“STUDY OF FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF LUMBAR SPONDYLOLISTHESIS WITH PEDICLE SCREW FIXATION AND POSTEROLATERAL FUSION”

by

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Dissertation submitted to

B.L.D.E. (Deemed to be) UNIVERSITY VIJAYAPURA, KARNATAKA.

In partial fulfillment of the requirements for the degree of

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IN
ORTHOPAEDICS

Under the guidance of
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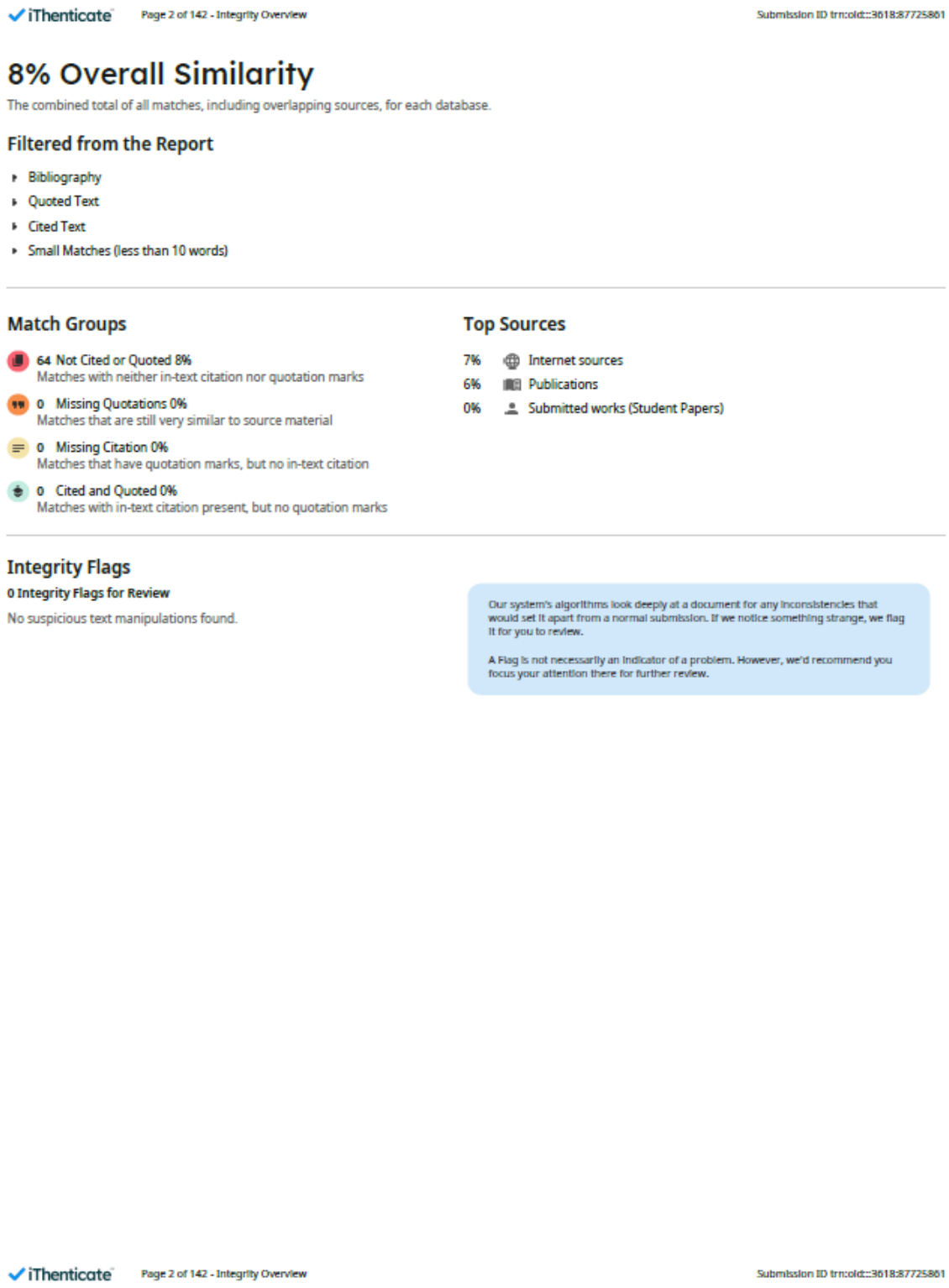
Dr. CHARAN SAI REDDY MUNUGALA

Plagiarism report



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ABBREVIATIONS

PLF – Poster-lateral fusion

ALIF - Anterior Lumbar Interbody Fusion

TLIF - Transforaminal Lumbar Interbody Fusion

PLIF - Posterior Lumbar Interbody Fusion

IBF – Interbody Fusion

BMI – body mass index

ODS – Oswestry disability score.

ODI – Oswestry disability index.

M ODS – Modified Oswestry disability score.

M ODI – Modified Oswestry disability index.

VAS – Visual analogue score

JOA – Japanese orthopaedic association

MRI – Magnetic resonance imaging

CT – Computed tomography

SPECT – Single photon emission computed tomography

OP – Operative

LS – Lumbo-sacral

FIG – Figure

LAT – Lateral

AP – Antero-posterior

MIS – Minimally invasive spine

SA – Slip Angle

LSA – Lumbo-sacral Angle

PI – Pelvic index

PT – Pelvic tilt

SS – Sacral slope

LL – Lumbar lordosis

SLR – Straight Leg Raise

SNRI – Selective nerve root injection

ABSTRACT

INTRODUCTION

Low back pain ranks among the most frequently reported health issues globally. The primary causes of low back pain include injuries, overuse, and pressure on nerve tissue due to various conditions such as spondylolisthesis, disc herniation, spinal canal stenosis, and degenerative disc diseases.

Spondylolisthesis is termed when the vertebra slides over another. It is one common cause of instability. It is derived from Greek words ‘Spondylos – vertebra’ and ‘olisthesis – slip. Spondylolisthesis can result from ligamentous laxity, defects in the pars interarticularis, and post-surgical procedures or may occur as a result of trauma.

Pedicle screw fixation and posterolateral fusion is done to stabilize the unstable spinal segment by fusion and avoidance of further progression of slip.

OBJECTIVES

The aim of this study is to evaluate the functional outcome of surgical treatment for lumbar spondylolisthesis using pedicle screw fixation and posterolateral fusion

MATERIALS AND METHODS

It is a prospective observational study. The patients who met the inclusion and exclusion criteria were admitted to the Department of Orthopedics in B.L.D.E.

(DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Hospital and Research Centre. The patients were informed about the study in all respects and informed written consent was obtained. Period of study was between 1st may 2023 to 1st December 2024. Follow up period was of 6 months.

RESULTS

We studied 36 cases in our series with 16 males and 20 female patients. The radiological union was found to be 72.2 percent. From surgical incision to wound closure, the average operating time was 3.5 hours. The average blood loss was 248 ml.

The improvement of post-operative VAS Score at six months mark was drastic and significant, as proven by a "p value" of < 0.00001.

Improvement of quality of life, based on the Wilcoxon signed rank test comparing preoperative and postoperative modified Oswestry disability index score was statistically significant, showing significant reduction in post operative modified Oswestry disability index scores indicating significant improvement in quality of life.

CONCLUSION

In our study we have concluded that using a pedicle screw-rod system combined with posterolateral fusion is a safe and effective option, especially for low-grade cases. In terms of results, minimal postoperative complications were noted. The positive outcomes were primarily linked to neurological deficits present preoperatively, percentage of slip and number of spinal

segments fused. We would recommend pedicle screw-rod system combined with posterolateral fusion to be appropriate treatment for spondylolisthesis.

KEYWORDS

Spondylolisthesis, pedicle screw fixation, posterolateral fusion, modified Oswestry disability score

INTRODUCTION

- Low back pain ranks among the most frequently reported health issues globally. The primary causes of low back pain include injuries, overuse, and pressure on nerve tissue due to various conditions (such as spondylolisthesis, disc herniation, spinal canal stenosis, and degenerative disc diseases).
- Spondylolisthesis is termed when the vertebra slides over another. It is one common cause of instability. It is derived from Greek words 'Spondylos – vertebra' and 'olisthesis – slip.' [(1)]
- Herbineaux, a Belgian obstetrician, first observed this condition, and Killian introduced the term. Spondylolisthesis can result from ligamentous laxity, defects in the pars interarticularis, and prior surgical procedures or may occur as a result of trauma affecting about 5% of total population. [(2)]
- Neugebauer, Newman categorize spondylolisthesis into five distinct types. Meyerding's classification system classifies spondylolisthesis according to the percentage of slip, with types 1 and 2 classified as low grade, while types 3, 4, and 5 are labelled as high grade.
- Surgical intervention for spondylolisthesis is required in cases presenting with claudication, persistent radiculopathy, low backache not resolving, neurological symptoms, failed medical and physiotherapy, instability and progressing spondylolisthesis.
- Advances in comprehending spinal biomechanics, enhancements in bone fusion methods, invention of diverse spinal instrumentation tools, advancements in surgical techniques, the evolution of MIS surgeries etc. have led to obtain the stability in any given segment.

- The main goal of spine fusion surgeries is to resolve the patients pain by removing pain causing tissues and stabilizing unstable spinal segments. Other surgical techniques that are currently employed for the treatment of lumbar spondylolisthesis include
    - Pars Repair.
    - Decompression.
    - In-situ Fusion.
    - Bilateral posterolateral fusion.
    - ALIF - Anterior Lumbar Interbody Fusion
    - TLIF - Transforaminal Lumbar Interbody Fusion
    - PLIF - Posterior Lumbar Interbody Fusion
    - Posterior Instrumentation with Reduction and Fusion
    - Anterior Fusion and release with posterior Fusion (360-degree Fusion). [3]

OBJECTIVES OF THE STUDY

- The aim of this study is to evaluate the functional outcome of surgical treatment for lumbar spondylolisthesis using pedicle screw fixation and posterolateral fusion, in terms of:

  • The reduction of clinical features associated with backache and radiculopathy, with or without neurological deficits.

  • The attainment of correction in the percentage of slip.

  • The prevention of any additional progression of the slip.

REVIEW OF LITERATURE

Benguluri R, Kumar CS. Surgical Management of Spondylolisthesis by Pedicular Screw Rod System and Postero-Lateral fusion. IOSRJDMS. 2018;17(4):61-70. concluded that posterolateral lumbar fusion and spinal decompression is an effective method for treating spondylolisthesis, providing good spinal fusion, fewer complications, and a satisfactory clinical outcome. Based on their findings, they determined that listhesis was common reason for decompression, stabilizing the spine with posterolateral fusion in their hospital. The surgeries were successful, showing a reduced incidence of complications tied to hardware biomechanics. The surgical intervention experienced few postoperative complications, largely conducted under fluoroscopic guidance. The positive results were primarily associated with preoperative neurological deficits and the degree of slippage. In addition to surgical treatment, lifestyle modification is also recommended to prevent surgical failure. [(4)]

Campbell RC, Mobbs RJ, Lu VM, Xu J, Rao PJ, Phan K. Posterolateral fusion versus interbody fusion for degenerative spondylolisthesis: systematic review and meta-analysis. Global spine journal. 2017 Aug;7(5):482-90. Conducted a systematic review and meta-analysis which compared Posterolateral fusion (PLF) to Interbody fusion (IBF) for listhesis. included six studies, encompassing a total of 721 patients. Among these, 458 patients (63.5%) underwent fusion alone, while 263 patients (36.5%) received interbody fusion. The analysis revealed no statistically significant differences

in functional outcomes, when outcomes were compared with ODI (p = 0.29) and VAS score (P = 0.15), between the two surgical methods. Additionally, there were no significant differences in operative outcomes, including blood loss (p = 0.38), reoperation rates (p = 0.66), length of hospital stay (p = 0.96), complication rates (p = 0.78), or fusion rates (p = 0.15) when comparing fusion alone to interbody fusion. The findings indicate that the addition of PLIF/TLIF to PLF does not significantly impact the complication rates, reoperation rates, blood loss and duration of hospital stay. While there may be slight advantages in patient outcomes, such as ODI and VAS, and fusion rates, the results from the currently available literature indicate that these are not statistically significant. [5]

Tattari BP, Nimmagadda VV, Tapadar JI. A prospective study on surgical management of lumbar spondylolisthesis with pedicle screw fixation and posterolateral fusion. International Journal of Research in Orthopaedics. 2017 Oct 25;3(6):1113. A study was conducted in patients who underwent pedicle screw fixation with posterolateral fusion in about 30 patients, all of whom met the inclusion and exclusion criteria. Follow-up was conducted from Feb-2015 to Jan-2017. The age group of the study was 21 to 60 with mean age of 46 years, and were followed up for about 17 months. Evaluation of outcomes according to the Kirkadly-Willis criteria showed 90% excellent to good results, concluding that this procedure achieves good decompression, minimizing instability correcting the slip and achieving the fusion. A solid and successful fusion with good mechanical alignment was observed in most patients. [6]

Chaitanya M, Mittal A, Rallapalli R, Teja R, Prasad YS. Surgical Management of Spondylolisthesis by Pedicular Screw Rod System and Postero-Lateral Fusion. Open Journal of Orthopedics. 2015 Jun 11;5(6):163-74. A total of 86 patients, studied from July 2010 to June 2012, Patients who received posterolateral fusion were monitored and evaluated using the VAS for low back pain, the ODI score, and assessment of neurological deficits. The follow-up included 83% of the initial study cohort, totaling 86 participants.the patients were collowed up for an average of 13 months. At the final follow-up, the mean difference in VAS scores from preoperative to postoperative was 3.5 cm (SD = 2.94). The ODI scores showed a reduction of 28% at 4 months and 36% at 8 months. Patients experienced relief from claudication pain, with functional outcomes categorized as good (67%), fair (27.5%), and poor in (5.5%). Additionally, 75% of the patients underwent fusion, with an average time of 5.5 months post-surgery. Posterolateral lumbar fusion and spinal decompression are effective methods for treating spondylolisthesis, providing good spinal fusion, fewer complications, and satisfactory clinical outcomes. The success rate was primarily related to preoperative neurological deficits and the degree of slippage. [7]

Babu S, Thanigai ST. Pedicle Screw Fixation and Posterolateral Fusion in Lumbar Spondylolisthesis-A Prospective Analysis. Indian Journal of Orthopaedics Surgery. 2015;1(3):168-70. This prospective study included patients who were treated with transpedicular screws fixation with iliac bone grafting in 20 patients between January 2013 and March 2014. These patients were periodically evaluated clinically and radiologically for 6 months after

surgical fixation. The Japanese Orthopaedic Association (JOA) scoring system was used to determine outcome. Patients' perceptions with regards to quality of life improved markedly. Clinical results were categorized ad excellent, good, fair and poor depending upon the correction of slip achieved, outcome post-surgery and stability. 50 percent of patients had excellent results. 30 percent achieved good results, while 20 percent had fair results. It is concluded that pedicle screw fixation and posterolateral fusion is an effective treatment modality for patients with spondylolisthesis. [8]

Schuller S, Charles YP, Steib JP. Sagittal spinopelvic alignment and body mass index in patients with degenerative spondylolisthesis. European Spine Journal. 2011 May;20:713-9. A study was conducted to investigate the relationship between sagittal spinopelvic alignment, body mass index (BMI), and facet joint degeneration in patients with degenerative spondylolisthesis. The research included 49 individuals diagnosed with L4-L5 degenerative spondylolisthesis (12 men and 37 women, with an average age of 65.9 years), who were compared to a control group of 77 patients suffering from low back pain but without spondylolisthesis (41 men and 36 women, average age 65.5 years). Height and weight measurements were taken to calculate BMI. Key parameters were evaluated through standing lateral lumbar radiographs, which included L1-S1 lordosis, segmental lordosis from L1-L2 to L5-S1, pelvic tilt, pelvic incidence, and sacral slope. The sagittal orientation and presence of facet joint osteoarthritis were assessed using transverse plane computed tomography (CT). The average BMI in the spondylolisthesis group was significantly higher ($P = 0.030$) compared to the control group (28.2 vs. 24.8), with 71.4% of spondylolisthesis patients having

a BMI over 25. Radiographic analysis showed a significant increase in several parameters for the spondylolisthesis group: pelvic tilt (25.6 degrees vs. 21.0 degrees; P = 0.046), sacral slope (42.3 degrees vs. 33.4 degrees; P = 0.002), pelvic incidence (66.2 degrees vs. 54.2 degrees; P = 0.001), and L1-S1 lordosis (57.2 degrees vs. 49.6 degrees; P = 0.045). Additionally, segmental lumbar lordosis was significantly greater (P = 0.05) at L1-L2 and L2-L3 in the spondylolisthesis group. CT imaging of the L4-L5 facet joints indicated a sagittal orientation in this group (36.5 degrees vs. 44.4 degrees; P = 0.001). The anatomical positioning of the pelvis, marked by a high incidence and sacral slope, seems to contribute to the development of degenerative spondylolisthesis. Although L1-S1 lordosis was comparable to that of the control group, the increased pelvic tilt suggests a compensatory posterior pelvic tilt in patients with a high pelvic incidence.(9)

Faldini C, Pagkrati S, Acri F, Miscione MT, Francesconi D, Giannini S. Surgical treatment of symptomatic degenerative lumbar spondylolisthesis by decompression and instrumented fusion. Journal of Orthopaedics and Traumatology. 2007 Sep;8:128-33. The research evaluated both clinical and radiographic outcomes in 22 patients diagnosed with symptomatic degenerative spondylolisthesis who underwent a decompressive laminectomy along with posterolateral instrumented interbody fusion (PLIF). The patients had an average age of 64 years, with ages ranging from 57 to 72. Clinical results were assessed using questionnaires during the final follow-up appointment, concentrating on postoperative low back and leg pain, restrictions in daily activities, and the ability to return to sports. Lumbar spine radiographs were employed to assess the integrity of fixation devices,

the degree of spondylolisthesis reduction, lumbar sagittal alignment, and the status of spinal fusion. The average follow-up period lasted 4 years, with a range of 3 to 6 years. Results showed that 19 patients experienced excellent or good clinical outcomes, while 3 had fair results. Prior to surgery, the average anterior vertebral slip measured 5 mm on neutral lateral radiographs, which improved to 3 mm postoperatively. Additionally, mean sagittal motion decreased from 3 to 1 mm, and the angular movement reduced from 8° to 1° after the procedure. The findings indicate that this surgical approach is a viable option for treating degenerative spondylolisthesis accompanied by symptomatic spinal stenosis, with significant improvements in pain relief and activity levels, alongside a high fusion rate. [10]

Ghogawala Z, Benzel EC, Amin-Hanjani S, Barker FG, Harrington JF, Magge SN, Strugar J, Coumans JV, Borges LF. Prospective outcomes evaluation after decompression with or without instrumented fusion for lumbar stenosis and degenerative Grade I spondylolisthesis. Journal of Neurosurgery: Spine. 2004 Oct 1;1(3):267-72. evaluated the outcomes of patients treated between 2000 and 2002 at two institutions to determine whether fusion improves functional outcome 1 year after surgery following decompression with or without instrumented fusion for lumbar stenosis and grade I degenerative spondylolisthesis. Patient ages ranged from 50 to 81 years. They exhibited grade I degenerative spondylolisthesis, with displacements between 3 and 14 mm, and lumbar spinal stenosis without notable instability (3 mm of movement at the subluxation). Some patients underwent only decompression (20 cases), while others received decompression along with posterolateral instrumentation and fusion (14

cases), depending on the surgeon's discretion. The initial demographic data, radiographic assessments, and scores on the Oswestry Disability Index (ODI) and SF-36 were similar across both groups. The fusion rate after one year reached 93%. Both surgical methods resulted in significant improvements from baseline, as reflected in the ODI and SF-36 Physical Component Summary (PCS) scores ($p = 0.001$). The combination of decompression and fusion led to a 27.5-point enhancement in ODI scores, while decompression alone resulted in a 13.6-point increase ($p = 0.02$). Additionally, analysis of the SF-36 PCS data showed a significant difference between the groups ($p = 0.003$), suggesting that surgery markedly improved one-year outcomes, as measured by established assessment tools, in patients with spondylolisthesis and grade I stenosis. The fusion procedure was associated with greater functional improvement. [11]

SURGICAL ANATOMY

The vertebral column is composed of 33 vertebrae, classified into five regions:

• 7 cervical

• 12 thoracic

• 5 lumbar

• 5 sacral

• 4 coccygeal

The sacral and coccygeal vertebrae are fused, resulting in 24 mobile segments. (Fig. 1)

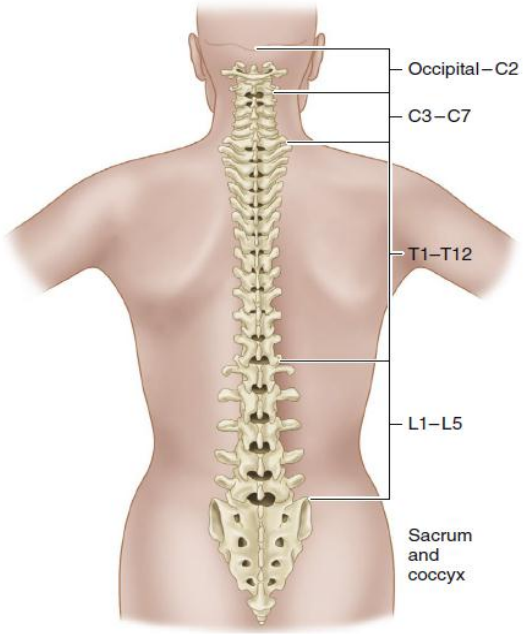


Fig. 1 – Vertebral column

THE VERTEBRAL COLUMN

- Males typically have spinal column about 72 cm long, while females tend to have a spine 7 to 10 cm shorter.
- A typical vertebra is made up of anterior and posterior, which together create the spinal canal.
- The vertebral arch includes two pedicles and laminae that converge to create the spinous process. Flanking the vertebral arch are the transverse, superior, and inferior articular processes. The linkage between the superior and inferior articular processes of neighboring vertebrae forms synovial joints.
- Orientation of articular processes affects different types of movements that can occur in each part of the spine. (Fig. 2)

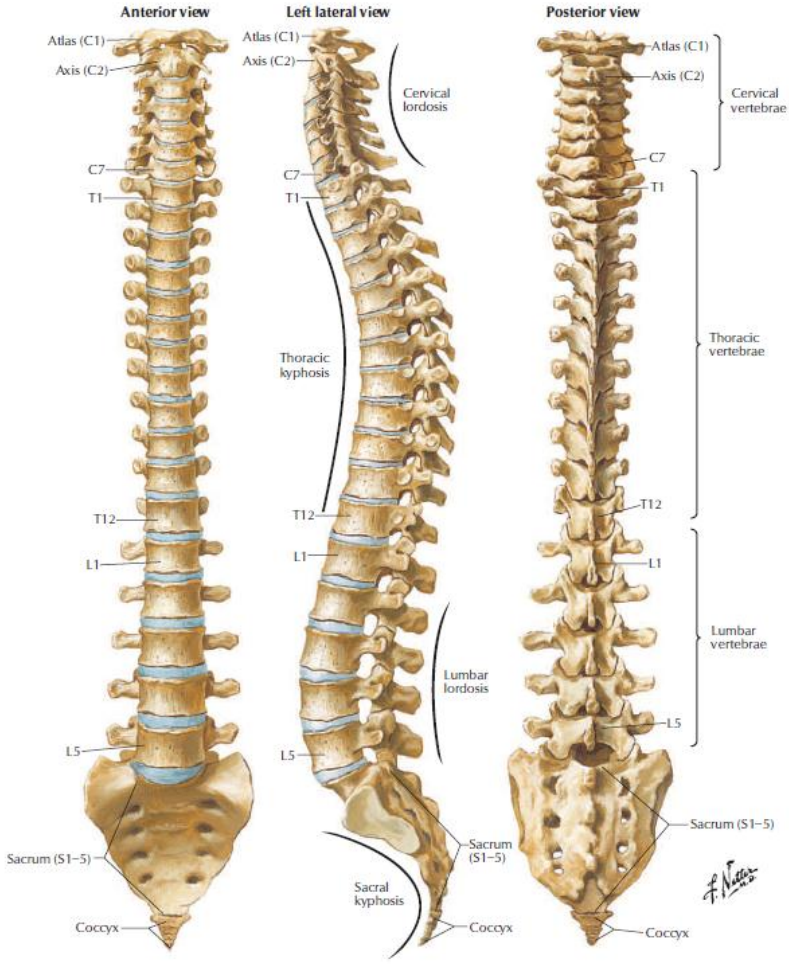


Fig. 2 – Vertebral column in anterior, lateral and posterior views (12)

LUMBAR VERTEBRAE

- The bodies of the lumbar vertebrae widen as they go downwards, which is similarly seen behind with the expanding space between the articular processes. At L1 and L2, four processes typically form a vertical rectangle.
- For L3, these processes may continue to take on a vertical rectangle shape, or at L4, they might form a square; however, at L5, they take on a horizontal rectangle configuration.
- Like smaller thoracic vertebrae, lumbar body is vertically concave, has pedicles in its upper section, and a pair of Basi vertebral veins on the posterior surface.
- Unlike the heart-shaped thoracic vertebrae, the lumbar vertebrae are kidney-shaped, and their posterior surface is flatter and less concave, resulting in a slightly triangular cross-section of the vertebral canal. (Fig.3)
- The length of the transverse processes varies, L3 usually is the longest. The transverse process of the L5 vertebra has unique characteristics, it is short, robust, and triangular in shape.
- The transverse process of this vertebra uniquely connects directly to the vertebral body, in contrast to the typical attachment at the junction of the pedicle and lamina. The pedicles create intervertebral foramina akin to those found in the thoracic vertebrae; however, the laminae are less inclined downward compared to their thoracic equivalents. Additionally, the spinous process is quadrangular in shape and oriented horizontally, featuring a straight upper edge and a concave lower edge.

