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Unilateral Fenestration versus Open Laminectomy in Treatment of Degenerative Stenosis of Lumbar Spine

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ABSTRACT

Background: The syndrome of degenerative lumbar canal stenosis accounts for a large percentage of causes 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 at comparing the safety and outcome of conventional laminectomy to unilateral fenestration in cases of lumbar canal stenosis.

Patients and methods: It took place at the Neurosurgery Department at Zagazig University and included thirty six patients with lumbar canal stenosis; eighteen patients were treated by conventional laminectomy and eighteen patients were treated by unilateral fenestration.

Results: Decompression led to an intense decrease of total pain in both groups. Matched with that experience in group I, but, with more remaining back and leg pain was found in group II, 6.58±0.99 and 6.75±0.96, respectively, compared with 2.16±0.57 and 2.75±0.86 , respectively, at the 12 weeks follow-up assessment ($p < 0.001$). The most obvious symptom of lumbar stenosis, neurogenic claudication improved in 91% of patients in group I compared to 83% in Group II. Patient satisfaction was higher in Group I, as the patients who underwent unilateral fenestration showed more decrease in total pain with 12 weeks postoperatively.

Conclusion: Unilateral fenestration allows acceptable and safe decompression of the spinal canal in patients with degenerative lumbar stenosis.

Keywords: Degenerative Stenosis, Lumbar Spine, Open Laminectomy, Unilateral Fenestration.

INTRODUCTION

The term lumbar spinal stenosis (LSS) refers to the anatomical narrowing of the lumbar spinal canal with diminished space available for the neural and vascular elements in the lumbar spine resulting in buttock or lower extremity pain, which may occur with or without low back pain [(1)].

Lumbar spinal stenosis can be classified according to etiology (primary and secondary stenosis) and to anatomy (central, lateral or foraminal stenosis). Primary stenosis is caused by congenital narrowing of the spinal canal, whereas secondary stenosis can result from a wide range of conditions, most often chronic degeneration. Other causes of secondary stenosis include rheumatoid diseases, osteomyelitis, trauma and tumors [(2)].

The amount of space available for nerve roots in the lumbar spinal canal and foramina is determined both by spinal developmental variations and by articular degenerative responses. Stenotic lesions can occur in any of three anatomic sites: the central canal, bordered by the vertebral bodies, discs and articular processes; the subarticular canal or lateral recess, which extends from the thecal sac to the pedicle and the intervertebral foramen or nerve root canal lying below the pedicle [(3)].

Typically, patient symptoms comprise unilateral or bilateral buttock and leg pain, which slowly develops and persists over several months, or even years with or without back pain. The back pain is localized to the lumbar spine and can radiate towards the gluteal region, groin and legs, frequently displaying a pseudoradicular pattern. Neurogenic claudication is the most specific symptom of LSS [(4)].

CT allows precise evaluation of the spinal canal and differentiation between spinal canal stenosis caused by discs, ligaments and bony structures [(5)]. MR imaging brought on clearer information regarding the morphology of the spinal canal and revealed its stenosis, which can be central or lateral (of the lateral recess or foramina). MRI is the preferred imaging modality for the assessment of LSS [(6)].

Conservative treatment for LSS should be applied for 3–6 months, with the aim of achieving satisfactory improvement of the symptoms. In patients in whom severe symptoms persist and functional impairment develops, surgery is the recommended option. All surgical procedures used in LSS aim to decompress the entrapped neural elements, without disrupting the stability of the segment. Laminectomy has been the gold standard of surgical treatment for lumbar spinal stenosis. Subsequently, less invasive

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techniques have been conceived: (unilateral laminectomy), (bilateral fenestration with foraminotomy), (unilateral fenestration with foraminotomy and ipsilateral and /or contralateral nerve root decompression) [7].

The aim of this study was to compare between traditional laminectomy vs unilateral fenestration in the management of degenerative lumbar canal stenosis.

PATIENTS AND METHODS

Site of study: This study was conducted in Neurosurgery Department, Zagazig University Hospitals.

Time of study: This study was conducted during the period from June 2019 to March 2020.

Study design: prospective clinical trial.

Sample size: 36 cases with degenerative lumbar canal stenosis were included.

Inclusion criteria:

1. Patients of any age group were included.
2. Both sexes were included.
3. Patients with degenerative lumbar canal stenosis who were: not responding to a six months medical treatment regimen, complaining of pure neurogenic claudication and complaining of claudication with unilateral sciatica or predominant unilateral sciatica.
4. Patients with cauda equina or functional deficit.
5. Patients who were generally fit for surgery.

