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Comparison Of Operative Outcomes of Open Versus Percutaneous Pedicle Screw Fixation for the Treatment of Lumbar Spondylolisthesis

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ABSTRACT

Lumbar spondylolisthesis often requires surgical correction, with options like open or percutaneous pedicle screw fixation. **Objectives:** To compare their outcomes, focusing on reduced trauma, blood loss, and postoperative pain with the percutaneous approach. **Methods:** A quasi-experimental trial at Sir Ganga Ram Hospital, Lahore, included 44 patients with lumbar spondylolisthesis. Exclusion criteria were metabolic bone diseases, prior spine surgery, pregnancy, and spinal malignancy. Patients were divided into Group A (percutaneous fixation) and Group B (open Pedicle screw fixation). Intraoperative time, blood loss, and VAS pain scores were recorded. The outcome variables were postoperative hospital stay, blood loss, and surgery duration. Data was analyzed by using SPSS 25.0. **Results:** Among 44 participants, 20 were male, and 24 were female. Group A had 6 males (27.3%) and 16 females (72.7%), while Group B had 14 males (63.6%) and 8 females (36.4%). Mean intraoperative time was 44.45 ± 6.87 minutes in Group A vs. 51.27 ± 3.45 in Group B. Blood loss was significantly lower in Group A (52.82 ± 3.45 mL) compared to Group B (349.23 ± 92 mL, $p<0.05$). Postoperative pain at 6 weeks (Group A: 3.09 ± 1.41 vs. Group B: 3.36 ± 1.59) and 3 months (Group A: 2.18 ± 1.09 vs. Group B: 2.0 ± 1.02), indicating no statistical difference. **Conclusions:** Compared with traditional posterior muscle stripping treatments, percutaneous pedicle screw fixation proves an effective treatment in terms of less postoperative blood loss and operative time. This highlights the technique's potential advantages in improving patient recovery without compromising long-term pain outcomes.

INTRODUCTION

Spondylolisthesis is caused by vertebral migration or slip, mainly in the lumbar spine, and has spondylolytic and degenerative aetiologies [1]. Lumbar spondylolisthesis is a common spine condition causing pain and requiring surgery [2]. Children often experience it, but adults are more symptomatic [3]. Spondylolytic spondylolisthesis is a common youth or early adult fracture of the pars interarticularis [4]. Degenerative spondylolisthesis is the most frequent type of adult disease that causes vertebral body slip [5]. Spondylolisthesis prevalence in symptomatic and asymptomatic subjects varies, with most studies focusing on anatomical features [6]. Taiwan and Denmark have a 6% women's prevalence, while the USA has a 4-31% men's prevalence [7, 8]. Spondylolisthesis is a condition that affects women three times more often than men, typically causing back pain due to vertebral locking

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dysfunction. Diagnosis is confirmed through imaging techniques such as X-rays, MRI, or CT scans [9]. Surgical procedures for spondylolisthesis correction include neuronal decompression, interbody fusion, and fixation, available alone or in combination for effective treatment [10]. Conservative management is typically used for spondylolisthesis patients without neurological deficits. Surgery is recommended for significant deficits, advancement in spondylolisthesis grade, and daily life activities affecting daily activities [11]. Previous studies have shown the advantages of surgical procedures, but recent advances show the widespread popularity of minimally invasive procedures like PPF for lumbar interbody fusions. Pedicle screw fixation is crucial for degenerative lumbar spondylolisthesis, ensuring adequate spinal correction [12]. Screw invasion in upper facet joints can cause stress distribution changes, leading to spontaneous fusion, spondylolisthesis, and increased likelihood of revision surgery. Percutaneous fixation technique reduces paravertebral muscle mass stripping and iatrogenic injury in lumbar and back muscles [13]. Percutaneous pedicle screw fixation is gaining popularity among neurosurgeons due to its minimal invasiveness and minimal spondylolisthesis. However, the technique's degree of compression and spondylolisthesis remains controversial. Percutaneous pedicle screw fixation with posterior immobilization is gaining popularity due to its minimal spinal tissue trauma, shorter surgery time, blood loss reduction, and posterior arch preservation. However, long-term follow-up studies on clinical and radiological outcomes remain scarce for adults with grade 1 and grade 2 spondylolisthesis [14].