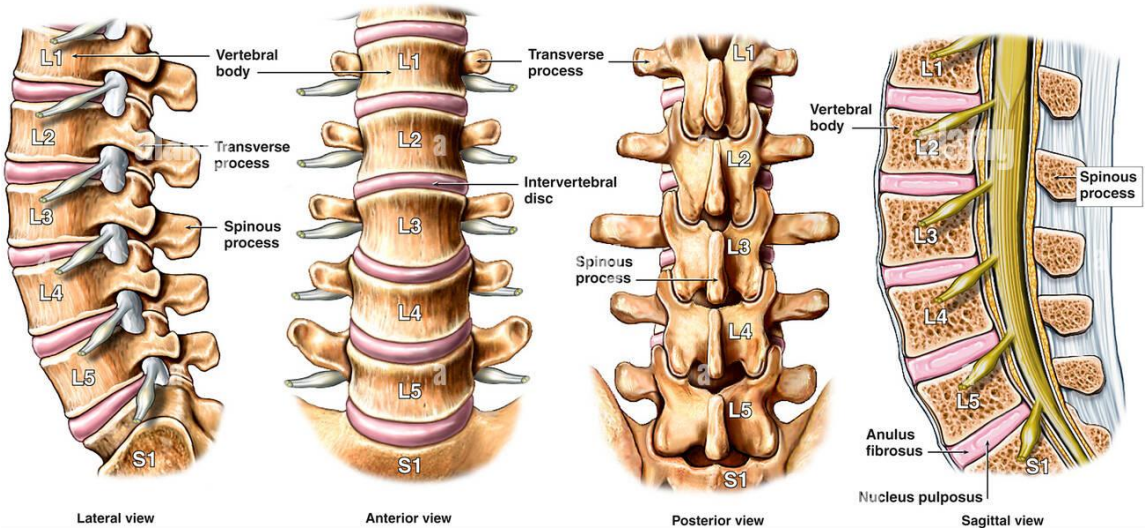


Fig. 3 – Lumbar spine in lateral, anterior, posterior views and sagittal section.

- At L5, the pedicle is widest in the horizontal plane, whereas at T5 it is narrowest; at T11, the pedicles are widest in the sagittal plane, and at T1, they are narrowest. Due to the pedicle's oval shape, its width in sagittal plane exceeds that in the horizontal plane. (Fig. 4)

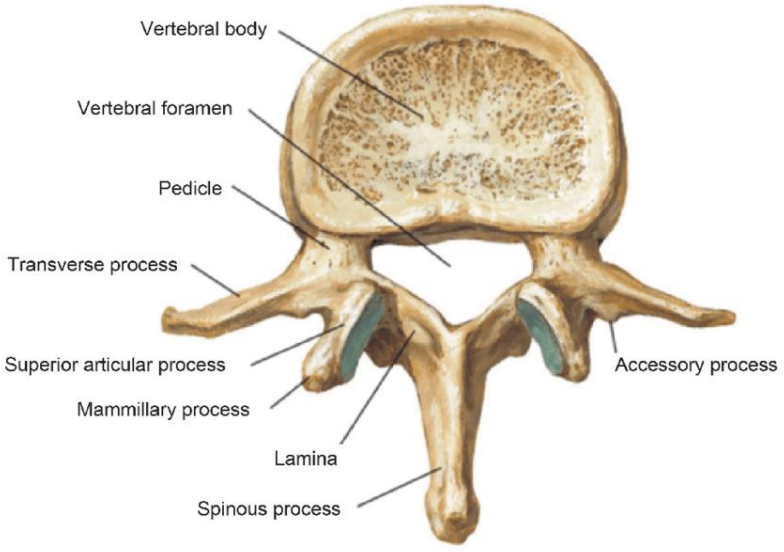


Fig. 4 – Lumbar vertebra axial view

- The superior and inferior articular processes join to form zygapophyseal joints which are synovial type located directly beneath it. The superior process extends superiorly and has medially oriented articular facets.
- In contrast, the inferior process projects laterally downward and is convex from front to back. Articular cartilage, synovial membrane, and joint capsule surround these articular surfaces. (Fig. 5) The posterior main branches provide innervation to these joints. The mammillary process is a protuberance that extends posteriorly from the edge of the superior articular process, and a smaller accessory tubercle lies below it at the base of the transverse process. [13]

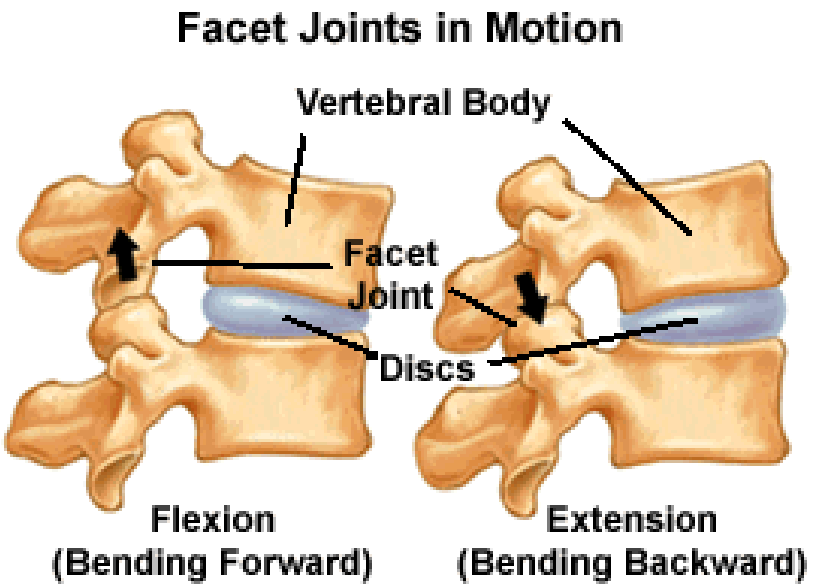


Fig. 5 – Lumbar spine showing movement at facet joints.

INTERVERTEBRAL DISC

- The intervertebral discs are large avascular tissues that receive nutrition through diffusion from blood vessels of vertebral endplates.
- These discs exists between all the vertebrae except C1-C2.
- Each disc is composed of the upper and lower vertebral endplates, with the nucleus pulposus in the center and the annulus fibrosus surrounding it. (Fig. 6)
- The fifth lumbar vertebra's inferior articular processes face forward and fit into the posterior facets of the sacrum, creating a locking mechanism that prevents the fifth lumbar vertebra from slipping forward over sacrum.

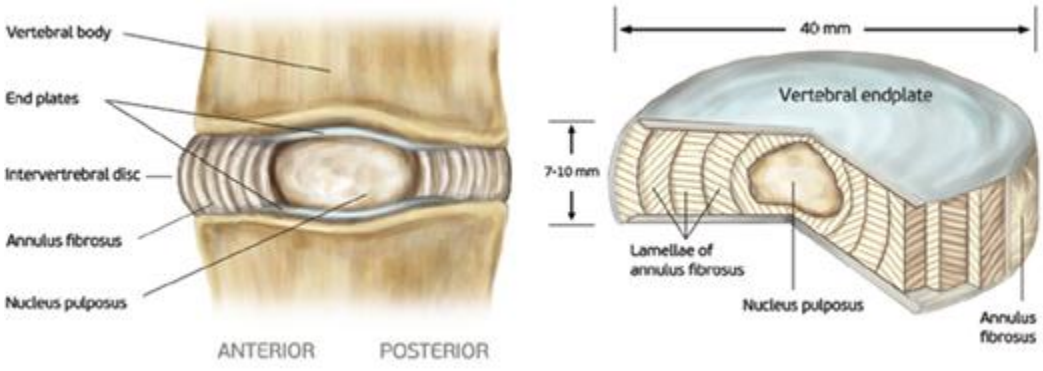


Fig. 6 – Disc anatomy

- Moreover, vertebrae are firmly connected with discs between them and maintains a high level of stability although the lumbosacral joint tilts and supports the entire weight of the body. A strongly contracted erector spinae muscle provides a supportive structure in the back.
- If the vertebral column is affected at pars interarticularis, the L5 vertebra may be prone to sliding down and forward, leading to spondylolisthesis.
- The last lumbar vertebra sometimes fuse to sacrum on one or the either sides to be termed as "sacralization." Less commonly, the first sacral vertebra may be partially or completely separated, a condition known as “lumbarization.” [14] [15]

SACRUM

- The sacrum is formed by the fusion of five progressively smaller sacral vertebrae and their costal elements, resulting in a triangular shape that curves inward toward the pelvis.
- The lateral surface features an articular area that links to the ilium, contributing to the upper posterior wall of the pelvis. Below the sacroiliac joints, the sacrum narrows towards its apex. The upper surface of the first sacral vertebra serves as the base of the sacrum.
- The first sacral vertebra is the largest with its anterior border referred to as the sacral promontory. On either side of the body lies the wing-like ala of the sacrum, which consists of fused coastal elements and transverse processes. (Fig. 7)
- The sympathetic trunk traverses the ala of the nose, the lumbosacral trunk, and the obturator nerve from a medial to lateral direction at the front. In the typical anatomical stance, the upper surface of the base slopes forward at an angle of 30 degrees or greater. From this orientation, the sacrum shifts backward before bending downward over the pelvic cavity.

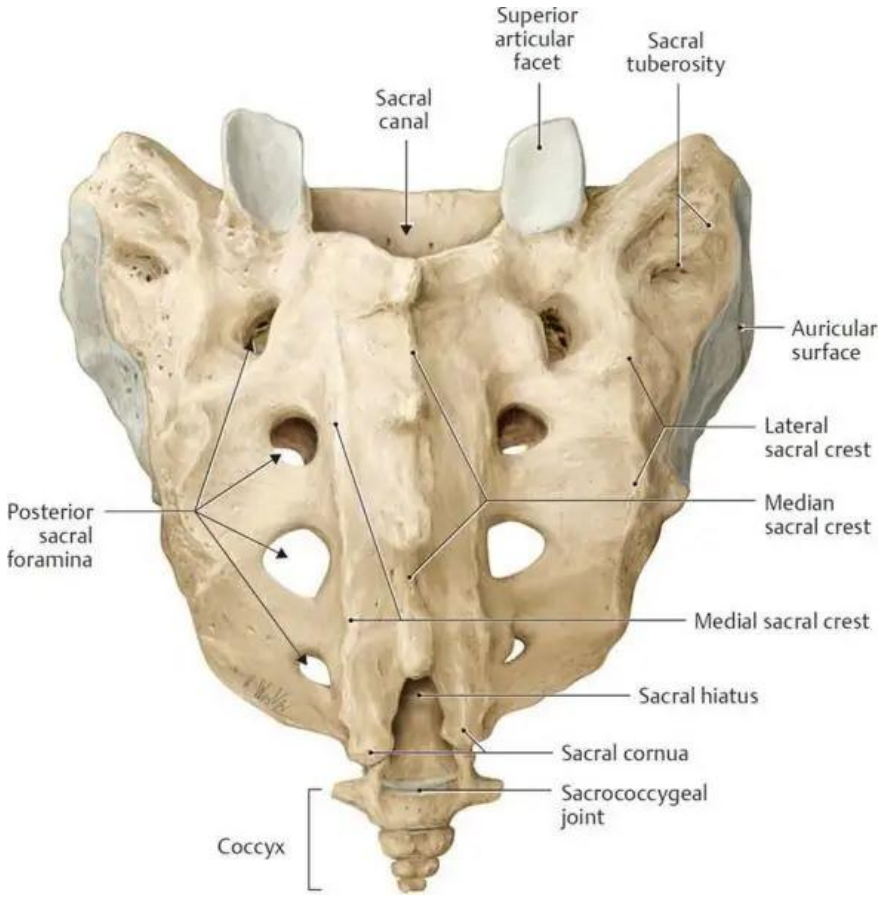


Fig. 7 – Sacrum posterior view

SPINAL CORD

- Spinal cord terminates as conus medullaris at the level of L1 vertebra. The fibrous strand connecting the conus to the dorsal side of the first coccygeal segment is the filum terminale.
- The spinal cord is encased in three protective membranes: the dura mater, the arachnoid mater, and the pia mater, arranged from the outermost to the innermost layer. The area situated between the pia mater and the arachnoid mater, known as the subarachnoid space, is filled with cerebrospinal fluid.
- At every vertebral level through intervertebral foramen the spinal nerves exit, a ganglion forms outside the foramen before the dorsal root connects with its ventral counterpart, known as the dorsal root ganglion, which can trigger a dysesthetic pain response if interfered with. (Fig. 8)
- At C2-7 level nerves exit at a segment above, while C8 nerve travels through C7 and T1 foramina. The nerve roots distal to C8 travel through a segment below.
- Spinal cord length is smaller than that of the vertebral column, leading the spinal nerves to become increasingly vertical as they travel downward.

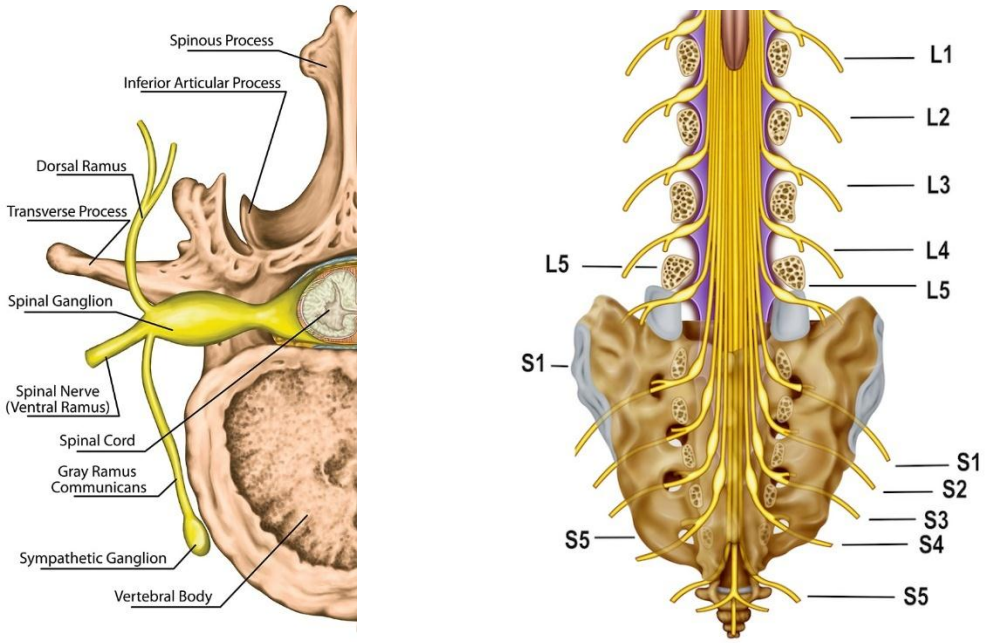


Fig. 8 – Spinal cord and Exiting nerve roots

SPONDYLOLISTHESIS CLASSIFICATION

Wiltse, Neugebouer, and Newman categorize spondylolisthesis into several types. (Fig. 9)

1) Congenital or dysplastic

2) Isthmic

3) Degenerative

4) Traumatic

5) Pathological

6) Iatrogenic

Congenital or dysplastic

- Anterior displacement of a vertebral body typically occurs at birth and is frequently linked to spinal anomalies that are part of various congenital conditions. In cases of true dysplastic spondylolisthesis, the condition may involve dysplasia of the upper sacrum, especially at the facet joints, or a thinning of the interarticular pars.
- As the displacement progresses and the isthmus becomes increasingly stretched, it may eventually fracture; this fracture is a result of the slippage rather than its initial cause. Such slippage tends to happen early in life and is often accompanied by considerable displacement.

- A key clinical characteristic of this condition is the lack of isthmus abnormalities. When no abnormalities are present, the neural arch moves forward along with the vertebra, which can result in compression of the cauda equina between the L4 and L5 vertebrae and the dorsal side of the S1 vertebra. This condition can manifest suddenly, a phenomenon referred to as a "listhetic crisis."
- A full recovery without surgical intervention is unlikely. Attempting to reduce the slip is inadvisable. A laminectomy will be necessary if there are signs of root tension or impaired root conduction. Stabilization is needed for all patients, and currently, Ala-transverse fusion is considered the most effective fusion method.

Isthmic type

- Lytic:

  This is characterized by a fracture of the pars due to stress, most frequently associated at L5 vertebrae.

  - The pathology here lies in Pars.
  - Here, listhesis usually develops at the age of 5 to 7 and progress till10 to 15 years of age and very uncommon later.
  - The major resistance to advancement arises from the robust iliolumbar ligament, the large transverse process of L5, the disc and annulus, as well as the deep positioning of L5 underneath the intercristal line.

- Symptoms may not always manifest with significant radiological findings, the pathology leading to backache may vary.

- Elongated:
  - This condition arises from multiple microfractures of the pars which heal in an elongated state.
- Trauma:
  - The lesion in the pars arises from trauma, either due to forced hyperextension or forced flexion strain. The healing of the lesion upon immobilization provides undeniable proof of the lesion's traumatic origin.

Degenerative

- Junghann(16) initially referred to this type as pseudo spondylolisthesis, but Newman later renamed it "degenerative spondylolisthesis." The degree of slip is typically minimal, with the most common site being the L4 - L5 interspace, particularly prevalent among females.
- The L4 - L5 segment of the lumbar spine usually exhibits higher mobility when compared and this accompanied with more sagittal aligned facets with stenotic changes are noted in degenerative type of listhesis.

Traumatic

- Traumatic injuries may lead to dislocations of the posterior joints or fractures in the spinous process that extend into structures deeper.

Pathological

- Widespread pathologies as seen in brittle bone disease, achondroplasia, Paget's disease with secondary deposits which weaken the pedicles allows the vertebrae to slip forward.

Iatrogenic

- This condition arises as a result of aggressive surgical techniques that destabilize the spinal segment, which is not included in this classification. It most frequently occurs following decompression for spinal stenosis without fusion, particularly when excessive portions of the facet joint are removed, resulting in a subsequent slip at the surgical level. [17]

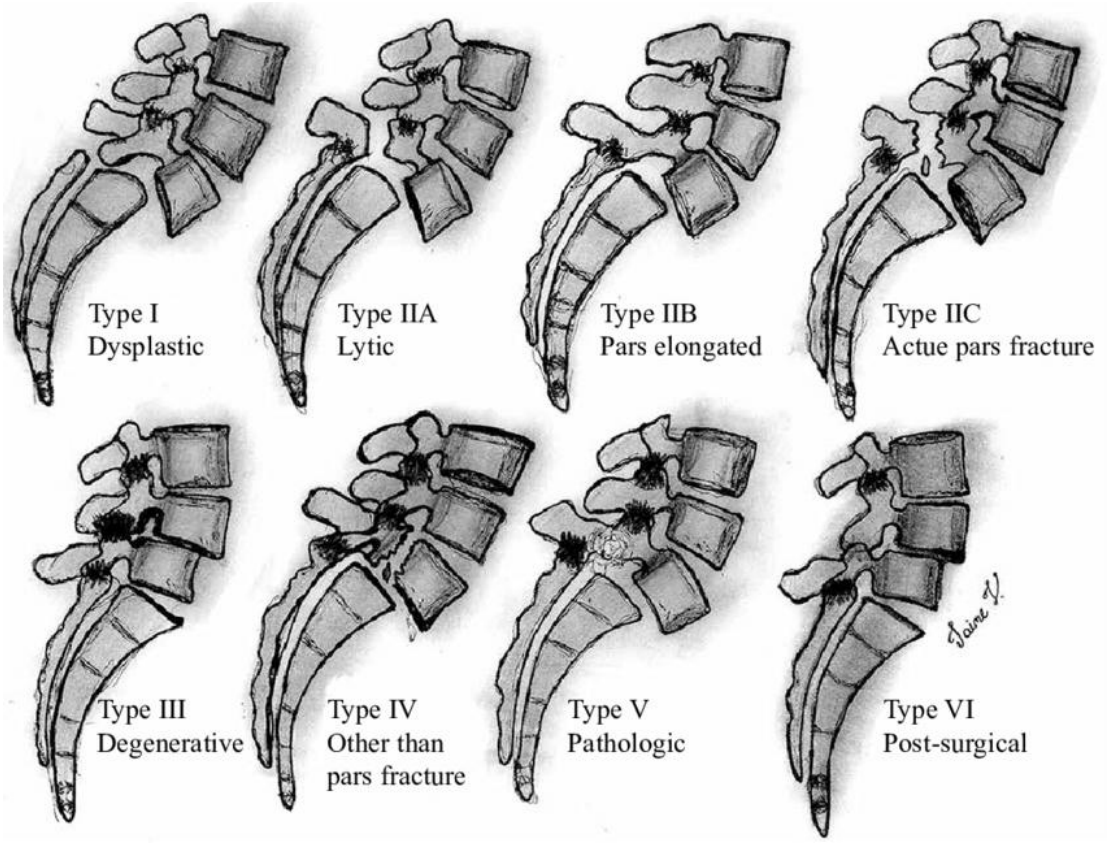


Fig. 9 – Classification according to Wiltse and Newman

Spondylolisthesis based on **Meyerding's** grading:

- To evaluate the grade of spondylolisthesis using the Meyerding classification, two vertical lines are drawn along the posterior borders of the upper and lower vertebrae, and the space between these lines is measured. Additionally, the length of the lower vertebral body is noted. The grade is determined by calculating the ratio of these measurements.: (Fig. 10)
    - Grade 1 – 0 to 25%
    - Grade 2 – 26 to 50%
    - Grade 3 – 51 to 75%
    - Grade 4 – 76 to 100%
    - Grade 5 - > 100% (Spondyloptosis)

