTED TOMOGRAPHY

Principal strength of CT is good definition of bony anatomy. Better visualization of the vertebral arches, facet joints and neural canal can be obtained with CT. [67]

It is superior to MRI for diagnosis of small fractures of posterior elements.

CT is diagnostic for burst fractures, and clearly deplicates fracture pattern.

Disadvantage s of CT lies in the fact that it cannot show cord directly, hence associated cord injuries cannot be seen with CT

Some of the indications for CT study are : - [68]

Identifiable vertebral body compression

Increased interpedicular distance – which is a specific sign of a burst fracture

Transverse process fractures – since they can be associated with other significant injuries of the spine and pelvis.

4.CONTRAST – CT

Differentiation of the neural elements from other soft tissues requires intrathecal administration of a contrast medium. This is necessary when neurological deficit cannot be explained by the bony pathology by plain radiography and CT. Iohexol (Omnipaque) and Isovue (Iopamidol) are the water soluble nonionic iodinated dyes most commonly used.

5.MAGNETIC RESONANCE IMAGING

MRI is becoming the modality of choice for evaluation of spinal disorders. With few exceptions MRI is the diagnostic tool of choice for evaluation of degenerative disorders, tumours of entire spine and spinal cord lesions .

Advantages:

a. Better delineation of intramedullary lesions such as post traumatic cysts, hematomas, and cord edema. Prognosis for recovery can be made more accurately.
b. Extramedullary compression by disc, hematoma and bone is accurately made out

Indications

1. Modality of choice when neurological deficit cannot be explained by the bony pathology demonstrated by plain radiography and CT without intrathecal contrast.
2. Assessment of the posterior ligamentous complex.
3. Examination of soft tissue.
4. Examination of spinal cord conditions

Contra indications

Ferromagnetic aneurysm clips, periocular metallic fragments, metallic implants, electronic implants (e.g. cardiac pacemakers), hemodynamic instability and severe claustrophobia.

CLASSIFICATION

The ideal classification system would be simple logical comprehensive and precise. It would allow prognositication, guide management and serve as a research tool to assess diagnostic and therapeutic options.[66] The interobserver and intraobserver variability should be low.

There are two fundamental categories of spinal instability [69]: Acute & Chronic Instability

These are further subdivided -

I) Acute - 1) Overt instability

2) Limited Instability

II)Chronic – 1) Glacial instability

2) dysfunctional segmental motion

ACUTE SPINAL INSTABILITY[69]

Overt instability :

It is inability of spine to support the turso during normal activity.

Causes - Trauma, surgical destabilization, Neoplasia, advanced degenerative disease & infection.

The integrity of the spine is insufficient to prevent significant deformation , such that neural elements are at risk. There is circumferential loss of integrity of structural support of spinal canal .

Limited instability

In this exclusively dorsal or ventral spinal integrity is impaired. The involved spine is sufficiently stable to support some normal activity of the spine.

CHRONIC SPINAL INSTABILITY [69]

Glacial instability :

Here there is no rapid development of deformities but, like glacier, the deformity progresses gradually with time. Repeated radiographs helps identifying instability.

Dysfunctional segmental motion :

It's the mechanical instability with pain of spinal origin due to disc interspace or vertebral body degenerative changes, tumour or infection. It is associate with characteristic pain pattern seen with loading and relieved with rest.

FRACTURES :-

Denis Classification [64] (Fig. 10)

Type	**Mechanism**
1. Compression	Flexion
Anterior	Anterior flexion
Lateral	Lateral flexion
2. Burst	
A	Axial load
B	Axial load plus flexion
C	Axial load plus flexion
D	Axial load plus rotation
E	Axial load plus lateral flexion

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

SPONDYLOLYSTHESIS :- [70] (Fig. 11)

Newmans classification of spondylolisthesis

1) Congenital (dysplastic) spondylolisthesis
2) Isthemic (spondylolytic) spondylolisthesis
3) Degenerative spondylolisthesis
4) Traumatic spondylolisthesis
5) Pathologic spondylolisthesis
6) Post surgical spondylolisthesis (spondylolisthesis acquisita)

CLASSIFICATION OF DISC PROLAPSE [71]

1) **Intraspongi – nuclear herniation**

Nucleus migrates from the central region of disc and into the inner annular fibers but does not cause any change in the configuration of the outer most annular fibres .

2) **Protrusion :**

The displaced disc material causes a bulge of the outermost annular fibers.

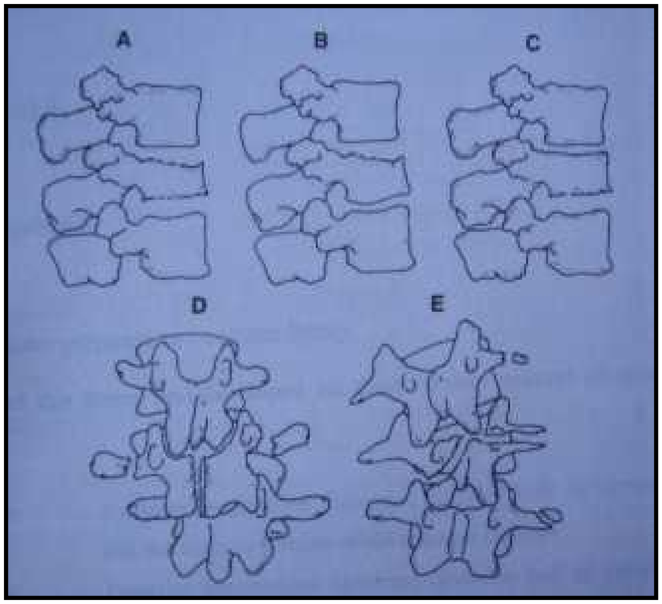


Fig 10 : Denis Fracture classification

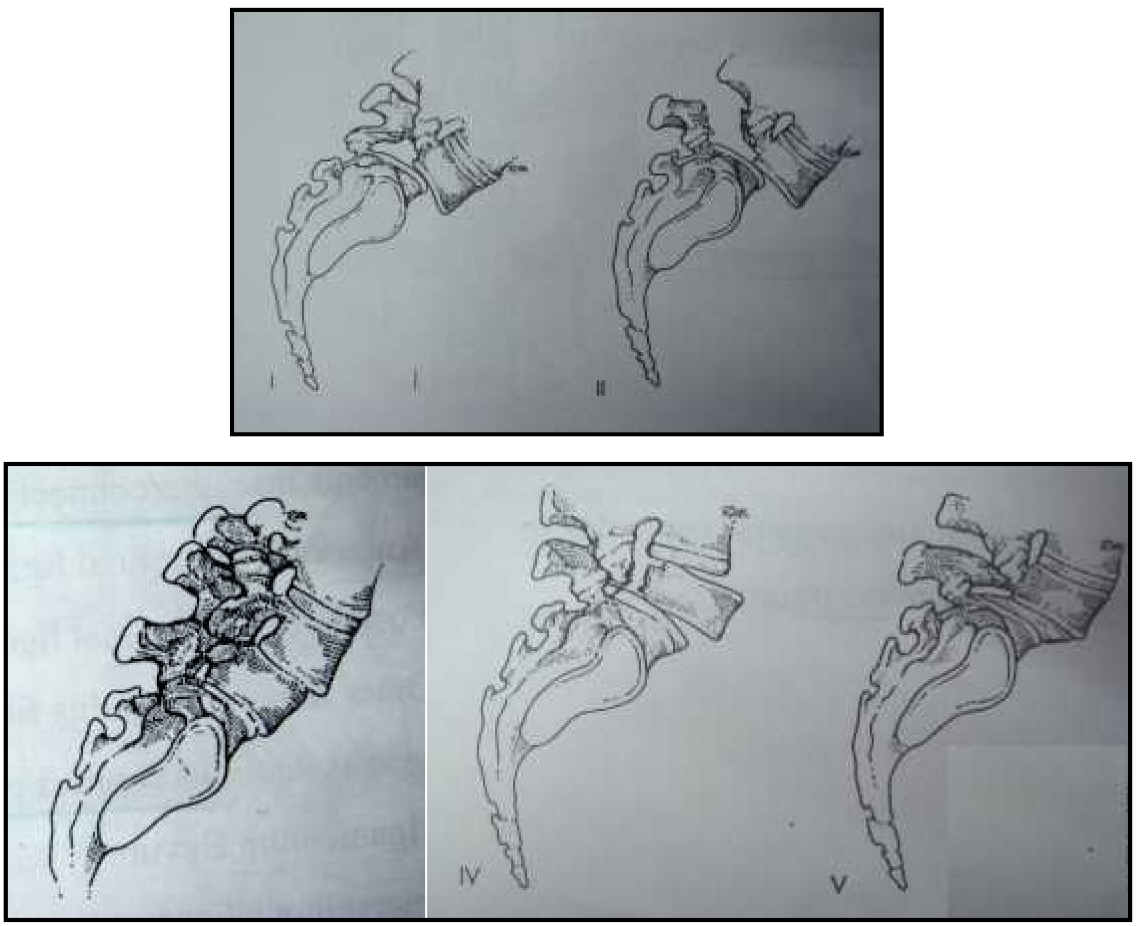


Fig 11 : Spondylolithesis Classification

3) **Extrusion :**

The nuclear material escapes through all the annular fibres but still remains connected to the nuclear material within disc.

4) **Sequestration :**

Nuclear annulus has extruded through the fibres of annulus fibrosus and lies in the canal as free fragment .

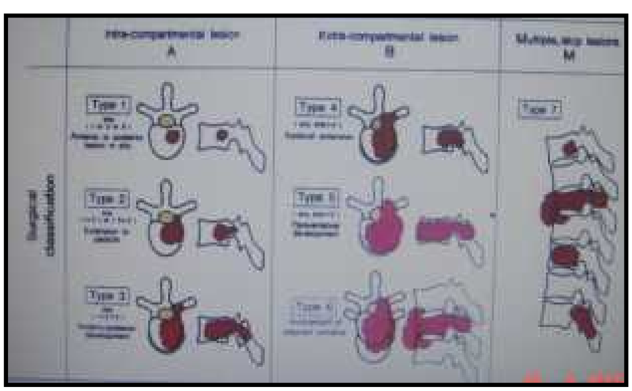
CLASSIFICATION OF VERTBRAL TUMOURS :[72] (Fig 12)

SURGICAL CLASSIFICATION OF VERTEBRAL TUMOURS .

1. Vertebral body (anterior or posterior)
2. Pedicle
3. Lamina & spinus process
4. Spinal canal (epidural space)
5. Paravertebral area.
6. Adjacent vertebra
7. Multiple lesions

Type A - intra compartmental Type B – ex compartmental lesion

Type M – multiple skip lesion



NEUROLOGICAL EXAMINATION

Importance of accurate and detailed neurological examination cannot be over emphasized.[73] In thoracic and lumbar spinal lesions it is important to determine the level and extent i.e. complete or incomplete , neurological injury. In case of trauma the most important step is to establish level of consciousness. Glasgow coma scale is universally accepted method for determining this.

Spinal shock , if present it rarely lasts longer than 24 hrs, but might last for days or weeks exceptionally. A positive bulbocavernous reflex or return of anal wink reflex indicates the end of spinal shock. An initial examination should include a detailed sensory examination, motor examination and reflex functions. Sacral sensory sparing is an important evidence of incomplete neurological injury.

The most widely accepted classification for categorizing patients with neurological injury is the one proposed by American spinal injury association (ASIA) [74] impairment scale.

ASIA impairment scale for patients with spinal cord injuries (modified From Frankel)

Grade A : Absent motor (Grade 0/5) and sensory function below the injury level

Grade B : Sensation present, motor function absent (grade 0/5)

Grade C : Sensation present, motor function active but not useful (grade 1 to 2/5)

Grade D : Sensation present, motor function active and useful (grade 3 to 4/5)

Grade E : Normal motor (Grade 5/5) and sensation function.

MANAGEMENT

Management of thoracic and lumbar spinal lesions is still controversial. There are proponents for both conservative as well as operative management. The neurological recovery may not be dependent on the modality of treatment.

1. Non operative management :

This chiefly consists of bed rest, traction , physiotherapy , casting and application of an orthosis or a combination of these. It is a very labor intensive treatment and not benign neglect. In case of fractures the spinal column cannot bear weight immediately. Bed rest of 4 to 6 weeks can be followed with cast or orthosis for further 4 to 6 weeks.

Indications :

The first 3 from below are primary indications and all 3 must be present

1. No neurological deficit, minor stable deficit, resolving deficit, deficit that does not correlate to demonstrable compression, deformity or instability
2. Acceptable alignment (initial or after postural reduction)
3. Chronic mechanical stability can be achieved (no major ligamentous disruption)
4. Surgery is contraindicated (e.g. burns or skin loss over region of the approach, hemodynamic instability, severe head injury, active sepsis, severe medical comorbidities.

Contraindications :

Non surgical treatment is not advised in the following circumstances

1. Complete dislocation (i.e. 100% or more translation)
2. Soft tissue disruption that will not heal with competent ligamentous integrity
3. Documented neurological deterioration.
4. Severe degenerative disease with gross instability

5. Gross infection with associated instability
6. Increasing pain or mal alignment despite appropriate non operative management

Disadvantages :

1. High rate of complications due to prolonged recumbency like bedsores, thromboembolic events, hypostatic pneumonia, muscle wasting and associated deconditioning etc.
2. High cost

The patient's hygiene and integrity of skin have to be maintained. Breathing exercises are encouraged. This can be done in conventional beds by regular turning of patients. Other option is use of modern rotating kinetic beds. Prophylaxis against thromboembolism consists of foot, leg and thigh antiembolism stockings along with mechanical compression devices. In case of traumatic spinal injuries anticoagulants are avoided in the early post injury phase to reduce the expanding epidural hematoma with neural compression.

Steroids in spinal trauma [75,76]

The national spinal cord injury study (NASCIS) experienced sufficient neurological improvement with early administration of high dose methyl prednisolone to establish this intervention as the standard for acute form of spinal cord injury patients.

NASCIS, I, II and III protocol : -

Methyl prednisolone bolus 30 mg / kg then infusion 5.4 mg/kg/ps infusion for 24 hours if bolus given within 8 hours of injury.

Infusion for 48 hours if bolus given within 3 to 8 hours after injury.

- No benefit if methyl Prednisolone started more than 8 hours after injury
- No benefit with Naloxone
- No benefit with Tirilazad mesylate.

2. Surgical treatment :

The **goals of surgical treatment** include restoring alignment, correcting deformity, decompressing neural structures and achieving stable spinal column. Surgical treatment offers significant advantages in select cases.

- It restores sagittal plane alignment, corrects translation and decompresses the neural structures
- Operative management may facilitate neurological improvement
- It may decrease rehabilitation time compared to recumbent treatment
- Fusion with instrumentation gives stable spine construct.

Surgical decompression

This is commonly done by posterior or by anterior decompression. The aim of the surgery is to decompress the spinal cord and give it a better chance for neurological recovery.

Indications

- Demonstrable neural compression and worsening neurological deficit
- Demonstrable neural compression and myelopathy, especially worsening
- Demonstrable neural compression and persistent or worsening radicular symptoms (relative)

Surgical stabilization

This is achieved by arthrodesis. To achieve a high success rate with arthrodesis, a good bone graft technique and stabilization of spine with instrumentation are pre-requisites.

Indications

- All cases requiring surgical decompression
- Disruption of the posterior ligamentous complex
- Dislocation of the thoracolumbar and lumbar spine
- Compression fractures with loss of greater than 50% of the vertebral body height or angulation greater than 20.
- Severe degenerative disease with gross segmental instability.
- Gross infective or tumours involvement of vertebrae leading to instability
- Traumatic spondylolisthesis
- Post operative instability.
- Malalignment that cannot be corrected and maintained long term by non-surgical measures e.g. lumbar lordosis
- Cosmetically unacceptable deformity (relative)
- Intolerance of non operative management
- Failure of non operative management (new neurological symptoms or signs, instability, increasing pain, increasing or unacceptable deformity).