The rationale of the study is the choice of surgery for correction of spondylolisthesis, whether open or percutaneous. Although these procedures have been compared previously and have a very scarce literature review, prioritizing percutaneous screw fixation. The Percutaneous Pedicle Screw Fixation (PPSF) has been introduced as a less invasive procedure to replace an open pedicle screw Fixation (OPSF) in treating the Lumbar Spondylolisthesis, with the possible benefits being a lower surgical morbidity. Nonetheless, there is not much comparative data on early postoperative outcomes. The study aimed to compare the postoperative pain, intraoperative blood loss, and operative time between PPSF and OPSF.

METHODS

A quasi-experimental trial was conducted in the Department of Neurosurgery at Sir Ganga Ram Hospital, Lahore. The study duration was from June 2023 to June 2024. Ethical approval was obtained from the Institutional Review Board (Ref: 23-MD-Neurosurgery/IRB) before commencement of the study. All patients meeting the inclusion criteria were enrolled after obtaining written informed consent following an explanation of the risks and benefits. Basic demographic data were recorded for all participants. Each patient underwent a detailed pre-operative clinical and neurological examination as part of routine spine assessment. A total of 44 patients (aged 30–60 years) with lumbar spondylolisthesis were included. The calculated sample size using the mean difference of hospital stay in open Vs. Percutaneous pedicle screw fixation was (3.98 ± 1.17 vs 3.06 ± 0.89) was 44 (22 in each group), by taking 80% power of the test and 95% confidence interval [15]. Patients were allocated to Group A or Group B using non-random consecutive sampling based on surgeon preference and clinical indications. The prone position of patients was applied with the assistance of a C-arm under fluoroscopic guidance. In Group A (open pedicle screw fixation), an average midline posterior incision was used, and then the paraspinal musculature was dissected subperiosteally to reveal the posterior components of the spine. The pedicle screws were placed under the influence of fluoroscopes by using the traditional freehand method, and rods were fixed and fastened with set screws. In Group B (percutaneous fixation), AP-Ferguson views were used, and a Jamshidi needle was placed at right angles to the vertebra and moved in a bullseye direction to preserve the integrity of pedicles. A guide wire was inserted and then, successively, dilators and a working sleeve. A reamed pedicle was made, and a cannulated screw of suitable size was inserted. The screw tulips were passed with rods that were then fixed with set screws, and the result was confirmed on AP and lateral fluoroscopic images. Both groups underwent no interbody fusion or bone grafting; only pedicle screw fixation and stabilization were done. Fixation of wounds was followed by a layered wound closure. All surgeries were performed by consultant spine surgeons with more than 5 years of experience in spine surgery and pedicle screw fixation. After general anesthesia, a midline incision exposed the affected vertebrae. Pedicle entry points were identified, and screw trajectories were confirmed with a C-arm. Screws were inserted bilaterally, and rods were positioned to reduce spondylolisthesis via ligamentotaxis. Spinal decompression was performed, and hemostasis was achieved. The fascia was closed watertight, followed by subcutaneous and skin closure with aseptic dressing. The intraoperative time was noted from the time of incision to the closure of the wound and documented in the required proforma. After the surgery, intraoperative blood loss was calculated and documented. The pain relief was assessed at the 1st week, 6th week, and at 3 months postoperatively via VAS.

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All the data were noted and analyzed using SPSS version 25.0. Numerical variables, i.e., age, intraoperative blood loss, duration of surgery, post-operative pain, and postoperative hospital stay was presented by mean ± SD. All the qualitative variables, such as gender was presented by frequency and percentages. An independent sample t-test was applied for the comparison of mean postoperative hospital stay, blood loss, and duration of surgery between the two groups. The p-value of <0.050 was statistically significant.

