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Unilateral fenestration versus laminectomy in treatment of degenerative lumbar spinal stenosis. Comparative study

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ABSTRACT

Background: The syndrome of degenerative Lumbar spinal stenosis (LSS) accounts for a large percentage of cases of low back pain in the elderly worldwide. Surgical management has demonstrated better clinical and radiological results than conservative treatment. It allows for adequate decompression of the thecal sac and the compressed nerve roots. However, aggressive laminectomy with facetectomy has been linked with many postoperative complications, including instability. Hence, new, less invasive modalities have been introduced, such as fenestration and endoscopic laminotomy.

Objective: This study aimed to compare the safety and outcome of conventional laminectomy to unilateral fenestration in cases of degenerative LSS.

Methods: This prospective study was conducted in the Neurosurgery Department, Mansoura University Hospitals, between February 2023 and January 2025. Consecutive patients with degenerative LSS were randomly assigned to either conventional laminectomy or unilateral fenestration and decompression. Demographic data, intraoperative findings and clinical outcomes were analysed.

Results: Fifty patients were included; 25 patients underwent unilateral fenestration, and 25 patients underwent conventional laminectomy. Stratifying patients based on the affected vertebral level revealed that in the single-level cohort, the mean age was 65.65 ± 5.30 in fenestration group vs. 70.15 ± 6.69 years in laminectomy group; $p = 0.016$. Fenestration achieved a markedly shorter incision (3.25 ± 0.33 vs. 5.25 ± 0.61 cm; $p < 0.001$) and tended toward less blood loss (33.60 ± 3.87 vs. 36.10 ± 4.17 mL; $p = 0.053$). There was no significant difference regarding complication rate, the length of hospital stays and operative time. In the double-level cohort, fenestration was associated with smaller incisions and less blood loss, as well as shorter hospital stay and lower instability risk. However, in all other variables, we observed no statistically significant difference between the two groups. Both procedures significantly reduced pain and disability scores over six months, with comparable effectiveness.

Conclusion: Unilateral Fenestration is safe and comparable to conventional laminectomy in efficacy and should be considered as a viable minimal-invasive option in the treatment of lumbar stenosis patients due to its ability to produce adequate clinical outcomes with minimal bleeding risk and shorter hospital stay.

Keywords
fenestration, laminectomy, LSS

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Introduction

Lumbar spinal stenosis (LSS) is defined as a narrowing of the lumbar spinal canal, reducing the available space for neural and vascular components. This condition often leads to pain in the buttocks or lower limbs and may or may not be accompanied by lower back pain (1). LSS is categorized by its cause—either primary or secondary—and by the affected anatomical region: central, lateral, or foraminal. Primary stenosis results from congenital spinal canal narrowing, whereas secondary stenosis arises from multiple conditions, most commonly age-related degeneration. Other secondary causes include trauma, tumors, infections like osteomyelitis, and inflammatory diseases such as rheumatoid arthritis (2).

The size of the spinal canal and foramina, which determines nerve root space, is influenced by both developmental anatomy and degenerative joint changes. Stenosis can develop in three main areas: the central canal (bounded by vertebral bodies, discs, and facet joints), the lateral recess or subarticular zone (between the thecal sac and pedicle), and the neural foramen (beneath the pedicle) (3).

Symptoms usually involve persistent or gradually worsening leg and/or buttock pain over months or years, which may or may not include back pain. This pain, localized to the lumbar region, can radiate to the gluteal area, groin, or legs and may resemble radicular symptoms without true nerve root involvement. Neurogenic claudication—leg discomfort induced by walking and relieved by sitting—is considered the hallmark symptom of LSS (4).

CT scanning enables accurate assessment of the spinal canal and can help differentiate between causes of stenosis such as disc bulges, ligament thickening, or bony overgrowth

(5). However, MRI provides superior detail regarding spinal canal morphology and better visualizes both central and lateral types of stenosis, making it the imaging method of choice in LSS evaluation(6).

Initial management should be conservative, typically lasting 3 to 6 months, focusing on symptom relief and functional improvement. If symptoms remain severe and lead to significant disability, surgical intervention is indicated. The goal of surgery is to relieve pressure on the affected neural structures while maintaining spinal stability. The traditional approach is laminectomy, which has long been considered the standard. Recently, less invasive methods have been introduced, including unilateral laminectomy, bilateral fenestration with foraminotomy, and unilateral fenestration with nerve root decompression on either or both sides(7,8).

This study compares the safety and clinical outcomes of standard laminectomy versus unilateral fenestration in patients with degenerative lumbar spinal stenosis.

Materials and methods

Patient selection criteria

This prospective study was conducted in Neurosurgery Department, Mansoura University Hospitals during the period from February 2023 to January 2025. Consecutive patients with degenerative LSS were randomly assigned to either conventional laminectomy or unilateral fenestration and decompression.

Patients with the following criteria were enrolled in our study: 1) patients > 30 years old; 2) degenerative LSS not responding to medical treatment for 6 months; 3) pure neurogenic claudication; 4) unilateral or bilateral sciatica more predominant to one side. Patients with congenital or discogenic LSS, vascular claudication, radiological evidence of instability or medical condition that could affect the outcome were excluded.