When surgical therapy is contemplated, the timing of surgery depends on the patient's general condition, neurological status and the type of fracture.

Approaches

Successful spinal instrumentation depends significantly on the technique of surgical exposure and fusion. Meticulous exposure is essential in performing proper instrumentation and is in achieving a solid fusion.[77]

Different approaches for decompression and stabilization of spine are :

1. Posterior approach

This is the most familiar approach to orthopedic and neurosurgeons. A midline incision is taken. Laminectomy rarely decompresses the neural elements, but it gives access to the dural sac. In the middle or lower lumbar spine, the thecal sac may be gently retracted and bone fragments in the canal removed or reduced using clamps. These maneuvers are not done at the level of cord. At these segments pedicle is drilled down to create cavity within the body.[78] Then the pedicle itself is burred away. Now the dural sac is retracted, and any bony prominence is tapped. This does not give as good visualization as anterior approach. Further, the procedure is tedious and often bloody. In most cases these maneuvers are not necessary as distraction achieves good decompression. The main advantage of this approach is posterior instrumentation gives good stability and high fusion rates when compared to anterior instrumentation. Dissection is safe and no important structures are at danger unlike anterior approach.

2. Anterior approach

Most of the pathology in spinal trauma leading to neurological damage is anterior to the cord. Anterior approach is ideal for exploration in these patients. Vertebral body damage is better visualized and so adequate decompression can be done. It allows for the direct attack on the pathology. The main disadvantage is unfamiliarity of Orthopaedic surgeons to this approach. So this is technically demanding.

This approach consists of transthoracic, transabdominal, retroperitoneal or combination of these. Generally, corpectomy is done to expose the posterior longitudinal ligaments. This is incised to expose the cord. Thorough decompression is done. Generous corticocancellous strut grafts are put and anterior or /and posterior instrumentation is done. The combined anterior and posterior instrumentation gives very high fusion rate.

3. Lateral extracavitary approach

This is the extension of costotransvectomy approach. Capener originally described it. Larson et al combined it with the transpedicular approach on the contralateral side.

4. Combined approaches

Most commonly anterior and posterior approaches are combined. The decompression and structure grafting is done anteriorly followed by posterior instrumentation.

Internal fixation devices

Spinal instrumentation has evolved far beyond the original Harrington design with increasing complexity and capabilities.

1.Anterior implants

- Kaneda device
- Z-plate
- Zeilke
- Kostuick – Harrington
- TSRH

2.Posterior implants

a. Hook devices

- Harrington – distraction and compression
- Edwards
- Jacobs locking hook rod

b. Segmental fixation devices

- Luque
- Harriluque
- Winconsin (Drummond)
- Hartshill

a Pedicle implants

- Roy Camille
- Whitse
- Dynalock
- Steffee
- Luque
- Moss miami
- AO fixature internal

b Combined

- Cotrel Dubousset
- TSRH

I. ANTERIOR INSTRUMENTATION

Anterior fusion and fixation techniques limit the number of motion segments needing fusion. With an anterior approach, pathology in the anterior and middle column is managed directly with anterior fusion and stabilization, allowing a single level to be fused and sparing normal segments above and below the lesion. These require a retroperitoneal or transpleural approach for exposure. They are generally of two types

The first consists of tricortical bone autografts, cortical allografts, cages, distraction rods and hooks or methylmethacrylate interposed between adjacent vertebrae without any rigid attachment. They depend on the stability of the posterior and middle columns for resistance to flexion, axial rotation and anterior shear.

The second group consists of devices, which are firmly attached to adjacent vertebrae using screws. These are more rigid than the first group but are still load sharing implants, requiring precise placement of strut grafts or methyl methacrylate for additional support. Fixation devices such as the Kaneda system, syracuse I plate, TSRH, Zeilke etc. offer biomechanically sound fixation for anterior stabilization.

II. POSTERIOR INSTRUMENTATION

Advantage of posterior approach

1. Long segment fixation is easier
2. Does not compromise lung function, which may already be compromised after injury
3. Fracture reduction, where necessary is easier
4. Familiar approach to most orthopedic surgeons
5. Complication rates are low

Disadvantages

1. Decompression of canal is difficult and often incomplete

(i.) Harrington instrumentation [79]

The first Harrington instrumentation originated as early as 1950. Harrington presented his modified system at the American orthopedic association meeting in 1960. Modern Harrington rod has undergone 47 changes. It has been the gold standard for the comparison of instrumentation systems used to effect spinal fusion.

Modifications

1. Dr. John Moe modified square end nails and square hooks distally for better rotational control
2. Tongue to lock sublaminar hook
3. Two upper hooks
4. Bifid facet hooks to gain purchase around the pedicle
5. Harriluque technique

   Hybrid consisting of Moe – modified Harrington distraction rods with hooks combined with segmental wiring.

Indications

a. Distraction system

- Where the anterior longitudinal ligament is intact
- Good in axial loading injuries such as compression flexion and vertical compression injuries

b. Compression system

- In distraction flexion injuries ex. Chance fracture
- Posterior ligament disruptions, facet dislocation

Middle column assessment is important. If there is compression failure of middle column, Harrington distraction instrumentation should be used. If there is distractive injury to middle column, compressive instrumentation should be used.

Contra indication

1. Translational injury to middle column or with an injury to anterior longitudinal ligament, there is risk of further neurological injury. Segmental instrumentation is indicated in these three column injuries.
2. Harrington compression system is contraindicated in any injury with axial instability.

Disadvantages

1. Limited sagittal plane control
2. Minimal derotating ability
3. Relatively high pseudarthrosis for thoracolumbar and lumbar curves – 4%
4. Hook dislocation is high 3%
5. Need for external support – harriluque eliminates it
6. Loss of lordosis with flat back syndrome in lumbar region. It causes abnormal gait, back pain and disability
7. Hook migration into canal
8. Neurological deterioration
9. Rod breakage due to notches

(ii.) 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 to 18 gauze wires. Instrumentation is recommended for 3 levels above and 3 levels below the effected segment.

Indications

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

Disadvantages

1. No rigid fixation for unstable burst fractures
2. Axial loading is not resisted
2. Increased risk of cord injury during the passage of sublaminar wires
3. Not suited for upper thoracic spine as the canal is very narrow

(iii.) Jacobs Locking Hook Instrumentation [80]

- Spans at least 5 motion segments
- Not recommended for lower lumbar spine
- It is a modification of Harrington system
    a. Instead of notches, both the ends of rods are threaded. This gives possibility of linear distraction of any distance. Weakening of the rod because of notches is avoided
    b. Hooks are fixed with locking nuts and can be freely rotated on the rod
    c. Rod can be contoured to the shape of the spine

(**iv.) Winconsin (Drummond) interspinous segmental spinal instrumentation**

- Indications similar to Luque instrumentation
- Devised to provide stability of Luque instrumentation without the risk of passage of sublaminar wires.
- Button wire implant is passed through the base of the spinous process. Care should be taken to avoid middle or the tip of the process
- It is safe and simple
- Risk of neurological injury is very low.

(v.) Edwards instrumentation

- Rod sleeve fixation technique
- Improved reduction and biomechanical fixation
- Modification of Harrington instrumentation. It consists of distraction rods, polyethylene sleeves and anatomical hook design

(vi.) Pedicle screw instrumentation

Pedicular screw placement system as a means of transpedicular fixation of unstable spine is a very rigid fixation system. This is achieved by entering pedicle through the “force nucleus”/ The junction of the pedicle superior and inferior facets, the pages, transverse process and lamina.[81]

The VSP system consist of two bilaterally placed stainless steel rods or plates with noted slots allowing precise placement of spirally designed screws at any angle necessary for rigid fixation. The screw consists of a long cancellous threaded portion that enters the pedicle cord, a machine threaded section or it stands with an integrated basement between both portion assisting in level placement of the slotted path.

The screw length vary from 16-55 mm with screw diameter of 4.5, 5.5,6.25 and 7.0 mm. three different plate spacer washes (3 mm, 5 mm and taperrt) are used between the these blood of the cancellous portion of the screws and the undersurface of the plate to achieve level metal to metal contact between the plate and screw stands. A VSP tapered nut is used to secure the plate to pedicle screw and a VSP locks nut in is used on all VSP screws to secure the fixation device.[82]

Biomechanics of Pedicular screw : (Fig 13)

Average adult spine takes about 400 Newton of axial force during quiet standing and 7000 N of force during heavy lifting Kraggi, Zindrucks, Goel, and others found that[83]

a. Pedicle screws with largest diameter threads have the best pullout fixation strength over all.
b. Screws that penetrate the anterior cortex of vertebral body have much greater fixation
c. Screw with continuous threading throughout length have greater fixation strength
d. Force to failure was inversely proportional to the degree of vertebral osteoporosis.
e. The axial stiffness, stress and measured stern tensile axial load endurance was good in various pedicular screw system.

Advantages

a. Short, rigid immobilization
b. High fusion rates
c. Early mobilization
d. Low percentage of hardware failure
e. Maintains curvature of spine

Disadvantages

a. Increased degenerative changes in motion segment above and below the VSP plate

b. Fatigue failure

c. Screw loosening

d. Spinal cord injury

e. Vascular injury – aorta, inferior venacava and their branches

f. Steep learning curve it requires experienced

g . Potential for recurrence of deformity after lumbar burst fractures because of labs of anterior support.

Clinical outcome in thoracic and lumbar lesions after instrumentation can be judged by using **Denis pain and work scale**

Denis work scale

W_1 Able to return to previous employment (Heavy Labour) or physically demanding activities

W_2 Able to return to previous employment or return to heavy labour with restriction

W_3 Unable to return to previous employment but work fulltime at new job.

W_4 Unable to return to full time work

W_5 No work, completely disabled

Denis pain scale

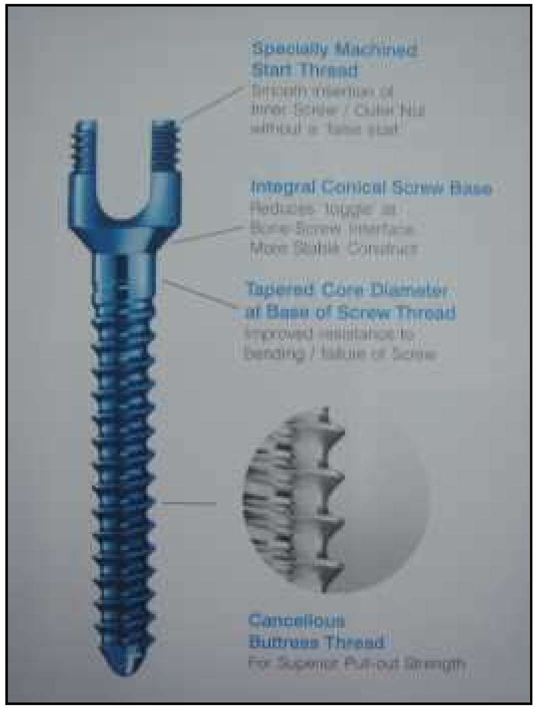
P_1 No pain

P_2 Occasional minimal pain and no need for medication

P_3 Moderate pain occasional medication needed and no interruption of work or activities of daily living.

P_4 Moderate or severe pain, occasional absence from work and significant changes in activities of daily living

P_5 Constant severe pain and need for chronic medication



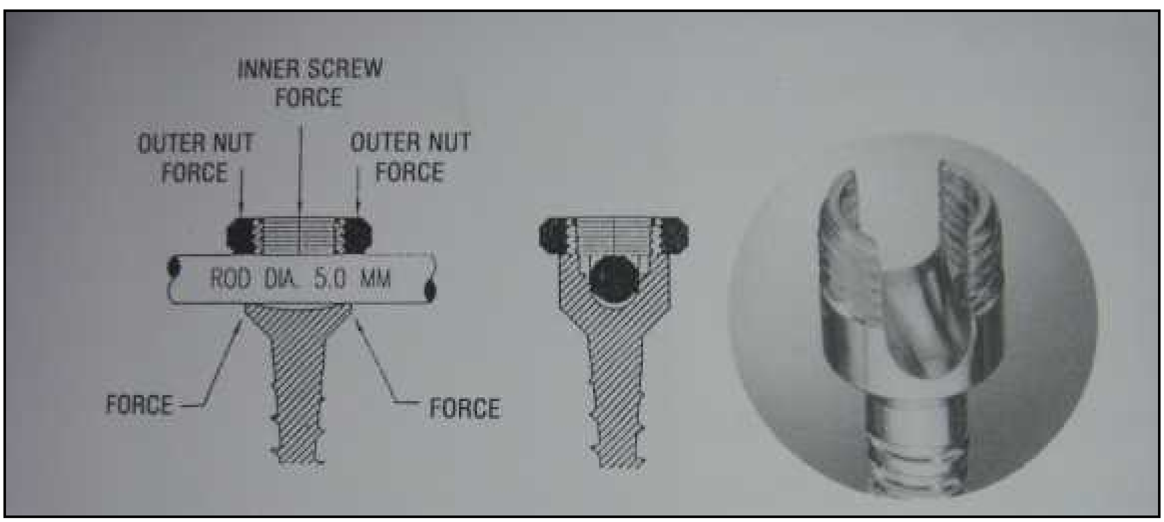


Fig 13 : Pedicular Screw

METHODOLOGY

This study is a prospective clinical study of pedicular screw fixation in thoracic and lumbar spinal lesion.

In all, a total of 21 cases were evaluated and assessed during the period from 1st September 2006 to 30th September 2007. The study was conducted in the Department of Orthopaedics, Jawaharlal Nehru Medical College and KLES Dr. Prabhakar Kore Hospital and MRC, Belgaum.

All the above patients underwent treatment, as per a specific treatment plan.

All the patients were initially assessed in the OPD or casualty according to their presentation and then they underwent a detailed evaluation of their haemodynamics, spine, neurological status and other injuries if associated with trauma. The patients were interviewed, their epidemiological, historical, subjective and physical findings were noted.

After initial investigations and haemodynamic stabilization, patients were assessed neurologically in detail. A neurological chart was maintained for each patient.

All the patients had routine X-rays of thoracolumbar and lumboscaral spine in both AP and Lateral views. Patients with degenerative spinal disease underwent additional dynamic thoracolumbar flexion and extension x-rays. In all the patients MRI was done.

The pre-operative neurological status was graded on the basis of ASIA grading. It was also used to assess post operative recovery and follow-up.

3 patients had significant additional injuries. 1 patients had calcaneal fractures for which below knee cast was applied. 2 patients had fracture distal end radius which was treated in below elbow cast.

The indications for the surgery was instability for which instrumentation was needed to restore spinal stability or to protect neurological elements. The instability was also assessed using certain radiographic criteria.

Inclusion criteria :

1. Age group ≥ 18 groups
2. Neurological involvement
3. Patients with unstable thoracic and lumbar fracture which included
    a. Compression fracture with loss of greater than 50% of vertebral height
    b. Angulation (Kyphosis) > 20°
    c. Fracture dislocation and subluxation
    d. Translation of more than 2.5 mm between vertebral bodies in any plane

       or

       any major displacement of facet joints or spinous processes without fracture suggesting ligament injury and angular displacement
    e. Bilateral facet dislocation indicating complete rupture of the disc and posterior ligaments.
4. Patients with unstable degenerative spine and spondylolisthesis which included
    a) Dynamic x-ray showing anterior slip of 5mm or more in thoracic and lumbar spine.

b) Difference in angular motion of two adjacent motion segments more that 11 degrees from T1-L5.

c) Persistence of major symptoms for atleast 1yr despite activity modification and physical therapy

d) Progressive neurological deficit.

e) Asymptomatic patients with slip beyond 25-50 %

5. Thoracic and lumbar instability due to spinal malignancy which included

   a) Involvement of vertebral body sparing the pedicles and posterior elements

   b) Multiple level involvement anteriorly.