- These grades are further classified into-
    - "low-grade": grades 1 & 2
    - "high-grade": grades 3, 4 & 5 [18]

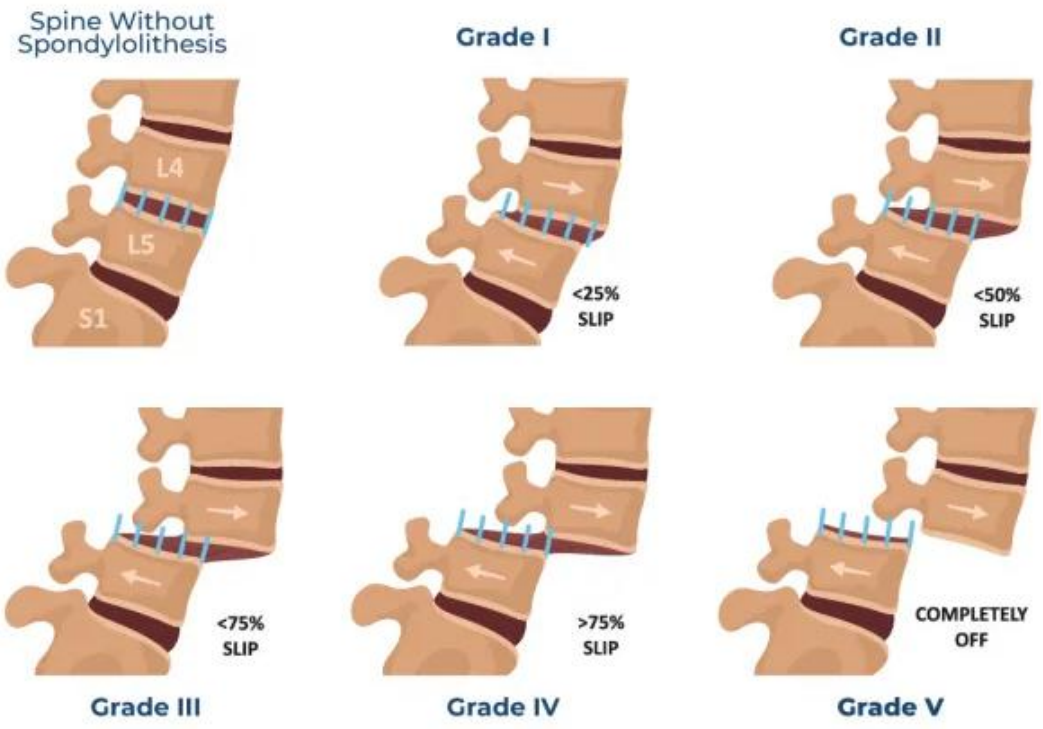


Fig. 10 –Meyerding's Classification

Spondylolisthesis based on **Marchetti and Bartolozzi classification-**

Developemental	**Acquired**
High Dysplastic	Traumatic
with Interaricular lysis	Acute fracture
with pars elongation	Stress fracture
	Post surgical
Low Dysplastic	Direct effect of surgery
with Interaricular lysis	Indirect effect of surgery
with pars elongation	Pathologic
	Local pathology
	Systemic pathology
	Degenerative
	Primary
	Secondary

The Spinal Deformity Study Group (SDSG) classification system [19] (fig. 11)

Type	Slip grade	Sacropelvic balance	Global spinopelvic balance
Type 1	< 50%	Low pelvic incidence (< 45°)	
Type 2	< 50%	Normal pelvic incidence (45°-60°)	
Type 3	< 50%	High pelvic incidence (> 60°)	
Type 4	> 50%	Balanced (high sacral slope/low pelvic tilt)	
Type 5	> 50%	Retroverted (low sacral slop/high pelvic tilt)	Balanced (C7 plumb line between the femoral heads and sacrum)
Type 6	> 50%	Retroverted (low sacral slope/high pelvic tilt)	Unbalanced (C7 plumb line anterior to the femoral head or posterior to the sacrum)

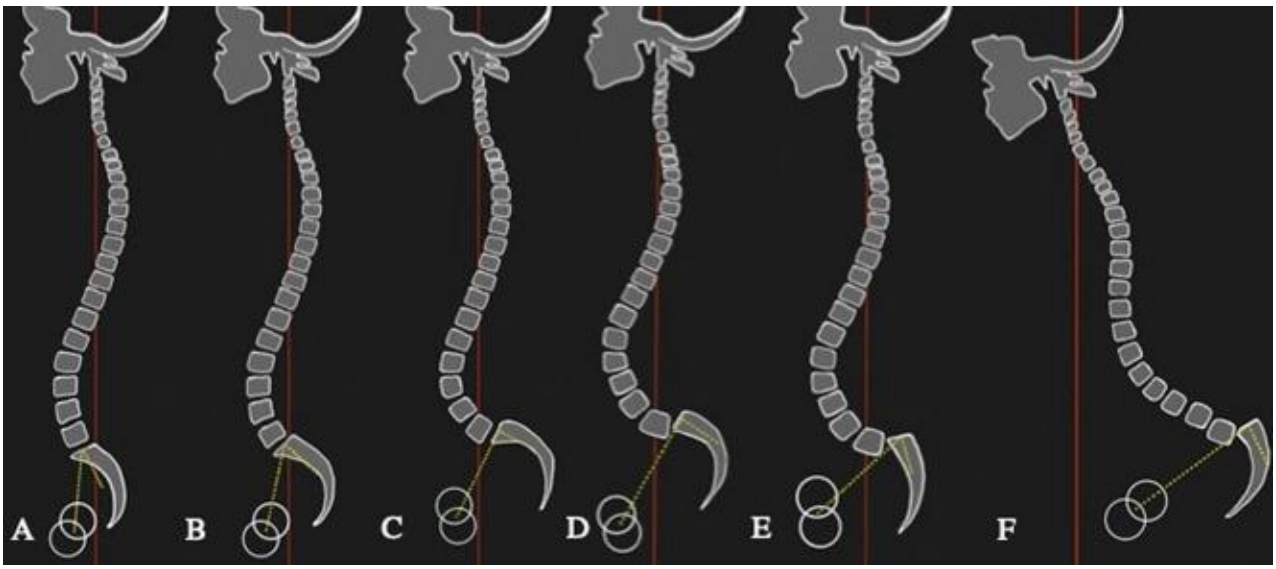


Fig. 11 – The Spinal Deformity Study Group (SDSG) Classification

ETIO-PATHO-PHYSIOLOGY OF SLIP

Spondylolisthesis, irrespective of its type, has multiple contributing factors and is most often preceded by spondylolysis. This condition encompasses the following aspects:

- A fracture of the pars interarticularis.
- This impacts the construct of vertebrae, potentially resulting in the slippage of the vertebral body, known as spondylolisthesis.
- Consequently, results with features of instability
- The slip occurs in both directions more often in forward direction, termed anterolisthesis, or in the backward direction, termed retrolisthesis.
- The genetic factors are not entirely understood, with the incidence generally ranging from 4% to 8%, while it is observed in 25% to 30% among close relatives.

BIOMECHANICS

Sagittal facet theory

- This theory suggests a tendency for slippage due to the orientation of facets that do not resist anterior translational forces, eventually leading to degenerative listhesis.

Disc degeneration theory

- It postulates that the disc narrows, causing the facets to overlap, which leads to arthritic changes, remodeling followed by anterolisthesis. No matter the exact triggering factor, this instability results in facet joint arthritis, degeneration of the disc, and hypertrophy of the ligamentum flavum. (Fig. 12)
- According to Frymoyer [20], degenerative listhesis is considered unstable in adults and represents a translational form of segmental degenerative instability. Patients typically experience recurrent back pain episodes alongside extensor muscle weakness.
- Classic radiological findings include tractional osteophytes with vacuum disc phenomena. Women particularly over 40 years are five-fold more affected than men.
- This condition primarily involves the L4-L5 interspace. The angulation at facets is cause for the pathology. Boden et al. found that individuals with degenerative listhesis have a mean facet orientation of 60°, contrasting with 41° in asymptomatic participants. [21]

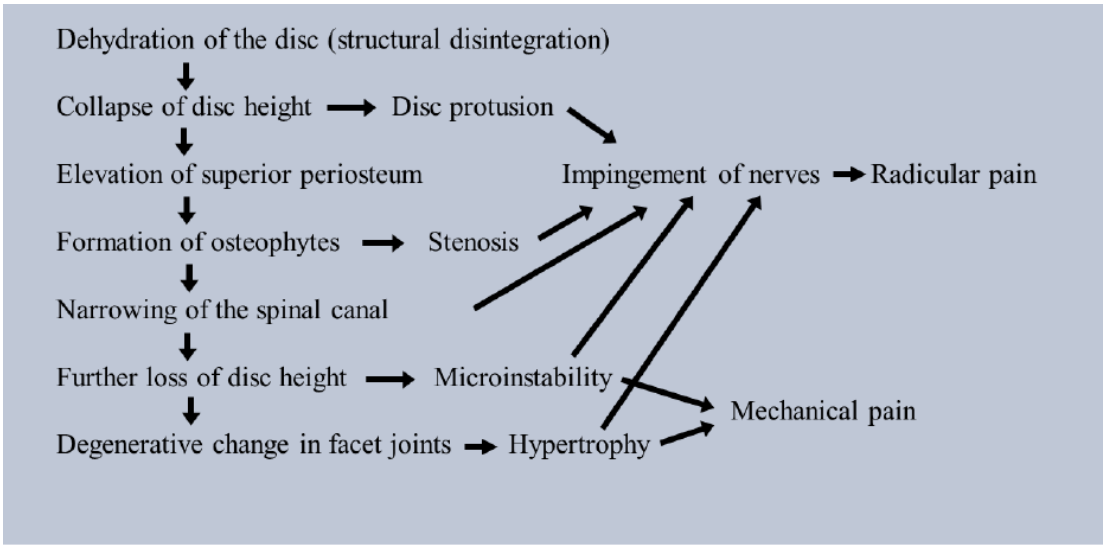


Fig. 12 – Disc Degenerative theory

Adult isthmic spondylolisthesis

- Characterized by its non-progressive nature, occurs due to stress fracture of pars after reaching skeletal maturity. Seventy-five per cent of individuals with spondylolysis also present with spondylolisthesis. However, progression of the slip is infrequently noted. [22]
- A defect in the pars interarticularis interrupts the bony hook of the spinal motion segment that is affected. The structure comprises the pedicle, isthmus, and inferior articular facet of the upper segment, along with the superior articular facet of the lower segment. Consequently, this anatomical linkage is weakened and unable to support translational instability, leading to anterior displacement of the body. The progression of L5 listhesis is rare due to the existing constraints.

- A callus develops at the pars, and fibrocartilaginous tissue typically forms in the pars region from unsuccessful attempts of fracture healing. The hook is elevated as projection anteriorly due to the overgrowth of the superior articular facet, which narrows the neural foramen.
- As nerve gets tethered in the foramina, any further progression of slip will manifest as radiating pain.

CLINICAL PRESENTATION

- Patients commonly experience low back pain with radiculopathy in cases of lumbar spondylolisthesis.
- The pain intensifies when extending the affected segment, as this can produce mechanical discomfort from movement, resulting in a reduced range of motion (ROM) in the spine. The pain diminishes when the patient adopts a flexed position, alleviating pressure on the impinged nerve.
- Pain may worsen with direct pressure applied on the affected segment.
- The discomfort may also present as radicular pain, as the nerve roots leaving the spinal column can become compressed from the narrowing of the foramina when one vertebra displaces over another, with the nerve root traveling to the adjacent level potentially impacted by associated lateral recess narrowing, disc bulging, or central canal constriction.
- Sometimes, relief in pain can occur in specific positions, like sleeping on the back. This occurs as a result of direct reduction of instability in that position by opening up canal or foraminal stenosis.
- Listhesis can be acute or exacerbated chronic affection. Patients experience severe worsening of backache and radiculopathy, hamstring spasms, and a crouched gait.
- The crouching gait, referred to as the Phalen-Dickson sign, is characterized by an upright sacrum, lumbosacral kyphosis, compensatory lordosis in the upper spine, and flexion at the knees and hips. This gait can manifest irrespective of the extent of slip present.

- Muscular atrophy and muscular weakness can be noted. Tightness or spasms in the hamstrings are not uncommon. Coordination and balance may be disrupted, leading to challenges with walking.
- Loss of bowel or bladder control is rarely seen. [23]

INVESTIGATIONS

I) Plain radiography

Views

- Anteroposterior
  - Reverse Napolean Hat sign is seen in Grade 5 Spondylolisthesis.

Fig. 13 – Reverse Napolean Hat sign

  - Spondylosis is seen as unilateral wedging of vertebral body.

Fig. 14 – Unilateral Wedging

- Lateral view
    - Meyerding's grading

  Ferguson's view (caudal tilt of 30 degrees) – to better visualize fusion when obscured by instrumentation.

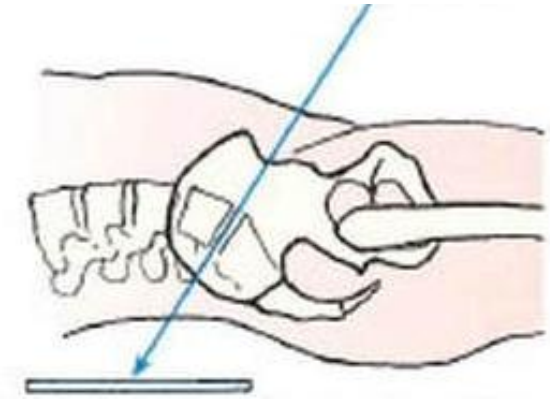


Fig. 15 – Ferguson View

- Lumbar spine oblique view ("Scotty dog" view)

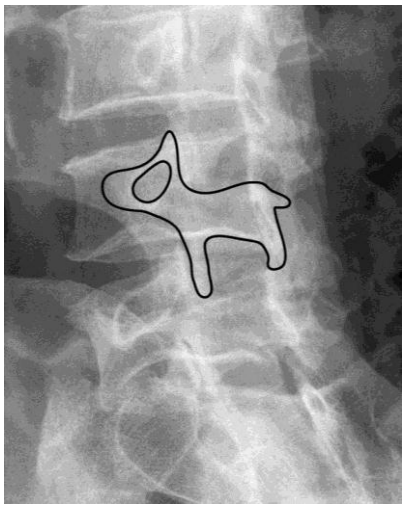


Fig. 16 – Scottish dog view

- Dynamic views – lateral view in flexion and extension.

Fig. 17,18 – Dynamic views

- Compression and traction X-rays.

Uses of special views

• Detects lucency indicating a pars fracture, particularly in cases of isthmic type.

• Applying pressure on the spine helps visualize any listhesis, making the pars fracture more apparent.

• Identifies up to 19% of pars fractures that might otherwise go unnoticed.

• Used for preoperative planning and assessing hypermobility.

• Ferguson's AP view is beneficial for evaluating the postoperative state of the posterolateral fusion mass, which is frequently obscured by the sacral ala in standard AP views.

X-rays in detail:

- AP, Lateral and Dynamic views serve as the first-line imaging for diagnosing spondylolisthesis. Primary focus is observing misalignment between adjacent vertebral bodies and assessing potential flexion and extension motion, indicating instability (translation of 4 to 5 mm or rotation of 10-15 degrees).
- In cases of isthmic spondylolisthesis, a pars defect may be present, referred to as the "Scotty dog collar." The "Scotty dog collar" is noted by hyperdensity where the collar would appear on the cartoon dog, signifying a fracture in the pars interarticularis. [24]
- The slip angle (SA) was the initial descriptor of the kyphotic alignment between L5 and S1. Along with the percentage of slippage, SA aids in evaluating instability and to see further increase in slip while being managed conservatively or surgically.
- The lumbosacral-angle (LSA) is determined using landmarks minimally impacted by listhesis, It classifies spondylolisthesis into:
    - Non-progressive, marked by a 'horizontal' sacrum that leads to an LSA of 100 or more, which infrequently requires surgical intervention, and
    - progressive, exhibiting a 'vertical' sacrum with an LSA below 100, usually symptomatic and necessitating surgical intervention.

- Additionally, if the pelvic angle measures less than 100° on preoperative hyperextension and traction radiographs, it is recommended to consider an anterior approach prior to conducting a posterolateral fusion. Among the various angles used to evaluate lumbosacral kyphosis, the pelvic angle exhibits the most significant correlation with the degree of slippage.
- "Pelvic incidence (PI) is defined as the angle formed between a line that is perpendicular to the center of the sacral plateau and a line that connects the midpoint of the sacrum to the center of the femoral heads.
- Sacral slope (SS) measures the angle of the S1 plateau in relation to the horizontal plane. Pelvic tilt (PT) is characterized as the angle between the line that runs through the midpoint of the S1 plateau and the vertical axis of the femoral heads. The relationship can be represented by the formula: PI = SS + PT. While PI may experience slight variations during childhood, it tends to remain relatively constant after skeletal maturity.
- In contrast, PT and SS are parameters of spatial orientation that can change based on the orientation or sagittal position of the sacrum and pelvis. A high PT indicates pelvic retroversion, whereas a low PT is typically linked to pelvic anteversion. (Fig. 19)"
- PI is associated with the degree of lumbar lordosis (LL), allowing for a tenfold variation between the two measurements. An elevated PI heightens the risk of developing isthmic spondylolisthesis or exacerbating dysplastic spondylolisthesis.

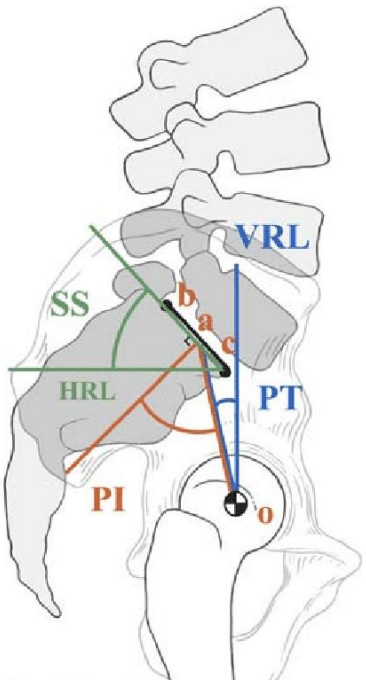


Fig. 19 – Spino-Pelvic measurements

Sagittal rotation refers to the angle created between the sacrum and the L5 vertebra. This angle is calculated by measuring the intersection between a line that follows the anterior edge of the L5 vertebral body and another line that aligns with the posterior edge of the S1 vertebra.

Radiological risk factors include:

- Dysplastic listhesis
- A dome-shaped, vertical sacrum
- A trapezoidal configuration of the L5 body
- A slip greater than 50%, specifically Grade III and IV
- An increased slip angle
- Evidence of instability

Computed tomography (CT)

CT scan of the spine offers high levels of sensitivity and specificity for diagnosing spondylolisthesis. Spondylolisthesis is more easily visualized in sagittal reconstructions compared to axial CT imaging. (Fig. 20)

Fig. 20 – CT sagittal view

II) MRI

This non-invasive method is utilized for: (Fig. 21)

- Identifying compression affecting neural structures
- Detecting early signs of disc desiccation
- Assessing spinal stenosis
- Determining facet joint overgrowth
- Examining Ligamentum flaval hypertrophy
- Identifying cysts around facets.

Sagittal cuts provide insights into:

- Discs
- Vertebral canal

Parasagittal Cuts provide:

- neuronal foramina.
- Disc desiccation on T2W images.

Fig. 21 – MRI of L/S Spine

III) Bone Scintigraphy

It is an investigation of exclusion. Bone scintigraphy rather rules out other similar pathological conditions to diagnosing spondylolisthesis.

IV) CT Myelography

This dynamic examination helps in observing the Fluid flow along conus medullaris and the nerve roots.

Indications include:

- Radiculopathy with pathological MRI findings.
- Persistent radiating pain without MRI findings
- Radiculopathy coupled with a notable deformity that makes MRI unfeasible
- Situations where MRI is contraindicated

V) Discography

During preoperative assessment of the patient, Discography finds its importance.

Indications-

Patients who present with degenerative changes in multiple segments, discography has been proven beneficial. If the localization of pain comes in favor of one or two segments, fusion surgeries are recommended.

VI) SPECT Bone Scan

This scan assesses the increase in uptake around the pars interarticularis. If increased uptake is detected, a CT scan can then be performed to evaluate the presence of thickened cortices indicative of a stress reaction or an acute stress fracture. [25]

TREATMENT

Non operative

Operative

Non-operative

This approach is applied to patients exhibiting mild symptoms and minor slippage.

- Limiting the patient's activities.
- Application of fomentation and stretching, along with a regimen of nonsteroidal anti-inflammatory drugs.
- Rehabilitation focuses on the back and abdominal muscle strengthening.
- Use of back brace occasionally.
- Selective nerve root injection (SNRI) under fluoroscopic guidance using corticosteroids, typically performed as a series of three injections spaced three weeks apart, is a common procedure.

- This alleviates symptoms, enabling patients to exercise more vigorously.

For asymptomatic patients with a 25% to 50% slippage, Wiltse

- advised against participating in contact sports
- avoiding activities with risk of injuries to the spine.
- Lateral radiographs of lumbar-sacral junction in standing should be taken every half yearly ideally until growth is complete. This is particularly crucial for females at a higher risk of slippage progression.[26] [27]

Operative

Indications

- The primary reason is ongoing, intolerable backache and leg pain.
- Radiating pain.
- Worsening neurological deficits.
- Worsening of slippage.
- Continuously tight hamstrings, abnormal walking patterns, or deformities of the pelvic and trunk.

Surgical options

- Pars Repair.
- Decompression.
- In-situ Fusion.
- Bilateral posterolateral fusion.
- ALIF - Anterior Lumbar Interbody Fusion
- TLIF - Transforaminal Lumbar Interbody Fusion
- PLIF - Posterior Lumbar Interbody Fusion
- Posterior Instrumentation with Reduction and Fusion
- Anterior Fusion and release with posterior Fusion (360-degree Fusion).
- Cast reduction and Fusion. [28]

1. Pars repair

A high success rate is expected if the pars defect is the primary pain source and there are no radicular symptoms. Directly repair includes bone graft, osteosynthesis, decortication. Stabilization is attained by hooks, screws or tension band wiring.

Techniques include

Buck technique - screws are passed across pars defect [29]

Braford technique – segmental wire fixation along with bone grafting is [30]

2. Decompression

Without fusion

Indicated when instability is minimal and doesn't cause symptoms.

Techniques

- Gill's laminectomy decompression.
- Fenestration decompression (limited decompression).
- Hemilaminectomy. [31]

With Fusion

The indications for Fusion are:

- Maintained disc height.
- Presence of osteoporosis.
- Instability in dynamic views.

- Absence of osteophytes.

Outcomes are more favorable when Fusion is included and is now considered standard practice. [32]

TYPES OF FUSION

Posterolateral fusion

This is advised for patients with low grade slips whose symptoms persist despite conservative approaches. An isolated laminectomy is not recommended. Reduction is not generally required in all cases for instance, low-grade isthmic types often successfully treated with in situ fusion, achieving about 90% positive outcomes. True anteroposterior (Ferguson's) views of the lumbar-sacral junction are necessary to assess the success of arthrodesis. For adult patients with isthmic spondylolisthesis, standard treatment involves fusing from L5 to S1, with or without instrumentation, utilizing autogenous bone grafting. [33] [34]

Interbody fusion

Ideal candidates for interbody Fusion include:

- Single level affection with radiating pain
- Absence of degenerative changes
- Maintained disc height.
- Small transverse process at fusion level

ALIF (Anterior Lumbar Interbody Fusion)

The procedure can be done in combination with posterior instrumentation or alone.