Exclusion criteria:

1. Patients with congenital lumbar canal stenosis.
2. Patients complaining of bilateral sciatica of discogenic origin.
3. Patients with vascular claudication.
4. Patients with radiological evidence of lumbar spondylolysis or spondylolisthesis (instability).
5. Patients who were generally unfit for surgery.
6. Patients with general illness that could obscure the outcome e.g., advanced diabetic peripheral neuropathy.

The patients were classified into 2 groups:

Group I: Includes, eighteen patients who were operated upon with **unilateral fenestration**.

Group II: includes, eighteen patients who were operated upon with **conventional laminectomy**.

The steps included:

1) History was taken from the patient in details, with emphasis on and analysis of sciatica and claudication pain.
2) The patient was examined both generally and neurologically with emphasis on (straight leg raising test, femoral stretch test, motor and sensory examinations).
3) Exclusion of neuropathic pain due to other causes.
4) Exclusion of vascular claudication either clinically or using Doppler study whenever needed.
5) The patient was investigated for :
   i. General laboratory investigations: (CBC, CPK, Liver and Kidney functions tests, PT, PTT and INR).
   ii. Radiological investigations: **Lumbosacral Spine x-ray** (AP, lateral and stress dynamic) to show few direct signs of LSS, they included short bulky pedicles, reduced inter-pedicular distance, thickened laminae and decreased AP diameter of the lumbar canal. Also **CT** was done to delineate the bony anatomy well, advanced measurements of the lumbar canal AP diameter, lateral recess and IVF. **MRI** was done to show pressure on the dural sac, loss of CSF, crowding of the roots of the cauda equina and the 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 root in the foramen
6) The patient was operated upon for decompression using either unilateral fenestration or using conventional laminectomy.
7) The patients in both groups were subjected to follow up using the following methods :
   i. Clinically (1 day, 1 week and 12 weeks postoperatively) to assess the improvement of symptoms using pain Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI).
   ii. Radiological: CT and MRI (3 months postoperatively) to assess the degree of decompression postoperatively, also dynamic x-ray to assess the stability of the spine whenever needed.
   iii. Creatine phosphokinase (CPK) (12-48 hours postoperatively) to assess degree of muscle destruction and liability for healing.
   iv. Multifidus muscle cross sectional area which is calculated in a 3 months postoperative MRI. It is a good indicator of muscle healing and expected recovery from postoperative low back pain.

Statistical analysis

Recorded data were analyzed using the statistical package for the social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean±standard deviation (SD).

Qualitative data were expressed as frequency and percentage. Chi square test (χ^2) was used to study comparison and association between two qualitative variables. Independent t-test: was used for comparison between two groups having quantitative variables with normal distribution (for parametric data), while paired t-test was used to compare paired means for the same group. Mann-Whitney U test was used for comparison between two groups having quantitative variables without normal distribution. Wilcoxon Signed Ranks test was used for comparison between paired data not normally distributed having nominal variables. A P-value of < 0.05 was considered statistically significant and <0.001 for high significant result for two tailed tests.

RESULTS

This table (1) shows no significant difference as regard age and sex between the group with unilateral fenestration and the group with laminectomy.

Table (1): Comparison between the two groups as regard age and sex

Variable	Group I (unilateral fenestration) (N=18)		Group II (laminectomy) (N=18)		P value
Age (Years) **Mean ±SD** **Range**	59.41±5.55 (50-69)		62.83±5.21 (52-70)		0.0651
Variable	**No**	**%**	**No**	**%**	**P value**
Sex **Male** **female**	9 9	50.0 50.0	12 6	66.67 33.3	0.31

This table (2) shows highly significant difference between two operations as regard time of operation and estimated blood loss in CC (EBL) with increasing time of operation, blood loss and length of incision in laminectomy more than unilateral fenestration.

Table (2): Comparison between two groups as regard operative time, EBL and length of incision

	Group I (unilateral fenestration) (N=18)	Group II (laminectomy) (N=18)	P value
***Operative time(min)** **Mean± SD**	125.0± 16.65	150.83± 9.0	<0.001* HS
***EBL (Estimated blood loss in CC)** **Mean± SD**	259.17±46.79	497.50± 33.60	<0.001* HS
***Length of incision** **Mean± SD**	6.02± 1.25	8.33±0.44	<0.001* HS

*HS means highly significant difference

Morbidity and Mortality of Surgery: We did not have perioperative deaths. Of totally treated levels unintentional durotomy happened once; in a patient of group II that has been operated upon with conventional laminectomy. This Dural tear was not obviously related to postoperative morbidity, but was related to increased duration of surgery and augmented EBL. In that case, direct dural repair was done. No subsequent postoperative CSF fistula was detected. No extra hospital stay was needed. No cases suffered from neither increased radicular pain nor acute postoperative neurological deficit. Overall, the perioperative morbidity rate, including the clinically occult incidental durotomies, showed no significant statistical differences between both groups (Table 3).