Exclusion criteria

a. Any associated cervical or sacral spinal fracture

b. Previous operation on spine

c. Age < 18 yrs.

d. Spinal instability due congenital spinal abnormality.

Preoperative work up

1. Plain radiograph (static and dynamic wherever necessary)

i. Anteroposterior views

ii. Lateral views

To assess level of lesion, extent of degeneration, instability, mechanism of injury, fracture pattern and its severity and canal compromise or deformity.

2. **Magnetic resonance imaging (MRI)** was useful in determining

   i. The condition of the spinal cord, facetal hypertrophy, canal compromise .

   ii. Any soft tissue encroachment (intervertebral disc) on the spinal cord.

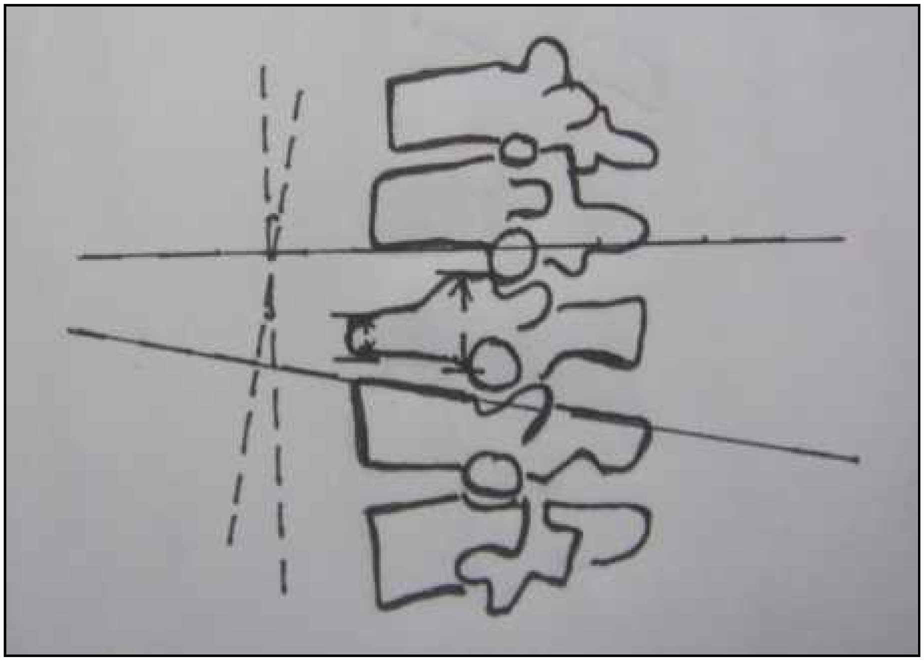


Fig 14 : Sagittal angle & Index

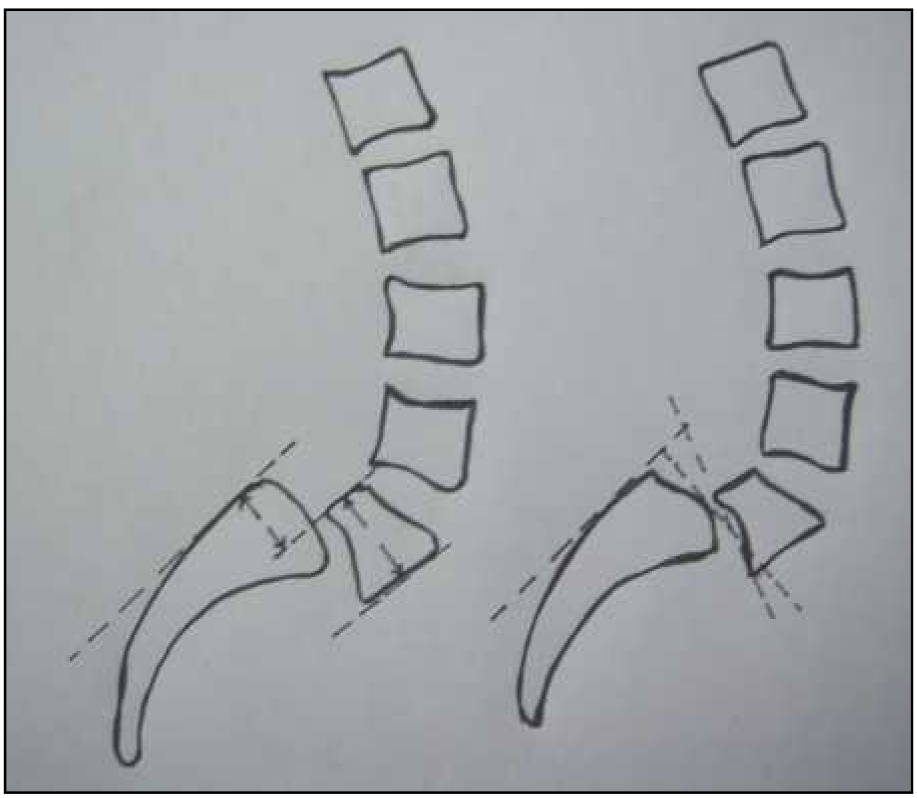


Fig 15 : Sagittal angle & slip %

3. The following **measurements** were taken using plain X rays of the injured spine

a. **Sagittal Angle** : (Fig 14)

This was calculated by drawing two lines. One line passing through the inferior end plate of upper vertebral body adjoining the affected disc space and another line passing through the end plate below the affected disc space. Perpendiculars are dropped on these two lines equidistant from the posterior borders of the respective vertebrae. The angle between the two perpendicular lines gives the sagittal angle. Positive is Kyphosis and negative is Lordosis.

b. **Sagittal Index :** (Fig 14)

This is also calculated from the lateral X ray film. This is a ratio between anterior and posterior heights of the fractured vertebrae

a. **Slip percentage** : (Fig 15)

Calculated by measuring distance from the line parallel to posterior portion of inferior vertebrae to posterior portion of slipped vertebrae .

b. **Slip angle** : (Fig 15)

Formed by intersection of a line drawn parallel to inferior aspect of slipped vertebrae and a line drawn perpendicular to posterior aspect of lower vertebrae

Instrumentation

1. Pedicular screw and rod system
2. The screw consists of long cancellous threaded portion that refers to pedicle and a machine thread portion on its shank with integrated hex nut between both portions assisting in level placement of the slotted plates.

3. The screw has a cancellous threaded portion, screw head and outer long threaded part. It has a tapered nut and locknut. The screws come in different diameters i.e. 4.5 mm, 5.5 mms. 6.25 and 7.00 mm and different lengths.
4. Rod is a 6 mm thick made of stainless steel , 70 – 350 mm .
5. The average length of screw used are 32,34, 36 mm for dorsal spine and 34,36,38 mm for lumbar spine. It comes in size from 16-55 mm.

Instruments

1 General orthopaedic instruments

2 Mastoid retractors

3 Awl

4 Pedicle probe

5 Wrench

6 Karrison's rouge

7 Tap 4.5 mm and 5.5 mm

8 Distractor

9 Universal plate / rod bender

10 Depth gauge

11 K wires 2.0 and 2.5 mm

Procedure

Prophylactic intravenous antibiotics were given preoperatively. In supine position general anaesthesia with endotracheal intubation was administered.

The patient was put in prone position on a radiolucent table. Padded spinal frame or chest and pelvic rolls were used. This position avoids venous stasis and decreases intra abdominal pressure, thus reducing venous bleeding. All bony prominences were padded.

In selected cases requiring bone grafting generous cancellous grafts were harvested from posterior iliac crest. The grafts were preserved in normal saline.

The skin, subcutaneous tissues, and paraspinal muscles down to the level of lamina were infiltrated with 1:50000 epinephrine solution to minimize bleeding. A posterior midline incision was made centering over the involved spinal unit and extending 2 levels above and below. The incision was deepened to expose posterior elements of the vertebrae one level above and one below the injury. The dissection was carried laterally to the tips of the transverse processes, maintaining meticulous homeostasis. The transverse process, lamina and the facet joints to be fused were decorticated and prepared for fusion. Laminectomy at the level of lesion was done. When ever a thorough decompression was required. If a fracture fragment was protruding into the canal, the cord was retracted and the bony piece removed. In infective cases , through debridement and decompression was carried out .Nerve roots were decompressed and degenerative osteophytes if present were osteotomised .

The pedicles were identified, by identifying the point of convergence of a horizontal line along center of transverse process and vertical line along centre of superior facet. Using a rongeur cortical bone was removed to expose underlying cancellous bone. Blunt Kirschner wires were placed into the pedicle and their position was confirmed under image intensifier on both anterioposterior and lateral views. The pedicle was probed in all four quandrants to make sure that solid tube of bone exists and violation of pedicular cortex has not occurred. Now the pedicles were tapped. The vertebral bodies were not tapped to increase the screw purchase. The screws of appropriate lengths were selected and inserted into the pedicles. The size was measured using the depth gauge. The screw should penetrate 50 to 75% of the vertebral body. Cancellous grafts, previously harvested were generously spread over the prepared fusion bed. The appropriate sized rods were contoured. The rods were placed over screws and tapered nut and lock nut were applied. Screws were tightened after achieving acceptable reduction of deformed vertebral column.

A thorough homeostasis was achieved and the wound was closed in layers. Clean dressing was applied.

Post operative treatment :

All the patients were given post op intravenous antibiotics (third generation cephalosporin + aminoglycoside) for 5 days. They were switched over to oral antibiotics till suture removal. Intravenous dexamethasone 4 mg IV was given for 3 days. Physiotherapy was started from first day post operatively. Sutures were removed on eleventh day. On the second day patients were allowed to roll from side to side. They were allowed to sit up and were mobilized on a wheel chair after application of thoracolumbar belt on third or fourth post operative day. A close watch was kept for any improvement or deterioration in the neurological status.

Patients wore thoracolumbar belt for about 12 weeks. Those with incomplete neurological deficits were given physiotherapy and gradually ambulated. Patients with complete neurological deficits were given physiotherapy and ambulated on wheel chair. Routine postoperative X-rays were taken prior to discharge. The neurological grading and radiological parameters were recorded on 3rd day of the operation.

Follow up

All the patients were followed up in OPD every 4th week after surgery for 6 months and at each follow up clinical, radiological & neurological examination was done to assess spinal stability.

At the end of 6 month of follow up the patients were evaluated clinically by using Denis work and pain scale.

Denis work and pain scale has 2 components

- Denis work scale
- Denis pain scale

Denis work scale

W_1 Able to return to previous employment (Heavy Labour) or physically demanding activities

W_2 Able to return to previous employment or return to heavy labour with restriction

W_3 Unable to return to previous employment but work fulltime at new job.

W_4 Unable to return to full time work

W_5 No work, completely disabled

Denis pain scale

P_1 No pain

P_2 Occasional minimal pain and no need for medication

P_3 Moderate pain occasional medication needed and no interruption of work or activities of daily living.

P_4 Moderate or severe pain, occasional absence from work and significant changes in activities of daily living

P_5 Constant severe pain and need for chronic medication

RESULTS

In our study, 21 cases of thoracic and lumbar spinal lesions were treated by pedicular screw and rod system and who were followed up for a minimum period of at least 6 months. It was conducted in the department of Orthopaedics, Jawaharlal Nehru Institute of Medical Sciences and KLES Dr. Prabhakar Kore Hospital and MRC, Belgaum between September 2006 to December 2007.

Table 1 : Sex Distribution

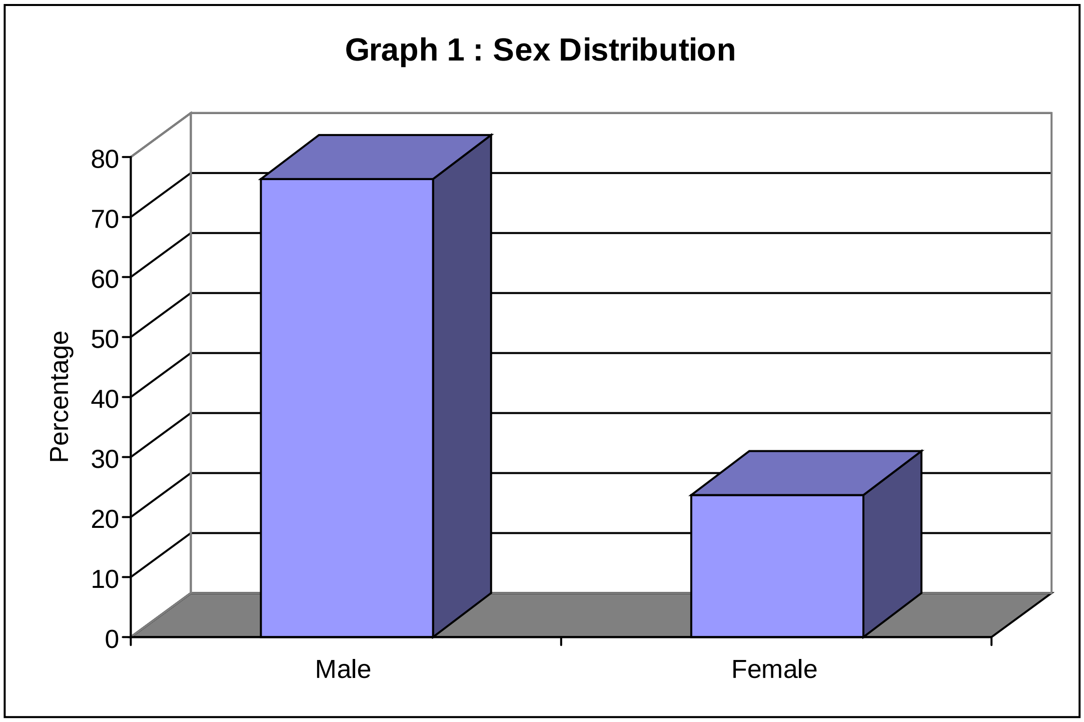
Sex	No. of Cases	Percentage (%)
Male	16	76.2
Female	5	23.8
Total	21	100

In our study of 30 patients 23 were male and 7 were female

Table No. 2 : Age Distribution

In our study the most common age group was between 41-50 years. 16 out of 21 i.e. 76.2% patients were between 31 to 50 years, hence the adults were most commonly involved with increased male preponderance. The distribution was as shown in table 2

Age	Male	Female	Total
18-20	2	0	2
21-30	2	0	2
31-40	4	1	5
41-50	7	4	11
51-60	1	0	1
More than 60	0	0	0
Total	**16**	**5**	**21**