Advantages

- Extensive approach to the intervertebral disc with ability to perform complete discectomy result in higher fusion rates.
- Complete release of ligamentous structures.
- Avoidance of stripping posterior muscles.
- Prevention of epidural scarring
- Supports anterior column.

Disadvantages

- Challenges in attainment of rigid construct.
- Risk of graft failure or implant migration.
- Possibility of injury to iliac veins and the autonomic plexus, which can lead to bleeding and urinary complications. [35,36]

PLIF (Posterior Lumbar Interbody Fusion)

This procedure allows surgeons to fuse all three columns of the affected spinal segment through a single incision on the posterior side. This technique is biomechanically sound as compressive forces travel anteriorly through disc space. Initially introduced by CLOWARD [37] to address lumbar disc herniation, its early popularity declined due to a high incidence of

pseudoarthrosis and graft dislodgement. However, modern advancements in instrumentation and methodology have led to a resurgence in using the PLIF technique, particularly with threaded interbody fusion cages. The technique is built on four key principles:

- Ensure the integrity of the posterior motion segment to provide stability and compression for the graft.
- Safeguard the cortical endplates to avoid embedding the graft within the soft cancellous bone of the vertebral bodies.
- Optimize the extraction of disc material.
- Fill the disc space with a compacted autogenous bone graft. [38,39]

Advantages

- A single incision.
- Corrects the slip angle.
- Maintains disc height.
- A success rate of fusion is comparatively high.
- Eliminating the need for a second surgery to support the anterior column.
- Reduced risk of iatrogenic trauma to hypogastric plexus.

Disadvantage

- The procedure is technically challenging.
- Risk of displacement of graft.
- Risk of destabilization of spinal columns.

- An increased risk of nerve root injuries, dural tears, and epidural fibrosis due to excessive retraction. [40]

Contraindications

- Epidural scarring that prevents root mobilization.
- Osteoporosis.

Pathological conditions located above the mid-lumbar level, particularly at the conus level or higher. [41]

TLIF (Transforaminal Lumbar Interbody Fusion)

It was introduced by Harms as an alternative to PLIF, requiring less retraction of neural elements, thereby minimizing the risk of neural injuries. There are no significant differences in blood loss, duration of hospital stay, or surgical time between PLIF and TLIF, but TLIF has a lower complication rate [42]. Interbody fusion can be achieved using one or two cages unilaterally or bilaterally. Theoretical benefits of ALIF include the thorough resection of the potentially symptomatic disc and the capacity to place a graft in the interspace. Indirect nerve root decompression is achieved by increasing the height of the intervertebral disc space, which alleviates the vertical pressure on the neural foramen. Anterior column fusion can be performed using either a transforaminal posterior approach or a direct anterior approach. The transforaminal interbody fusion technique is now widely employed; it allows for grafting of both the anterior and posterior columns, direct decompression of one or both L-5 roots, and attainment of rigid posterior fixation.[43]

Circumferential fusion

This procedure entails distinct anterior and posterior methods for accessing the spine. It is technically intricate and carries a considerable risk of complications. It is best suited for patients who exhibit significant instability or substantial anterior bone loss due to conditions like osteomyelitis. In instances of degenerative diseases, this approach is typically limited to those suffering from severe disability, particularly in patients with a background of several unsuccessful spinal surgeries.

Indications

- Patients who are at risk of pseudoarthosis.
- Involvement at multiple levels with significant segmental instability (due to infection or trauma).
- Need for anterior column support in individuals with considerable osteoporosis.
- The combination of interbody fusion and PL fusion has proven effective in achieving fusion and preventing progression in high-grade spondylolisthesis. [44]

When compared to distraction constructs and Luque rods or rectangles, pedicle screw implants have shown better effectiveness in preserving anatomical alignment. At the same time, the latter is associated with a worsening of anterolisthesis. The fusion success rate is also higher (86%) with pedicle screws compared to rod constructs (69%).

Factors contributing to fusion failure include:

- Tobacco use is among the most significant cause of fusion failure.
- The use of anti-inflammatory medications.
- Attempting fusion without instrumentation.

Complications

- A higher incidence of wound infections with instrumented fusion.
- Accelerated degeneration of adjacent segments.
- Failure of graft.
- Neurologic impairments.
- SIADH syndrome (syndrome of inappropriate antidiuretic hormone secretion). [45]

Reduction

- Low grade spondylolisthesis is generally managed through fusion in situ leading to satisfactory outcomes, unlike high-grade slips. The pathological changes observed in high-grade slips include lumbosacral kyphosis, which begins when the slip of L5 relative to S1 crosses 50%.
- Root compression occurs more frequently with high-grade slips, and it may also stretch the sacral nerve roots over the L5-S1 disc and the posterior dome of the sacrum, leading to cauda equina symptoms. [46]
- Various reduction methods have been suggested, with most authors highlighting about the major aim to correct lumbosacral kyphosis, while reducing the slip is next priority. The kyphosis has the most detrimental impact on the balance of the lumbar spine and trunk, making its reversal crucial. [47]

Advantages

- Reduction decreases the slip angle, putting less tensile stress on the fusion mass.
- It relieves pressure on the anterior part of the sacrum, promoting sacral remodeling.
- It mitigates the risk of deformity progression.
- The physical appearance of the affected individual improves.

Complication

- Associated complications with this procedure pose a high risk of L5 nerve injury, with reports indicating up to 40% occurrence. Although many of these cases are resolved, there is potential for permanent injuries, including foot drop and lasting disability.

Minimizing the risk of neurological injury can be accomplished by:

- Staging the procedure with a 1–2-week interval between surgeries.
- Performing sacral dome osteotomy to shorten the spine when excess axial lengthening is expected, utilizing neurological monitoring and conducting one or more wake-up tests.
- Accepting partial reduction

Reduction techniques can also be used in combination with other fusion methods.

SCREW INSERTION TECHNIQUE

Screw insertion sites were identified and detailed by Roy-Camille, Saillant, Mazel, and Louis. The primary reference points are the facet joint space and the center of the transverse process. A drill or hand curette is used to create an opening in the pedicle, followed by the insertion of a self-tapping screw through the pedicle into the vertebral body. The pedicles of the thoracic and lumbar vertebrae are tubular bony structures that link the anterior and posterior columns of the spine. The dural sac is situated medially to the inner wall of the pedicle, while the nerve root is positioned beneath this medial wall, within the neural foramen. The lumbar roots are typically found in the upper third of the foramen, making it riskier to penetrate the pedicle medially or inferiorly than laterally or superiorly. [48]

The following techniques may be employed,

The intersection technique

- This is frequently employed technique for identifying pedicles. It requires drawing a line from the lateral aspect of the facet joint that intersects a line bisecting the transverse process at a location overlying the pedicle. [49] (Fig. 22,23,24)

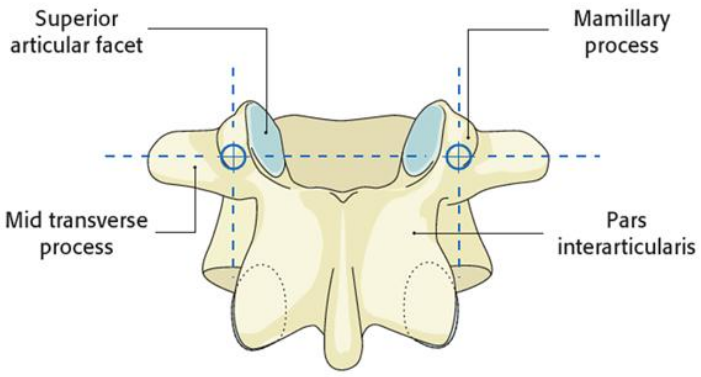


Fig. 22 – posterior landmarks for screw insertion

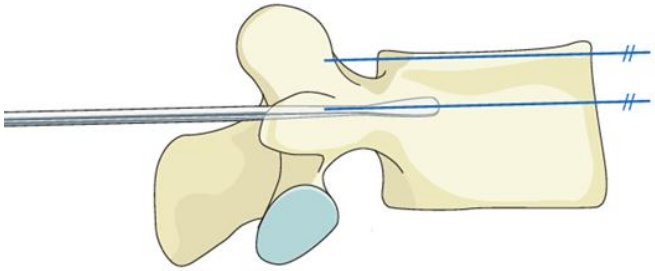


Fig. 23 - lateral view landmarks for screw insertion

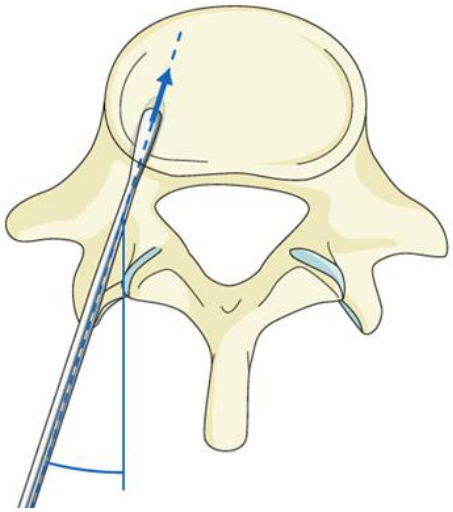


Fig. 24 - axial view landmarks for screw insertion

The pars interarticularis technique:

- The interarticular pars refers to the bony region where the pedicle connects with the lamina. This area is easily recognizable during surgical procedures, as the laminae and interarticular pars serve as key reference points for locating the starting position of a pedicle drill. Patients suffering from isthmic spondylolisthesis typically exhibit a relatively small transverse process at the L-5 level.
- Additionally, due to the characteristics of the interarticular pars defect, its lateral side is often difficult to access for decortication and bone grafting. Consequently, when placing a pedicle screw, it is essential to position the L-5 screw as medially as possible to optimize the surface area of the transverse process available for decortication and grafting.

The mammillary process technique

- The mammillary process, a minor projection located at the base of the transverse process, acts as the entry point. In the pars interarticularis technique, the starting point is positioned more medially compared to the intersection technique, which is also situated more medially than the mammillary process. (Fig. 25)

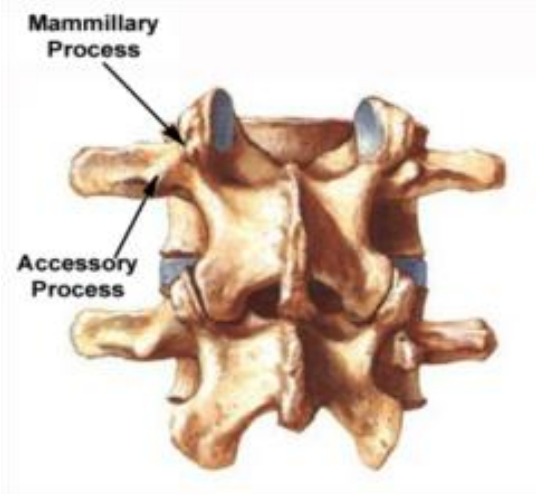


Fig. 25 – Screw insertion through Mammillary process technique

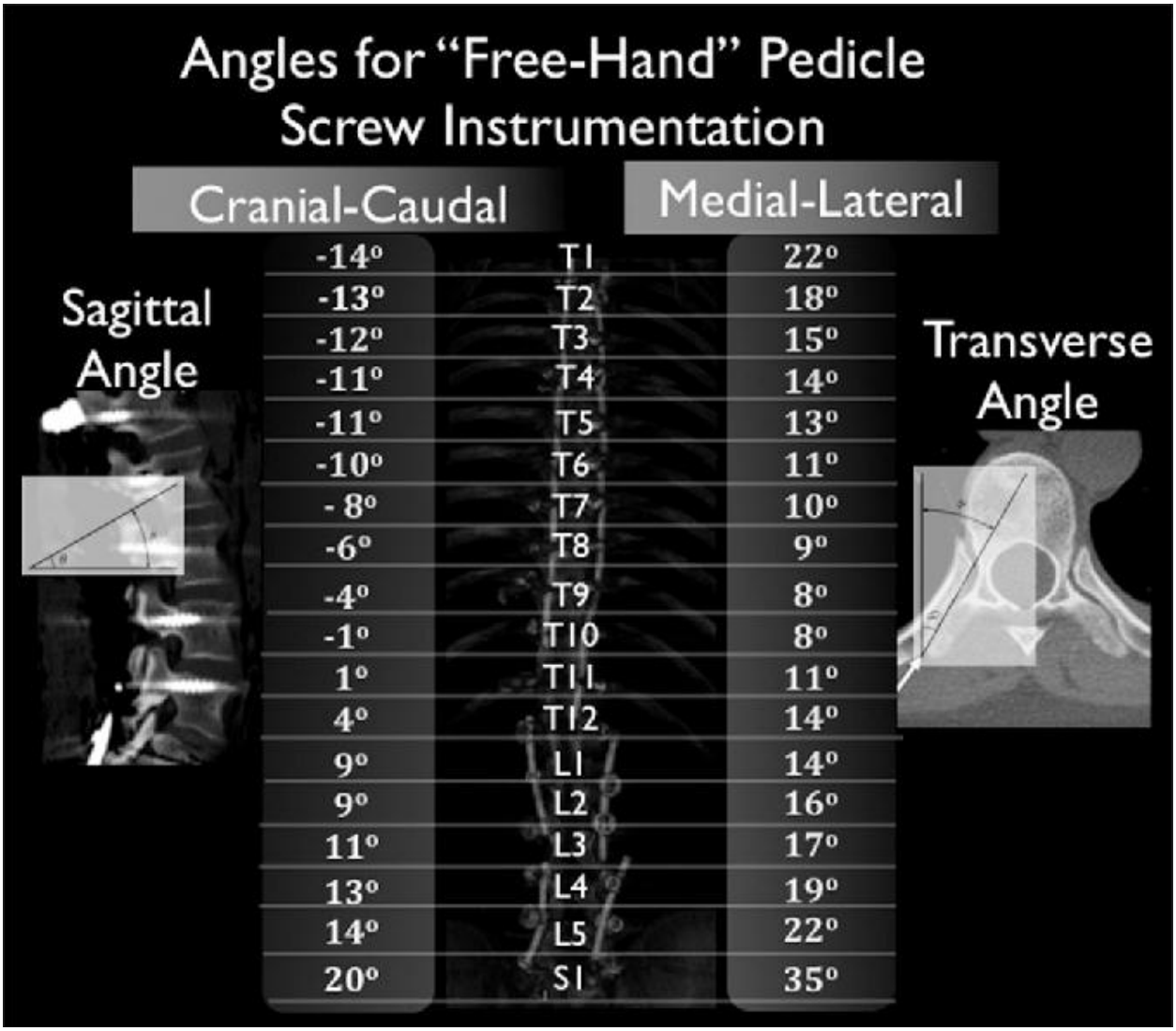


Fig. 26 – Screw insertion angles using free hand technique (50)

MATERIALS AND METHODS

- This study consists of patients admitted to the Department of Orthopedics in B.L.D.E. (DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Hospital and Research Centre, Vijayapura with the diagnosis of lumbar spondylolisthesis.
- The patients will be informed about the study in all respects and informed written consent would be obtained.
- The period of study will be from 1st March 2023- 1st March 2025
- Follow up period will be 1 month, 3 months, and 6 months.

DESIGN OF STUDY: PROSPECTIVE STUDY

METHOD OF COLLECTION OF DATA:

- Patients admitted to the department of Orthopedics in B.L.D.E. (DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Hospital and Research Centre,
    - by clinical examination.
    - history taking
    - Diagnosis- Clinical and Radiological

ETHICAL CONSIDERATION

Necessary ethical clearance was obtained from the Institutional Ethics Committee.

INCLUSION CRITERIA

- Age 18 years and above.
- Patients diagnosed with spondylolisthesis with failed conservative management.
- Neurological deficit
- Neurological claudication
- Patients giving consent for surgery.

EXCLUSION CRITERIA

- Patients with previous spinal surgeries.
- Patients with congenital spinal deformities.
- Patients medically unfit for surgery.

SAMPLE SIZE CALCULATION:

- As per the study done by Mohammad Reza Etemadifar et al, Considering the VAS score of back pain, the Mean of these studies to be 9 with +/- 1.3 Standard deviation and margin of error 0.5. The sample size computed using the following formula

Sample size (n) = $(Z * \sigma/d)^2$

- Where,
- n is the population size
- z is the z score= 2.17
- d is the margin of error= 0.5
- σ is the Standard Deviation =1.3
- α is the level of significance =0.03
- The estimated sample size of this study is 32.

STATISTICAL ANALYSIS:

The data obtained is entered in a Microsoft Excel sheet, and statistical analyses are performed using a statistical package for the social sciences (SPSS) (Version 20).

Results are presented as Mean, SD, counts and percentages, and diagrams. For normally distributed continuous variables between the two groups will be compared using an independent sample test. For not normally distributed variables, the Mann-Whitney U test is used. For Categorical variables between the two groups, are compared using the Chi-square test/Fisher's exact test. If there are more than two groups we will use ANOVA, For not normally distributed, Kruskal-Walli H Test. If p<0.05 will be considered statistically significant. All statistics are performed two-tailed.

PROCEDURE

- A thorough initial examination was carried out to assess the neurological impairments, and X-rays and MRI scans were utilized to verify the severity of the condition. Further evaluations were conducted, such as a complete blood count and blood glucose tests.

- The patients were informed in detail about the necessity of the surgery and its significance and potential complications. The necessary forms were completed, and the preoperative plan was established.

- The planning process included an evaluation of the patient's medical history, acquisition of preoperative dynamic anteroposterior and lateral radiographs and MRIs, determination of slippage severity based on the Meyerding classification, and recording preoperative scores on the Visual Analog Scale and modified Oswestry Disability Index.

- Clinical and radiological evaluations were conducted at 1, 3, and 6 months following surgery, utilizing postoperative Visual Analog Scale and Oswestry Disability Index scores, along with radiographic imaging.

FUNCTIONAL OUTCOME EVALUAYTION DONE BY THE FOLLOWING SCORING SYSTEMS

1. MODIFIED OSWESTRY LOW BACK DISABILITY SCORE-

- this questionnaire is based on difficulty in performing 10 following daily activities

Daily living.
Pain intensity.
Personal care
Lifting
Walking
Sitting
Standing
Sleeping
Social life
Travel
Employment/ homemaking. [51] [52] [53]

ODI score (percentage)	Interpretation
0% to 20%	Minimal disability - No treatment may be indicated except for suggestions on lifting, posture, physical fitness and diet. In the case of sedentary patients, more problems may need to be addressed.
21% to 40%	Moderate disability - Conservative treatment may be sufficient. The level of impairment increases and patients may experience more problems with sitting, standing, sexual activity or traveling.
41% to 60%	Severe disability – Recommendation for detailed evaluation as pain is primary problem.
61% to 80%	Patient is crippled – back or leg pain are impacting daily living. Recommendation for active treatment.
81% to 100%	Patient bedbound or exaggerating their symptoms.

Patient Name:_____ **Date**_____

Modified Oswestry Low Back Pain Disability Questionnaire[a]

This questionnaire has been designed to give your doctor information as to how your back pain has affected your ability to manage in everyday life. Please answer every section and mark in each section only ONE box that best describes your condition today. We realize you may feel that two of the statements may describe your condition, but **please mark only the box that MOST CLOSELY describes your current condition**.

Pain Intensity
- ☐ I can tolerate the pain I have without having to use pain medication.
- ☐ The pain is bad, but I can manage without having to take pain medication.
- ☐ Pain medication provides me with complete relief from pain.
- ☐ Pain medication provides me with moderate relief from pain.
- ☐ Pain medication provides me with little relief from pain.
- ☐ Pain medication has no effect on my pain.

Personal Care (e.g., Washing, Dressing)
- ☐ I can take care of myself normally without causing increased pain.
- ☐ I can take care of myself normally, but it increases my pain.
- ☐ It is painful to take care of myself, and I am slow and careful.
- ☐ I need help, but I am able to manage most of my personal care.
- ☐ I need help every day in most aspects of my care.
- ☐ I do not get dressed, I wash with difficulty, and I stay in bed.

Lifting
- ☐ I can lift heavy weights without increased pain.
- ☐ I can lift heavy weights, but it causes increased pain.
- ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if the weights are conveniently positioned (e.g., on a table).
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned.
- ☐ I can lift only very light weights.
- ☐ I cannot lift or carry anything at all.

Walking
- ☐ Pain does not prevent me from walking any distance.
- ☐ Pain prevents me from walking more than 1 mile. (1 mile = 1.6 km).
- ☐ Pain prevents me from walking more than 1/2 mile.
- ☐ Pain prevents me from walking more than 1/4 mile.
- ☐ I can walk only with crutches or a cane.
- ☐ I am in bed most of the time and have to crawl to the toilet.

Sitting
- ☐ I can sit in any chair as long as I like.
- ☐ I can only sit in my favorite chair as long as I like.
- ☐ Pain prevents me from sitting for more than 1 hour.
- ☐ Pain prevents me from sitting for more than 1/2 hour.
- ☐ Pain prevents me from sitting for more than 10 minutes.
- ☐ Pain prevents me from sitting at all.

Standing
- ☐ I can stand as long as I want without increased pain.
- ☐ I can stand as long as I want, but it increases my pain.
- ☐ Pain prevents me from standing for more than 1 hour.
- ☐ Pain prevents me from standing for more than 1/2 hour.
- ☐ Pain prevents me from standing for more than 10 minutes.
- ☐ Pain prevents me from standing at all.

Sleeping
- ☐ Pain does not prevent me from sleeping well.
- ☐ I can sleep well only by using pain medication.
- ☐ Even when I take medication, I sleep less than 6 hours.
- ☐ Even when I take medication, I sleep less than 4 hours.
- ☐ Even when I take medication, I sleep less than 2 hours.
- ☐ Pain prevents me from sleeping at all.

Social Life
- ☐ My social life is normal and does not increase my pain.
- ☐ My social life is normal, but it increases my level of pain.
- ☐ Pain prevents me from participating in more energetic activities (e.g., sports, dancing).
- ☐ Pain prevents me from going out very often.
- ☐ Pain has restricted my social life to my home.
- ☐ I have hardly any social life because of my pain.

Traveling
- ☐ I can travel anywhere without increased pain.
- ☐ I can travel anywhere, but it increases my pain.
- ☐ My pain restricts my travel over 2 hours.
- ☐ My pain restricts my travel over 1 hour.
- ☐ My pain restricts my travel to short necessary journeys under 1/2 hour.
- ☐ My pain prevents all travel except for visits to the physician / therapist or hospital.

Employment / Homemaking
- ☐ My normal homemaking / job activities do not cause pain.
- ☐ My normal homemaking / job activities increase my pain, but I can still perform all that is required of me.
- ☐ I can perform most of my homemaking / job duties, but pain prevents me from performing more physically stressful activities (e.g., lifting, vacuuming).
- ☐ Pain prevents me from doing anything but light duties.
- ☐ Pain prevents me from doing even light duties.
- ☐ Pain prevents me from performing any job or homemaking chores.