RESULTS

Group A had a mean age of 45.18+3.02 years, and Group B had a mean age of 44.05 ± 2.34 years. The mean BMI in Group A was 28.2 ± 2.35, while in Group B, it was 28.18 ± 3.33. Of the total participants, 20 were male, and 24 were female. In Group A, there were 6 males (27.3%) and 16 females (72.7%), whereas Group B had 14 males (63.6%) and 8 females (36.4%) (Table 1).

Table 1: Age and Gender Distribution of Patients

Variables	Group A (n=22)	Group B (n=22)	Total (n=44)
Mean Age (Years)	45.18 ± 3.02	44.05 ± 2.34	–
Mean BMI (kg/m^2)	28.2 ± 2.35	28.18 ± 3.33	–
Male, n (%)	6 (27.3%)	14 (63.6%)	20
Female, n (%)	16 (72.7%)	8 (36.4%)	24

The average intraoperative time was 44.45 ± 6.87 minutes in Group A, compared to 51.27 ± 3.45 minutes in Group B. The difference between the two groups regarding operative time was statistically significant, with a p-value of 0.029. The mean blood loss in Group A was 52.82 ± 3.45 mL, whereas in Group B, it was significantly higher at 349.23 ± 92 mL. The comparison yielded a p-value of 0.001. The mean duration of hospitalization was 4.2 ± 0.32 days for Group A and 7.12 ± 0.45 days for Group B. The difference in hospital stay was statistically significant, with a p-value of 0.001 (Table 2).

Table 2: Comparison of Intraoperative Outcomes Among Both Groups

Variables	Group A	Group B	p-value
Operative Time	44.45 ± 6.87	51.27 ± 3.45	0.029*
Intraoperative blood loss	52.82 ± 3.45	349.23 ± 92.6	0.001*
Hospital stays	4.2 ± 0.32	7.12 ± 0.45	0.001*

VAS score- a gradual decrease in the duration of the post-operative symptomatic pain in Group A and Group B. The two groups had similar pain scores immediately after surgery. Nonetheless, the percentage decrease in the level of pain is observed in Group A at 1 week after the operation than in Group B (mean VAS: 4.18 vs 5.45). This continues up to the 6th week, where Group A still scores lower on the pain scale than Group B (mean VAS: 3.09 vs 3.36). The comparison of post-operative pain between the two groups is not significant (p>0.050), which means that the surgical method applied in Group A is related to better early and short-term pain results than in the case of Group B (Figure 1).

