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Radiological and clinical prognosis of posterior lumbar intervertebral body cage versus posterior transpedicular screw fixation in patient with isthmic spondylolisthesis

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Abstract

Background and objectives: Isthmic type of Spondylolisthesis, resulting from the failure of the anterior column, requires fixation by a transpedicular screw posteriorly. The research aimed to distinguish discrepancies in clinical presentation, functional outcomes, and mechanical characteristics by evaluating clinical, radiographic, activity, and pain information.
Methods: A Prospective study was conducted from January 2016 until March 2020, at Erbil Teaching and Paky Hospital, Pedicle screw fixation was performed on 70 consecutive patients diagnosed with isthmic spondylolisthesis. Posterior transpedicular screw fixation was performed in 36 persons, while posterior lumbar intervertebral body fusion was performed in 34 persons. The assessments of the activity and pain statuses were performed prior to and post the surgical procedure.

Results: There was no statistically significant divergence of the modifications. The statistical analysis conducted within the groups has demonstrated that the surgery had a significant impact on the subluxation percentage, angle of slippage, and foraminal area. Nevertheless, it had no impact on the sacral inclination or the segmental lordosis. The 3-year follow-up examination did not demonstrate any statistical intergroup differences regarding improvement neurologically (p=1.01), Activity outcome (p=0.52), Pain outcome (p=0.87), fusion rate (p=0.47). Nonetheless, the group that underwent PLIF procedure showed maintained subluxation correction, disc height, and foraminal area which was not observed in the fusion by only posterolateral approach group (p_0.07).

Conclusion: The interbody fusion procedure provides enhanced mechanical strength to the spinal structure in instances of Isthmic spondylolisthesis. It is anticipated that the degree of correction attained will slowly decrease when posterior transpedicular fixation clinically.

Keywords: Posterior Intervertebral Body Fusion, Spinal Fusion, Spondylolisthesis, Transpedicular Screw

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Introduction:

Spondylolisthesis, an anterior subluxation of a vertebra onto another, occurs due to the inadequate posteriorly directed force vector caused by the failure of compensatory mechanisms.[1] The shear forces that arise within the disc space between intervertebral bodies lead to the anterior displacement of the vertebra. Isthmic spondylolisthesis arises due to a fault in the pars interarticularis and can afflict approximately 8% of the entire populace across all age groups.[2] Spondylolisthesis commonly arises from the gradual malalignment of the lumbar vertebral bodies of the spine. The isthmic and degenerative subtypes of spondylolisthesis constitute ninety percent of the total cases of vertebral body displacement.[3] The ailment afflicts an estimated 20.7% of the overall populace between the ages of 40 to 80 years. Just a few minorities of clinically symptomatic patients necessitate surgical intervention. With posterolateral fusion (PLF) not only fulfilling the pivotal function of stabilizing the lumbar vertebrae Some critics contend that halting the advancement of disease is inadequate and that surgeons should also rectify the malalignment of the spine. In a clinical analysis of spondylotic spondylolisthesis, this was exemplified.[4] contended that performing a posterior decompression procedure, subsequent to PLF, resulted in a substantial interval at the spondylolisthesis level.[5] Tropiano et, al have proposed a bisected resolution. Firstly, bolstering of the anterior column ought to be done by employing an intervertebral body bone graft on the spondylolisthesis level. Secondly, the reduction of the listhesis should be promptly carried out during the intraoperative phase thereby, reducing the disparity and limiting the bending movement across the intervertebral graft. Notwithstanding these purported advantages, medical professionals have engaged in protracted discussions regarding the function of interbody fusions since Cloward initially expounded upon the posterior lumbar intervertebral body fusion (PLIF) technique in 1943, which was subsequently revised with a transforaminal approach (TLIF).[6] Dantas et, al The posterior element fusion of lumbar vertebrae in conjunction with the insertion of instruments offers a viable resolution for strengthening the spine and may result in a robust fusion in up to ninety percent of persons.[7] The process entailed segmental immobilization combined with either posterior lateral fixation or posterior lumbar intervertebral body fusion (PLIF). Our objective in comparing these methodologies was to scrutinize the existence of disparities within them. Clinical and practical results, as well as in characteristic biomechanically.[8]