FOR OFFICE USE ONLY

Score: /50 x 100 = ____% points

Scoring: For each section the total possible score is 5: if the first statement is marked the section score = 0, if the last statement is marked it = 5. If all ten sections are completed the score is calculated as follows: Example: 16 (total scored) / 50 (total possible score) x 100 = 32%

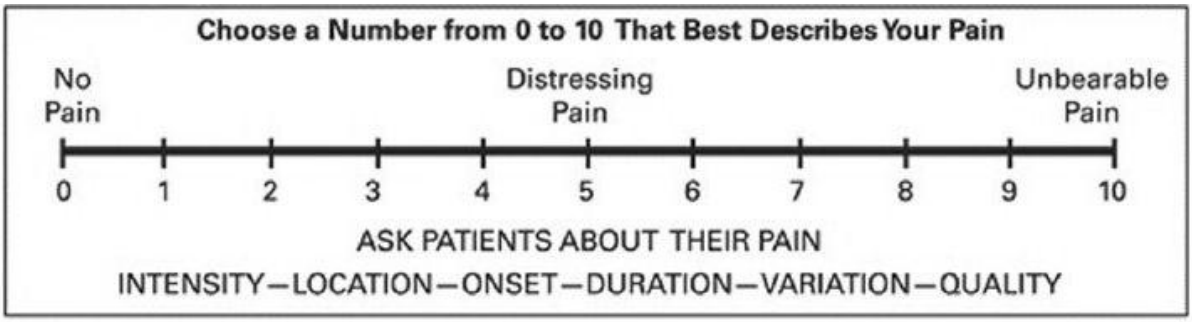
If one section is missed or not applicable the score is calculated: 16 (total scored) / 45 (total possible score) x 100 = 35.5%

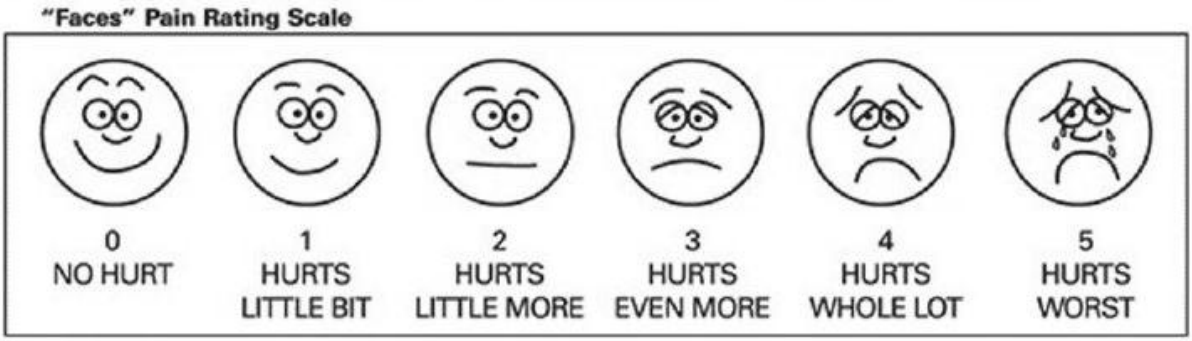
Minimum Detectable Change (90% confidence): 10% points (Change of less than this amount may be attributed to error in the measurement.)

Source: Fritz JM, Irrgang JJ. A comparison of a modified Oswestry Low Back Pain Disability Questionnaire and the Quebec Back Pain Disability Scale. Physical Therapy. 2001;81:776-788.

[a]Modified by Fritz & Irrgang with permission of The Chartered Society of Physiotherapy, from Fairbanks JCT, Couper J, Davies JB, et al. The Oswestry Low Back Pain Disability Questionnaire. Physiotherapy. 1980;66:271-273.

2. VISUAL ANALOGUE SCORE-





DESCRIPTION OF PEDICLE SCREW FIXATION WITH POSTEROLATERAL FUSION OF LUMBAR SPONDYLOLISTHESIS PROCEDURE

Anaesthesia

- The procedure is conducted under general anesthesia. The patient is intubated and placed on a ventilator. Pre-operative intravenous antibiotics are administered.

Position

- Urinary catheter is inserted, patient in put in a prone position with help of bolsters, on an operating table designed for radiolucent use in hyperextension to enhance lumbar lordosis, allowing the abdomen to hang freely with well-padded pressure points. (Fig. 27, 28)
- The following instruments and implants shown in Fig. 29 -37 are to be kept ready autoclaved. Scrub, painting and draping of the parts needs to be done. (Fig. 38)

Fig. 27 – Positioning of the patient from side

Fig. 28 – Positioning of the patient from top

Instruments and Implants:

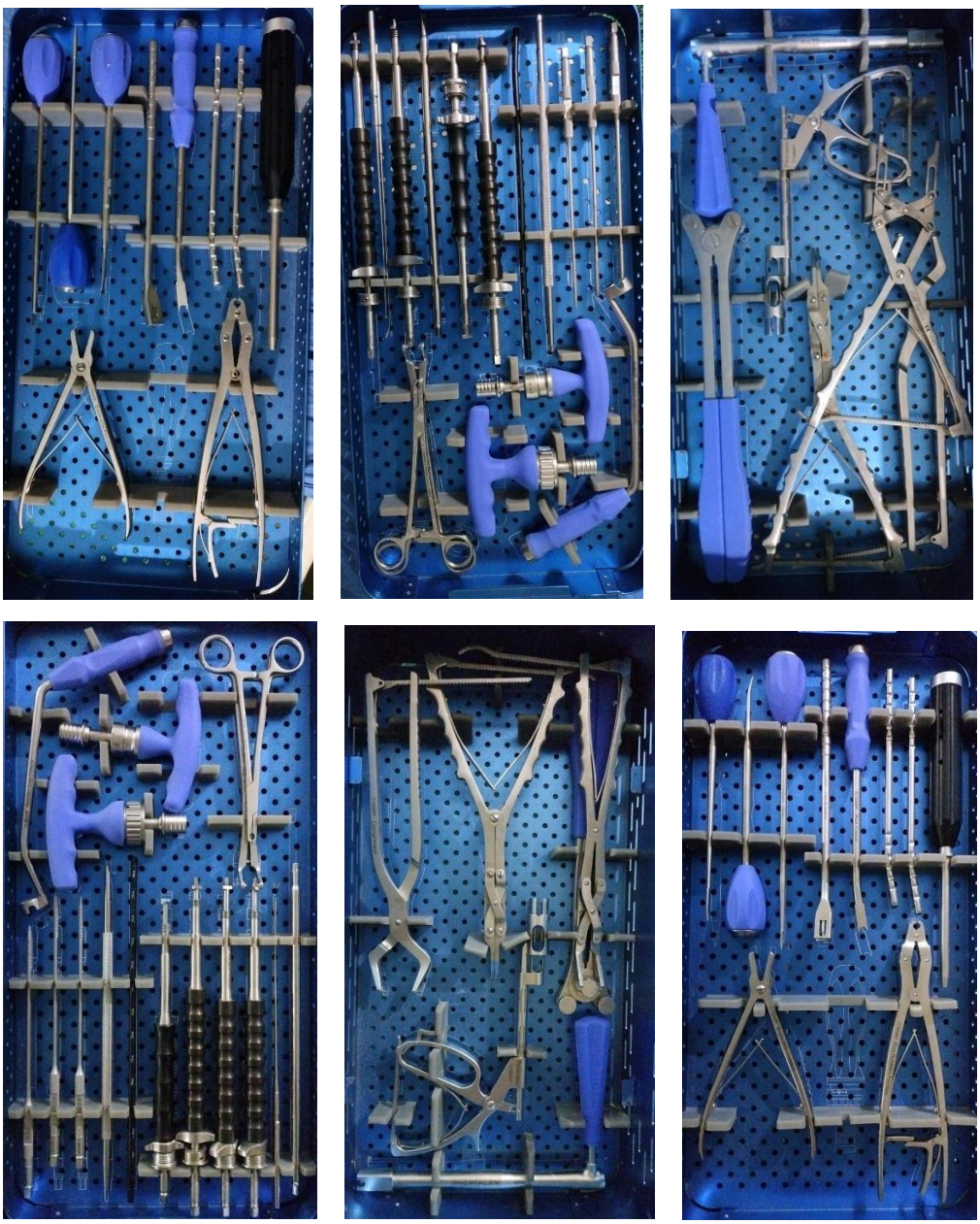


Fig. 29 – 34 - Instruments

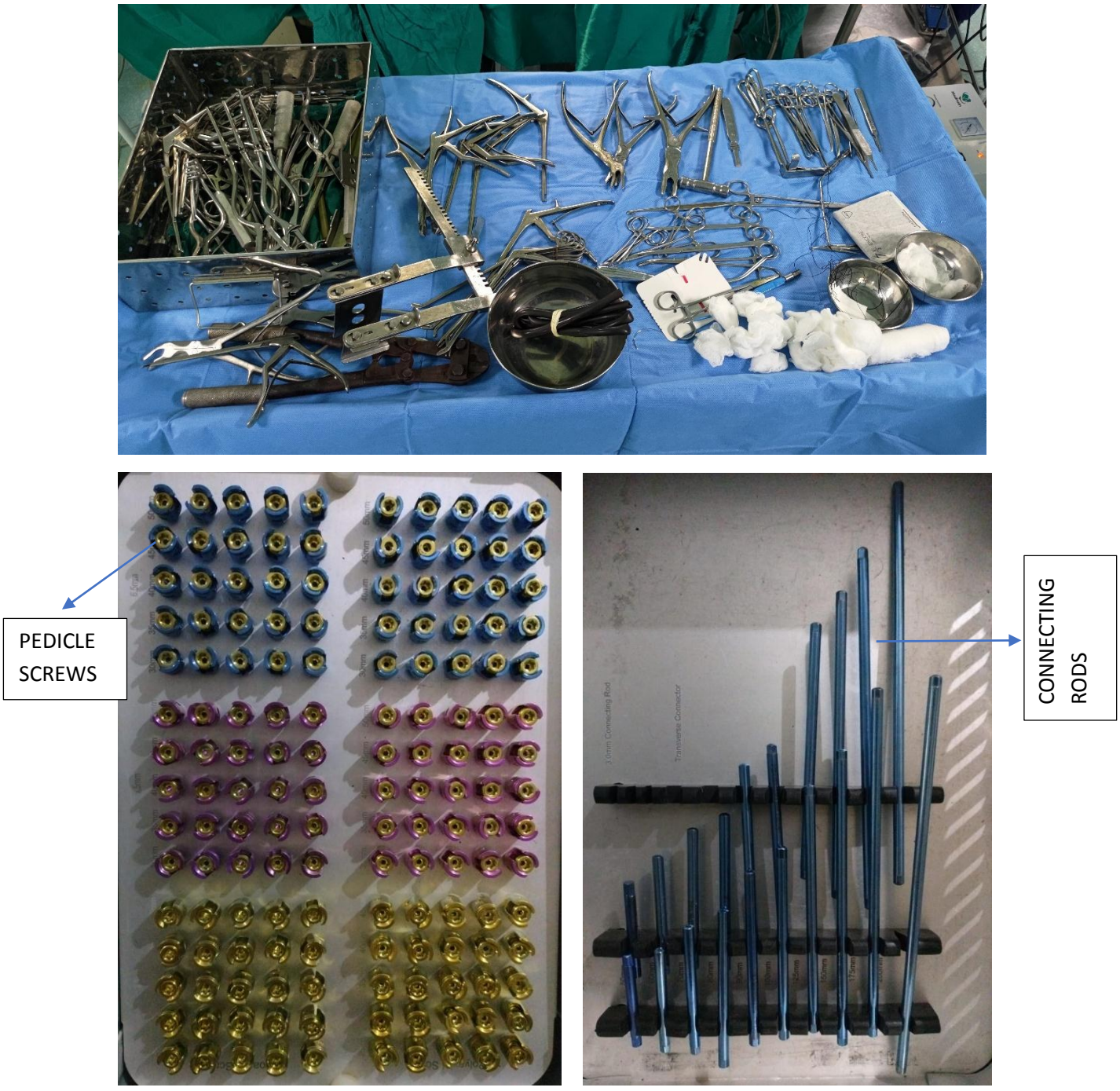


Fig. 35 – 37 Instruments and Implants

Incision and procedure:

- The surgical site is scrubbed, cleaned with antiseptics, and draped (Fig. 38). A 10–15-centimeter midline incision is taken (Fig. 39).
- Deep fascia being incised in the same plane, with paraspinal muscles stripped or cauterized along the lamina. (Fig. 40)
- Retractors are positioned for adequate exposure (Fig. 41), followed by confirmation of the spinal level for surgery using an image intensifier.

Fig. 38 - Draping

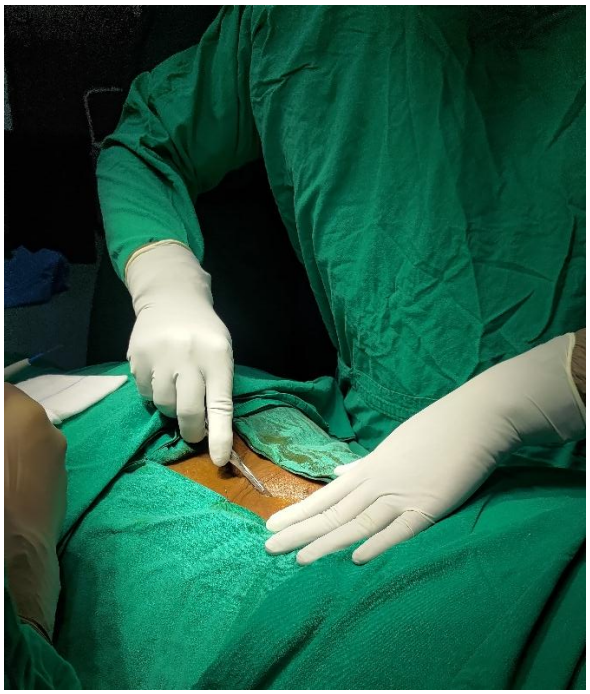


Fig. 39 - Incision

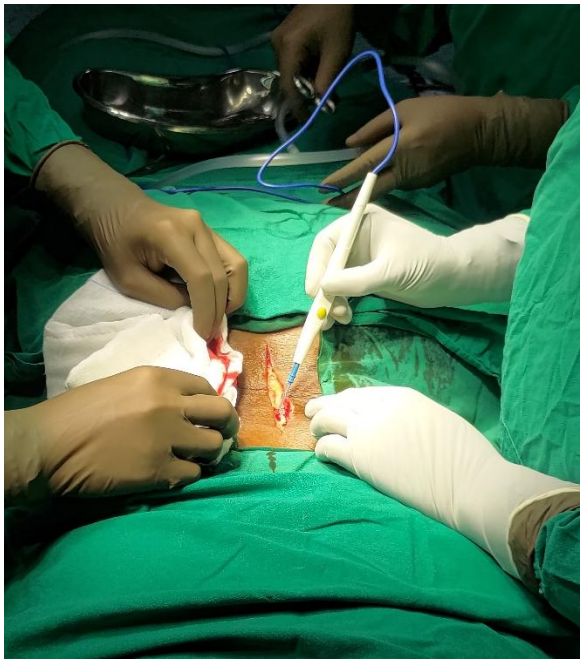


Fig. 40 – Fascia dissection

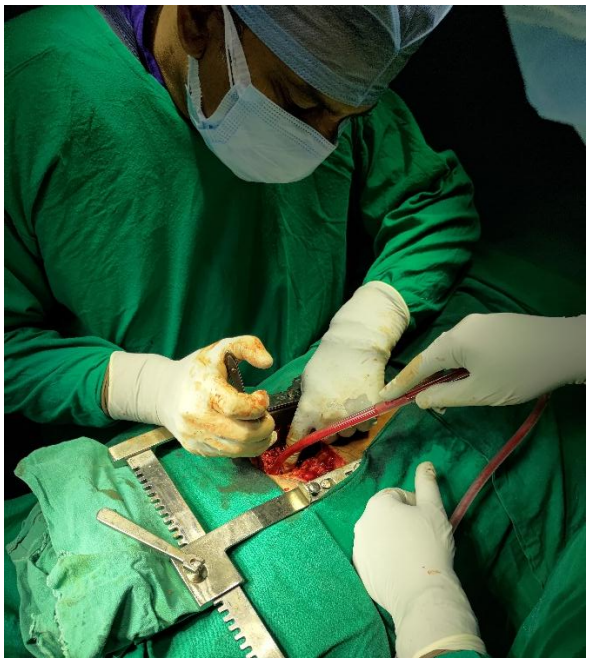


Fig. 41 – Placement of retractors and exposure of the spine

Pedicle screw insertion:

- The entry point for the pedicle is established under fluoroscopic guidance (Fig. 42 - 46), and all walls are assessed for integrity. Titanium polyaxial pedicle screws (Fig. 47 - 49) are inserted into the upper and lower vertebral bodies.

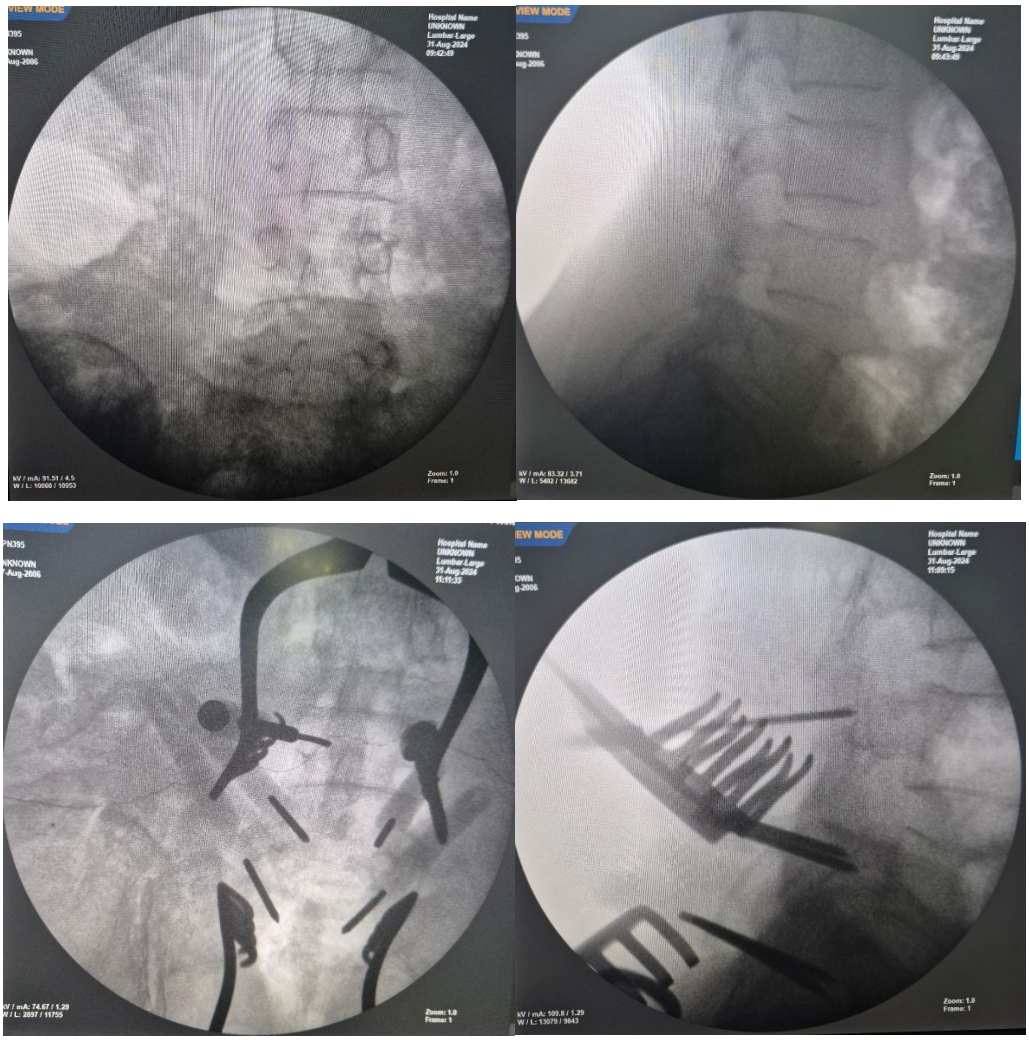


Fig. 42 -45 – showing intra op c- arm images establishing the entry points with guide pins

Fig. 46 – Guide pins clinical picture

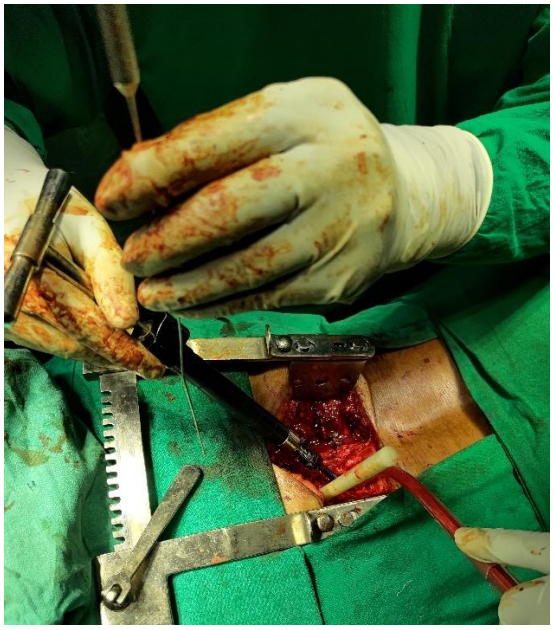


Fig. 47 – insertion of Polyaxial titanium pedicle screw

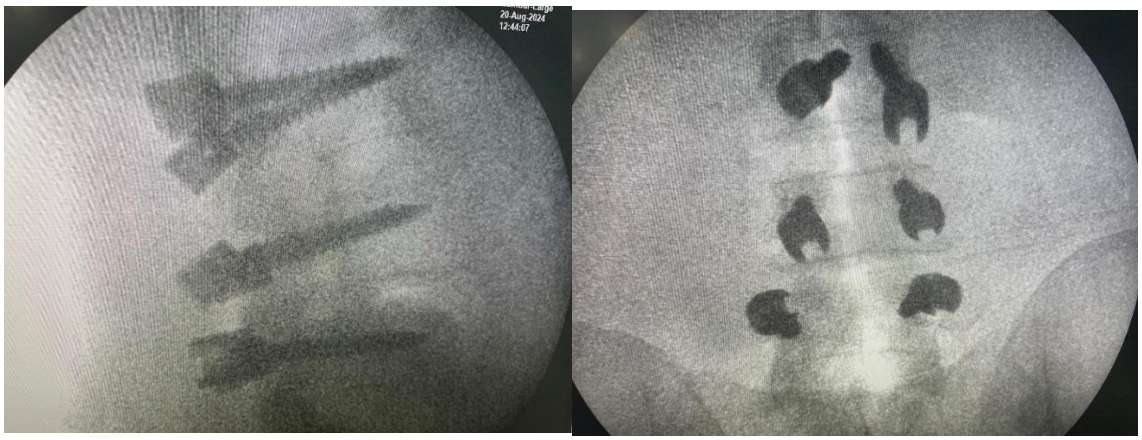


Fig. 48 – 49 Intra- op C arm images after Pedicle screw placement.