Graph 1 : Sex Distribution
Percentage
0
10
20
30
40
50
60
70
80
Male
Female

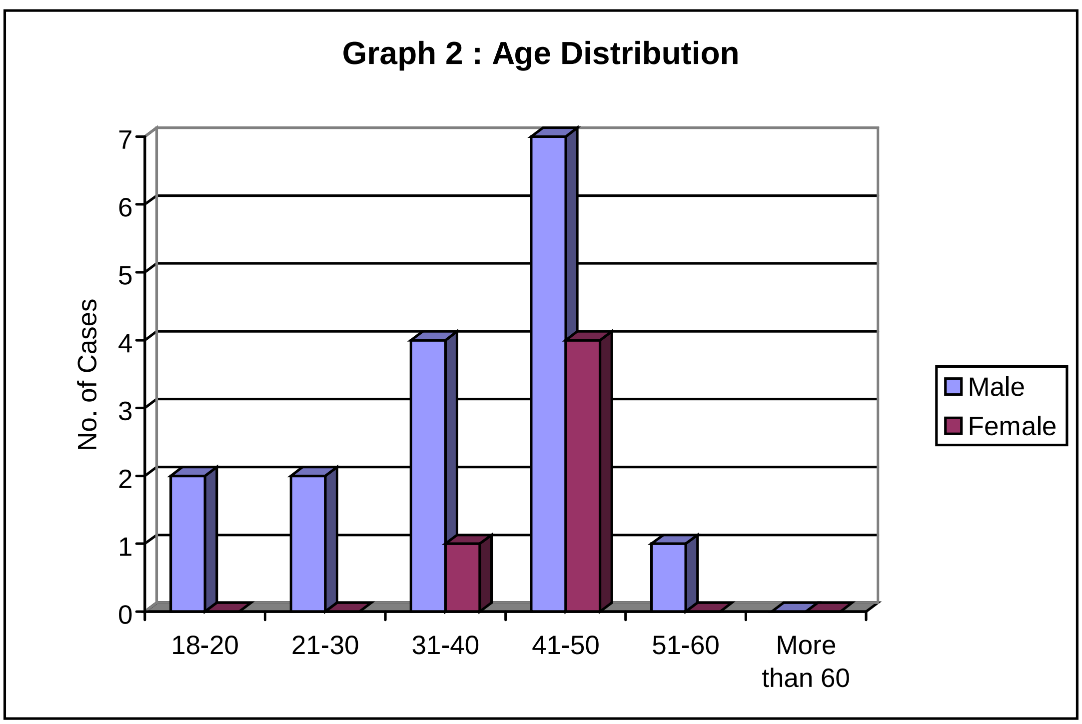
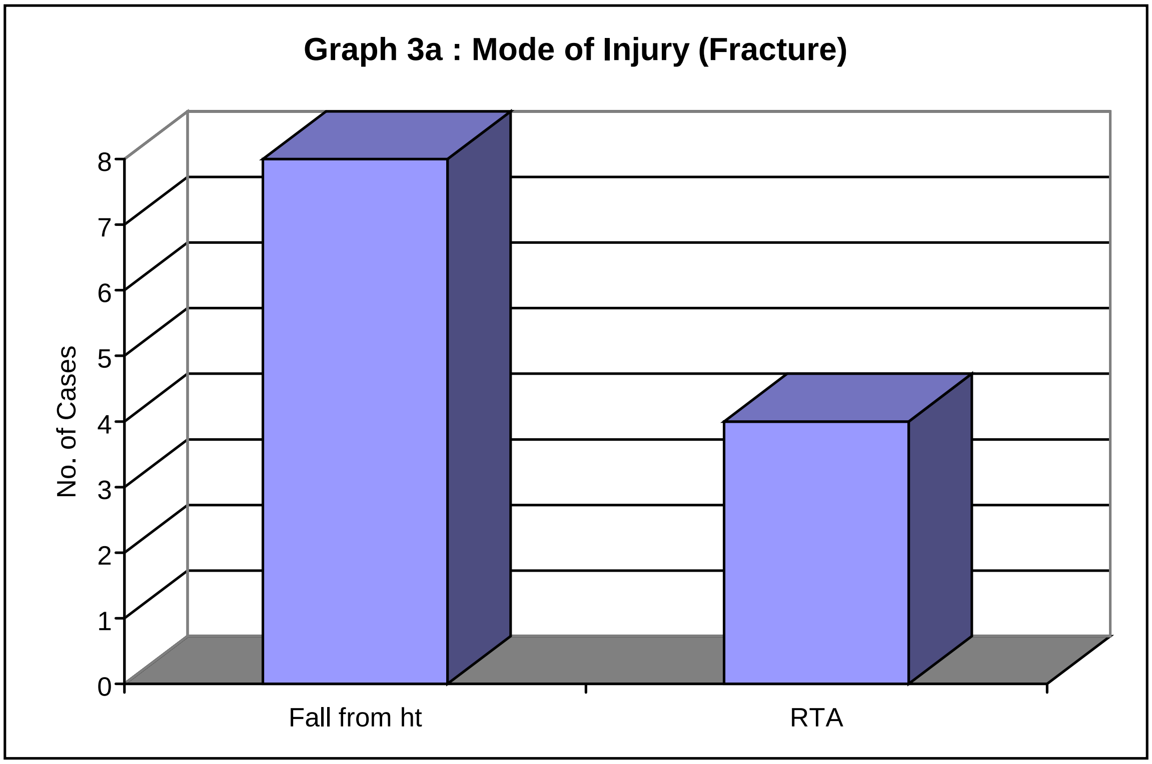

Graph 2 : Age Distribution
No. of Cases
0
1
2
3
4
5
6
7
18-20
21-30
31-40
41-50
51-60
More than 60
Male
Female

Table No. 3 : Mode of Injury

Type of lesion	No. of Cases	Mode / Type of lesion	
Fracture	**12**	**Mode of injury**	**No of Cases**
		Fall from ht	8
		RTA	4
Spondylolisthesis	**9**	**Type of lesion**	**No of Cases**
		Degenerative	8
		Trauma	1
Total	**21**		**21**

In our study, spinal lesions seen were fracture and spodylolisthesis. Among fracture group fall from height was the commonest mode of injury, and among spondylolisthesis group degeneration was the commonest cause of lysthesis. The distribution is shown in table No. 3.


Graph 3a : Mode of Injury (Fracture)
No. of Cases
0
1
2
3
4
5
6
7
8
Fall from ht
RTA

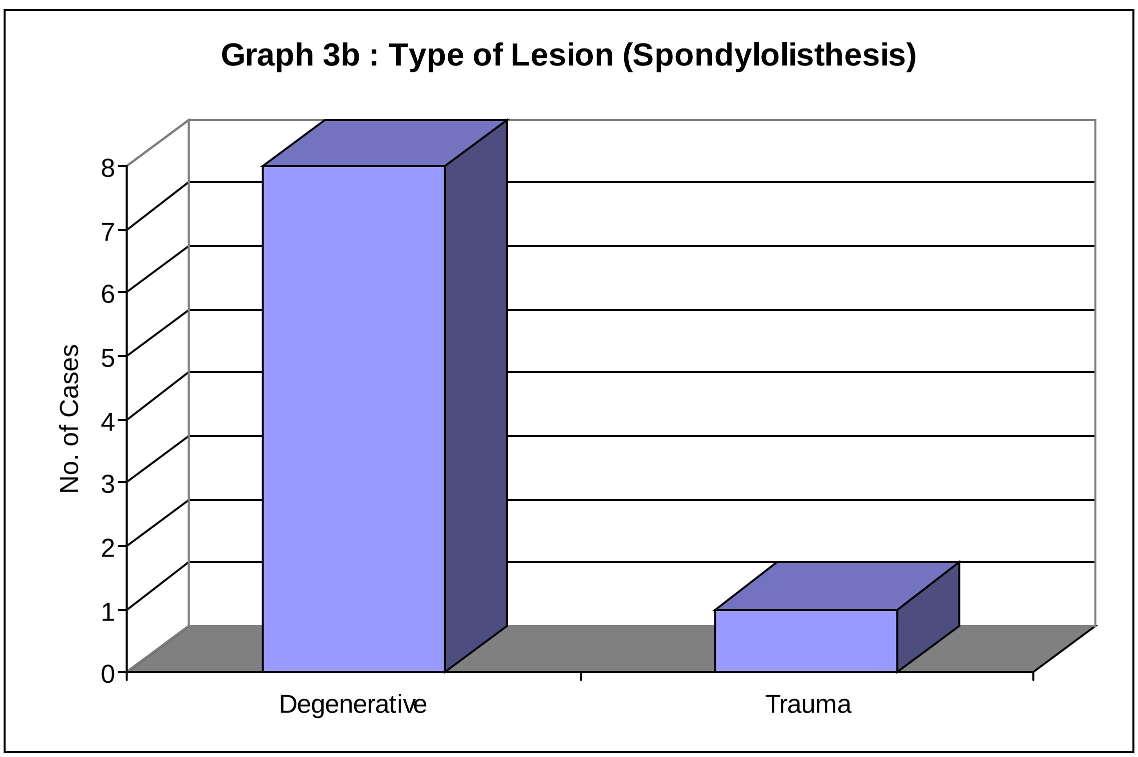

Graph 3b : Type of Lesion (Spondylolisthesis)
No. of Cases
0
1
2
3
4
5
6
7
8
Degenerative
Trauma

Table No. 4 : Type of Fracture

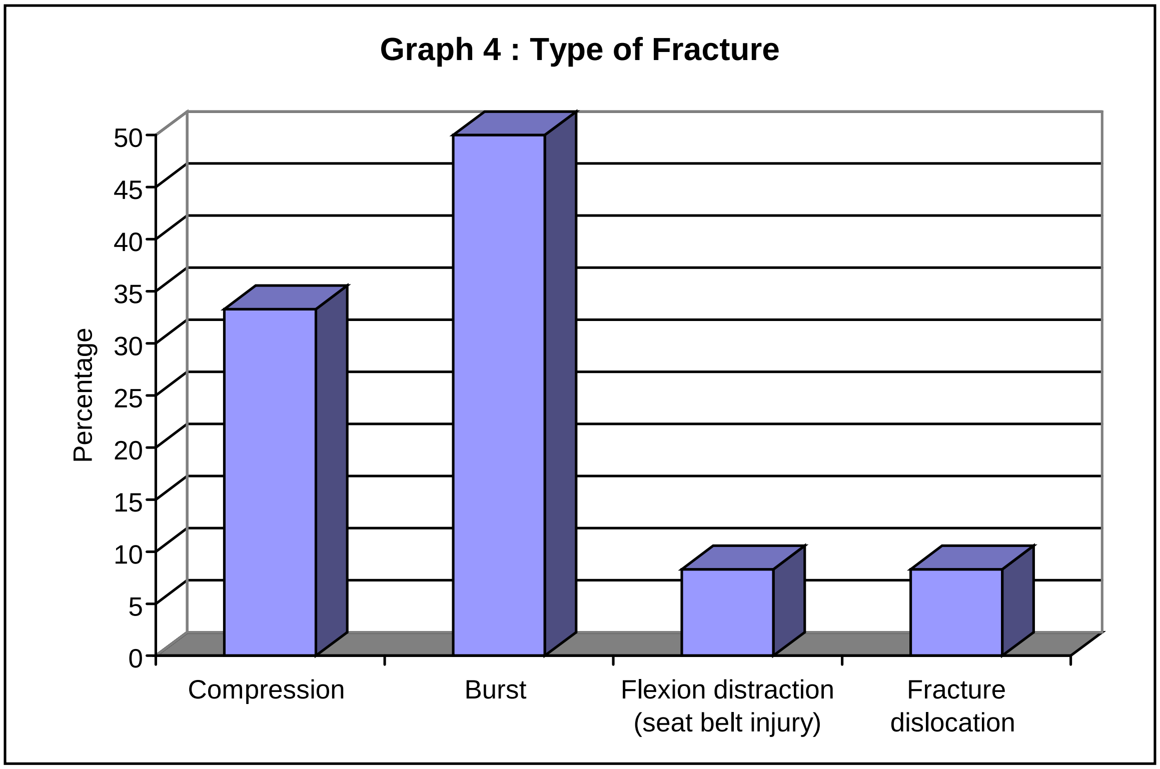
Type of Fracture	No. of Cases	Percentage (%)
Compression	4	33.3
Burst	6	50
Flexion distraction (seat belt injury)	1	8.3
Fracture dislocation	1	8.3
Total	**12**	**100**

In our study 12 out of 21 patients sustained fracture spine which were classified according to the Denis classification. Among these, compression and Burst fractures accounted for 88% (10 patients) of the fracture. The distribution was as shown in table 4.

Table No. 5 : Type of Spondylolisthesis

Type of lysthesis	No of Cases	Percentage (%)
Congenital	0	0
Isthamic	0	0
Degenerative	8	88.8
Traumatic	1	11.2
Pathological	0	0
Post operative	0	0
Total	9	100

In our study, degenerative type was the most commonest type of listhesis accounting for 88.8% of this group.


Graph 4 : Type of Fracture
Percentage
0
5
10
15
20
25
30
35
40
45
50
Compression
Burst
Flexion distraction (seat belt injury)
Fracture dislocation

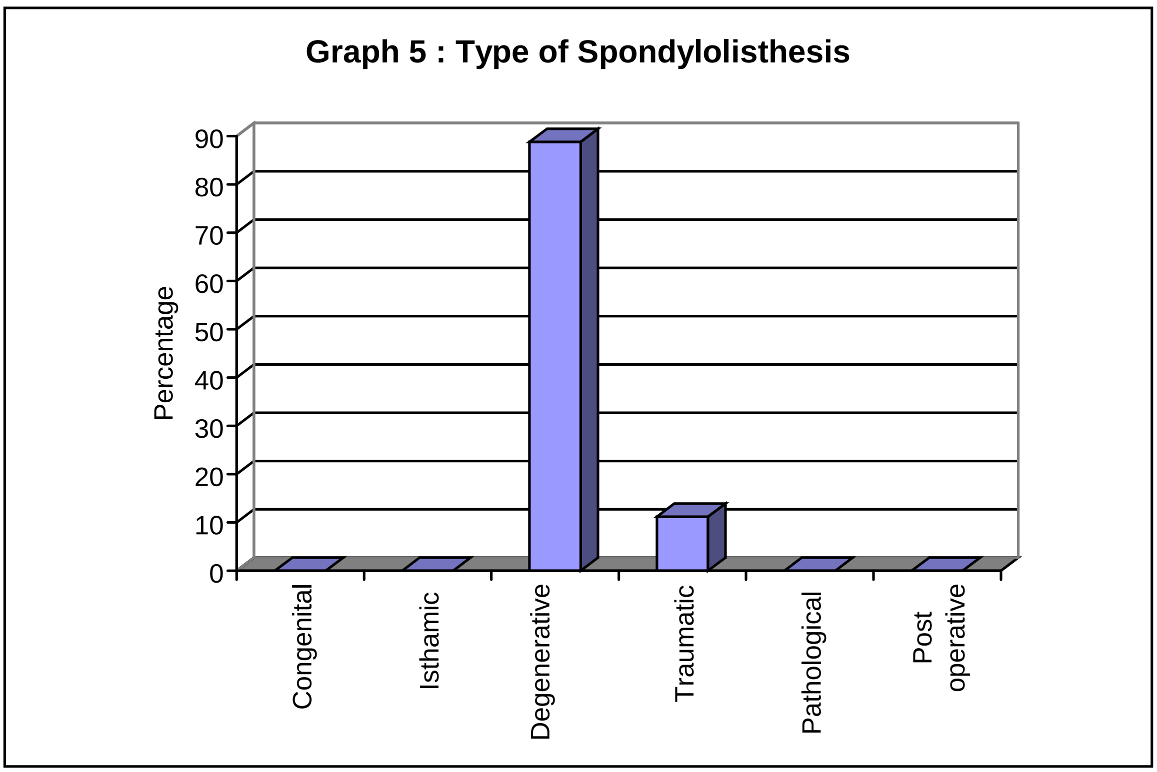

Graph 5 : Type of Spondylolisthesis
Percentage
0
10
20
30
40
50
60
70
80
90
Congenital
Isthamic
Degenerative
Traumatic
Pathological
Post operative

Table No. 6 : Level of Fracture

In our study of 21 patients, fracture was seen among 12 patients. The commonest site of fracture were T12 & L1. And both accounted upto 66.6 %

The distribution according to the level of fracture is shown in the table 6.