Patients and methods

A Prospective study was conducted from January 2016 until March 2020, at Erbil teaching hospital and Paky Private Hospital, seventy adult persons with a diagnosis of isthmic spondylolisthesis were subjected to the implantation of a uniform transpedicular screw system. Among them, 36 individuals received a simple posterolateral fusion while a PLIF was added to the remaining 34 patients. The test cohort consisted of 42 male and 28 female individuals; the age of 42.5 years is an average age of them (25 to 60 years). The assessments of the activity and pain statuses were performed prior to and post the surgical procedure. The 3-year follow-up examination did not demonstrate any statistical intergroup differences regarding improvement neurologically ($p = 1.01$), Activity outcome ($p = 0.52$), Pain outcome ($p = 0.87$), or fusion rate ($p = 0.47$). Nonetheless, the group that underwent the PLIF procedure showed maintained subluxation correction, disc height, and foraminal area which was not observed in the fusion by only the posterolateral approach group ($p \_ 0.07$). The patients exhibited

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symptoms such as claudication-induced pain in the lumbar region, gluteal area, and posterior femoral region, along with lumbosacral radicular pain. Tenderness in the lumbosacral region was manifest in 48 patients (68.5%), while restricted lateral bending was present in 34 (48.5%). Dermatomal sensory disturbances were seen in 40 patients (57.1%), disturbances of motor function in 32 (45.7%), and responses to straight-leg raising tests were positive measured in 30 (42.8%). Additionally, reflexes were diminished which was noted in 36 patients (51.4%) and 16 (22.8%) showed indications of bladder dysfunction. It is noteworthy to mention that 24 patients were smokers. In individuals undergoing medical treatment conservatively, including immobilization, anti-inflammatory pharmacotherapy, physical rehabilitation, and external brace application, treatment has not yielded resolution of symptoms. The economic and functional statuses of the patients were evaluated preoperatively and postoperatively, utilizing the methodology suggested by Prolo et al. [9] The preliminary radiographic evaluation consisted of dynamic, lateral, oblique, and anteroposterior imaging analyses carried out in an upright position. The VB slippage percentage was evaluated utilizing the classification system of Meyerding for spondylolisthesis. [10]

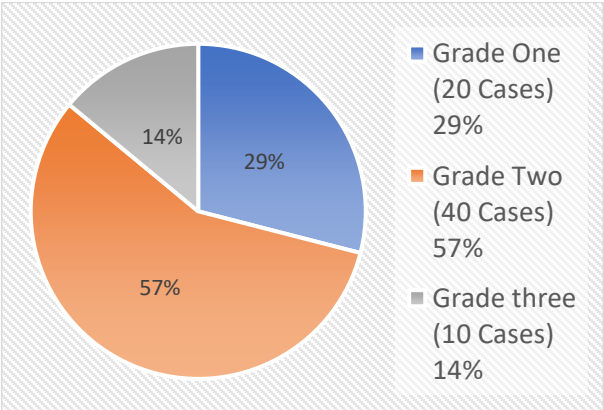

Figure (1): Grades of subluxation and its percentage

Vertebral slippage was categorized based on Grades; Grade I (consisting of 20 patients), Grade II (consisting of 40 patients), and Grade III (consisting of 10 patients). The area affected was the lumbar or lumbosacral spondylolisthesis, and the highest degree of dislodgment observed was approximately 63%. To determine the degree of neural compression, we conducted a computerized tomography and magnetic resonance radiologic study, which concluded the research summarized in Figure (1). The prior to operative clinical, activity economically, and neuroradiologic findings have been succinctly concise in Table (1).

