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Research Article

Comparison of Clinical Outcomes of Conservative Treatment, Percutaneous Intralaminar Stabilization of Pars Defect, and Posterolateral Fusion with Interbody Fusion in Spondylolysis

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Abstract

Aim: This study aimed to compare the clinical efficacy of posterior lumbar interbody fusion (PLIF), percutaneous intralaminar screw pars stabilization (PS), and conservative treatment (CT) for symptomatic spondylolysis (SL).

Material and Method: A retrospective randomized study was conducted on 45 patients, with 15 in each group (PLIF, PS, and CT), who underwent bilateral L5 SL and were treated between 2017 and 2022. Surgical indications included low back pain lasting >6 months that was unresponsive to CT and without sciatica. The CT group comprised patients with similar pain profiles. Clinical outcomes were measured using the visual analog scale (VAS), Oswestry Disability Index (ODI), and Short Form 36 (SF-36) scores at 0, 1, 3, 6, and 12 months.

Results: The study included 65% female patients with a mean age of 52 (PLIF), 44 (PS), and 46 (CT) years. Both the PS and PLIF groups showed significant clinical improvement compared with the CT group ($p<0.05$). No intraoperative complications were observed. The mean hospital stay was shorter in the PS group (2.7±1.3 days) than in the PLIF group (5.4±1.8 days). The operation time was 40±15 minutes for PS and 168±41 minutes for PLIF, with blood loss of 50±15 cc for PS and 350±170 cc for PLIF.

Conclusion: PS and PLIF resulted in better clinical outcomes than CT for L5 spondylolysis. PS is a minimally invasive and safe option with less muscle and soft tissue disruption; however, the final follow-up scores did not differ significantly between the PS and PLIF groups.

Keywords: Spondylolysis, pars stabilization, isthmic defect, intralaminar screw, conservative treatment

INTRODUCTION

The term spondylolysis (SL) originates from the Greek words spondylo (vertebra) and lysis (separation) and is defined as the separation or defect of the pars interarticularis (1-3). Repetitive hyperextension and rotation of the spine in SL causes microtrauma in the pars interarticularis and leads to stress fractures (4-6). It is a common cause of low back pain, particularly in athletic adolescents and young adults (2,7). Its prevalence is approximately 6-8%, and it is most commonly seen at the L5 level, followed by L4, and less frequently at the upper levels (8). It is mostly asymptomatic and becomes symptomatic after repeated lumbosacral strain during heavy physical labor. Mild or moderate low back pain, which increases with activity and resolves with rest, and complaints of tension in the hamstring muscles are common. Clear neurological deficits or radicular findings are very rare. Anteroposterior, lateral, and oblique direct radiographs of the lumbosacral region are the first steps in diagnosis. Computed tomography is the technique that best demonstrates the bony architecture of the pars; however, it should be chosen with caution, especially in young people, because of the risk of ionizing radiation. Magnetic resonance imaging (MRI) is the first choice for complaints of sciatica, young patients, and neurological deficits and is the gold standard for the detection of stress reactions (9). Initial treatment in symptomatic patients includes rest, use of a lumbar corset, and physiotherapy for 4-6 weeks. Regular daily activities are gradually increased as symptoms decrease. Surgery may be performed in patients in whom symptoms persist or who are unresponsive to conservative treatment (CT). Surgical fusion is an effective method for stabilizing the spine during lumbar spondylolysis and is preferred for reducing

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chronic back pain and disability. In the surgical treatment of SL, many surgical techniques ranging from percutaneous screw fixation of the pars defect with percutaneous technique to posterolateral segmental fusion are applied according to the patient's and physician's decision, and a success rate of 60-90% has been reported (4,10). The aim of this study was to evaluate and compare operative factors and the visual analog scale (VAS), Oswestry Disability Index (ODI), and Short Form 36 (SF-36) clinical scores of patients with SL who were followed up with conservative methods, those who underwent percutaneous intralaminar screw pars defect fixation (PS), and those who underwent posterior lumbar interbody fusion (PLIF) with open surgery to determine which method was more effective.

MATERIAL AND METHOD

Ethical Approval

This study protocol was approved by the University of Health Sciences Kanuni Sultan Süleyman Training and Research Hospital Ethical Review Board (Subject No: KAEK/2022.02.38; approval date: 10/02/2022). All the procedures were performed in accordance with the principles of the Declaration of Helsinki.