Level	No. of Cases	Percentage (%)
T_8	1	8.3
T_{10}	1	8.3
T_{12}	4	33.3
L_1	4	33.3
L_4	2	16.8
Total	**12**	**100**

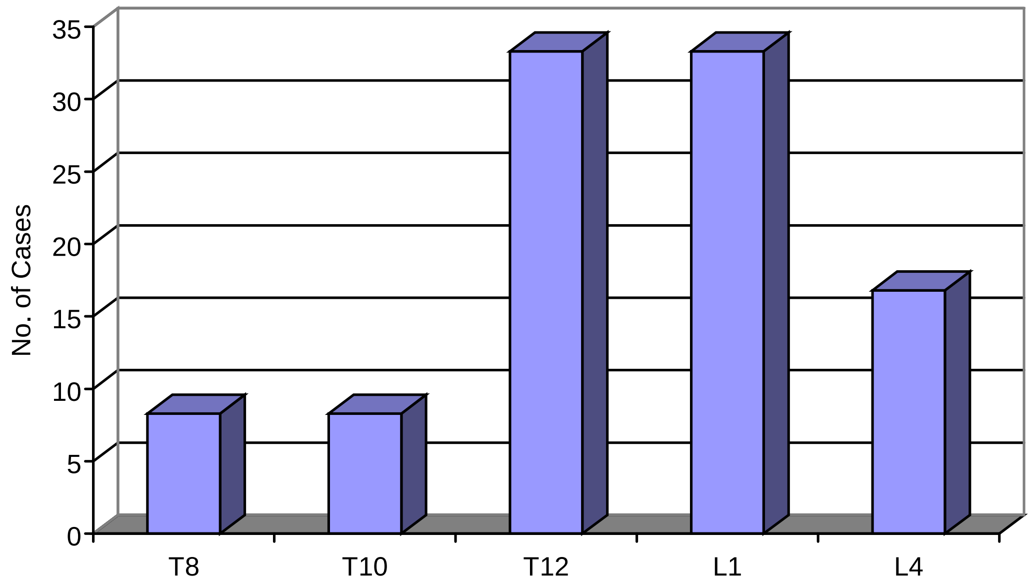
Table No. 7 : Level of Lysthesis

Level	No. of Cases	Percentage (%)
L_3-L_4	2	22.2
L_4-L_5	5	55.6
L_5-S_1	2	22.2
Total	**9**	**100**

Out of 21 patients in our study, 9 suffered from spondylolisthesis, commonest level lesion was seen at L4-L5 region , which accounted upto 55.6 %

The distribution according to the level of lysthesis is shown in the table 6.

Graph 6 : Level of Fracture



Graph 7 : Level of Lysthesis

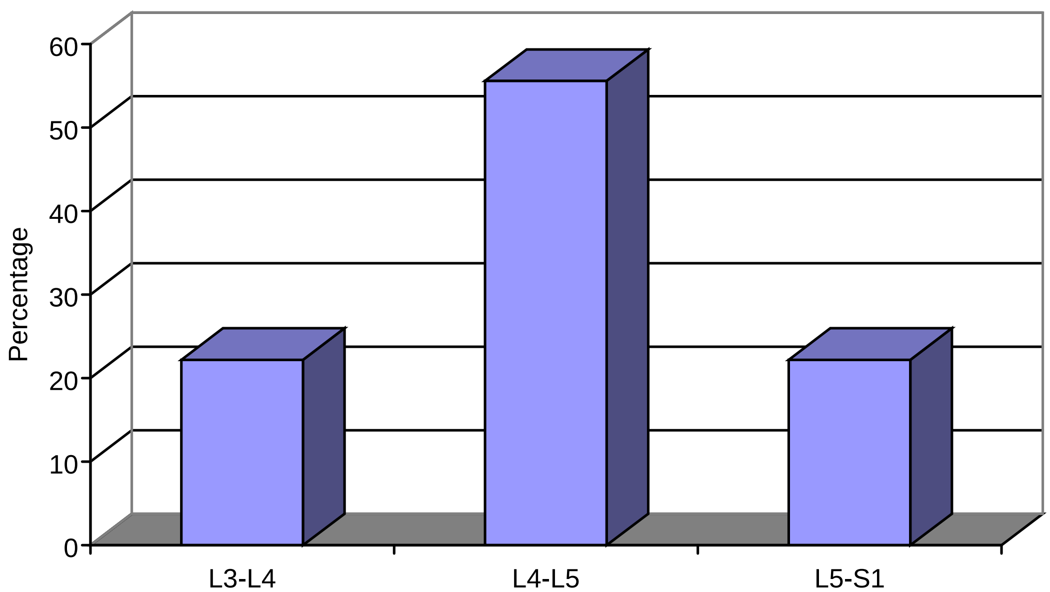


Table No. 8 : Neurological Course

In our study all the 21 patients were assessed according to American spinal injury association (ASIA) score preoperatively, postoperatively and during follow-up.

All patients in our study had neurodeficit.

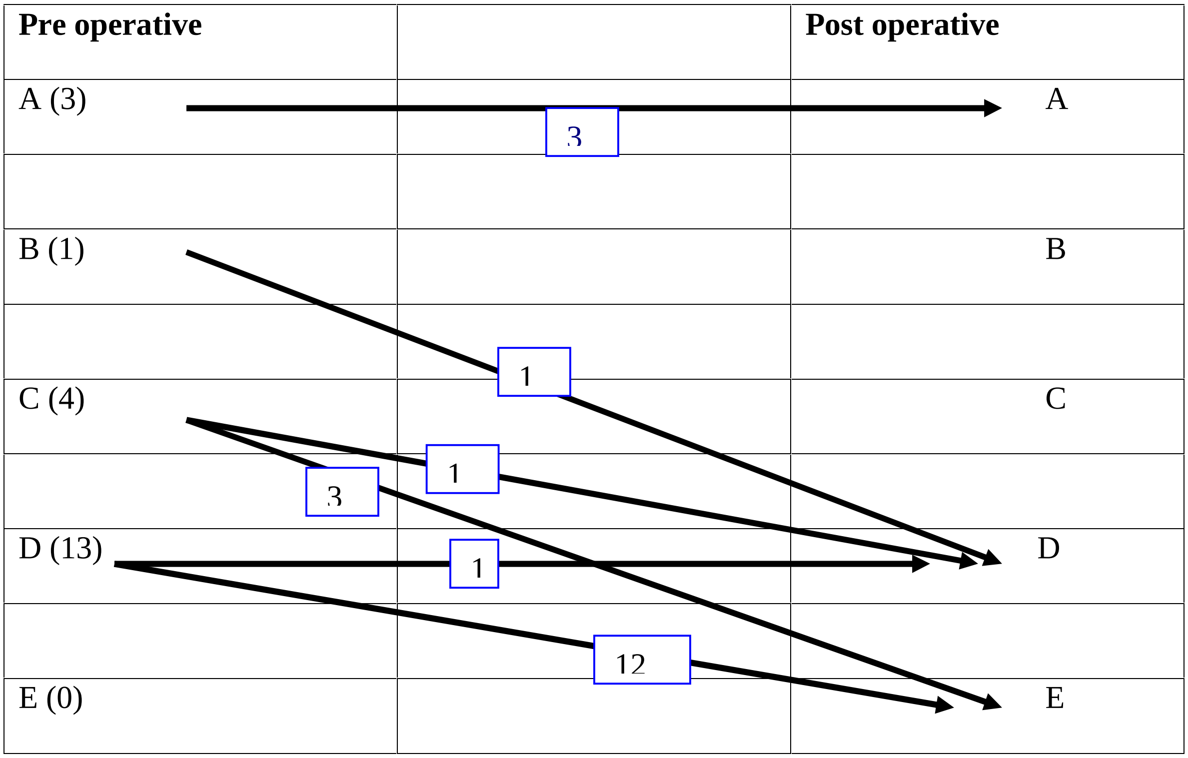
	Complete Paraplegia	**Incomplete Paraplegia**
No. of Patients	3 (14.3 %)	17 (80.9 %)

In our study 3 patients (14.2%) presented with complete paraplegia and 18 patients (85.7%) with incomplete deficits.

ASIA	**Pre Operative**	**A**	**B**	**C**	**D**	**E**
A	3	3				
B	1				1	
C	4			1	3	
D	13				1	12
E	0	0	0	0	0	0
Total	21	3	0	1	4	12

In our study none of the patients deteriorated neurologically after operation. Of the 3 patients who presented with ASIA grade A, all 3 remained as grade A and showed no improvement. 1 patient presented as grade B who improved to grade D. 4 patients presented with grade C and all at them showed some improvement after treatment. Out of 4, 3 improved to normal neurological status i.e. grade E and 1 improved to grade D. 13 patients presented with grade D and out of 13, 12 improved to normal neurological status i.e. grade E while the remaining 1 remained as grade D.

ASIA neurological grading pre and post operative assessment :



Thus, from above result, 21 patients all of whom had some neurological involvement, 4 (19.1%)out of them showed no improvement in their neurological status and out of remaining 17 (80.9%), 13 showed improvement by 1 grade and 4 showed improvement by 2 grades . The average grade of improvement was 1.23 ASIA grade

Table 9: Radiological course

Fracture group :

Table 9a : Sagittal angle (Kyphotic angle)

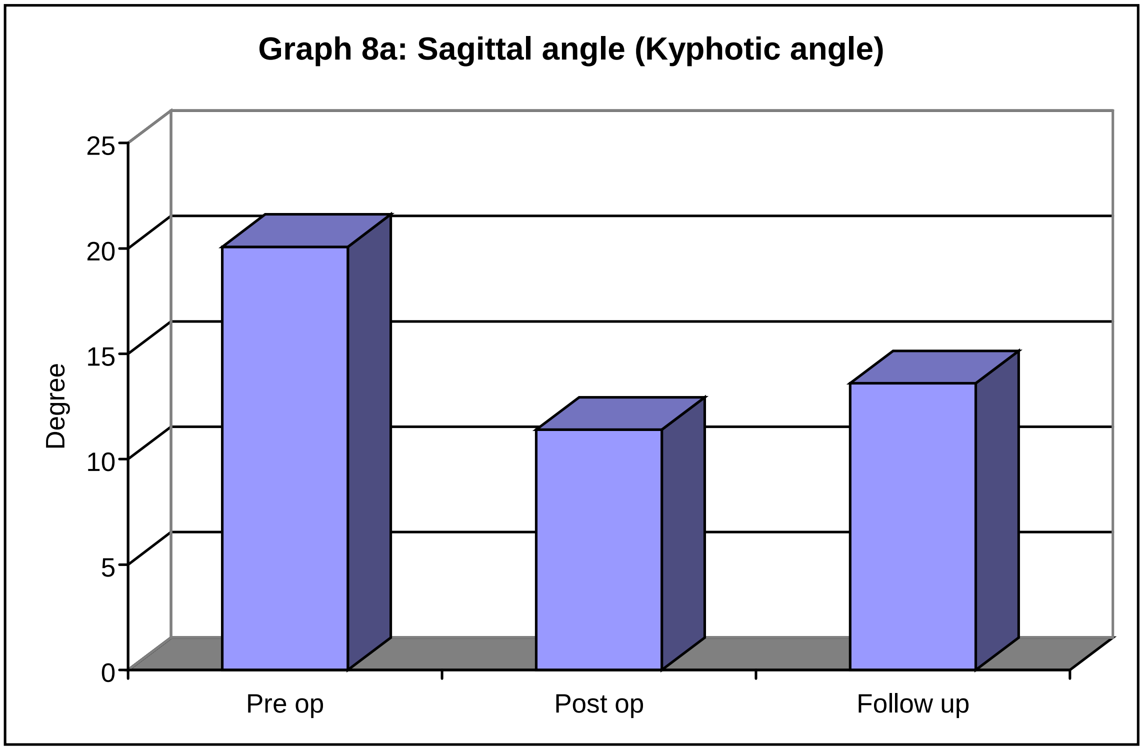
	Pre op	Post op	Follow up
Sagittal angle	20.08°	11.4°	13.6°

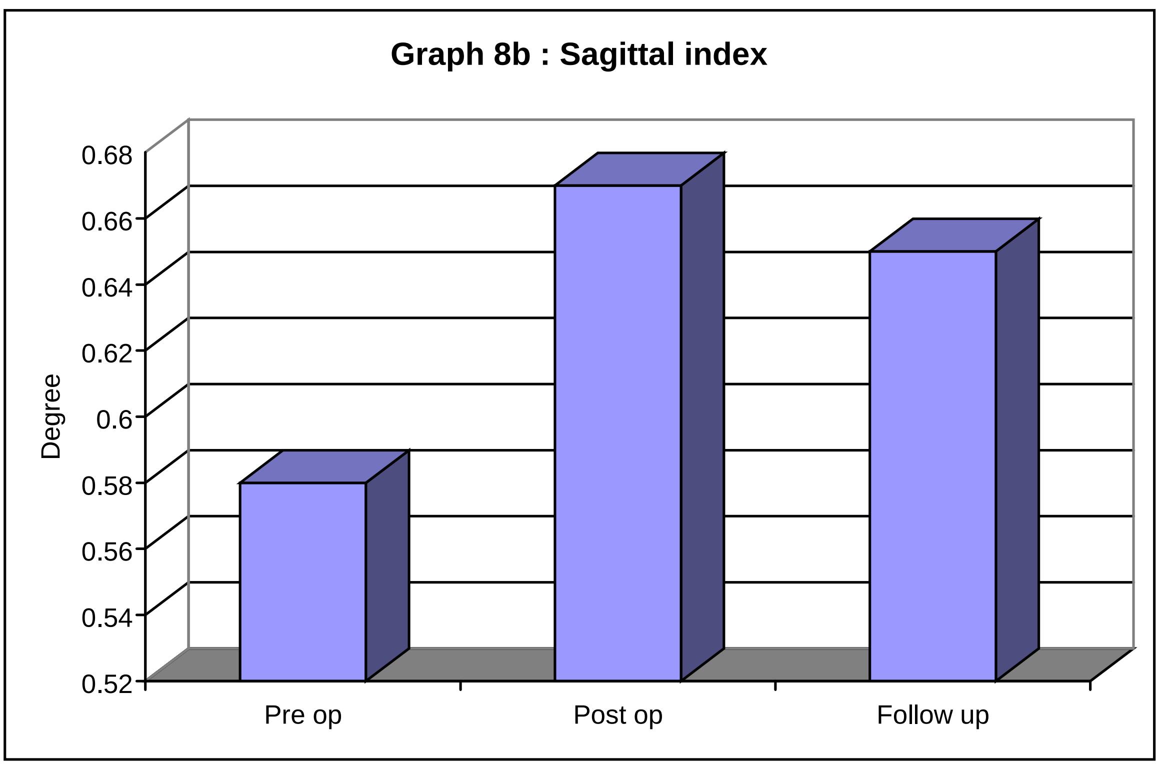
The mean kyphotic angle pre-operatively was 20.08° (± 9.28), the mean kyphotic angle post - operative was 11.4° (± 7.54), which is statically significant with p= 0.015 and on follow-up mean kyphotic angle was 13.6° (±7.35), which is also statically significant p=0.040. There was mean loss of sagittal angle by 2.2°

Table No. 9(b) : Sagittal index

	Pre op	Post op	Follow up
Sagittal index	0.58	0.67	0.65

The mean sagittal index preoperatively was 0.58 (± 0.16) on post operative X rays it was 0.67(± 0.13), which was statically significant P=0.00133 and on follow up the mean sagittal index was 0.65 (± 0.13), which is also statically significant P=0.0014. There was mean loss of sagittal index by 0.02


Graph 8a: Sagittal angle (Kyphotic angle)
Degree
25
20
15
10
5
0
Pre op
Post op
Follow up