Table (1): Radiological and clinical studies prior operation

	PLF	PLF+PLIF
Activity Score	3	3
Pain Score	2	3
Slippage (%)	39	36
Slip angle (degree)	69	71
Sacral inclination (degree)	43	48
Segmental lordosis	17	17
Foramina area (square mm)	116	104

Fusion occurred in all patients combined with implantation.[15] Before the insertion of screws and the maneuvers for reduction, decompressive surgery encompassing removal of the spinous process, removal of laminae bilaterally, removal of facet partially in both sides and widening of foramen was carried out. The intervertebral spaces were meticulously evaluated for protrusions of content of disc herniation or conspicuous bulges, and the intervertebral discs were excised, if deemed demanded. The placement of the instrumentation has been explicated.[11] Following the insertion of pedicle screws, longitudinal distraction was executed using a threaded spindle. Reduction maneuvers were

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subsequently executed by means of the detachable levers that were inserted into the pedicle screws. Fusion was executed posterolateral. The bony structures of the transverse processes and articular processes underwent decortication via the employment of a high-velocity rotary drill. Subsequently, the cancellous bone derived from the dorsal arch was employed to fill the stripped area. Ultimately, cortical strips were intricately intertwined above the bony material graft. A lumbar intervertebral body fusion by posterior approach (PLIF) was performed in 34 patients using a peak cage with a cuboidal shape measuring 0.7 cm in width, 0.7-1.3 cm in height, and 2.2 cm in length. The block was coated with porous pure titanium, which has been shown to promote growth of the bone.[12] After the mobilization of the sac of the dura, a three-step procedure was employed for the removal of the disc and preparation of endplates, involving the use of dedicated instruments for reaming, rasping, and broaching. The bone cortex underwent intentional roughening and was partially excised. Subsequently, pairs of peak cage fusion blocks were skillfully inserted and advanced. Cancellous material of bone, harvested from the patient's own body, was meticulously inserted into the grooves positioned on both aspects of the implant laterally and medially. All individuals received successive clinical evaluations at fixed intervals every 4 months, spanning from the 4th to the 24th month after the operation. Prior to operation records were thoroughly examined, and the cases were individually interviewed. After the surgical procedure, a neutral third party, who had no involvement in the surgery or hospitalization, assigned activity economically and pain functionally classifies the cases. The change in economic activity and functional pain categories for each individual was assessed and subsequently compared between the groups. Postoperative radiographs were acquired at regular intervals of four months for a period of 24 months, to evaluate the degree of dislodgment reduced and ensure the proper positioning and long-lastingness of the prosthesis.[13] Fusion was delineated successfully as the following: The absence of motion perceived in dynamic imagery, and the lack of a perimeter encompassing the prosthesis captured in imaging studies; the existence of uninterrupted, bilaterally located trabecular bone among the merged segments. Computed tomography or magnetic resonance imaging with bone window was conducted postoperatively on all cases to assess the outcomes of decompression of neural structures. The foraminal area for neurons was estimated through lateral imaging prior to intervention, post-intervention, and during the two-year follow-up evaluation. Along the same lines, we determined the height of the disc, inclination of the sacrum, sagittal rotation, and segmental lordosis of the lumbar region. The assessment of lumbar lordosis was conducted at the segmental level either at L4-5 or L5-S1. For the evaluation of segmental lordosis at L4-5, lines were traced in a parallel manner, aligning with the cephalad endplate of L4 and the caudal endplate of L5 a supplementary line was subsequently traced perpendicular to each of the aforementioned parallel lines. The resultant angle, formed by the intersection of the second set of lines, was utilized to determine the segmental lordotic angle.[14] The same methodology was utilized to rectify lordosis at the L5-S1 level, employing the upper aspect of the sacrum and the cephalad L-5 endplate. The method of Wiltse and Winter was used to measure sacral inclination and sagittal rotation. [15] A Paired Student's t-test was conducted to analyze the data continuously between the groups, comprising the percentage of subluxation, area of the foraminal, height of the disc, angle of slippage, inclination of sacrum, and lordosis of the segment. Additionally, the

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unpaired t-test was employed to conduct a comparative analysis of the data among the groups. The Fisher's precise examination was implemented to compare the frequency of nonunion incidence, and correspondingly to juxtapose the rate of recovery neurologically. Additionally, The Mann-Whitney U-test in which the categorical data was employed for comparative analysis, specifically the economic activity and functional pain outcomes. The statistical significance was determined by considering the probability value of 0.05. The study has been approved by the Ethical Committee of Erbil Health directory. The statistical analysis was performed using. Version 23 of the Statistical Package for Social Science (SPSS).