Study Characteristics and Patient Population

Between 2017 and 2022, patients with single-level L5 spondylolysis who were treated either conservatively or surgically and followed up were randomly included in the study. A total of 45 patients (15 in each group) treated with percutaneous intralaminar stabilization, posterolateral interbody fusion and stabilization, or conservative methods were included in this retrospective, randomized study. The inclusion criteria were L5 bilateral spondylolysis, listhesis <3 mm, posterior opening >5°, and no neurological deficits. The exclusion criteria were spondylolisthesis, concomitant spinal disorders (scoliosis, trauma, infection, and tumor), and osteoporosis.

All patients were diagnosed with spondylolysis by dynamic imaging, computed tomography, and MRI within normal limits and had listhesis <3 mm, which is considered normal according to many studies (9).

The main complaint of all the patients was low back pain without sciatica. For clinical outcomes, the VAS was used to measure pain level, the ODI to assess functional limitations in activities of daily living, and the SF-36 to assess general health and quality of life at admission and at 1, 3, 6, and 12 months follow-up. Changes over time and differences between the conservative and surgical groups were analyzed. The duration of hospital stay, duration of surgery, amount of bleeding, and use of drains were analyzed.

Conservative Treatment Method (CT)

Patients were followed up with analgesics, activity restriction, exercises focusing on the deep abdominal musculature and lumbar multifidus muscles, daily life modification, and lumbosacral bracing for 4-6 weeks. Patients were allowed to start limited activities 4 weeks after the start of treatment (Figure 1).

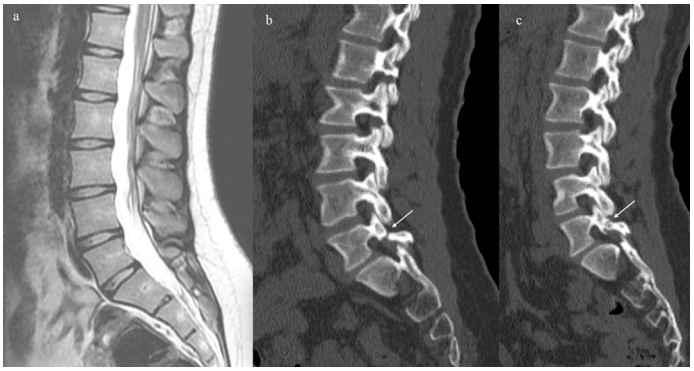

Figure 1. In patient 8 in the conservative treatment group, lumbar T2 sequence midsagital MRI (**a**), right pars defect (white arrow) (**b**), left pars defect (white arrow) (**c**) in parasagittal section image of lumbar computed tomography

Percutaneous Intralaminar Screw Stabilization Method (PS)

Using the percutaneous technique, with the help of two anteroposterior and lateral scopes and after a 2 cm sacral skin incision, a Jamshidi needle was inserted inferiorly caudal to the L5 lamina, close to the facet joint. A guidewire was advanced through the lamina, pars defect, defective pars neck, and pedicle using a high-speed drill with the help of a guidewire through a Jamshidi needle. A working cannula was inserted under the guidance of a guidewire, with the guidewire remaining in place. With the help of the guidewire, the lamina and pars defect were drilled with a 3 mm diameter drill, the cannulated screw was placed to terminate near the superior cortex of the pedicle, and the guidewire was removed. The mean screw diameter was 4-4.5 mm and length was 3.5-4 cm. The pars defect was debrided using an ultrasonic bone microshaver through the same working cannula under scopic visualization. Intralaminar screw fixation of the contralateral pars defect was performed using the same incision, and the skin was sutured (Figure 2).

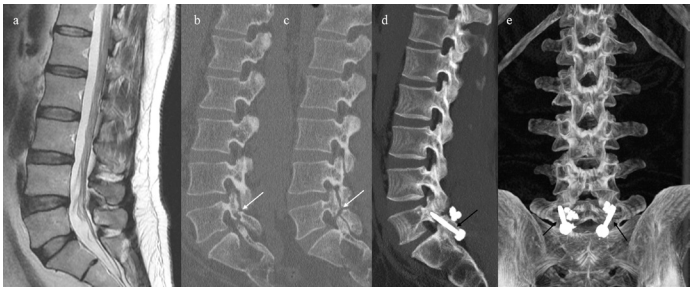

Figure 2. In the 10th patient in the pars stabilization group, lumbar T2 sequence midsagital MRI (**a**), right pars defect (white arrow) (**b**), left pars defect (white arrow) (**c**) in parasagittal section image in lumbar computed tomography, L5 pars screw (black arrow) in sagittal image (**d**), right and left pars screws (black arrow) (**e**) in coronal image with 3D reconstruction in lumbar computed tomography

Posterolateral Interbody Fusion and Fixation Method (PLIF)

After L5-S1 midline skin incision, subcutaneous and fascia incision, and paravertebral blunt dissection with conventional surgery, bilateral pedicle screws were inserted into the L5 and S1 pedicles under scopic control.