Graph 8b : Sagittal index
Degree
0.68
0.66
0.64
0.62
0.6
0.58
0.56
0.54
0.52
Pre op
Post op
Follow up

Spondylolithesis group :

Table No. 9(c) : Slip Percentage

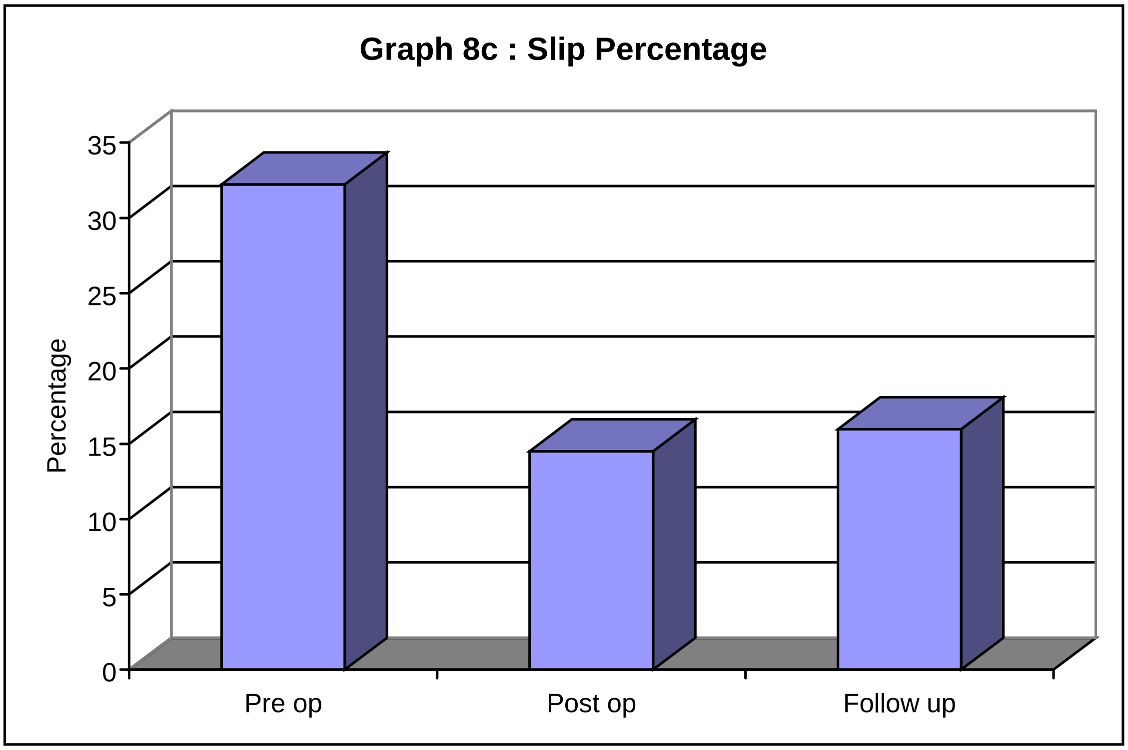
	Pre op	**Post op**	**Follow up**
Slip percentage	32.22 %	14.51 %	15.97 %

The mean slip percentage pre operatively was 32.22 % (± 10.35) on post operative X rays it was 14.51 % (± 7.74) , which is statically highly significant P =0.000013 and on follow up the mean slip percentage was 15.97 % (± 8.16), which is also statistically very significant p= 0.0090. There was mean loss of slip percentage by 1.64%

Table No. 9(d) : Slip Angle

	Pre op	**Post op**	**Follow up**
Slip angle	10.11^0	6.22^0	6.22^0

The mean slip angle pre-operatively was 10.11° (± 4.83^0) on post-operative X rays it was 6.22° (± 2.59°), which statically very significant .No change in slip angle was seen on follow up in the mean slip angle i.e., there was no mean loss in slip angle .


Graph 8c : Slip Percentage
Percentage
35
30
25
20
15
10
5
0
Pre op
Post op
Follow up

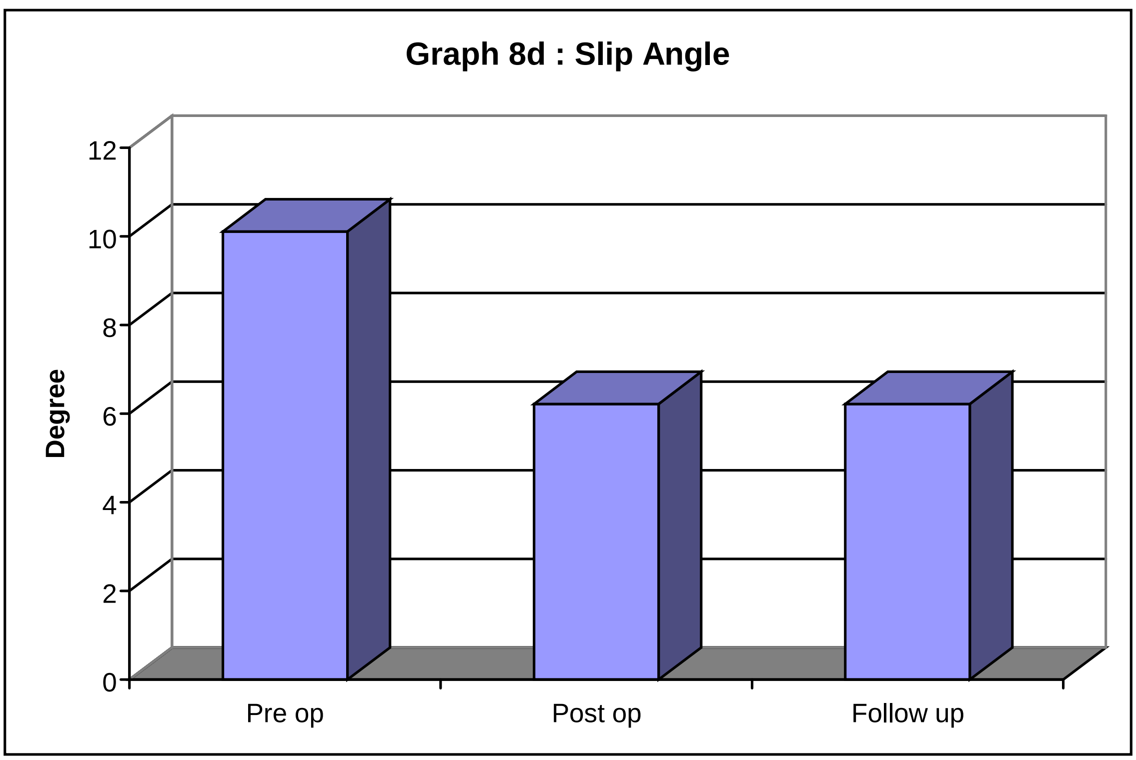

Graph 8d : Slip Angle
Degree
12
10
8
6
4
2
0
Pre op
Post op
Follow up

Table No. 10 : Associated Injury

Associated Injury	No. of Patients
Calcaneal fracture	1
Fracture distal end radius	2

Out of 21 patients, 3 patients (14.3%) had associated injury

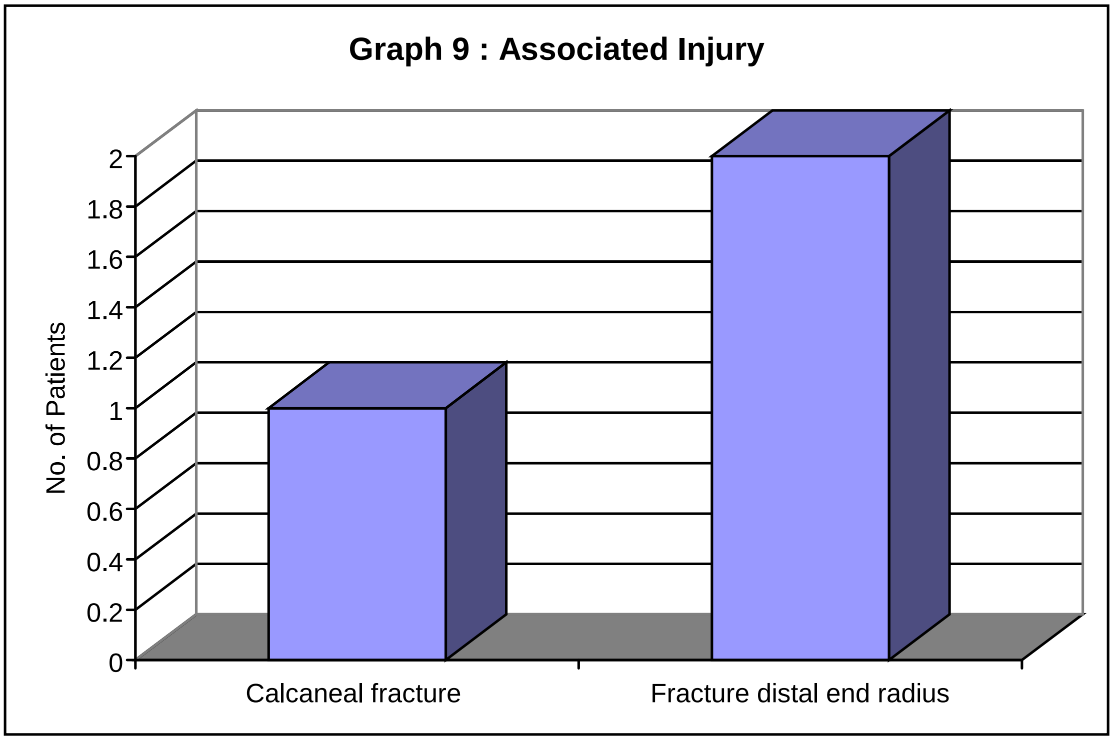
1 patient had sustained fracture calcaneum for which below knee cast was applied. 2 patients had fracture distal end radius. Both were treated by closed reduction below elbow cast application. The associated injuries were more common in patients who sustained a fall.

Table No. 11 : Complications

In our study of pedicular screw and rod fixation for unstable thoracic and lumbar lesions, The following complications were observed

Complications	No. of Cases	Percentage (%)
Urinary tract infection	3	14.3
Paralytic ileus	1	4.8
Bed sores	1	4.8
Implant failure	1	4.8

1. **Urinary tract infection** : 3 patients had urinary tract infection. All the patients had no bladder control. In all patients urinary culture and sensitivity was done and appropriate antibiotic was started and bladder wash was given. All responded well to treatment. They were taught CISC (Clean intermittent self catheterization) and discharged.
2. **Paralytic ileus** : 1 patients had paralytic ileus. NBM and early mobilization showed good response .
3. **Bed sores** : 1 patients had bed sores. It occurred in completely paralysed patient after discharging from hospital. It was superfacial in nature and was treated with antiseptic dressing, antibiotics and water bed.
4. **Implant failure** : Occurred in operated case of lysthisis . During 2nd month post op follow up patient presented with pain in lower back . X- ray showed slipping of rod from right lower pedicular screw . This occurred due early excessive loading of spine as patient had started labours work .


Graph 9 : Associated Injury
No. of Patients
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Calcaneal fracture
Fracture distal end radius

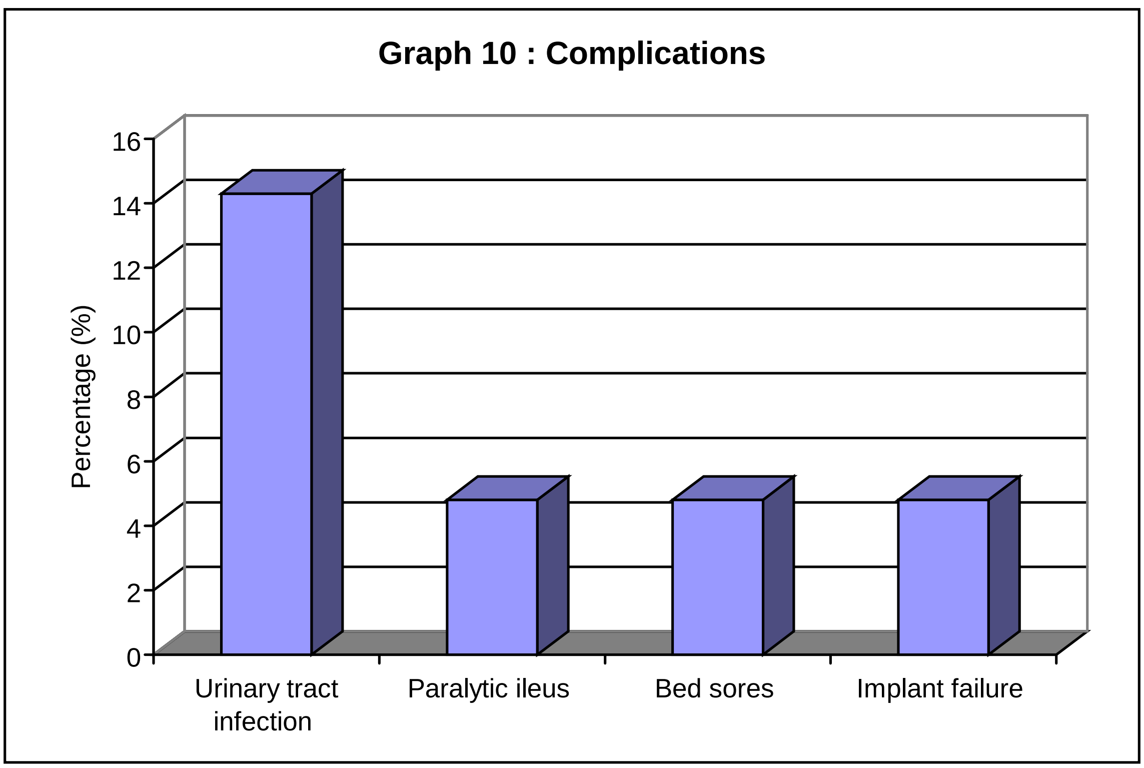

Graph 10 : Complications
Percentage (%)
0
2
4
6
8
10
12
14
16
Urinary tract infection
Paralytic ileus
Bed sores
Implant failure

Table No. 12 : Clinical Outcome

In our study, the clinical outcome is judged using the Denis work and pain scale at the end of 6 months of follow up.

Denis Work Scale	At end of 6 months	Percentage
W_1	8	39.09
W_2	5	23.8
W_3	3	14.28
W_4	2	9.5
W_5	3	14.28
Denis Pain Scale		
P_1	2	9.5
P_2	11	52.38
P_3	6	28.57
P_4	2	9.5
P_5	0	0

DISCUSSION

Though surgery has been performed on the spine since prehistoric times it has been only in the past few decades that spinal surgery has evolved into a speciality of its own.[17]

Pedicle screw fixation has been in clinical use for more than 25 years, and the efficacy and safety of these devices have been amply documented. Internal fixation of the spine has proved useful in various conditions of the spine. Pedicle screw and rod fixation technique is one technique that has gained wide acceptance. This technique allows fusion to be achieved while maintaining mobility in healthy segments of the spine This may be important in maintaining activities of daily leaving . Another advantage of this technique is that screws are placed into the pedicle, which is the strongest part of the spine .

The clinical use of transpedicular screw fixation for managing various spinal problems has been well documented by many authors. However this particular study was not done in population surrounding Belgaum and our study supports the use of pedicular screw and rod fixation in unstable thoracic and lumbar spinal lesions.