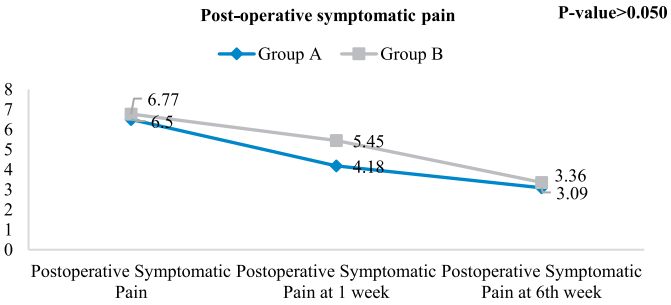

Figure 1: Postoperative Pain Comparison Between Study Groups

DISCUSSION

The aging population has led to a rise in low back pain from lumbar degenerative disease, often linked to spinal alignment and pelvic sagittal balance. Adjustments to spino-pelvic parameters are crucial for managing sagittal imbalance and associated symptoms. The demand for a better quality of life has driven advancements in surgical approaches for spondylolisthesis [16]. Therefore, this study was conducted to compare the outcomes of open and percutaneous pedicle screw fixation in the treatment of lumbar spondylolisthesis. In this study, we compared intraoperative outcomes between two groups. Group A had a significantly shorter average intraoperative time of 44.45 ± 6.87 minutes versus 51.27 ± 3.45 minutes for Group B (p=0.029). Blood loss was also notably lower in Group A at 52.82 ± 3.45 mL compared to 349.23 ± 92 mL in Group B (p=0.001). Additionally, the average pain score one-week post-operation was lower in Group A at 4.18 ± 1.53 compared to 5.45 ± 1.96 in Group B, reinforcing the significant advantages of Group A's outcomes. A randomized controlled study also reported that percutaneous pedicle screw fixation (PPSF) and open pedicle screw fixation (OPSF) lead to similar clinical outcomes in patients with thoracolumbar spine fractures without any neurological impairment. The research showed that PPSF was not linked with a lower intra-operative blood loss, whereas the scores of post-operative pain and operative time were comparable between the 2 methods [17]. However, literature reports that advanced percutaneous spinal fixation techniques have been developed to overcome the limitations of open screw-rod instrumentation, including higher infection rates, increased blood loss, and prolonged hospital stays, to enhance patient safety and clinical outcomes [18]. A major benefit of percutaneous spinal fixation over traditional open techniques that has been reported with high consistency is the large cutdown in intraoperative blood loss. It has been shown that percutaneous pedicle screw fixation (PPSF) is related to

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significantly reduced blood loss when compared to open posterior instrumented fusion (OPIF) [19]. This benefit is credited to a great extent to the least soft-tissue dissection, less paraspinal muscle stripping, and minimal surgical exposure in minimally invasive methods. A meta-analysis and systematic review of percutaneous and open surgical methods of thoracolumbar fracture in patients showed statistically significantly less intraoperative blood loss in patients who have undergone percutaneous fixation [20]. The same has been reported in patients with thoracolumbar spinal metastases, where PPSF had led to reduced blood loss in a significant margin over OPIF [21]. However, another investigation found that patients who underwent conventional open surgery experienced average intraoperative and postoperative blood losses of 380 and 441.1 mL, respectively [22]. Reduced postoperative pain may lead to faster mobilization, faster recovery, a shorter stay in the hospital, and lower hospital expenses. The recent study also reported the lesser postoperative pain and faster recovery. To compare the results, a systematic review and meta-analysis were done. 279 individuals getting percutaneous fixation were compared to 340 patients undergoing open fixation using data from 12 pertinent studies. The percutaneous group's surgical time was much shorter. A shorter hospital stay was also linked to the percutaneous method. Although there was no difference in screw mispositioning, the percutaneous technique had better clinical outcomes on the visual analogue scale and a lower incidence of infection [23].

Although the advantages of the percutaneous pedicle screw fixation (PPSF) have been well-documented, there are still significant factors to consider: first, the learning curve related to minimally invasive approaches, the required specific equipment, and the inability to reach the best result with complicated fractures. Effective practice of PPSF needs specific training and a comprehensive knowledge of the anatomy of the spine, the possibility of guidance of imaging, and operative biomechanics. This research has some limitations, such as it was carried out in one center, and this might not apply to the rest of the population. The quasi-experimental design did not have the possibility of blinding because it did not allow it, which could have affected subjective outcome measures. Also, the six-week follow-up was not sufficient to evaluate the long-term results, including the success of fusion and long-term clinical effectiveness.

CONCLUSIONS

It was concluded that, compared with traditional posterior muscle stripping treatments, percutaneous pedicle screw fixation proves an effective treatment in terms of less postoperative blood loss, pain, and operative time. The percutaneous pedicle screw technique offers reduced blood loss, less pain, and shorter hospital stays. Despite a steeper learning curve, its benefits, such as minimal muscle damage and comparable accuracy, make it a strong alternative to the traditional open approach. This paper has noted that percutaneous fixation with minimal invasion can be incorporated as a possible alternative to traditional open fixation in that it can provide better early post-surgical recovery and does not negatively affect the outcome of short-term stabilization.

Authors' Contribution

Conceptualization: SS, SF, TA, AH
Methodology: TA, AH
Formal analysis: SS, SF, DS, MA
Writing and Drafting: SS, AH
Review and Editing: SS, SF, DS, TA, MA, AH, FAKL

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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