After partial medial facetectomy and hemilaminectomy, microdiscectomy was performed and a bone graft and/or cage was placed in the disc space. A bone graft was placed on the screw and rod edges. After controlling the bleeding, the muscle and fascia were closed anatomically, and the skin was sutured (Figure 3).

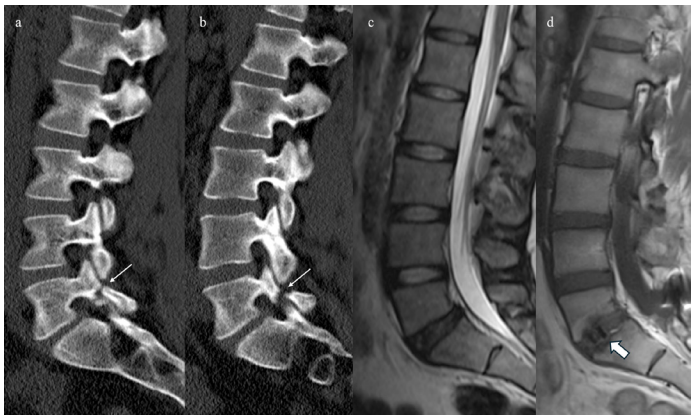

Figure 3. In the 15th patient in the posterolateral interbody fusion group, right pars defect (white arrow) (**a**), left pars defect (white arrow) (**b**) on lumbar computed tomography parasagittal image, preoperative lumbar T2 sequence midsagital MRI (**c**), postoperative lumbar magnetic resonance sagittal section image with plif (thick white arrow) (**d**)

Statistical Analysis

IBM SPSS statistical software (version 23.0, IBM Corp., Armonk, NY, USA) was used for statistical analysis. The study data were analyzed using descriptive statistical methods (mean, standard deviation [SD], median, quartile range, frequency, and proportion) and box plots. Conformity to normal distribution was analyzed using the Shapiro-Wilk test. Repeated measures analysis of variance (ANOVA) was used to examine within-group and between-time changes in normally distributed data. Two-way repeated measures ANOVA (treatment group and time factors) was used to determine the differences between treatment groups. In cases in which the data did not conform to a normal distribution, the Kruskal-Wallis test was used to evaluate the differences between groups, and Dunn's test was applied for post-hoc analyses. All analyses were performed with a 95% confidence interval (CI) and a significance level of $p<0.05$.

RESULTS

In the CT group, the mean age was 46±15 years (range, 21–68 years), with eight females and seven males. In the PS group, the mean age was 44±13 years (range, 23–59), with 10 females and 5 males. In the PLIF group, the mean age was 52±8 years (range, 29–64 years), with nine females and six males. The mean operative time was significantly shorter in the PS group compared with the PLIF group (PS group: 40±15 minutes; PLIF group: 168±41 minutes, $p<0.001$). Similarly, intraoperative blood loss was significantly lower in the PS group (PS group: 50±15 ml; PLIF group: 350±170 ml, $p<0.001$). The hospital stay was also significantly shorter in the PS group compared with the PLIF group (PS group: 2.7±1.3 days; PLIF group: 5.4±1.8 days, $p=0.03$). No blood transfusions were required in either group. Four patients in the PLIF group required surgical drainage, and one patient developed a surgical wound infection.

Neuropathic pain developed in two patients in the PLIF group and one patient in the PS group; however, the pain improved significantly by the 4th day of gabapentin treatment, after which the medication was discontinued. Upon admission, VAS scores were 7.6±1.4 in the CT group, 8.2±1.5 in the PS group, and 8.1±1.4 in the PLIF group, with no significant difference between the groups ($p>0.05$). ODI scores at admission were 43±3.5 in the CT group, 55±5.6 in the PS group, and 49±2.6 in the PLIF group. There was a significant difference between the CT and PS groups ($p=0.004$) and between the CT and PLIF groups ($p=0.003$) in terms of ODI scores at admission, whereas no significant difference was found between the PS and PLIF groups ($p=0.910$).