Decompression and reduction:

- In cases of degenerative spondylolisthesis, a laminectomy is performed (Fig. 50). Once the nerve roots are visible, the facet joints over the roots can be trimmed to create additional space for them.
- Bone spurs are located and excised with precision, ensuring the retraction and safeguarding of nerve roots and other neurological structures. Arthritic and hypertrophic bone spurs, along with the ligamentum flavum, are removed utilizing pituitary rongeurs, Kerrison rongeurs, and curettes as necessary for effective decompression.
- Pedicular rods placement in done and reduction is achieved when required and final screw set is tightened and position of instruments is confirmed on fluoroscopy. (Fig. 51-57)

Fig. 50 – Laminectomy being performed

Fig. 51 – Insertion of Rod

Fig. 52 – Parallel spreader

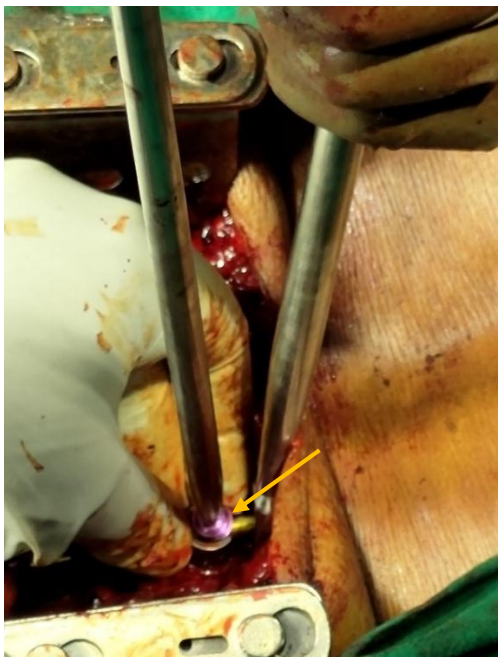


Fig. 53 – Insertion of screw set

Fig. 54 – Final tightening

Fig. 55 – Decompressive laminectomy with pedicle screw insertion

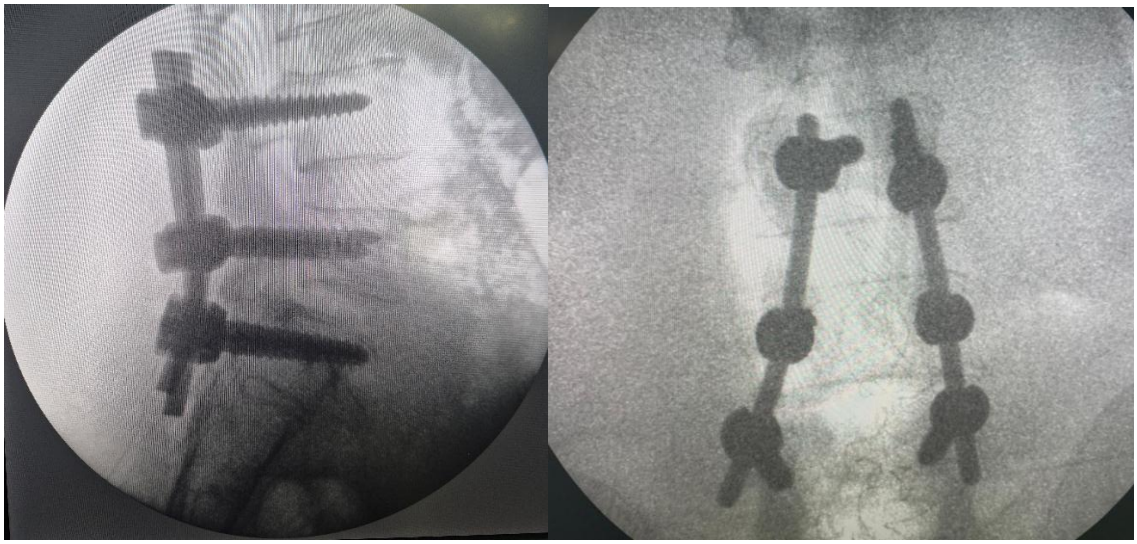


Fig. 56 – 57 – Intra op C arm images showing pedicle screw and rod insertion in Ap / Lat view.

Postero-Lateral Fusion-

- Decortication of the posterolateral spinal structures, which includes the transverse processes, the lateral aspect of the superior articular facet, and the sacral ala is carried out, after which an autologous bone graft is inserted. (Fig. 58-61)
- Tiny chip grafts fuse the transverse processes' facets, pars interarticularis, and bases. In contrast, the larger bone grafts are placed posteriorly over the transverse processes.

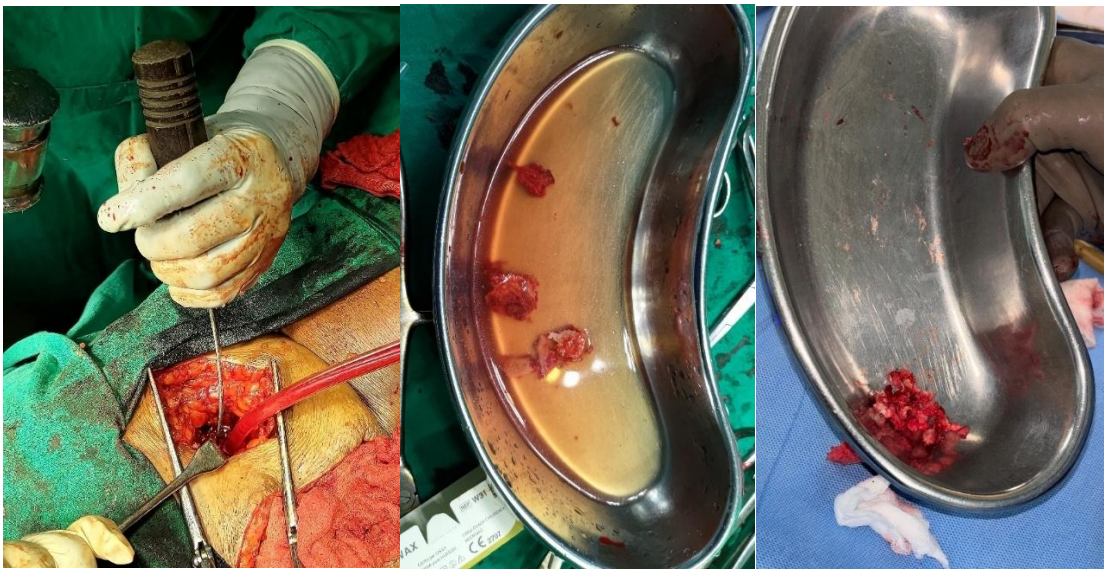


Fig. 58-60 – Bone graft extraction and preparation

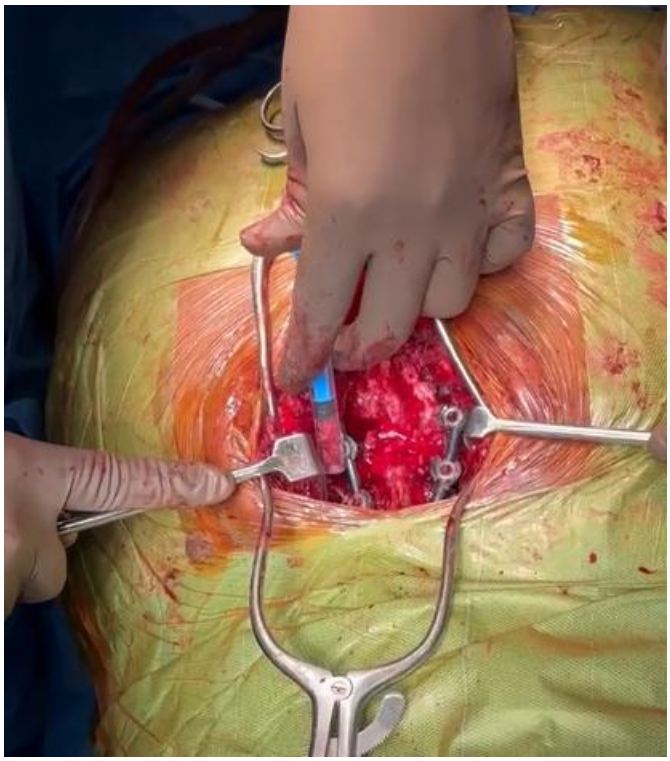


Fig. 61 – Bone graft placement

Closure

- The surgical area is thoroughly rinsed with saline prior to placing the bone graft. A 12 or 14-number drain is inserted, and an Ab gel is applied if excessive bleeding occurs.
- Deep fascia and sub-cutaneous layers are sutured using absorbable suture material. Non-absorbable sutures or skin staplers are used for the skin closure, followed by a sterile dressing. The overall duration of the surgery is approximately 3 to 4 hours. (Fig. 62)

Fig. 62 – Wound closure

Postoperative Care

- Dressing changes are performed on postoperative days 2 and 5, and patients are typically discharged following the second dressing change. Suture removal is done between days 12 and 14 after the operation.
- Patients receive detailed instructions for physiotherapy. It is recommended that they refrain from bending or twisting at the waist. and to avoid lifting weights exceeding five pounds during the first 2 to 4 weeks.
- By weeks 4 to 6, as pain subsides and muscles strengthen, they can resume these activities.

Brace

- Generally, a back brace is not required. However, a lumbar corset may be used during the early postoperative stage.

Wound care

- A sterile gauze pad, held in place with tape, should be applied to the wound area. The dressing needs to be replaced on the second post operative day, and a semipermeable waterproof dressing with silver should be applied on day five. (Fig. 63)

Fig. 63 – Semipermeable waterproof dressing.

Shower/Bath

- The incision site must be protected with a bandage and tape during bathing, ensuring that water does not directly contact the surgical area. Patients may usually bathe once a waterproof dressing is in place. The wound typically heals entirely within about 2 weeks, after which regular bathing can resume.

Driving

- The patient's discomfort typically starts to lessen within 1 – 2 weeks post-surgery, at which point they can resume to drive while they should avoid driving while taking narcotic drugs. Initially, they should start small trips along with a companion and can gradually drive alone as their pain diminishes.

Resumption of work and sports

- Physical therapy plays a crucial role in recovery. Patients may begin light occupational activities 2 to 3 weeks post-surgery. After three months, they can engage in moderate work and light recreational sports, assuming their pain has diminished and their back has regained sufficient strength. It is important to steer clear of heavy lifting, demanding tasks, and high-impact sports during this period.

Doctor's Visits and Follow-Up

- Follow-up appointments were scheduled at 1, 3, and 6-months post-surgery. An X-ray will be taken during each visit to verify the stability and healing of the fused region. Gentle back exercises through physical therapy will be started 8 to 12 weeks following the surgery.

Fusion Assessment:

- Fusion is successful when bridging trabecular bone is visible on the postero-lateral aspect. Fusion has been achieved if an X-ray taken during lateral flexion-extension shows less than 5 degrees of motion.

CASE ILLUSTRATIONS

CASE 1

A case of 46 years old female patient diagnosed with L5 over S1 anterolisthesis complaining of low backache with radiculopathy to right lower limb for 9 months.

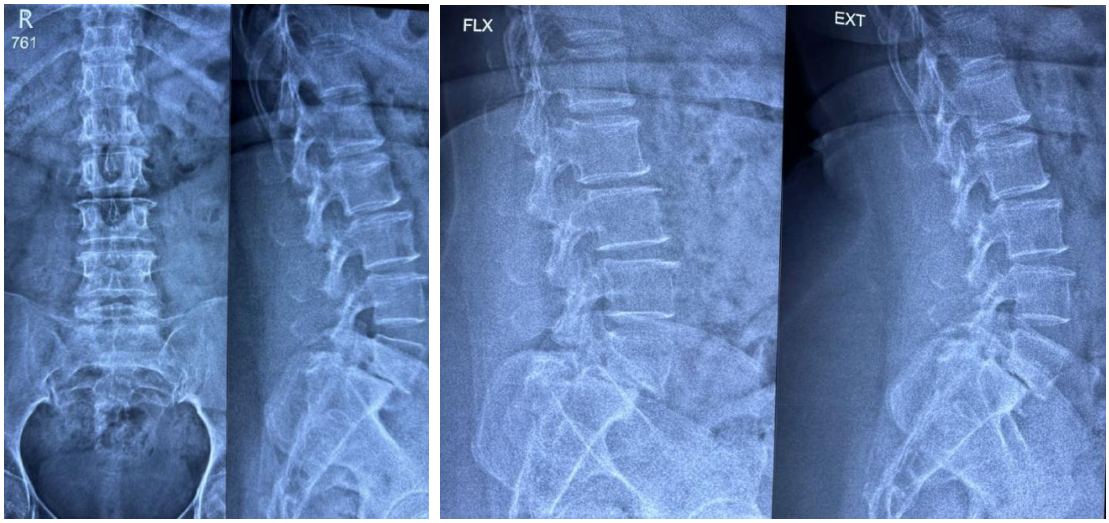


Fig. 64 – 65 Pre- op Ap/Lat and dynamic view x rays

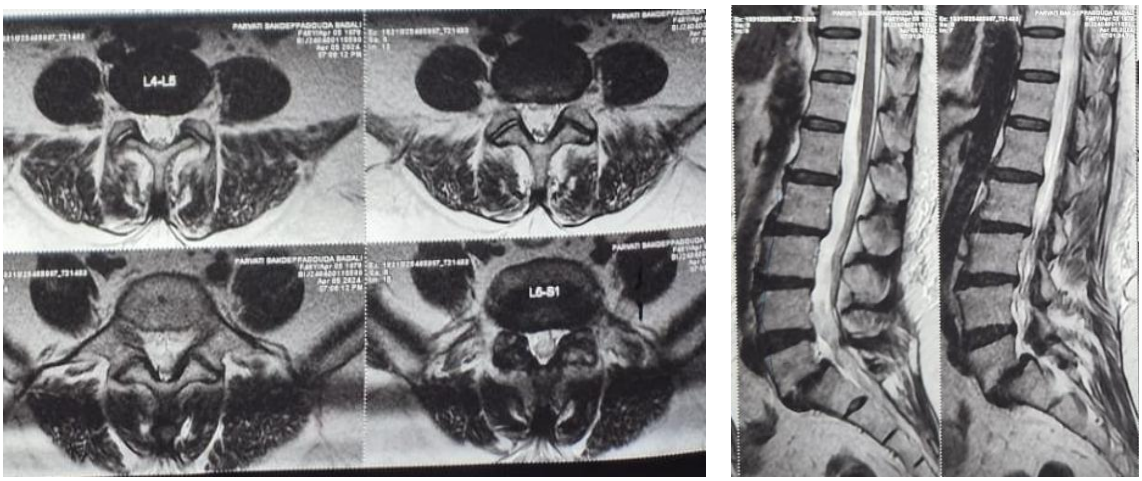


Fig. 66 – 67 – Pre op MRI showing L5-S1 listhesis with pseudo-Disc bulge.

Fig. 68 – 69 Pre op SLR

Fig. 70 - Immediate Post OP x rays

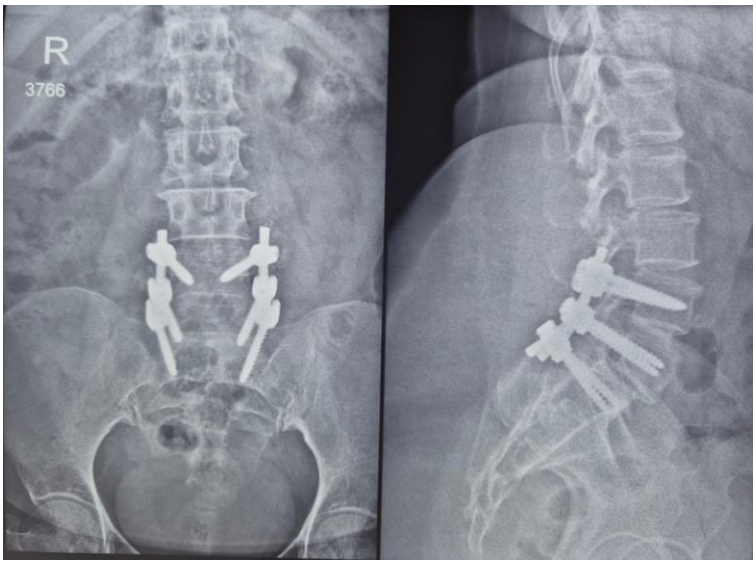


Fig. 71 - Post OP x rays after 6 months

Fig. 72 – 74 Post OP SLR and Squatting

CASE 2

A case of 41 years old female patient diagnosed with L4 over L5 spondylolisthesis complaining of low backache with radiculopathy to left lower limb for 6 months.

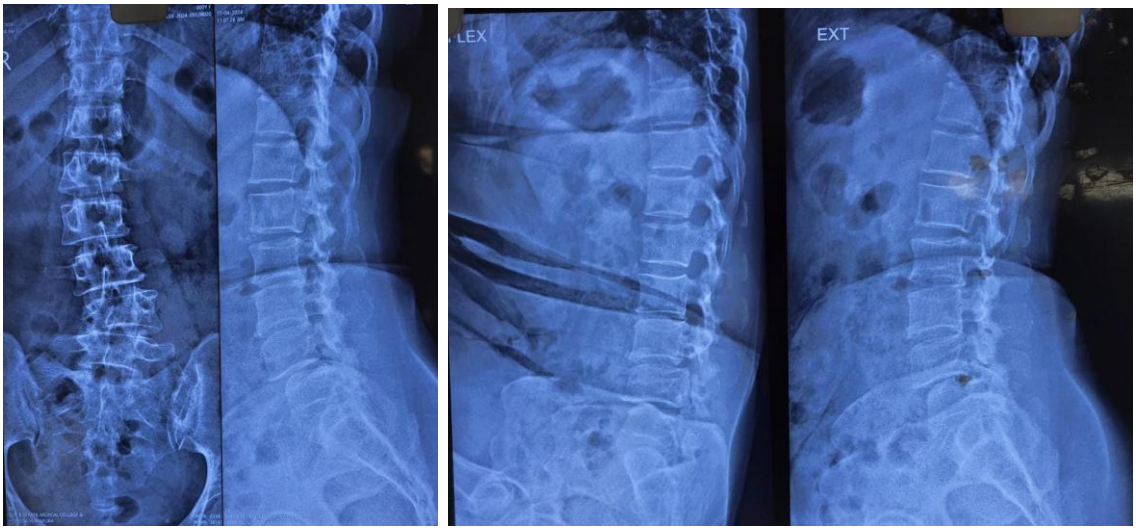


Fig. 75 – 76 Pre- op Ap/Lat and dynamic view x rays

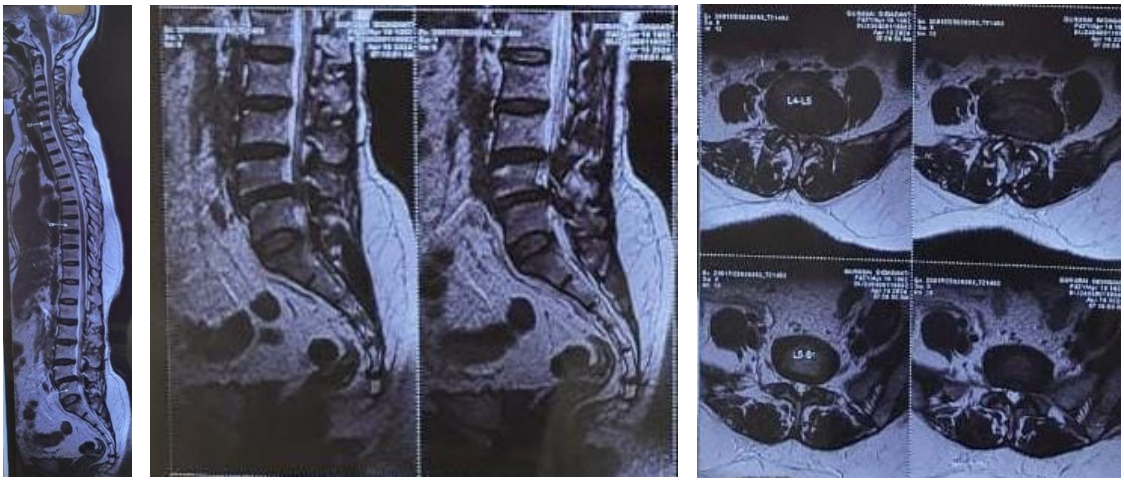


Fig. 77 – 79 Pre Op MRI showing L4-L5 Degenerative Spondylolisthesis

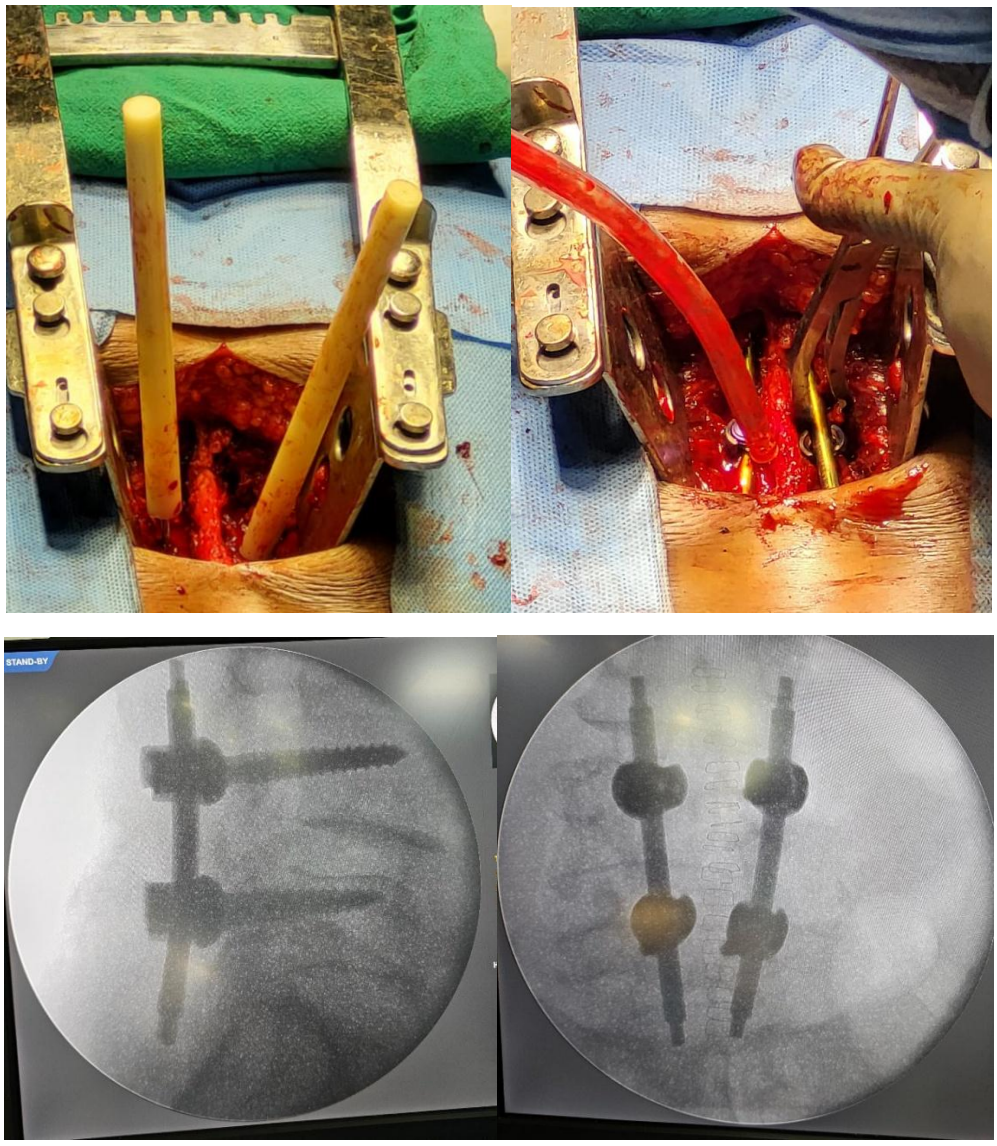


Fig. 80 -83 Intra OP clinical and Fluoroscopic images.