Careful history taking with emphasis on excluding neuropathic pain due to other causes as DM and analysis of sciatic pain and claudication. Thorough general and neurological examination with exclusion of vascular claudication either clinically or using Doppler study was done. Radiological investigations included: dynamic standing lumbosacral x- ray to show signs of lumbar spondylosis and instability; CT to delineate the bony anatomy and measure the diameters of lumbar canal AP, lateral recess and IVF; MRI to show pressure on the dural sac, loss of CSF, crowding of the roots of the cauda equina redundant nerve root sign, thickening of the ligamentum flavum and facet capsules, degeneration and subluxation of the facets, bulging or herniation of the disc and space available around nerve roots. Demographic data, intraoperative findings and clinical outcomes were analyzed.

Surgical technique

Patients were positioned prone on a radiolucent table with slight flexion (Wilson frame or chest rolls) to open interlaminar spaces. The level was confirmed using fluoroscopy. A midline skin incision about 2–3 cm over the affected level then subperiosteal muscle dissection was done. Laminectomy was done in the conventional way. Fenestration was done using high-speed drill or Kerrison rongeurs to remove the inferior edge of the superior lamina and superior edge of the inferior lamina at the interlaminar window. After decompressing the ipsilateral root and half of the canal, the retractor and table were adjusted to decompress the contralateral side. After ensuring hemostasis, layered closure was performed.

Follow-up

Patients were followed 1 day, 1 week, 3 weeks, and 3 months postoperatively. Clinical outcome was assessed using Visual Analogue Scale (VAS), Oswestry Disability Index (ODI) and length of hospital stay (LOHS). Radiological follow-up was done using CT and MRI 6 months postoperatively to assess the degree of decompression. Dynamic x- ray was done to assess the stability of the spine whenever needed.

Statistical analysis

Data analysis was performed by SPSS software, version 26 (SPSS Inc., PASW statistics for windows version 26. Chicago: SPSS Inc.). Qualitative data were described using number and percentage. Quantitative data were described using median (minimum and maximum) (interquartile range) for non-normally distributed data and mean± Standard deviation for normally distributed data after testing normality using Kolmogrov-Smirnov test / Shapiro Wilk test. The significance of the results obtained was judged at the (0.05) level. Chi-Square, Fisher exact test was used to compare qualitative data between groups as appropriate. Student t test was used to compare 2 independent groups for normally distributed data. The paired t test was used to compare 2 paired readings for normally distributed data.

Results

Stratifying patients based on the affected vertebral level revealed that in the single-level cohort, fenestration was more popular with younger patients compared with laminectomy (65.65 ± 5.30 vs. 70.15 ± 6.69 years; p = 0.016), while other demographic data such as gender distribution did not differ. Although there was no significant difference between the two groups regarding the complications rate, length of hospital stays and operative time, fenestration achieved a markedly shorter incision (3.25 ± 0.33 vs. 5.25 ± 0.61 cm; p < 0.001) and tended toward less blood loss (33.60 ± 3.87 vs. 36.10 ± 4.17 mL; p = 0.053). Risk of instability was similar between the two groups, with similar improvements in the VAS and ODI scores. On the other hand, in the double-level cohort, fenestration again was associated with smaller incision and less blood loss, as well as shorter hospital stay and lower instability risk. However, in all other variables we observed no statistically significant difference between the two groups.

In comparisons within the fenestration cohort, double-level procedures were associated with longer incisions (3.95 ± 0.23 vs. 3.25 ± 0.33 cm; p < 0.001), increased operative time (55.75 ± 4.98 vs. 50.85 ± 6.58 min; p = 0.012), greater blood loss (38.45 ± 4.02 vs. 33.60 ± 3.87 mL; p = 0.001), and longer hospitalizations (1.65 ± 0.67 vs. 1.05 ± 0.22 days; p = 0.001) than single-level fenestration. Furthermore, no differences in age, sex, complication rate, instability or clinical scores was observed. In the laminectomy cohort, double-level cases tended to be younger (65.65 ± 5.30 vs. 70.15 ± 6.69 years; p = 0.016), with longer incisions (5.96 ± 0.24 vs. 5.25 ± 0.61 cm; p < 0.001), more blood loss (48.45 ± 4.02 vs. 36.10 ± 4.17 mL; p = 0.001), and longer hospital stays (2.85 ± 1.53 vs. 1.25 ± 0.44 days; p = 0.001) than single-level laminectomy, while operative time, complications, stability, and patient-reported outcomes were otherwise comparable.