The SF-36 Mental Health (MH) scores were 49±4.2, 49±7.0, and 45±6.2 in the CT, PS, and PLIF groups, respectively, with no statistically significant difference between the groups ($p>0.05$). Similarly, the SF-36 Physical Health (PH) scores were 49±3.3, 49±3.7, and 48±3.6 in the CT, PS, and PLIF groups, respectively, with no significant differences ($p>0.05$). At 12 months, VAS scores decreased by 3.9, 6.2, and 6.8 points in the CT, PS, and PLIF groups, respectively ($p<0.05$). Statistically significant differences were found between the CT and PS groups ($p=0.023$) and between the CT and PLIF groups ($p=0.004$) at 12 months; however, no significant difference was observed between the PS and PLIF groups ($p=0.170$).

The ODI scores decreased by 18 points in the CT group, 45 points in the PS group, and 38 points in the PLIF group at 12 months compared with those at admission ($p<0.05$). Significant decreases were found between the CT and PS groups as well as between the CT and PLIF groups ($p<0.001$), with no significant difference between the PS and PLIF groups ($p=0.623$). The SF-36 MH scores increased by 3, 6, and 12 points in the CT, PS, and PLIF groups, respectively, at 12 months ($p<0.05$). A statistically significant difference was found between the CT and PLIF groups ($p=0.004$), whereas no significant difference was observed between the CT and PS groups ($p=0.064$) or between the PS and PLIF groups ($p=0.910$). The SF-36 PH scores increased by 4, 13, and 12 points in the CT, PS, and PLIF groups, respectively, at 12 months ($p<0.05$). Significant differences were found between the CT and PS groups ($p=0.009$) and between the CT and PLIF groups ($p=0.014$), with no significant difference between the PS and PLIF groups ($p=0.473$).

In all three groups, there was a significant decrease in the VAS and ODI scores and an increase in the SF-36 MH and SF-36 PH scores at the last follow-up compared with baseline ($p<0.0001$). Improvement in the CT group was less pronounced than that in the other groups. Overall, the VAS, ODI, SF-36 MH, and SF-36 PH scores for low back pain improved significantly in all three groups at follow-up ($p<0.05$). The PS and PLIF groups achieved better clinical

results than the CT group (p<0.05) (Figure 4). No patients in the CT group underwent surgery. In the postoperative period, a skin infection in one patient in the PS group was treated with topical antibiotics. In the PLIF group, two patients were treated with an iliolumbar trigger point injection.

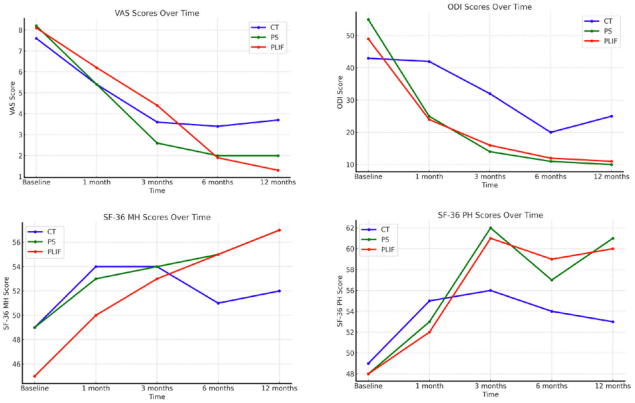

Figure 4. Results of VAS, SF-36 and oswestry disability index scores

DISCUSSION

SL is a neural vertebral arch defect that most commonly occurs at the L5 level and is usually asymptomatic (4). The cause of defect development is fatigue fracture of the pars (1). Two-way oblique direct radiography is the first choice for visualizing pars defects. While MRI is a sensitive method to reveal stress fractures and bone edema, computed tomography shows bone architecture in detail. Conservative methods are largely successful for treating symptomatic SL, but surgical intervention is required in 9-15% of cases (11). Classical or percutaneous surgical techniques are used for symptomatic patients. Many surgical techniques such as pars screwing, screw-wire, screw-rod, screw-hook techniques, posterolateral stabilization and interbody fusion and/or a mixture of these techniques are applied according to the decision of the surgeon and the patient, but there is no gold standard surgical technique. The PS technique provides minimally invasive rigid fixation of the pars defect with the help of percutaneous working cannulas, restoring impaired intrasegmental abnormal motion (4,9,12-15).

However, the PLIF approach provides direct decompression of the compressed neural elements through unilateral or bilateral access to the disc space after partial facetectomy and provides bony fusion of the posterior neural arch, but it impairs segmental motion.