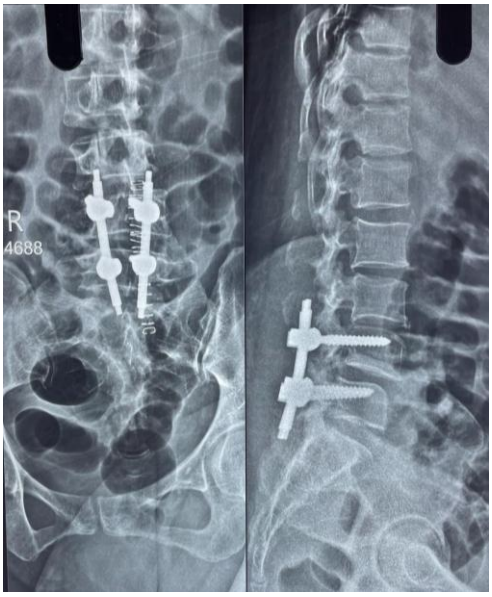


Fig. 84 - Immediate Post OP x rays

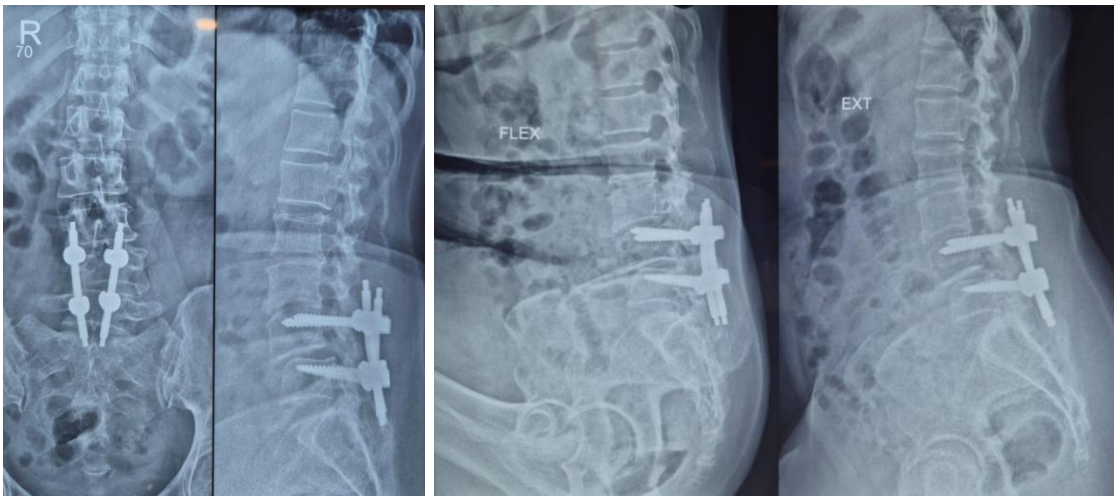


Fig. 85 – Post OP x rays after 6 months

Fig. 86 - Ferguson view to assess Fusion.

Fig. 87 – 90 – Post OP SLR, Squatting and Scar image at 6 months follow up.

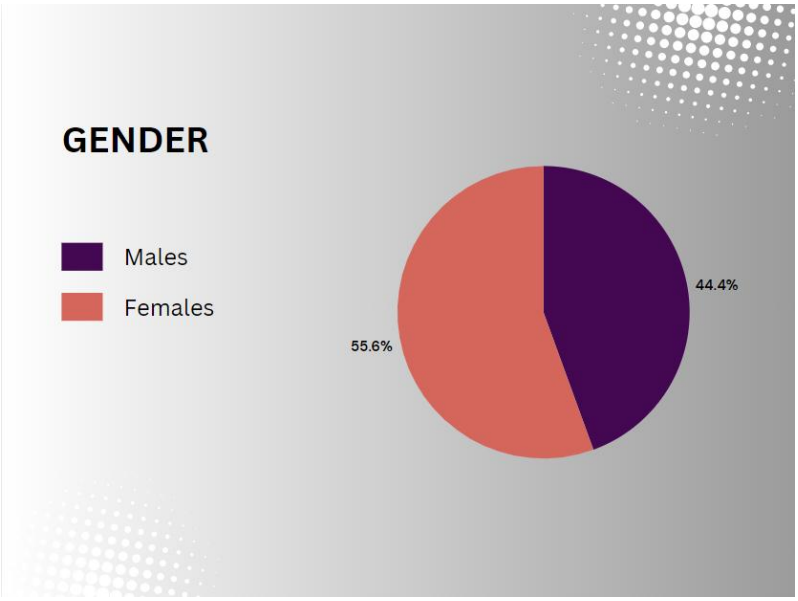
OBSERVATION AND ANALYSIS

GENDER

Table 1 and graph 1 showing number and percentage of males and females in the study.

GENDER	No. OF PATIENTS	PERCENTAGE
FEMALE	20	55.6%
MALES	16	44.4%
TOTAL	36	100%

Table 1



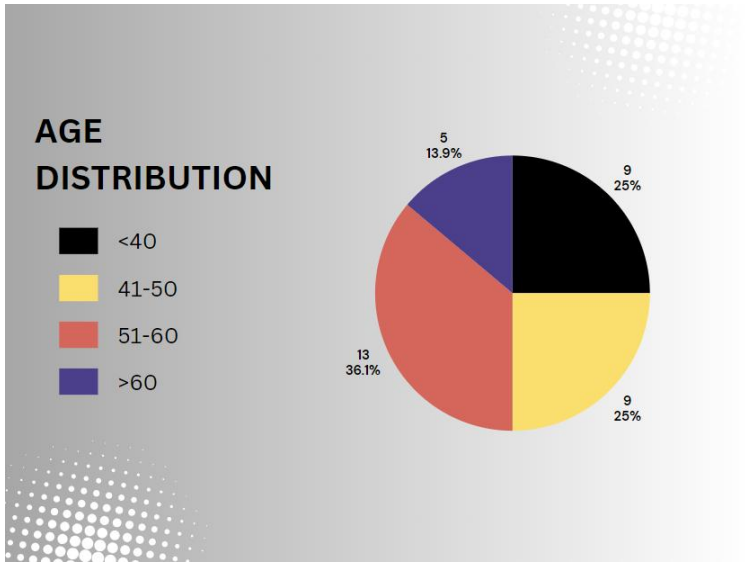
Graph 1

AGE DISTRIBUTION

Table 2 and graph 2 showing age distribution of the study.

AGE	No. OF PATIENTS	PERCENTAGE
<40	9	25%
41-50	9	25%
51-60	13	36.1%
>60	5	13.9%
TOTAL	36	100%

Table 2



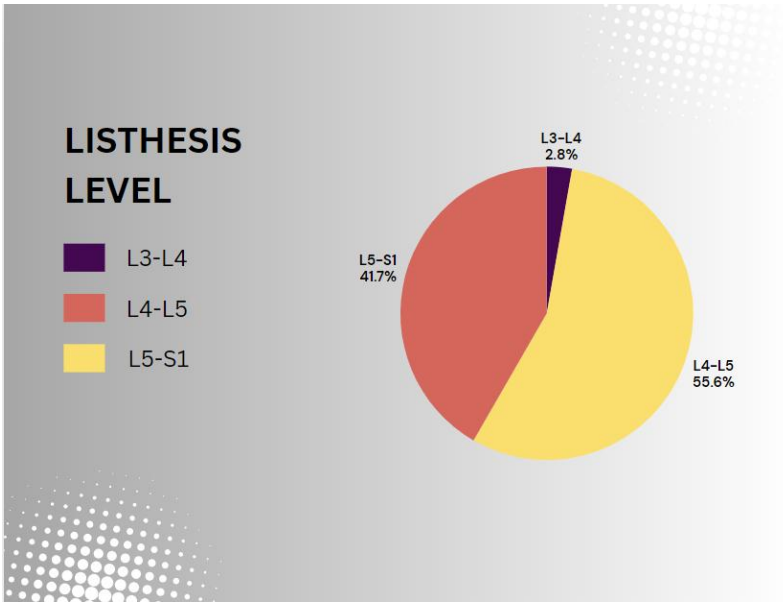
Graph 2

LISTHESIS LEVEL

Table 3 and graph 3 showing the level of lumbar spondylolisthesis in the study.

LISTHESIS LEVEL	No. OF PATIENTS	PERCENTAGE
L3 - L4	01	2.7%
L4 - L5	20	55.6%
L5 - S1	15	41.7%

Table 3



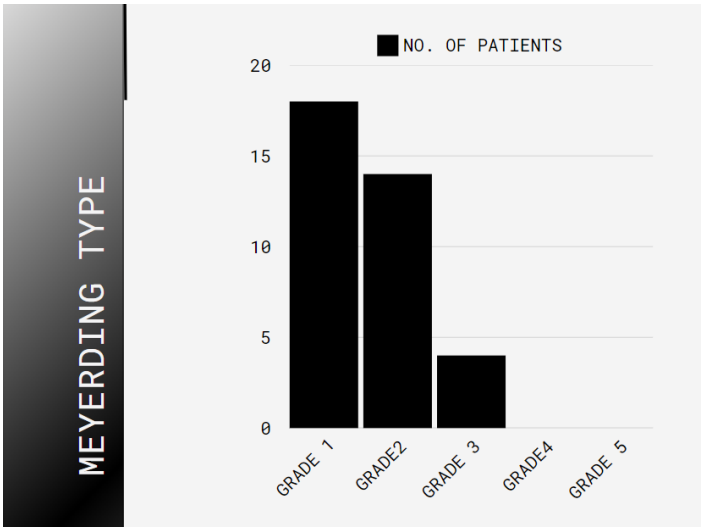
Graph 3

MEYERDING'S TYPE

Table 4 and graph 4 showing number and percentage of meyerding's grade of spondylolisthesis in the study.

MEYERDING'S TYPE	No. OF PATIENTS	PERCENTAGE
GRADE I	18	50%
GRADE II	14	38.9%
GRADE III	04	11.1%
GRADE IV	0	-
GRADE V	0	-

Table 4



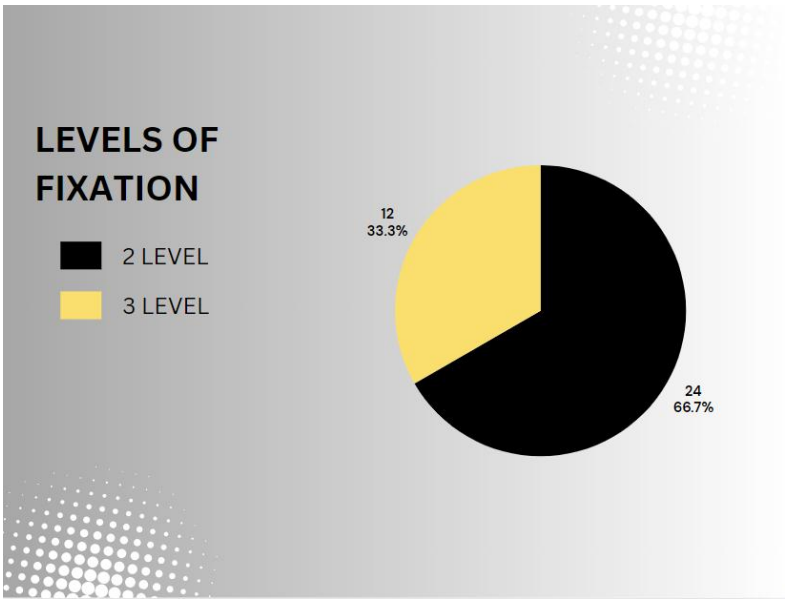
Graph 4

LEVELS OF FIXATION

The table 5 and the graph 5 showing, the pedicle screw fixation at two levels and three levels.

LEVELS OF FIXATION	NO. OF PATIENTS	PERCENTAGE
2 LEVEL	24	66.6%
3 LEVEL	12	33.3%

Table 5



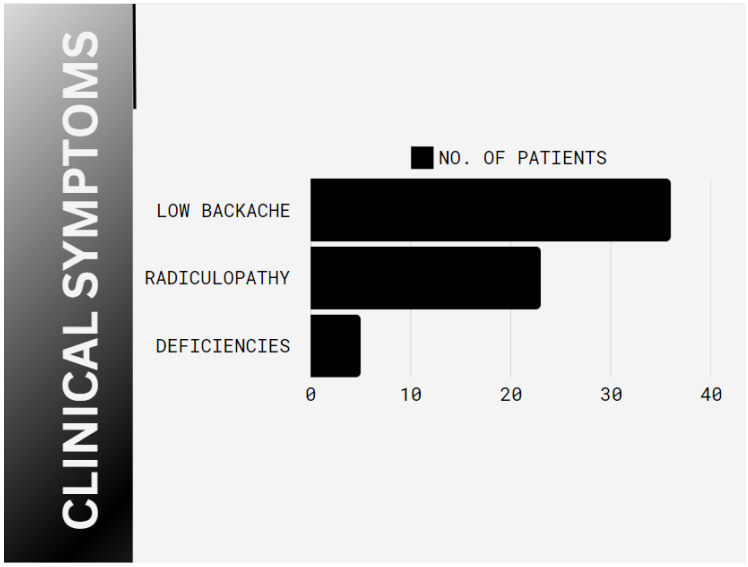
Graph 5

CLINICAL SYMPTOMS

Table 6 and graph 6 showing symptomatology of the study.

SYMPTOMS	NO. OF PATIENTS
LOW BACK ACHE	36
RADICULOPATHY	23
DEFICIENCIES	5

Table 6



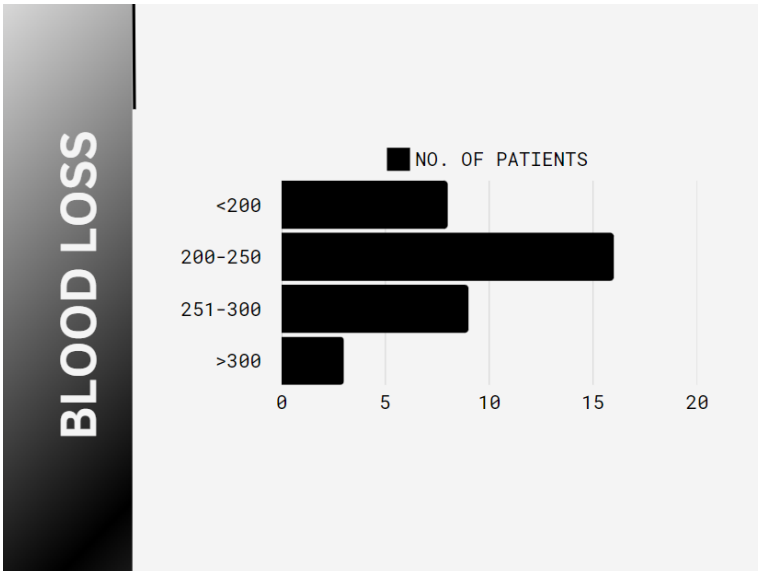
Graph 6

AVERAGE BLOOD LOSS

Blood loss was determined by counting the number of surgical wipes utilized (each holding 50 ml) and measuring the volume gathered in the suction device, after subtracting the saline used for irrigation. The average blood loss recorded in this study was 248 ml. The data is illustrated in Table 7 and Figure 7.

BLOOD LOSS IN ML	NO. OF PATIENTS
<200 ML	8
201-250 ML	16
251-300 ML	9
>350 ML	3

Table 7



Graph 7

OPERATING TIME:

Table 8 and the graph 8 showing the operating time which was counted from time of incision to the time of wound closure.

OPERATING TIME	NO. OF PATIENTS
<3 HOURS	9
3 – 3.5 HOURS	14
3.5 - 4 HOURS	11
> 4 HOURS	2

Table 8

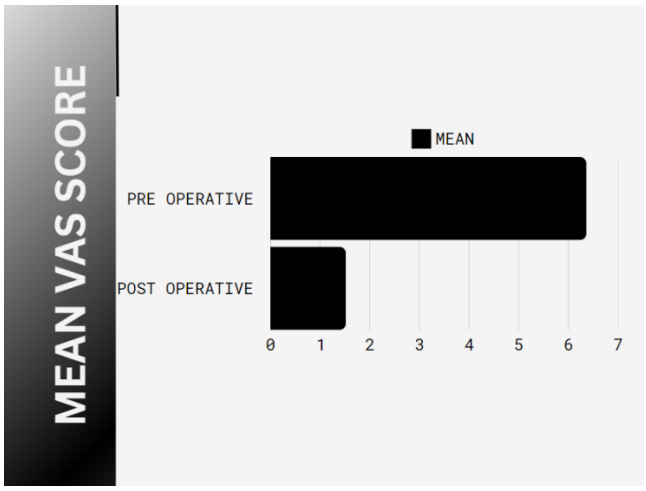
Graph 8

PAIN RELIEF

The Wilcoxon signed-rank test was employed to assess the differences between the Pre and Post-operative Visual Analogue Scale scores.

Variables	Pre		Post		Wilcoxon Signed rank test	P value
	Mean	+/- SD	Mean	+/- SD		
VAS	6.3611	0.83333	1.5277	1.5210	-5.292	0.00001

Table 9



Graph 9

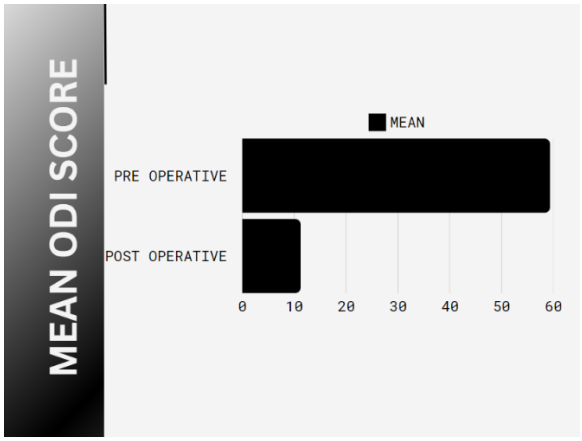
The table 9 and graph 9 shows pre operative versus post operative VAS score at 6 months. The “p value” <0.00001 is a significant comparison hence indicating the substantial pain relief.

IMPROVEMENT IN QUALITY OF LIFE

The Wilcoxon signed-rank test was employed to assess the differences between the Pre and Post-operative Modified Oswestry Disability score and the results are illustrated in table 10 and graph 10.

Variables	Pre		Post		Wilcoxon Signed rank test	P value
	Mean	+/- SD	Mean	+/- SD		
ODI	59.3888	6.5695	11.2777	7.7408	-5.2316	0.00001

Table 10



Graph 10

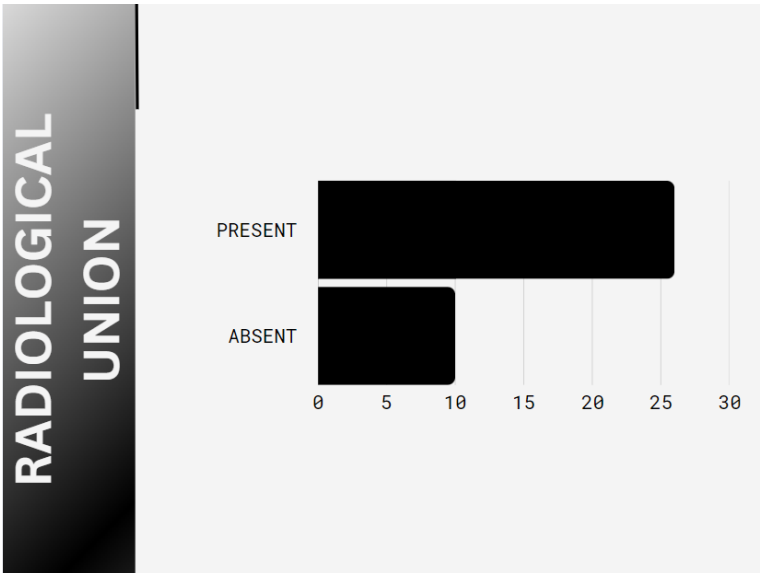
At 6 months. The “p value” <0.00001 is a significant comparison hence indicating the improvement in quality of life.

RADIOLOGICAL UNION

The table 11 and the bar chart 11 show the number of patients with radiological union following the posterolateral fusion.

RADIOLOGICAL UNION	NO. OF PATIENTS	PERCENTAGE
PRESENT	26	72.2%
ABSENT	10	27.8%

Table 11



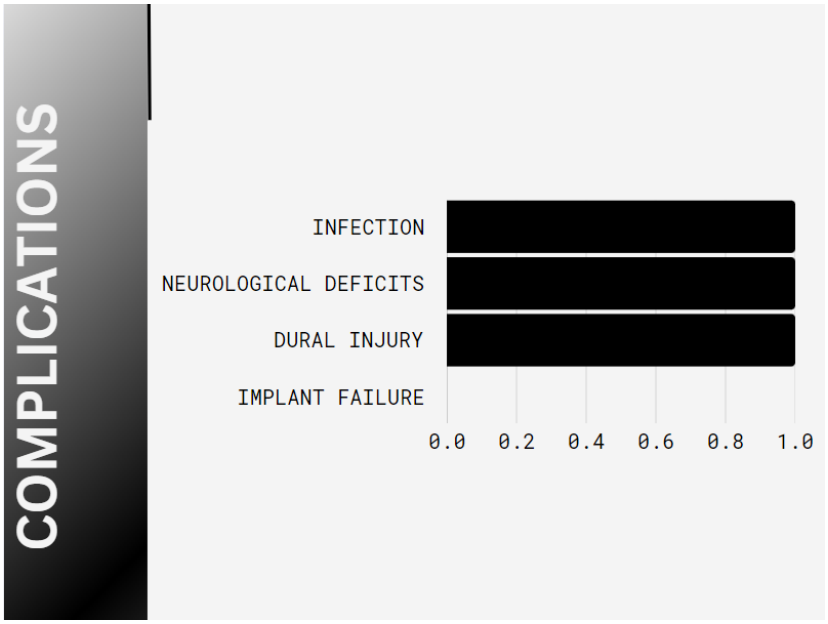
Graph 11

COMPLICATIONS

The table 12 and graph 12 shows the complications following the pedicle screw fixation and posterolateral fusion.

COMPLICATIONS	NO. OF PATIENTS
Infection	1
Neurological deficits	1
Dural injury	1
Implant failure	0

Table 12



Graph 12

RESULTS

- A total of 40 patients were surgically treated with pedicle screw fixation and posterolateral fusion out of which 36 cases turned up for follow ups until 6 months of surgery. Out of 36 patients 16 were males and 20 were females. The duration of symptoms ranged from 1 month to 8 years.
- Majority of patients had Meyerding's type 1 listhesis (50 %) followed by Meyerding's type 2 (38.9%). All the 36 patients had low backache, 23 patients had radiculopathy and 5 patients had deficiencies.
- The radiological union rate was determined to be 72.2 per cent.
- The average duration of surgery, from incision to closure, was recorded at 3.5 hours. The typical blood loss during the procedure averaged 248 milliliters.
- The significant enhancement in the postoperative VAS score at the six-month follow-up was demonstrated by a 'p-value' < 0.00001.
- The enhancement in quality of life, assessed through the Wilcoxon signed rank test comparing preoperative and postoperative Oswestry Disability Index (ODI), was statistically significant, demonstrating a reduction in the ODI post-surgery.
- The overall outcome of the study is graded into excellent, good and fair depending upon VAS, m ODI, improvement in radiculopathy and neurological deficits. Max score of 12 was given and a minimum of 4.
- A total of 27 patients had excellent outcome while 9 patients had good outcomes.

POINTS	3	2	1
VAS difference	>3.5	>3	<2.94
ODI difference	>40 %	10% - 40%	<10%
Radiculopathy	absent	present	persisting
Deficits	2 grades	1 grade	Not improved

Table 13 showing Parameters and scores

OUTCOME	SCORE	No. OF PATIENTS
Excellent	**≥ 10**	**27**
Good	**5 - 10**	**9**
Fair	**≤ 5**	**0**

Table 14 showing outcomes.