Results

From January 2016 until March 2020, seventy individuals who had been diagnosed with isthmic spondylolisthesis received identical pedicle screw systems. Among them, 36 patients received a simple posterolateral fusion while a PLIF was added to the remaining 34 patients. The sample group consisted of 42 male and 28 female cases with a mean age of 42.5 years (with a range of 25 to 60 years old). The evaluation of the activity and pain statuses was performed preoperatively and postoperatively. Tables (2) and (3) provide a summary of the intergroup comparison regarding the improvement of motor and sensory deficits. It is worth noting that this only applies to the group that exclusively underwent posterolateral fusion. All patients with sensory deficits showed a significant enhancement, while motor impairments were ameliorated in all cases except for two. Reflex responses did not noticeably change after surgery, most likely due to persistent clinical symptoms. However, in one case prior to the operation complaining of disturbance of urination, demonstrated substantial functional improvement. In individuals who underwent PLIF in addition to fusion posterolaterally, a significant enhancement was observed in 100% of cases reporting sensory deficits. Motor impairments showed a noticeable improvement in 80% of patients. Four patients who experienced preoperative urinary incontinence showed recuperation of bladder control.

Table (2): Comparison for sensory, motor, activity, pain in patients with PLF

		PLF	
	Before operation	After operation	Change
Sensory loss	14	0	100%
Motor weakness	20	2	80%
Activity Score	2.3	3.9	1.6
Pain Score	2.5	3.8	1.3

Table (3): Comparison for sensory, motor, activity, pain in patients with PLF+. PLIF

		PLF + PLIF	
	Before operation	After operation	Change
Sensory loss	18	0	100%
Motor weakness	20	2	80%
Activity Score	2.4	4.1	1.7
Pain Score	2.1	3.9	1.8

Concerning the subset of patients who exclusively underwent posterolateral fusion, prior to the surgical intervention, the average Prolo economic grade stood at 2 (with a range of 1 to 3). Following the operation, however, the grade improved to 4 (within a range of 2 to 6). Significantly, in 27 patients (75%), a positive outcome (Grade 4-5) was observed, while seven (19.4%) and another two (5.5%) demonstrated (Grade 3) which is fair and (Grade 1-2) in which outcome is poor, respectively. It is noteworthy that the mean

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change, including the standard deviation, the grade within this particular subgroup manifested as 1.3 ± 0.5. The average Prolo functional level before surgery was 2 (with a range of 1-3), while after surgery, it was 4 (with a range of 2-6). In 27 patients (75%), a positive outcome was observed with a functional grade of 4-5, whereas 7 patients (19.4%) showed fair outcomes with a grade of 3, and none (0%) had a poor outcome with a grade of 1-2. The average change in function was 1.5 ± 0.7. In the subset of individuals who underwent Posterior Lumbar Interbody Fusion, the average Prolo economic grade prior to the procedure was 2.5 (with a range of 1-4). However, following the operation, the mean grade improved to 4 (with a range of 2-6). Out of the 34 individuals, 26 experienced favorable outcomes (Grade 4-5), while 5 saw moderate results (Grade 3), and 3 exhibited (Grade 1-2) in which the outcome is poor. The average shift in grade, expressed as mean ±SD, was 1.3 ± 0.5. The prior operative Prolo functional grade had a mean of 2.5 (with a range of 1-4). After the operation, it rose to 4 (with a range of 2-6). A positive outcome (grades 4-5) was observed in 27 patients (79.4%), while 7 patients (20.5%) had a fair outcome (grade 3) and none (0%) had poor outcomes (grades 1-2). The mean improvement in function was 1.5± 0.6, as per Standard Deviation. For the economic and functional scores, the mean changes were calculated and compared. There was no statistically significant divergence of the modifications. Preliminary computations were performed for the proportion of slippage, foraminal dimensions, vertebral body slip angle, sacral slope, and segmental lordotic curvature. Tables (4) and (5) provide a succinct concise of the prior operative and after-operative values. The statistical analysis conducted within the groups has demonstrated that the surgery had a significant impact on the subluxation percentage, angle of slippage, and foraminal area. Nevertheless, it had no impact on the sacral inclination or the segmental lordosis.