Table (3): Comparison between two groups as regard type of operation and complication after each operation

Variable	Group I (unilateral fenestration) (n=18)		Group II (laminectomy) (n=18)		P value
***Type of operation**	No	%	No	%	
Double Level	17	94.4	14	77.7	
Triple Level	1	5.5	4	22.2	0.14
***Complications:**					
• **None**	17	94.4	17	94.4	0.37
• **Incidental Durotomy**	0	0	1	5.5	
• **Superficial wound infection**	1	5.5	0	0	

Assessment of Pain using Visual Analogue Scale: Decompression led to an intense decrease of total pain in both groups. Matched with that experience in group I, but, with more remaining back and leg pain was found in group II, at the 12 weeks follow-up assessment. The most characteristic symptom of lumbar stenosis, neurogenic claudication improved in 91% of patients in group I compared to 83% and in group II (Table 4).
Assessment of Disability: The same was true for the ODI scales; postoperative scales were significantly different from preoperative scales (Table 4).

Table (4): Evaluation of surgical outcome in patient with unilateral fenestration and laminectomy using VAS scale and ODI

	Preoperative (n=18)	12 weeks postoperative (n=18)	P value
Unilateral fenestration:			
*** VAS**			
Mean± SD	6.58±0.99	2.16±0.57	0.001*
*** ODI**			
Mean± SD	55.25±10.88	24.58± 6.92	0.001*
Laminectomy:			
*** VAS**			
Mean± SD	6.75±0.96	2.75±0.86	0.001*
*** ODI**			
Mean± SD	62.08±9.94	33.25±7.5	0.001*

Table (5) shows no significant difference between two groups in VAS and in ODI before operation, but there was significant difference between both groups 12 weeks after operation with more decrease in VAS in patients with unilateral fenestration operation more than patients with laminectomy.

Table (5): Comparison between two operations as regard VAS and ODI preoperative and postoperative

	Group I (unilateral fenestration) (N=18)	Group II (laminectomy) (N=18)	P value
***Preoperative**			
VAS			
Mean± SD	6.58±0.99	6.75±0.96	0.68
***12 weeks post-operative VAS**			
Mean± SD	2.16±0.57	2.75±0.86	0.04*
***Preoperative ODI%**			
Mean± SD	55.25±10.88	62.08±9.94	0.12
***12 weeks postoperative ODI%**			
Mean± SD	24.58± 6.92	33. 25±7.5	0.008*

This table (6) shows significant indirect correlation between degree of stenosis and VAS scale after operation in unilateral fenestration group.

Table (6): Correlation between degree of stenosis and outcome of both operations via VAS scale and ODI

Variable	Degree of Stenosis	
	R	P value
*** Group I**		
VAS scale	**-0.67**	**0.017***
ODI	**-0.40**	**0.188**
*** Group II**		
VAS scale	**-0.13**	**0.67**
ODI	**-0.43**	**0.15**

DISCUSSION

Regarding demographic data in our study, the mean of age group was 61.12, most of our studied groups were males (58.33 %) while females were (41.67%), 33.33% of the studied groups were housewives and retired, as regard marital status 83.33% were married.

Adam *et al.* [8] conducted a retrospective study on 58 LSS patients divided into two groups: group A (no=22) consisted of patients that underwent a laminectomy procedure and group B (no=36) of cases where unilateral fenestration was used. They reported that mean age for group A was (68 years) while mean age for group B was (69 years). Male was the predominant gender in both groups 12 (54%) and 22 (55%) respectively.

Regarding clinical symptoms in our study, the patients of both groups suffered from neurogenic claudication with mean claudication distance of (66.67 m) with range (30-120 m) for group of unilateral fenestration and (74.17 m) with range (30-120 m) for group of conventional laminectomy with no statistical significant difference between both groups. Also, there was no statistical significant difference between the patients of both groups regarding the straight leg raising test that was unilateral in 33 (91.6%) of patients more on left side while bilateral in 3 (8.3%). Other symptoms as low back pain was present in 10 patients (55.6%) of group I and in 9 (50%) of group II, leg pain was present in 11 patients (61.2%) of group I and 10 (50%) of group II while numbness was present in 8 patients (44.6%) of group I and 7 (38.8%) of group II.