When vertebral column injury occurs, some degree of neurological deficit is present in a significant percentage of cases, about 15% to 20% at thoracolumbar level.[3,84]

The extraordinary forces acting on the dorso lumbar region make the management of spinal lesions in this region a challenging task. The rational treatment of such injuries, necessarily requires the application of sound anatomical principles and mechanical properties to fix these biological problem.[85,86]

It has been proved beyond doubt that surgical management is definitely a superior choice to conservative treatment in the management of these lesions.[59,2,5,26,27,28]

Thoracolumbar fracture and degenerative spinal lesions are usually due to complex forces typically combining axial compression, flexion and rotation. These forces often disrupt the facets, surrounding ligaments leaving the spine unstable in all planes of motions. During the past decade there has been a steady increase in awareness of the need to directly reverse all deforming forces in order to achieve a more anatomical reduction and then provide corrective forces in all directions to maintain stable fixation. [55,56,57,58,59]

In 1973 Dickson first described the Harrington rods[11,12,13] in the treatment of spinal lesions . But due to various disadvantages associated with rod system like gap existed between rod and anatomic position of lamina, long segment fusion, rotational instability. All this led to the development of newer system i.e. segmental instrumentation and various studies have proved that in thoracic and lumbar lesions the pedicular screw is a better option.[26, 27, 32]

Patient population

Sex distribution : In our study of 21 patients, 16 were male (76.2%) and 5 were females (23.3%). Males being the major working force and bread earners of families in India, their incidence in our study is high.

Age Distribution

Of the 21 patients, 11 patients (52.38%) belonged to 41-50 yrs age group, i.e. spinal instability is prevalent in adult grouping in our study. Degenerative lesion and fractures of thoraco lumbar spine are commonly seen among adult population as osteoporosis prevails widely in this age group. The range was between 19 to 52 years. The mean age was 39.58 years.

Type of lesion

In our study, 12 (57.14 %) of 21 patients sustained spinal fractures and in this group the commonest cause was fall from height.

9 (42.85 %) out of 21 patients had spondylolisthesis and degeneration was the commonest cause .

The high incidence of fall from height in our study could be related to their occupation because most of the people who sustained injury were manual labourers, employed in construction, road work and farming.

Level of Fracture :

Since, the thoracolumbar junction is very vulnerable to injury due high mobility at this site, maximum number of fractures occur at this site and this has been proved by many studies. [35]

Level of listhesis :

Commonest level involved in our study was L4-5 (5 out of 9) accounting for 55.6% among listhesis group. Sagittal orientation of the facet joints [87-91] and increased pedicle-facet angle [87] have been described as predisposing factors. Also a contributing factor is the coronal orientation of the L5–S1 facet which increases stress at the L4-L5 level.

Type of fracture

All the fractures were classified according to the Denis classification.[70] Among these burst & compression fractures accounted for 83.3 %. Both these injuries were common in patients with fall from height . One Seat belt or flexion distraction type of lesion was seen in one road traffic accident patient.

Type of spondylisthesis :

In our study, degenerative type was the most commonest type of listhesis accounting for 88.8% of this group . Degeneration is the most common type seen in various studies .[89]

Neurological Course

In all patients ASIA grading was used pre operatively, post operatively and during the follow up. In our study 3 patients (14.2%) presented with complete paraplegia and 18 patients (85.7%) with incomplete deficits.

In our study none of the patients deteriorated neurologically after surgery . Of the 3 patients who presented with ASIA grade A, all 3 remained as grade A and showed no improvement , as there was complete transection of spinal cord. In all these cases injury was seen at T8 and T12 level . One patient presented as grade B who improved to grade D . Four patients presented with grade C and all at them showed some improvement after treatment. Out of 4, 3 improved to normal neurological status i.e. grade E and 1 improved to grade D. 13 patients presented with grade D and out of 13, 12 improved to normal neurological status i.e. grade E while the remaining 1 remained as grade D.

No patients had neurological deterioration**.** Thus, from above result, of the 21 patients who had some neurological involvement, 4 (19.1%) showed no improvement in their neurological status and of remaining 17 (80.9%), 13 showed improvement by 1 grade and 4 showed improvement by 2 grades. The average grade of improvement was 1.23 ASIA grade

Radiological course

Radiologically patients were assessed by sagittal angle and sagittal index for fracture group and by slip angle and slip percentage for spondylolisthesis group.

Fracture group :

Table 7a : Sagittal angle (Kyphotic angle)

The mean kyphotic angle pre-operatively was 20.08^0 (+/- 9.28^0) , the mean kyphotic angle post- operative was 11.4^0 (+/- 7.54^0) , which is statistically significant with P= 0.015 and on follow-up the mean kyphotic angle was 13.6^0 (+/- 7.35^0) , which is also statistically significant P=0.040. There was mean loss of sagittal angle by 2.2^0

Table No. 7(b) : Sagittal index

The mean sagittal index preoperatively was 0.58 (+/- 0.16) , on post operative X rays it was 0.67(+/- 0.13), which was statistically significant P=0.00133, and on follow up the mean sagittal index was 0.65 (+/- 0.13),which is also statistically significant P=0.0014 . There was mean loss of sagittal index by 0.02.

Spondylolithesis group :

Table No. 7(c) : Slip Percentage –

The mean slip percentage pre operatively was 32.22% (± 10.35) , on post operative X rays it was 14.51 % (± 7.74) , which is statistically highly significant P =0.000013 and on follow up the mean slip percentage was 15.97 %(± 8.16), which is also statistically very significant P= 0.0090. There was mean loss of slip percentage by 1.64%

Table No. 7(d) :- Slip Angle :-

The mean slip angle pre-operatively was 10.11^0 (± 4.83^0) , on post-operative X rays it was 6.22^0 (± 2.59^0), which is statistically very significant. No change in slip angle was seen on follow up i.e., there was no mean loss in slip angle.

CLINICAL OUTCOME

In our study the clinical outcome was judged by using the Denis work and pain scale after 6 months of follow up.

Denis work scale

In our study of 21 patients, 3 were having complete paraplegia and the remaining 18 patients had incomplete paraplegia.

All the 3 patients who were having complete paraplegia were completely disabled. 8(39.09 %) patients were able to return to previous employment. 5(23.8%) patients were able to return to previous work but with restriction. 3 (14.28%) patients were unable to return to previous employment but worked a full time new job. 2 (9.5%)

patients were able to return to light work but were unable to work full time and 3 (14.28 %) patients were completely disabled and were not able to carry out any work.

Thus post operatively, 16(76.19%) out of 21 patients were able to return to their previous work . Out of remaining 5, 3 were completely disabled and 2 were able to carry out light work.

Denis Pain Scale

In our study, Denis pain scale which is one of the component of Denis work pain scale is used.

According to this study 2 patients (9.5 %) did not have any pain at the end of 6 months, 11 patients (52.38 %) had occasionally minimal pain and there was no need for medication, 6 patients (28.57 %) had moderate pain, they required occasional medication but there was no interruption of work or activities of daily living.

2 Patients (9.5 %) were having moderate or severe pain , were occasionally absent from work and had a significant change in their activities of daily living . None of patient had constant pain and needed chronic medication.

Thus post operatively, 13 (61.90 %) out of 21 patients were relieved of pain with no medications required . 8 patients required medications to eliminate pain .

COMPLICATIONS :-

In our study 3 patients developed UTI , one patient developed paralytic ileus , one developed a bed sore & one patient had implant failure . Urinary tract infection was particularly seen in patients with prolonged catheterization who had completely lost their bladder control due to traumatic transection of spinal cord. Discharge was sent for culture and Gram staining. Regular bladder wash with diluted betadine was given and antibiotics according to sensitivity were started. UTI was brought under control by 2^{nd} –3^{rd} month Infection occurred in these patients due to lack of hygiene, which was later taught to patient and his relatives.

One patient developed paralytic ileus post operatively, who was kept NBM and on IV fluids and was started orally only after peristaltic sounds were heard and flatus was passed . This could have developed due to handling of nerve roots intra operatively which could have been prevented by minimal handling of cord and nerve roots.

One of the completely disabled paralytic patient developed bed sore, which healed by regular dressing, log rolling and placing the patient on water bed. Prevention of bed sore formation is very important. Regular examination, good hygiene, proper padding of pressure points and early mobilization in selected cases helps prevent bed sores.

In one patient operated for L4-L5 listhesis, implant failure was seen. This patient was a labourer and started working very early inspite of warning. According to our thinking, early excessive loading of the spine before fusion could have resulted in slipping of the rod and thus implant failure. Patient presented with increased pain at the operated site. She was advised to undergo are operation, but the patient did not follow up with us after six months.

CONCLUSIONS

In this study of ‘ **pedicular screw and rod fixation’** for thoracic & lumbar spinal instability which was done between 1st September 2006 to 30th September 2007, the following important conclusions have been derived -

1. Posterior stabilization with pedicular screw and rod system is an effective method of achieving spinal stabilization in thoracic and lumbar lesions .
2. Pedicular screw fixation is an effective method for restoring spinal angulation.
3. Pedicular screw fixation is an effective method for restoring and preventing slip in degenerative lesion of the spine .
4. Pedicular screw placement fairly helps in improving the neurological status.
5. The clinical outcome after Pedicular screw placement has been satisfactory, in terms of work and pain at follow up.
6. The disadvantage of pedicular screw fixation is that it has a steep learning curve
7. High technical expertise is required to minimize complications.

The results of our short series of 21 cases has been encouraging. But there is a need for more cases and a longer follow up to come to definative conclusion.

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PROFORMA

S.NO :

I.P.N : **O.P.NO :**

Name :

Age / Sex:

Religion : **Occupation :**

Income :

Address:

D.O.A : **D.O.D :**

History :

<u>Type of lesion:-</u>

Spinal fracture

Spondylolysthesis

Spinal infection

Spinal malignancy

e) Multiple disc excision

f) Laminectomy

B. Associated injuries

C. Significant past history

D Associated Medical Problems

E. Nourishment and general conditions.

Reflexes

1.Knee reflex	5. Cremastric reflex
2.Ankle reflex	6 .Bulbocavernous reflex
3.Abdominal reflex	7.Anal wink
4.Planter reflex	

Methyl Prednesolone /dexamethasone

	On admission	Ondischarge
ASIA Grading		

X-Ray:

MRI :

	Pre Op	Post Op	follow up
Sagittal index			
Sagital angle			
Slip angle			
Slip percentage			

Operative details

- Anaesthesia ----
- Position ----
- Approach ----
- Posterior decompression ----
- Bone grafting ----
- Screw and rod size ----

Blood transfusion.

Intra operative Complications

Post Op Conditions

- Wound condition
- Infection
- Sutures removed on post op date

Other Complication

- Bed sore
- Paralytic illness
- Misplacement of screw
- Implant prominence.

Follow up :

Duration	1mth	2mth	3mth	4mth	5mth	6mth

Complaints :

Bladder status

ASIA score

Sagital index

Sagital angle

Slip angle

Complication:

Infection

Nut loosening

Screw breakage

Device related neural injury

Bed sore

Urinary tract infection

At the end of 6 mths **Denis Pain** and **Work Scale** assessment.

Denis work scale

W_1 Able to return to previous employment (Heavy Labour) or physically demanding activities

W_2 Able to return to previous employment or return to heavy labour with restriction

W_3 Unable to return to previous employment but work fulltime at new job.

W_4 Unable to return to full time work

W_5 No work, completely disabled

Denis pain scale

P_1 No pain

P_2 Occasional minimal pain and no need for medication

P_3 Moderate pain occasional medication needed and no interruption of work or activities of daily living.

P_4 Moderate or severe pain, occasional absence from work and significant changes in activities of daily living

P_5 Constant severe pain and need for chronic medication

RESEARCH SUBJECT INFORMATION & CONSENT FORM

Mr/Mrs/Ms____

You are invited to participate in our research study that is "**A ONE YEAR STUDY OF ROLE OF PEDICULAR SCREW AND ROD FIXATION SYSTEM IN ACHIEVING STABILIZATION OF THORACIC & LUMBAR LESIONS OF SPINE , AT KLE HOSPITAL & MRC BELGAUM** "

Why I am being asked to participate in this research?

All patients attending in KLEs Dr. Prabhakar Kore Hospital & MRC Belgaum diagnosed to have unstable Thoracic and Lumbar lesions on clinical examination and diagnostic test are eligible to be part of this research. As you are diagnosed on initial evaluation to be a case of unstable Thoracic & Lumbar lesion so you are eligible to be part of the study and hence are asked to participate . The decision to participate is entirely your own.

Why is this research being done?

We are conducting this study to know the efficacy of pedicular screw and rod fixation system in achieving spinal stabilization in Thoracic-Lumbar lesions and its clinical outcome.

Procedure	By through clinical evaluation according to Performa , by investigation.
Risks	No life threatening risks .
Benefits	No monetary benefits are offered to the patients. Patient will be benefited by the outcome of the study in better understanding and treatment of the disease.

Outcome	To know the efficacy of pedicular screw and rod fixation in maintaining spinal stabilization in Thoracic-Lumbar lesions.

What is the purpose of the research?

1) To study the efficacy of pedicular screw & rod fixation in achieving spinal stabilization in Thoracic- Lumbar lesions.
2) To study clinical outcome by using spinal scoring system.

What are the procedure involved ?

Pedicular screw and rod fixation system will be used to stabilize the unstable spinal lesions under general anaesthesia.

What are potential risks or discomfort ?

The following are the risk-

- Difficulty in reduction .
- Difficulty in wound closure .
- Bleeding .
- Skin necrosis
- Breakage of implants .
- Wrong placement of screws .
- Implant prominence .
- Sinus
- Worsening of neurological status .

Are there benefits for taking part in this study?

No direct benefits are guaranteed to you from participating in our study. Your participation may benefit you and others suffering from same ailment in future, by helping us learn more about the treatment modalities. There are no financial incentives promised to you for being a part of this study . It will help in reducing pain , increase mobility and improvement of neurological status .

What other option are there ?

Your decision whether or not to participate in this study will not affect the quality of treatment you receive & you will be treated according to the existing protocol. Further you may withdraw from the treatment anytime.

Will I be told about the new information that may affect my decision to participate?

All new information regarding the subject of research & that collected during the study will be informed to the patient.

What about privacy and confidentiality ?

All information collected from you during the course of this study will be kept confidential to the extent of law. Information which identifies you personally will not be released without your written consent

What if I am injured as a result of my participation ?

In an event that you are physically injured as a result of your participation , emergency care will be available . There is however no commitment in providing compensation for research related injury.

What are the costs for participating in this research ?

There will not be any extra cost incurred by the participant.

The participant however have to pay for the investigations which are the part of existing management protocol for this ailment.

Will I be reimbursed for any of my expenses for participation in this research?

No, there is no commitment for any reimbursement or any other compensation for the participation.

Can I withdraw or be removed form the study?

Yes the participation in this study is entirely voluntary & patient can withdraw from the study any time or can be removed from this study.

Whom should I contact if I have any question

If you have any question about the study you man please contact the

1) Chief investigator Dr. Vikrant Magdum ,P.G ,Department Of Orthopaedics,JNMC Belgaum, contact No. 9886344015.
2) Dr.B.B.Putti Prof. and Head, Department of Orthopaedics, Guide, Contact No-9448112184.
3) Dr. V.D. Patil, Principal JNMC ,Belgaum and chairman of institutional Ethics Committee ,No- 0831-2471350.