Table (4): Comparison of before & after operative imagine data in patients with PLF

		PLF	
	Before operation	After operation	p value
VB Slippage (%)	41	12.8	<0.001
VB Slip Angle Degree	69.2	63.7	<0.001
Sacral Inclination Degree	41.6	44.9	NS
Segmental Lordosis Degree	15.9	18.9	NS
Foraminal area $(mm)^2$	113.9	138.9	<0.001

Table (5): Comparison of before & after operative imaging data in patients with PLF+PLIF

		PLF + PLIF	
	Before operation	After operation	p value
VB Slippage (%)	37.2	13.3	<0.001
VB Slip Angle Degree	70.2	62.9	<0.001
Sacral Inclination Degree	45.2	47.2	NS
Segmental Lordosis Degree	15.8	18.8	NS
Foraminal area $(mm)^2$	107.3	139.3	<0.001

At the assessment conducted two years after the initial evaluation, both groups exhibited changes in slippage and foraminal area as compared to the immediate postoperative

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values; these alterations exhibited a propensity to revert to the preoperative values. Nevertheless, the degree of subluxation did not manifest considerable alterations in either cohort Figures (2) and (3). The data analysis revealed a significantly higher maintenance of the rectified deformity in the cohort that received PLIF intervention as demonstrated in Figure (3).

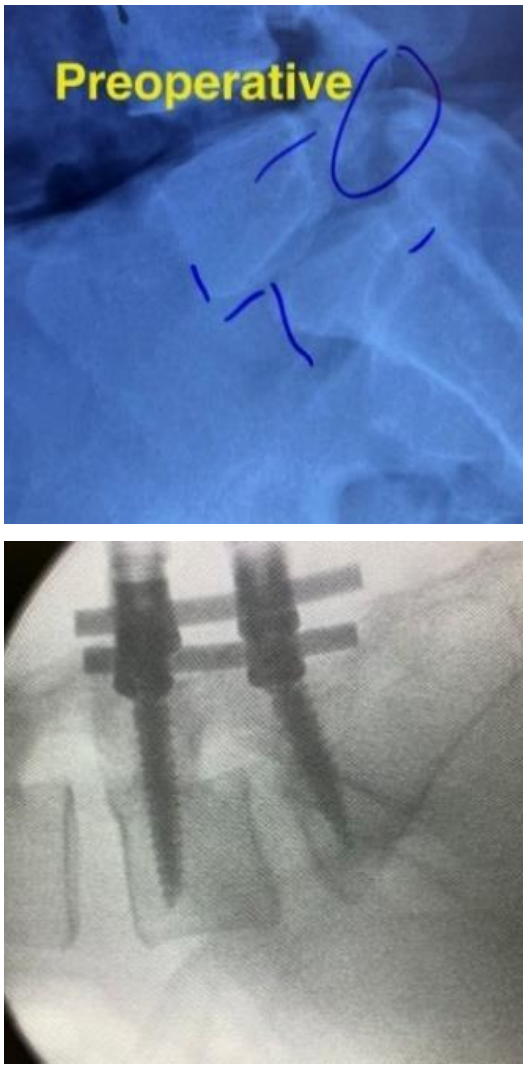

Figure (2): Preoperative and postoperative of PLF

Figure (2) Radiologic examinations taken in a subject diagnosed with spondylolisthesis. On the right side, the pre-surgical lateral radiograph reveals an isthmic L5-S1 subluxation with 35% vertebral body slippage. On the left side, after reduction and posterior lumbar fusion (PLF).