In the overall combined cohort of 80 patients, both fenestration and laminectomy techniques demonstrated comparable demographic and safety profiles; no statistically significant differences in age (66.05 ± 5.41 vs. 67.90 ± 6.38 years; p = 0.166), sex distribution (p = 0.818), CSF leak (p = 1.0), wound infection (p = 1.0), or postoperative instability on dynamic radiographs (p = 1.0). Moreover, we observed that operative times were similar between the two procedures (p = 0.924). Fenestration was associated with significantly smaller incisions (3.60 ± 0.46 vs. 5.61 ± 0.57 cm; p = 0.001), less intraoperative blood loss (36.03 ± 4.61 vs. 42.28 ±

7.45 mL; p = 0.001), and shorter hospital stays (1.35 ± 0.58 vs. 2.05 ± 1.38 days; p = 0.004) compared to conventional laminectomy. Regarding clinical outcomes, both techniques produced marked and statistically equivalent improvements in functional disability (preoperative ODI 52.1 ± 6.5 vs. 50.4 ± 6.8; six-month ODI 19.6 ± 5.7 vs. 20.3 ± 6.0; p = 0.583) and pain severity (preoperative VAS 5.58 ± 1.19 vs. 5.65 ± 1.17; six-month VAS 2.48 ± 0.59 vs. 2.55 ± 0.59; p = 0.576), with both groups demonstrating significant within-group reductions from baseline (all p = 0.001).

Discussion

Our analysis demonstrated that both unilateral fenestration and laminectomy techniques were effective in improving the symptomatic burden of the patients, evident by the statistically significant improvements in both the VAS and ODI scores from pre- operation status. Furthermore, in direct comparative analysis, no technique proved superior efficacy over the other, evident by the comparable non-significant differences in the VAS and ODI scores between the two interventions. We also observed that the improvement obtained with the two procedures was consistent and sustained over long periods of time during the 6-month follow-up time.

Our findings are consistent with previous reports from the literature investigating the same subject. Mohamed et al. included 36 patients with degenerative LSS and demonstrated that decompression of lumbar spinal cord via either unilateral fenestration or conventional laminectomy was associated with a significant improvement of the patients' pain and disabilities, and that improvement was sustained over the long term (9).

In another retrospective analysis conducted by Adam et al., the authors observed that unilateral fenestration was similarly safe and effective compared to conventional laminectomy, with even slightly superior efficacy during the first month post-operation (10).

The improvements in the pain and disability obtained with either operation could be attributed to the decompression of lumbar spinal cord. The two procedures of unilateral fenestration and laminectomy have the ability to achieve neural decompression by removing bony and ligamentous structures that compress the spinal nerves. This relief of pressure on the nerve roots or the spinal cord helps to reduce inflammation, restoring nerve function and alleviating spinal radicular pain. Furthermore, other benefits from the decompression includes: enhanced neural conduction, diminished neuropathic pain, improved mobility, which collectively can lead to decrease in the pain and functional disabilities associated with spinal stenosis (11–13).

Interestingly, we observed that the patients who were treated with unilateral fenestration were associated with smaller incision, lower risk of bleeding, lower blood loss and shorter hospital stay compared to patients who underwent the laminectomy operation.

This is consistent with the findings provided by Mohamed et al., in which the authors observed that the fenestration group experienced significantly less estimated blood loss (259.17±46.79 ml) compared to the conventional laminectomy group (497.50±33.60 ml, p<0.001) and significantly shorter skin incisions with unilateral fenestration (6.02±1.25 cm) compared to conventional laminectomy (8.33±0.44 cm, p<0.001) (9).

Albakry et al. also observed lower risk of bleeding and shorter incisions in patients who underwent fenestration procedures compared to those who received laminectomy as the main intervention (14).

This could be easily explained by the minimally invasive nature of the fenestration technique, which is generally associated with small incision wound that mechanically produces lower amounts of bleeding leading to reduced hospitalization periods. The reduced tissue trauma, preservation of anatomical structures and targeted tissue decompression are all landmarks of the minimally invasive spinal techniques (15,16).

Regarding the safety analysis, we observed post-operative adverse outcomes were rate and equivalent between the two interventions, evident by the non-statistically significant differences in the rates of post-operative wound infections and CSF leak. Additionally, postoperative instability on dynamic X-ray was also rare and equivalent (5% vs. 7.5%, p = 1.0).

Ultimately, our findings are in accordance with recent recommendations from guidelines in recommending lumbar decompressive surgical options in patients with moderate to severe symptoms who have failed conservative management (17).

Due to lack of data, there is still no consensus on whether microscopic techniques are equivalent to standard laminectomy for adequate spinal canal decompression. Our findings proved that minimally-invasive techniques such as unilateral fenestrations can produce adequate and satisfactory clinical outcomes with reduced blood loss and shorter hospital stay (17,18).

Limitations

The relative short period of follow up and small number of cases limited our detailed assessment of various parameters in our study. Surgeon experience may influence the outcomes. Larger studies with longer periods of follow up are mandatory to make more concise conclusions.

Conclusions

Unilateral fenestration, whether at one or two levels, consistently offers smaller incisions, less blood loss, fewer stability concerns, and shorter hospital stays compared with conventional laminectomy in cases of LSS, while achieving equivalent improvements in disability and pain at six months. Larger studies with longer follow up are necessary to make more concise conclusions.

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