COMPLICATIONS

- We encountered an instance where intraoperative dural injury occurred which was managed using a muscle graft, this subsequently resulted in a soft swelling on the back that eventually resolved over a three-month period.
- One patient experienced a postoperative surgical site infection on day five, it was managed successfully regular dressings and intravenous antibiotics based on the culture and sensitivity report.
- Another patient, who had a preoperative deficiency, did not exhibit an improvement in postoperative neurological function but did achieve union.
- There were no any instances of screw breakage, hardware failure or any further progression of slip in any of the patients.

DISCUSSION

- The main objective in managing lumbar or lumbosacral spondylolisthesis is to facilitate bone fusion. The rates of fusion generally improve with extended follow-up periods, irrespective of the instrumentation employed.

- The positive outcomes were specially associated with younger age group and low grade listhesis. In our study there was no significant difference in outcomes in terms of gender. The positive outcomes were specially associated with younger age group and low grade listhesis.

SEX	No OF PATIENTS	EXCELLENT	GOOD	FAIR
Males	16	12	4	0
female	20	15	5	0

Table 15 - showing correlation of outcome based on gender.

AGE GROUP	No OF PATIENTS	EXCELLENT	GOOD	FAIR
< 40	9	9	0	0
41-50	9	9	0	0
51-60	13	7	6	0
>60	5	2	3	0

Table 16 - showing correlation of outcome based on gender.

MEYERDING'S GRADE	No OF PATIENTS	EXCELLENT	GOOD	FAIR
I	18	16	2	0
II	14	9	5	0
III	4	2	2	0
IV	0	0	0	0
V	0	0	0	0

Table 17 - showing correlation of outcome based on grade of slip.

- Although the sample size was small, the fusion outcomes in our study were comparable to those from existing standard studies for the duration of the short follow-up period. Even though our study showed a radiological union rate of only 72.2 per cent at the six-month follow-up, the clinical outcomes, as gauged by improvements in functional indicators via the Modified Oswestry Disability Index, were excellent.

- Adult spondylolisthesis is a condition that can be diagnosed through radiographic assessment of lumbar segment mobility. It is essential to identify the unique symptoms, signs, and functional impairments that set spondylolisthesis apart from other sources of low back pain and sciatica. Even with conservative management, numerous patients still suffer from ongoing symptoms.

- In one study, the mean age of patients who underwent the PLF procedure was 47.3 years. [54] In the present study, we noted a

predominance of female patients compared to males, with a mean age of 49.7 years. Patients had symptom durations from 1 month to 8 years, resulting in a mean duration of 26.4 months.

- In our series, the L3-L4 level was affected in 1 case, L4-L5 level was affected in 20 cases more frequently than the L5-S1 level, which had 15 cases, additionally, grade 1 slip was noted in 18 patients, grade 2 slip in 14, and the remaining 4 noted to have grade 3 slip.

- Kim et al. found that 50% of the affected levels were at L4-L5., a finding that closely resembles our series, where 55.6% were similarly affected. [55]

- Dantas reported an equal percentage (45%) of patients at the L4-L5 and L5-S1 levels [56]. Yan et al. indicated that the affected rates were 52.27% for L5-S1 and 47.72% for L4-L5. [57]

- Postero-lateral fusion has been a standard surgical approach for treating lumbar spinal instability. With the advancements in spinal instrumentation techniques, this procedure continued to be in practice for degenerative spondylolisthesis.

- Out of the 36 patients examined, 26 (72.2%) successfully attained bony fusion, whereas 10 did not. The average duration to achieve bony fusion

was 5.5 months. Favorable outcomes were notably associated with younger patients, males, lower levels of slippage, and individuals in the radiological fusion category.

- No significant relationship was identified between the degree of instability and the final clinical results.

- When dealing with spondylolisthesis patients, attention to spinal biomechanics is crucial for effective surgical outcome.

- Crawford et al. replicated grade 1 Spondylolisthesis in cadavers. They examined the biomechanics of various combinations of hardware, including cages with and without intersomatic spacers, pedicle screws alone, and pedicle screws paired with cages. (58) There is ongoing debate regarding the preferred surgical method for treating spondylolisthesis, as an effective surgical intervention should fuse the fewest segments possible, limit dislocation, provide sufficient decompression, correct the sagittal axis, and achieve fusion. [(59)]

- Suk et al. conducted decompression, pedicle screw fixation, and fusion in 76 patients experiencing symptomatic spondylolisthesis along with a stenotic spinal canal. In the PLF group, the nonunion rate was 7.5%, while the PLIF group had no instances of nonunion. [(60)]

- Nevertheless, a study could not definitively determine which surgical technique (PLF, PLIF, anterior lumbar interbody fusion, or instrumentation) was the most effective for achieving fusion. In treating low-grade isthmic spondylolisthesis, the roles of instrumentation, decompression, reduction, and fusion can all be beneficial. [61] [62]

- However, in a prospective study, Kim et al. did not identify any significant differences in clinical outcomes or fusion rates after analyzing PLF, PLIF, and combined PLF/PLIF groups over three years. Moreover, the PLIF-only group experienced shorter operation times, reduced blood loss, and no pain at the iliac wing (the donor site for bone fusion). [55]

- Madan and Boeree compared 23 patients who underwent PLIF with 21 treated with PLF alongside instrumentation. The PLIF and PLF groups both demonstrated satisfactory clinical outcomes at a rate of 69.5%. While better clinical results were observed in the PLF group for patients with low-grade spondylolisthesis, the quality of fusion and correction proved superior in the PLIF group. [63]

- After two years of experience with both PLF and PLIF, Ekman et al. noted that these techniques yielded similar results in managing adult isthmic spondylolisthesis, except for a higher complication rate associated with the PLIF method. Patients achieving adequate fusion were likely to experience better clinical outcomes, and the opposite was

also true. Some researchers have indicated that clinical outcomes for PLIF do not surpass those of other fusion techniques. In individuals who underwent PLIF, the extensive retraction of the nerve root and thecal sac posed clear disadvantages, as it resulted in leg pain. [64]

- In a study, The Oswestry index reflected an 89% good or excellent result among PLIF patients, compared to 86% in the PLF group; however, this difference was not statistically significant. [65] [66]

- In a prospective randomized study focusing on degenerative lumbar disease, experiences with three fusion techniques: posterolateral fusion (PLF), posterior lumbar interbody fusion (PLIF), and PLIF combined with PLF (PLF+PLIF), showed no significant differences in either clinical outcomes or union rates among the three approaches. [67]

- The complications reported in patients who underwent PLF include fractures of screws and loosening of implants, which may necessitate reoperation. It is widely accepted that reduction during surgery is unnecessary for patients with symptomatic grades 1 and 2 spondylolisthesis.

- Patients who had a reduction during surgery experienced a higher rate of complications. While a successful fusion is considered a key indicator of clinical success in patients with mechanical lower back

pain, there was no correlation between fusion rates and clinical outcomes. [68] [69]

- In a prospective study, which aimed to evaluate and compare the clinical outcomes of posterior lumbar interbody fusion (PLIF) and posterolateral fusion (PLF) in cases of spondylolisthesis. Radiographs were conducted both before and after surgery to assess fusion status. Both surgical techniques proved effective; however, the PLF group exhibited a higher incidence of complications related to hardware mechanics. The PLIF group achieved a superior fusion rate compared to the PLF group, yet there was no significant statistical variation in clinical and functional outcomes between the two groups. [70] [71]

- Swan et al. examined two groups of patients with low-grade isthmic spondylolisthesis; the first group (comprising 50 consecutive patients) underwent a 1-level posterior instrumentation along with PLF, while the second group (also 50 consecutive patients) received combined anterior lumbar interbody fusion and PLF. After two years postoperatively, clinical examinations revealed that patients receiving the combined anterior and posterior treatment experienced a more significant correction of their unstable spondylolisthesis than those who underwent only posterior treatment. [72]

- The complications associated with spinal procedures include permanent neurological deficits occurring in 0.4%-1.7%, cerebrospinal

fluid (CSF) leaks in 0.4%-0.5%, radicular pain in 1.1%-2.5%, and deep wound infections in 0.6%-5% of the cases. [73]

- The complication rates linked to PLIF exceed those associated with PLF, and from a technical standpoint, PLF is simpler to execute. When compared PLF results in less blood loss to PLIF and PLIF is technically challenging due to increased bleeding, longer operation time, and more extensive dissection. CSF leaks can arise from spinal surgery or trauma and pose serious issues such as persistent headaches and potential meningitis. [74]

- Surgical intervention is frequently required and necessitates careful direct closure of the dura or closure using a fascial graft. Based on the findings, it was determined that for spondylolisthesis cases involving instability in the three-column spine, posterior interbody fusion using pedicle screws (PLIF) provides a stronger mechanical framework than relying solely on pedicle screws. While both surgical techniques were adequate, the PLF group was associated with more complications related to hardware mechanics. [75]

- Clinical and functional outcomes were comparable in both groups; no significant statistical differences were observed. However, PLIF demonstrated a higher fusion rate relative to PLF. Conservative treatment alternatives for segmental instability are suitable for patients

experiencing manageable pain. Surgical options become necessary when symptoms are severe enough to disrupt daily activities, if the condition worsens, or if there are notable neurological impairments. Posterolateral fusion can be an effective treatment option for lumbar spondylolisthesis management. [76]

- Though the literature suggests to fuse as fewer spinal segments as possible, our study concludes that 3 level fusion had a better functional outcome and pain relief when compared to two level fusion.

FIXATION LEVEL	No OF PATIENTS	EXCELLENT	GOOD	FAIR
2 LEVEL	24	16	8	0
3 LEVEL	12	11	1	0

Table 18 - showing correlation of outcome based on grade number of levels of fixation.

- Nonetheless, this study has limitations due to the relatively small patient population, highlighting the need for further research with larger sample sizes. With advancements in minimally invasive technology using operating microscopes, future comparisons of the current technique with other methods could provide adequate decompression and circumferential fusion while mitigating many drawbacks associated with traditional open approaches for degenerative listhesis.

CONCLUSION

- Spondylolisthesis is a prevalent condition frequently encountered in orthopaedic practices related to low backache and radiculopathy. Various surgical and non-surgical techniques for its treatment have been documented in the literature. Surgical decompression and stabilization of the spine are advised for patients who do not improve with conservative treatments or have significant spinal instability.

- Various methods, including anterior, posterior, or combined approaches, have been employed based on the severity of the spondylolisthesis. Posterolateral lumbar fusion with pedicle screw fixation, along with spinal decompression, is an effective treatment for spondylolisthesis, offering good spinal fusion outcomes, fewer complications, and satisfactory clinical results.

- While using a pedicle screw-rod system combined with posterolateral grafts and decompression is a safe and attractive option, especially for low-grade cases, It is important to explore and apply PLIF, TLIF, and ALIF methods to enhance clinical results in cases of high-grade spondylolisthesis.

- Our findings indicate that spondylolisthesis is among the leading causes for conducting posterior spinal decompression, stabilization, and posterolateral fusion (PLF) at our facility. The surgical techniques

employed have demonstrated effectiveness, accompanied by reduced complication rates associated with hardware biomechanics.

- Minimal postoperative complications were noted, especially when procedures were conducted with fluoroscopic guidance. The positive outcomes were primarily linked to neurological deficits present preoperatively, percentage of slip and number of spinal segments fused.

- In addition to surgical interventions, lifestyle modifications are advised to prevent surgical failure. Although preliminary results from existing studies are encouraging, the studies involved a comparatively small patient population, indicating the need for further research with larger cohorts.

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SHRI B.M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE, VIJAYAPURA - 586103

PROFORMA (Annexure 1)

CASE NO. :

NAME :

AGE/SEX :

IP NO :

DATE OF ADMISSION :

DATE OF SURGERY :

DATE OF DISCHARGE :

OCCUPATION :

RESIDENCE :

Presenting complaints with duration :

History of presenting complaints :

Family History :

Personal History :

Past History :

General Physical Examination

Pallor: present/absent

Icterus: present/absent

Clubbing: present/absent

Generalized lymphadenopathy: present/absent

Built: poor/moderate/well

Nourishment: poor/moderate/well

Vitals

PR: RR:

BP: TEMP:

Other Systemic Examination:

Local examination:

Inspection :

a) Attitude/ deformity- kyphosis/ exaggerated lumbar lordosis

b) Abnormal swelling

- Site
- Size
- Shape
- Extent

c) Skin

Palpation:

a) Local tenderness - direct, rotational, thrust

b) Bony step

c) Abnormal movement

d) Crepitus

e) Swelling

Movements:

LUMBAR SPINE

- Flexion
- Extension
- Lateral bending
- Axial rotation

NEUROLOGICAL EXAMINATION

1. Tone
2. Bulk
3. Power
4. Reflexes
5. Sensory examination
6. Special tests
   - SLRT
   - Patrick
   - Lasegue
   - Femoral nerve streatch test

SPINE EXAMINATION

INVESTIGATIONS

Plain radiological findings

- Standard AP and Lateral view
- Dynamic views
- Special views
- Meyerding grading

MRI

DIAGNOSIS:

PRE-OP PLANNING:

INTRA OP ASSESMENT:

Anesthesia

Position

Implant

Decompression and Reduction

Fixation

OPERATING TIME:

BLOOD LOSS:

FLUOROSCOPIC EXPOSURE:

INTRA OP COMPLICATIONS/

DIFFICULTIES POST OP PERIOD:

FOLLOW UP:

Assessment with VAS score and Modified Oswestry disability score.

B.L.D.E. (DEEMED TO BE UNIVERSITY) SHRI B.M.PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH

INFORMED CONSENT FOR PARTICIPATION IN DISSERTATION/RESEARCH (Annexure II)

I, the undersigned,_____ , S/O D/O W/O _____, aged ____years, ordinarily resident of _____ do hereby state/declare that **Dr. Munugala Charan Sai Reddy** of Shri. B. M. Patil Medical College Hospital and Research Centre has examined me thoroughly on _____ at _____ (place) and it has been explained to me in my own language that I am suffering from _____ disease (condition) and this disease/condition mimic following diseases. Further **Dr. Munugala Charan Sai Reddy** informed me that he/she is conducting dissertation/research titled "**STUDY OF FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF LUMBAR SPONDYLOLISTHESIS WITH PEDICLE SCREW FIXATION AND POSTERIOLATERAL FUSION**." under the guidance of **Dr. Ravi Kumar Biradar**. requesting my participation in the study. Apart from routine treatment procedure, the pre-operative, operative, post-operative and follow-up observations will be utilized for the study as reference data.

The Doctor has also informed me that during the conduct of this procedure like adverse results may be encountered. Among the above complications, most of them are treatable but are not anticipated; hence there is a chance of aggravation of my condition. In rare circumstances, it may prove fatal despite the anticipated diagnosis and best treatment made available. Further Doctor has informed me that my participation in this study help in the evaluation of the results of the study, which is a useful reference to the treatment of other similar cases soon, and also, I may be benefited in getting relieved of suffering or cure of the disease I am suffering.

The Doctor has also informed me that information given by me, observations made/ photographs/ video graphs taken upon me by the investigator will be kept secret and not assessed by the person other than my legal hirer or me except for academic purposes.

The Doctor did inform me that though my participation is purely voluntary, based on the information given by me, I can ask for any clarification during the course of treatment/study related to diagnosis, the procedure of treatment, result of treatment, or prognosis. I have been instructed that I can withdraw from my participation in this study at any time if I want, or the investigator can terminate me from the study at any time from the study but not the procedure of treatment and follow-up unless I request to be discharged.
After understanding the nature of dissertation or research, diagnosis made, mode of treatment, I the undersigned Shri/Smt _____ under my full conscious state of mind agree to participate in the said research/dissertation.

Signature of the patient:

Signature of Doctor:

Witness: 1.
2.

Date:

Place

Anneure III

Azadi Ka Amrit Mahotsav

BLDE
(DEEMED TO BE UNIVERSITY)
Declared as Deemed to be University u/s 3 of UGC Act, 1956
Accredited with 'A' Grade by NAAC (Cycle-2)
The Constituent College
SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA

BLDE (DU)/IEC/ 980/2022-23 10/4/2023

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this University met on **Saturday, 18th March, 2023 at 11.30 a.m. in the CAL Laboratory, Dept. of Pharmacology,** scrutinizes the Synopsis/ Research Projects of Post Graduate Student / Under Graduate Student /Faculty members of this University /Ph.D. Student College from ethical clearance point of view. After scrutiny, the following original/ corrected and revised version synopsis of the thesis/ research projects has been accorded ethical clearance.

TITLE: "STUDY OF FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF LUMBAR SPONDYLOLISTHESIS WITH PEDICLE SCREW FIXATION AND POSTEROLATERAL FUSION".

NAME OF THE STUDENT/PRINCIPAL INVESTIGATOR: DR.MUNUGALA CHARAN SAI REDDY.

NAME OF THE GUIDE: DR. RAVIKUMAR BIRADAR. PROFESSOR,
DEPT. OF ORTHOPAEDICS

Dr. Santoshkumar Jeevangi
Chairperson
IEC, BLDE (DU),
VIJAYAPURA

Chairman,
Institutional Ethical Committee,
BLDE (Deemed to be University)
Vijayapura

Dr.Akram A. Naikwadi
Member Secretary
IEC, BLDE (DU),
VIJAYAPURA

MEMBER SECRETARY
Institutional Ethics Committee
BLDE (Deemed to be University)
Vijayapura-586103. Karnataka

Following documents were placed before Ethical Committee for Scrutinization.

- Copy of Synopsis/Research Projects
- Copy of inform consent form
- Any other relevant document

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MASTERCHART

Sl No	Name	Age	Gender	IP No	Clinical symptoms	Etiology	Level of listhesis	Level of Fusion	Meyerding type	Pre modi ODI	Pre VAS	Post modi ODI	Post VAS	modi ODI diff score	VAS diff score	Radiculopathy	Deficiencies	Overal Score	Results
1	Mantesh	39	M	124865	LBA R	Degenerative	L4-L5	L4-L5	1	54	6	6	0	3	3	3	3	12	Excellent
2	Nagaraj	29	M	134890	LBA	Trauma	L4-L5	L4-L5	1	74	7	6	1	3	3	3	3	12	Excellent
3	Dundavva Hanamanth G	52	F	286397	LBA	Degenerative	L4-L5	L3-L4-L5	3	72	6	18	3	3	2	3	3	11	Excellent
4	Siddappa	35	M	106547	LBA	Degenerative	L4-L5	L4-L5	1	52	5	8	2	3	2	3	3	11	Excellent
5	Ganesh	42	M	180668	LBA	Degenerative	L4-L5	L4-L5-S1	3	64	7	8	0	3	3	3	3	12	Excellent
6	Gurubai Shrishail Gidaganti	41	F	128020	LBA	Degenerative	L5-S1	L5-S1	1	54	6	2	0	3	3	3	3	12	Excellent
7	Basamma	58	F	162904	LBA R	Degenerative	L5-S1	L5-S1	1	48	6	14	3	2	2	2	3	9	Good
8	Namdev Rathod	37	M	118986	LBA R	Degenerative	L4-L5	L3-L4-L5	2	54	6	6	0	3	3	3	3	12	Excellent
9	Parvati Banudas More	55	F	115344	LBA R D	Degenerative	L5-S1	L4-L5-S1	2	66	6	8	0	3	3	3	3	12	Excellent
10	Iramma	55	F	196780	LBA R	Degenerative	L5-S1	L5-S1	1	56	8	18	3	2	3	2	3	10	Excellent
11	Sundarabai	39	F	3687	LBA	Degenerative	L5-S1	L5-S1	1	56	5	12	0	3	3	3	3	12	Excellent
12	Channamma H Gogi	44	F	102462	LBA R D	Degenerative	L5-S1	L4-L5-S1	2	58	6	10	3	3	2	2	3	10	Excellent
13	Channappa Ashok Manur	33	M	142406	LBA R	Trauma	L4-L5	L4-L5	1	52	6	8	1	3	3	3	3	12	Excellent
14	Gurupad Patil	60	M	317299	LBA R D	Degenerative	L5-S1	L5-S1	2	58	5	20	2	2	2	2	3	9	Good
15	Madhusudhan Rao	44	M	155408	LBA	Degenerative	L4-L5	L4-L5	1	54	6	6	0	3	3	3	3	12	Excellent
16	Malkanna Ambaj Kattimani	70	M	410676	LBA R	Degenerative	L5-S1	L3-L5-S1	2	74	7	18	2	2	3	3	3	11	Excellent
17	Rajashri shivasharan	47	F	31220	LBA R	Degenerative	L5-S1	L4-L5-S1	2	62	8	14	0	3	3	3	3	12	Excellent
18	Rasulabee Myaginamani	60	F	52137	LBA R D	Degenerative	L4-L5	L4-L5	3	58	7	24	4	2	2	2	2	8	Good
19	Arshad	56	M	8719	LBA R	Degenerative	L5-S1	L5-S1	1	58	5	10	2	3	2	3	3	11	Excellent
20	Mallamma Talawar	50	F	188225	LBA	Degenerative	L5-S1	L5-S1	1	56	6	18	3	2	2	3	3	10	Excellent
21	Ambakka Channappa Jaalwadi	49	F	24734	LBA R	Degenerative	L4-L5	L4-L5-S1	1	52	5	0	0	3	3	3	3	12	Excellent
22	Bouramma S Hirekurbar	68	F	2300	LBA R	Degenerative	L4-L5	L4-L5	2	58	6	22	3	2	2	2	3	9	Good
23	Maitra Patil	35	F	284065	LBA	Degenerative	L5-S1	L5-S1	2	68	8	4	1	3	3	3	3	12	Excellent
24	Malasiddayya	66	M	82782	LBA R	Degenerative	L4-L5	L4-L5	2	56	7	18	4	2	2	2	3	9	Good
25	Mallamma	63	F	157888	LBA R	Degenerative	L4-L5	L4-L5-S1	2	64	7	8	0	3	3	3	3	12	Excellent
26	Ogeppa Pujari	66	M	250187	LBA R	Degenerative	L4-L5	L4-L5	2	58	6	22	3	2	2	2	3	9	Good
27	Parvati Bandeppagouda Bagali	46	F	900624	LBA R	Degenerative	L5-S1	L4-L5-S1	1	56	7	6	0	3	3	3	3	12	Excellent
28	Ranabayi N Jadhav	59	F	254207	LBA R	Degenerative	L4-L5	L4-L5	2	60	6	22	3	2	2	2	3	9	Good
29	Rangappa Hanamanth Haranatti	53	M	1754	LBA	Degenerative	L4-L5	L4-L5	2	56	7	20	4	2	2	3	3	10	Excellent
30	Sunanda Saibanna Hadari	45	F	388151	LBA	Degenerative	L3-L4	L3-L4-L5	1	66	7	0	1	3	3	3	3	12	Excellent
31	Suvarna D Dudagi	55	F	125889	LBA R	Degenerative	L4-L5	L4-L5	2	64	7	0	0	3	3	3	3	12	Excellent
32	Tukaram Veerbhadra Pare	52	M	110325	LBA R	Degenerative	L4-L5	L4-L5	1	62	6	14	0	3	3	3	3	12	Excellent
33	Budavva T	55	F	50458	LBA R D	Degenerative	L4-L5	L3-L4-L5	3	60	7	26	4	2	2	2	3	9	Good
34	Vithal Mahadevappa	37	M	51944	LBA	Degenerative	L5-S1	L5-S1	1	66	6	0	0	3	3	3	3	12	Excellent
35	Vaijawwa	38	F	41448	LBA	Degenerative	L5-S1	L5-S1	1	64	7	0	0	3	3	3	3	12	Excellent
36	Suresh Garudakar	59	M	43902	LBA R	Degenerative	L4-L5	L4-L5	1	48	6	10	3	2	2	2	3	9	Good