Signature of the participant or legally authorized representative:

Participant's Name: Signature:

Experimenter's/ Witness's Name: Signature:

Date:

KEY TO MASTER CHART

S.N.	Serial number
BS	Bed sore
D. O. A.	Date of Admission
D. O. O.	Date of Operation
F/U	Follow Up
I. P. No.	In Patient Number
Peri. Inj.	Perineal injury
PI	Paralytic ileus
RTA	Road Traffic Accident
Sup. Inf.	Superficial infection
UR	Urethral rupture
UTI	Urinary Tract Infection

PROCEDURE

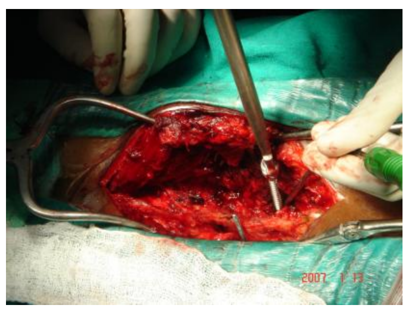
Instruments

Position

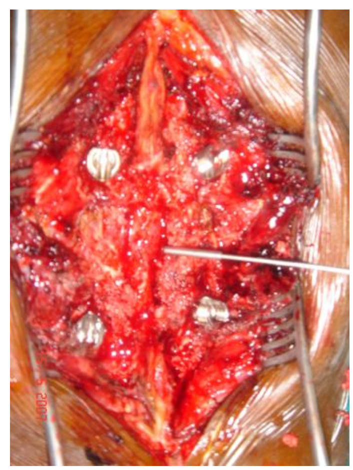
Incision

Exposure

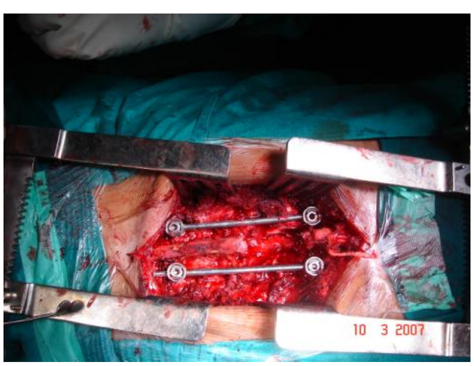
Pedicle Probing



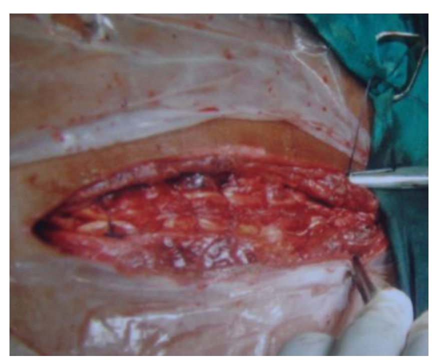
Screw insertion



Screws in situ



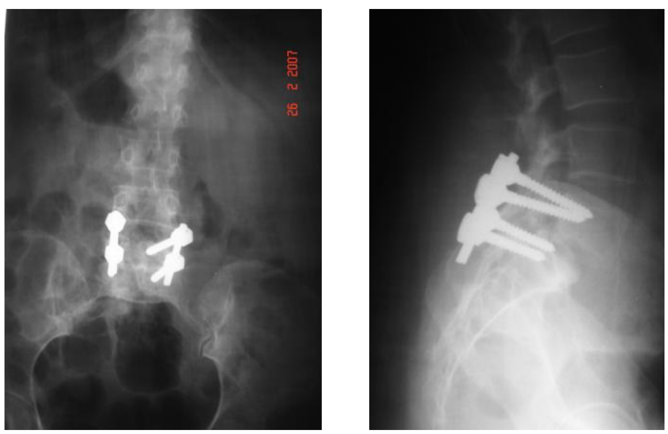
Screws with rod in situ



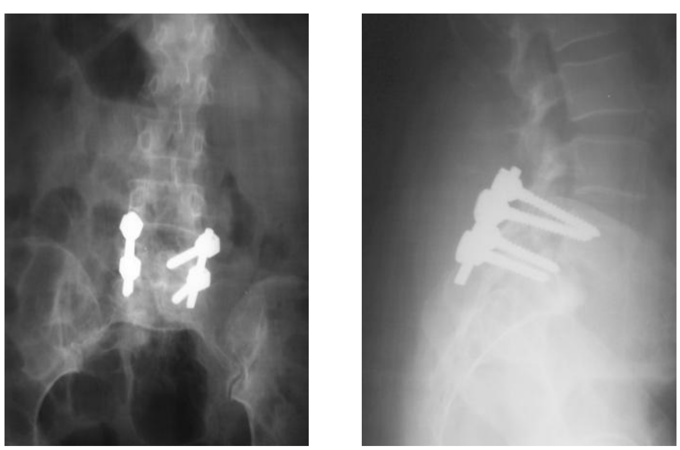
Wound closure in layers

CASE NO. 1

Pre Operative



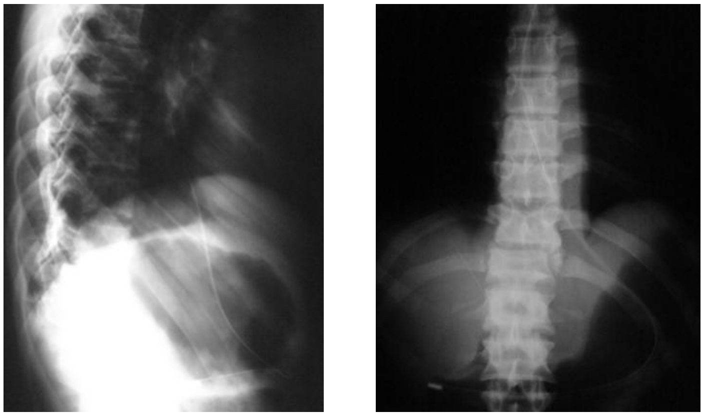
Post Operative



Follow Up

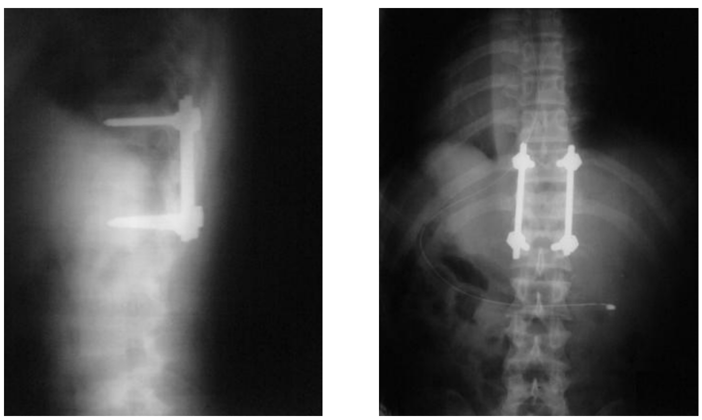
Fully Recovered

CASE NO. 2

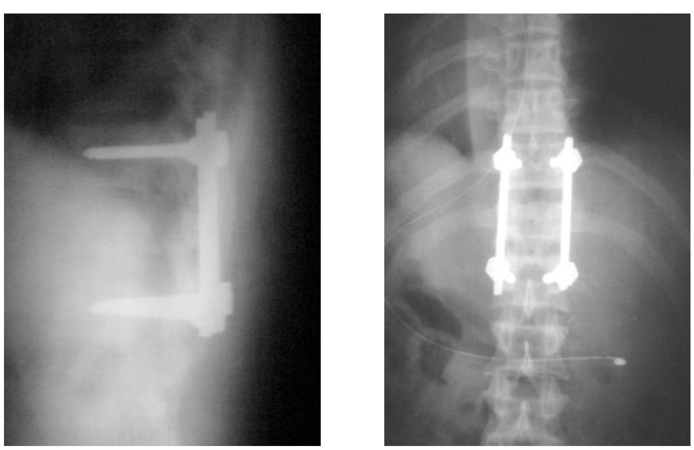


Pre-operative

Healed Scar



Post Operative



Follow Up

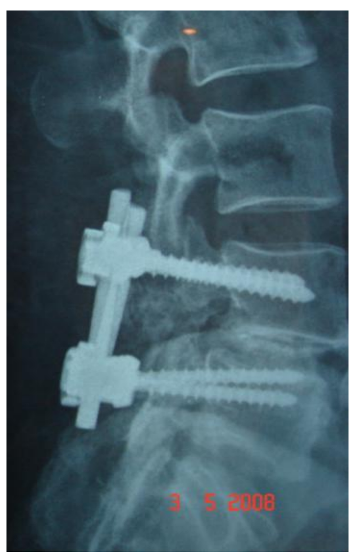
Fully Recovered

CASE NO. 3

Pre-Operative

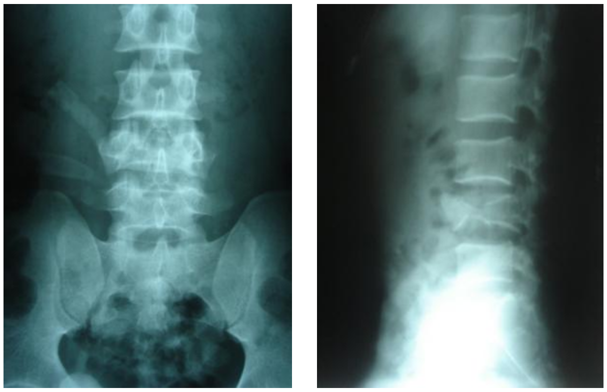
Post-Operative

Fully recovered

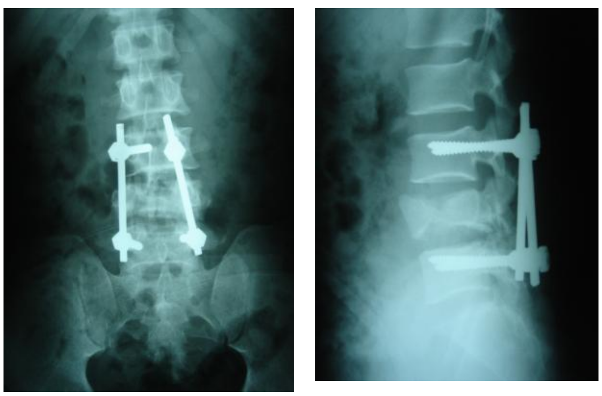


Follow - Up

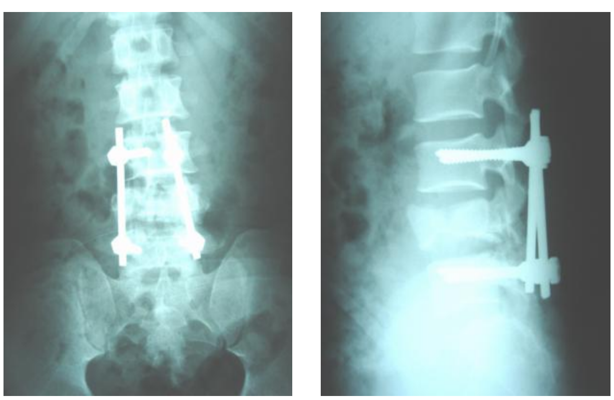
CASE NO. 4



Pre - Operative



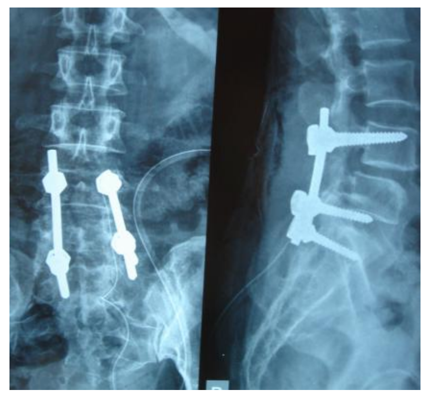
Post - Operative



Follow - Up

CASE NO. 5

Pre - Operative



Post - Operative

Implant Failure

ASSOCIATED INJURIES

Fracture distal end radius treated with below elbow cast

Fracture distal end radius treated with below elbow cast

Fracture calcaneum treated with below knee cast

Sr No	NAME	IP NO	DOA	AGE	SEX	F/U	# LEVEL	# TYPE	MODE INJU	ASS INJ	SLIP LEV	SLIP CAUS	COMLP	ASIS GRADING PRE OP	POST OP	F/U
1	Mallapa Chachode	228233	5/8/2007	40	M	6	L1	COMP #	FALL					D	E	E
2	Dhasharat Bogan	222894	3/26/2007	48	M	10	D12	BURST	FALL				UTI	A	A	A
3	Ramesh Gavade	224143	4/5/2007	50	M	12	D12	COMP #	FALL	# CAL R			UTI	A	A	A
4	Geeta Naik	176722	12/20/2006	45	F	8	L4	COMP #	FALL					B	C	D
5	Vinod Betgiri	177401	12/29/2006	19	M	8	L1	COMP #	FALL					D	E	E
6	Sandeep Nagar	176528	10/23/2006	20	M	10	L4	BURST	FALL					C	D	D
7	Ravi Akurkar	222172	3/17/2007	23		11	L1	BURST	FALL					D	E	E
8	Yallappa Udapudi	236179	7/15/2007	48	M	12	L1	BURST	FALL	# RADIUS				D	D	D
9	Krishna Bandache	241108	8/4/2007	40	M	8	D12	# DISLO	RTA					D	E	E
10	Shrikant Devdas	201260	1/31/2007	28	M	8	D10	# DISLO	RTA				Paralytic ileus	C	D	D
11	Rajendra Pawar	248364	8/16/2007	36	M	11	D12	BURST	RTA					C	D	D
12	Baburao Patil	233017	6/11/2007	52	M	9	D8	BURST	RTA	# RADIUS			UTI BS	A	A	A
13	Rohini	199201	1/6/2007	44	F	6					L5-S1	Degenr		D	E	E
14	Bhimrao Patil	270355	4/23/2007	48	M	7					L4-L5	Degenr		D	E	E
15	Malutai Patil	269869	3/13/2008	42	F	9					L5-S1	Degenr	IMP FAILURE	D	D	D
16	Mayappa Singade	225792	11/30/2006	45	M	7					L4-L5	Degenr		D	E	E
17	Shantalla Demmatti	208461	11/21/2006	35	F	6					L3-L4	Degenr		D	E	E
18	Vishwas Demmatti	200108	1/26/2007	36	M	8					L4-L5	Trauma		D	E	E
19	Vikram Bandiwad	155812	2/14/2007	47	M	7					L4-L5	Degenr		D	E	E
20	Kanchan Demmatti	234521	6/26/2007	48	F	8					L3-L4	Degenr		D	E	E
21	Basangouda	233187	5/14/2007	45	M	8					L4-L5	Degenr		C	D	E

Sr	SAGITAL ANGLE			SAGITAL INDEX			SLIP PERCENTAGE			SLIP ANGLE			DENIS SCALE		OCCUPATION
No	PRE OP	POST OP	F/U	PRE OP	POST OP	F/U	PRE OP	POST OP	F/U	PRE OP	POST OP	F/U	WORK	PAIN	
1	29	13	17	0.7	0.8	0.8							W1	P2	Farmer
2	30	6	8	0.63	0.76	0.72							W5	P2	Fact work
3	12	0	2	0.8	0.86	0.85							W5	P2	Farmer
4	8	5	7	0.65	0.75	0.71							W1	P1	Farmer
5	25	21	22	0.46	0.73	0.7							W4	P4	Fact work
6	5	26	26	0.9	0.8	0.85							W3	P3	Student
7	16	5	6	0.48	0.71	0.69							W3	P3	Farmer
8	31	17	19	0.5	0.9	0.85							W1	P2	Garderner
9	15	10	12	0.57	0.69	0.66							W4	P3	Driver
10	19	14	18	0.5	0.6	0.58							W2	P3	Business
11	32	6	9	0.32	0.44	0.4							W5	P2	Off work
12	19	14	18	0.5	0.6	0.58							W5	P2	Driver
13							50	30	32	5	5	5	W1	P2	Hw
14							30	10	14	10	8	8	W2	P3	Business
15							33	18	20	9	6	6	W3	P4	Labourer
16							38	7.6	7.8	6	2	2	W1	P2	Farmer
17							13	5	5	20	10	10	W1	P1	Hw
18							24	10	10	5	3	3	W1	P2	Farmer
19							32	18	20	10	6	6	W1	P2	Business
20							30	12	15	12	8	8	W2	P2	Hw
21							40	20	20	14	8	8	W2	P3	Farmer