Our results showed that neither surgical technique was superior in terms of pain or functional outcomes at the most recent follow-up; however, the clinical scores were better than those in the CT group. PS showed a significant reduction in surgical time and intraoperative blood loss compared with PLIF (p<0.001). No blood transfusion was required in either group, but surgical drainage was required in four patients who underwent PLIF. No minor intraoperative complications were observed. PLIF has been associated with a longer operative time, as in our case, and PS provides a shorter recovery time and earlier return to daily life. Adjacent segment development may be a significant problem in PLIF; however, adjacent segment development has not been reported using the PS method. Percutaneous and minimally invasive procedures are associated with rapid recovery time and low perioperative blood loss rate. Our study found that the hospital stay was significantly shorter in PS patients (4.7±2.3 days) compared with PLIF patients (6.4±2.8 days) (p=0.03). Surgical treatment should be considered in the absence of impressive improvement in symptoms after conservative treatment for 4-6 months on several occasions (16,17). Confirmatory testing of the pars defect with an anesthetic block should be performed before surgery for a differential diagnosis (4,18,19). Treatment options are classically divided into direct repair of the pars defect and spinal fusion. The choice of the most appropriate surgical intervention is largely determined by the severity of SL and the patient's clinical goals and perspective. Segmental fusion shows significant efficacy in reducing pain, and up to 70% of the patients with terminal SL experience significant pain relief (20,21). L5/S1 fusion with an autogenous iliac bone graft is often the first-line surgical treatment for adult patients with symptomatic L5 SL. In younger or more active patients, one of many different techniques, such as intralaminar screw fixation of the pars defect, V-rod technique, screw hook, and screw tape, may be preferred. Minimally invasive methods are preferred when muscle damage is undesirable in athletes or young individuals. In PS, segmental spinal motion is directly restored with pars defect repair and is generally preferred in adolescents and young adults if the intervertebral disc is intact (16,20,22). Direct repair is often recommended as the first-line surgical treatment for young athletes and patients with active lifestyles to prioritize functionality and accelerate their return to sports (23,24). Direct repair methods, including single-screw fixation (i.e., Buck's), hook screw fixation, pedicle screw band fixation, and robot-assisted direct repair, may vary according to the surgeon's experience and patient preference. Percutaneous intralaminar screw fixation may be preferred in pars injection-positive patients, patients with slippage of <3 mm, normal disc structure, and no radiculopathy (4,12,25). In our study, blood loss and length of hospital stay were lower with direct percutaneous pars screw fixation, but the learning curve was challenging. PLIF is the preferred surgical method for terminal-stage SL. The clinical scores were better in the two surgical groups than in the CT group. The main outcome measured was disability; when compared with the preoperative value, the difference between the PS and PLIF surgical groups in the final ODI assessment at 12 months after surgery was 10 points, and no screw malposition or fracture was detected in the PS group. The operative time was shorter for percutaneous PS (40 min) and longer for PLIF (3 h). Surgeons may favor open surgical methods in cases of abnormal laminar anatomy or pseudarthrosis, which may result in more heterogeneous studies (2,26). The primary limitation of our study is its retrospective design, which may introduce a potential bias in patient selection, despite adherence to standard

criteria. Additionally, the small sample size and single-center setting limits the generalizability of the findings, even though the patient groups were homogeneous. Furthermore, the ultimate goal of all these procedures is to achieve sound arthrodesis. Although all operations were performed by the same surgeon, ensuring consistency, the study's limitations could be addressed through larger-scale, long-term, prospective randomized trials to provide more comprehensive evaluations and reliable results. Future research may more clearly define the appropriate indications for PLIF and PS for which a minimally invasive or open approach should be used. The fact that there was no difference in the short-term results between PS and PLIF may indicate that the selection bias was low. The current study could be conducted as a randomized prospective study involving different groups.

CONCLUSION

There was no significant difference in the clinical outcomes between intralaminar pars stabilization and posterolateral interbody fusion. The PS method showed superior results in terms of operative time, estimated blood loss, and length of hospital stay. To our knowledge, this is the first study to compare the clinical outcomes of percutaneous intralaminar screw pars fixation and posterolateral lumbar interbody fusion with conservative treatment in SL; further prospective, multicenter studies are required to confirm these findings.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *This study protocol was approved by theUniversity of Health Sciences Kanuni Sultan Süleyman Training and Research Hospital Clinical Research Ethics Committee (Subject No: KAEK/2022.02.38; approval date: 10/02/2022). All the procedures were performed in accordance with the principles of the Declaration of Helsinki.*

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