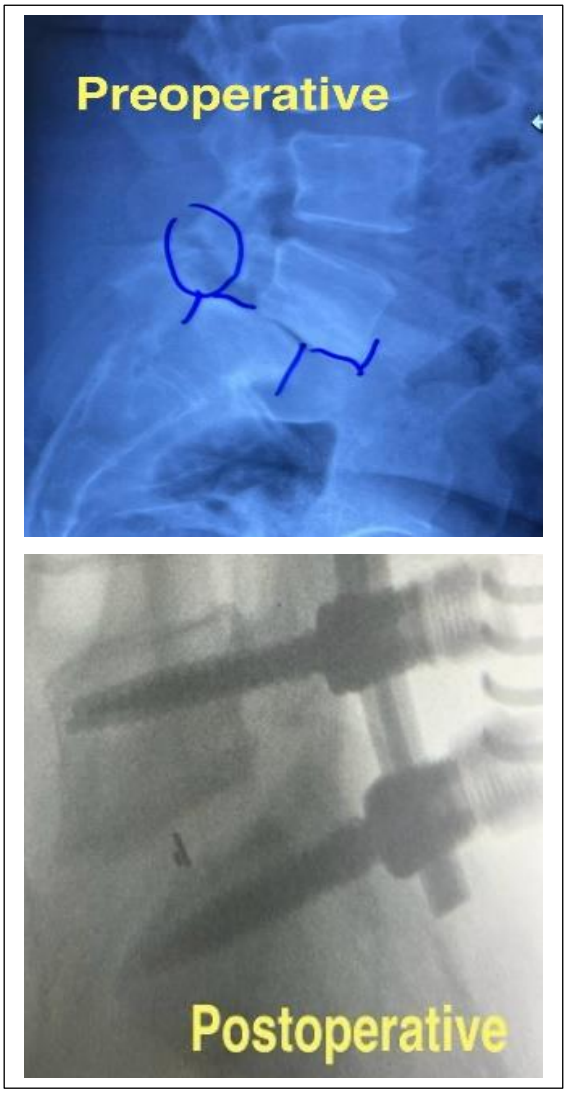

Figure (3): Preoperative and postoperative of PLIF

Figure: 3 Radiographic imaging acquired in a patient presenting with spondylolisthesis. On the right, a preoperative lateral x-ray film showcasing an isthmic L5-S1 subluxation with a 50% vertebral body slippage. On the left, there is a postoperative reduction observed after posterior lumbar fusion (PLF) and posterior lumbar interbody fusion (PLIF).

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Discussion

In a community-based study of Framingham Heart Study participants, the incidence of isthmic spondylolisthesis was reported to be 8.2%. The incidence of isthmic spondylolisthesis was documented at 8.2%. Surgical indications for isthmic spondylolisthesis encompass nonresponse to conservative treatment and gradual onset of neurologic deficits.[16]A fusion procedure is conducted with the intention of mitigating probable subsequent slippages of the vertebrae, while concurrently stabilizing the corresponding degenerative disc and arthritic facets. The radiographic rates of stringent fusion are enhanced when instrumentation is employed. Nevertheless, numerous investigations have manifested a deficiency of advantageous effects associated with instrumentation concerning outcomes centered on patients.[17] Ekman et al.[18] concluded that individuals suffering from symptomatic isthmic spondylolisthesis are improbable to witness significant recovery spontaneously over time; rather, such individuals are inclined towards experiencing chronic back pain, functional disability, and decreased quality of life throughout several years. Cheung et al.[19] Patients who received instrumentation displayed better outcomes in terms of back pain for up to a year following the surgery, as per the cohort study conducted on 765 patients from the Swedish Spine Register, which compared the results between instrumented and non-instrumented fusion procedures. In a previously treated cohort, solely posterolateral fusion was implemented, while in a more contemporary cohort, this technique was concomitantly carried out with posterior lumbar intervertebral body fusion (PLIF). In general, the PLIF procedure was associated with excellent mechanical dependability, as denoted by the preservation of spinal alignment ($p > 0.05$). Analysis of clinical results revealed no significant disparities between the groups ($p < 0.05$).The study conducted a retrospective analysis on two patient cohorts. The cohort of patients who underwent singular posterolateral fusion surgery was treated at the outset of the study when our proficiency with the implant system was nascent. During the latter phase of the study period, as we gained proficiency, we integrated a Posterior Lumbar Intervertebral Body Fusion (PLIF) procedure.

The learning curve appears to have been similarly impacted in both treatment cohorts. Moreover, the two groups exhibited homogeneity with respect to the majority of prior operative clinical and image parameters Table (1), and the same team of surgeons executed the implantation procedure. As a result, the two cohorts were deemed to be comparable, and selection bias was considered reasonably minimal. Improvement in the curvature of the lumbar spine could potentially increase the rate of fusion by reducing the forces of shear that cause forward sliding. [20]The process of reduction or distraction can also potentially rectify angular deformities in the sagittal plane caused by VB slippage. These deformities cause additional strain on the lumbar region, leading posture and gait abnormalities and low back pain.[21]

From this study, we have determined that the instrumentation-assisted technique is safe and effective in correcting anatomical changes in the lumbar spine caused by spondylolisthesis Figs. (2) and (3). Furthermore, we have deduced that this procedure possesses the capability to diminish displacement and angle of VB slippage while simultaneously reinstating the neural foraminal area.[22]The anterior column bears 80% of the axial load that occurs naturally in the lumbar spinal area, with the posterior components bearing the remaining 20%. On the other hand, the entire axial load passes through the system in fused parts

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without anterior support, decreasing the system's overall lifetime.Conversely, alternate writers have exhibited that this exceptional solidity is imparted upon conjoining interbody fusion instruments with screw/rod mechanisms, suggesting that the latter must not be employed as independent implants for managing lumbar spondylolisthesis.[23]Our findings confirm the observations that adding posterior lumbar interbody fusion (PLIF) strengthens the vertebral structure mechanically. However, in spite of these discussions, we did not find any appreciable intergroup differences in the fusion rate. These discussions, we did not find any appreciable intergroup differences in the fusion rate. 88.9% of the subgroup successfully achieved fusion. Who underwent posterolateral fusion, whereas it was attained by 100% in the posterolateral/PLIF-treated group ($p = 0.49$). This result was foreseeable and is substantiated by the extant literature. Regarding the fixation of the segments in isthmic spondylolisthesis.[24] Conducted a comparison between posterolateral fusion and PLIF. They discovered that 7.5% of the subgroup undergoing instrumentation-augmented posterolateral fusion experienced fusion failure, whereas PLIF led to successful fusion in all cases. Nonetheless, there existed no statistically significant dissimilarity amid the two cohorts. This observation is coherent with the new investigations conducted by Madan.[25] Research indicates that posterior lumbar structural fusion, when paired with instrumentation implanting, is a valid treatment option for lumbar spine instability, with up to 95% of cases showing evidence of a stable fusion. One of our aims was also to ascertain whether the image dissimilarities were correlated with disparate outcomes clinically.The improvement neurologically and alterations in functional and economic assessments, including the outcomes of pain, daily activities, and work productivity, did not exhibit significant disparity between the two cohorts ($p > 0.05$). In other words, both subcategories produced identical outcomes regardless of the respective mechanical characteristics of the two systems. The comparison between the overall favorable outcome (economic: 68.5%, functional: 71.4%) and the fusion rate (94.3%) revealed a lack of complete overlapping between these two values. While slightly unexpected, this is a commonly discovered outcome in the literature. Additionally, The decrease in intervertebral height. The observed phenomenon in the group that received posterolateral fusion treatment could have potentially contributed to some level of anterior reinforcement. Which was further amplified by the additional technique employed in the group subjected to posterior lumbar intervertebral body fusion (PLIF). This may have contributed to the stabilization of the system and its favorable impact on the reduction of pain.

Conclusion

Isthmic type of Spondylolisthesis, resulting from the failure of the anterior column, requires fixation by a transpedicular screw posteriorly, with or without interbody fusion, the interbody fusion procedure provides enhanced mechanical strength to the spinal structure in instances of Isthmic spondylolisthesis, It is anticipated that the degree of correction attained will slowly decrease when posterior transpedicular fixation is the sole intervention. This mechanical insufficiency, however, does not have an impact on the outcome clinically, However, the PLIF technique is comparatively more intricate and can increase the expenses and hazards associated with the procedure.

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Conflict of interest

There is no conflict of interest.

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