Yang *et al.* [9] conducted an observational study on 21 patients (10 men and 11 women) aged 53-82 years (64.1±8.9 years) and were followed-up for a minimum of 3 years (36-69 months) after bilateral micro decompression by unilateral laminotomy. They reported clinical symptoms distribution as following; back pain present in 10 (52.6%) of patients, leg pain present in 9 (47.4%), neurogenic claudication present in 10 (52.6%) and apparent motor weakness present in 7 (36.8%) of studied patients.

Regarding operative parameters in our study, although longer surgery time looks like a disadvantage of unilateral fenestration compared to the classic laminectomy procedure, surgery time for unilateral fenestration has been perceived to decline as the surgeon improves his learning curve, as in our study. This is because of wide interest and increased familiarity in the fenestration approach.

In our study, the duration of surgery was less in the group of unilateral fenestration than conventional laminectomy group. This may be due to the use of fine Kerrison rongeurs that donated to the longer surgery time as the surgeon had to act more industriously to avoid complications.

Usman *et al.* [10] conducted a cross-sectional study on 60 patients with lumbar stenosis, randomly assigned to undergo either a conventional laminectomy (30 patients, Group A), or a unilateral approach (30 patients, Group B). He reported that for conventional laminectomy, the mean operating time was (65 ± 0.1) minutes, while for unilateral approach it was (69 ±0.1) minutes. This may be due to conduction of the study on a single level decompression surgery only either by conventional laminectomy or unilateral approach. **Adam *et al.*** [8] conducted a retrospective study on 58 LSS patients divided into two groups: group A (no=22) consisted of patients that underwent a laminectomy procedure and group B (no=36) of cases where unilateral fenestration used. He reported that mean operation time for classic laminectomy was (107 min) and for unilateral laminotomy was (70 min).

Regarding skin incision in our study, noticeably, it was longer in conventional laminectomy group with range (7-9 cm) than unilateral fenestration group with range (5.5-10 cm), which underlines the less invasive procedure of the fenestration method. However, relevant statistics in the literature are rare, while the importance of the cosmetic consequence has been harnessed.

Regarding estimated blood loss in our study, it was less in the unilateral fenestration group compared to conventional laminectomy group.

Farzad *et al.* [11] reported in a retrospective comparative study comparing unilateral fenestration to conventional laminectomy that intergroup comparison showed that mean blood loss and operating time were both greater in unilateral fenestration group but only the increased operating time was statistically significant. This conflict can be explained by the unfamiliarity of orthopedic surgeons with the fenestration technique. **Lee *et al.*** [12] conducted a retrospectively reviewed clinical and radiological data from 270 patients, 72 of them received microsurgical unilateral laminotomy approach. They reported that estimated blood loss among those patients was 134.3 ml.

Regarding postoperative satisfaction in our study, both operating techniques led to a significant decrease in VAS score with a significant difference in favor of unilateral fenestration at the 12 weeks follow-up assessment over conventional laminectomy. Also both operating techniques led to a significant decrease in ODI scale with a significant difference in favor of unilateral fenestration at the 12 weeks follow-up assessment over conventional laminectomy.

The most characteristic symptom of lumbar stenosis, neurogenic claudication improved in 91% of patients in group of unilateral fenestration compared to 83% in group of conventional laminectomy. These outcomes suggest that unilateral fenestration is superior to conventional laminectomy.

Thomé *et al.* [13] reported a study in which 120 patients had undertaken lumbar canal stenosis decompression and were randomized to three treatment groups (unilateral fenestration, bilateral fenestration, and laminectomy). The least follow-up of 12 months occurred in 94% of patients. Residual pain was lowest in Group 1 (VAS score 2.3 ± 2.4 and 4 ± 1 in Group 3; p = 0.05 and 3.6 ± 2.7 in Group 2; p = 0.05). The Roland–Morris Scale score improved from 17 ± 4.3 before surgery to 8.1 ± 7, 8.5 ± 7.3, and 10.9 ± 7.5 (Groups 1–3, respectively; p = 0.001 compared with preoperative) corresponding to a dramatic increase in walking distance.

Adam *et al.* [8] conducted a retrospective study to analyze the results of laminectomy versus unilateral fenestration and foraminotomy with bilateral neural decompression in 58 LSS patients divided into two groups: group A (no=22) consisted of patients that underwent a laminectomy procedure and group B (no=36) of cases where unilateral fenestration used. They reported that the level of pain was reduced in both patient groups. Cases in group A (6.1) maintained higher levels of back pain in the first postoperative month versus group B (3.2). Improvement was faster for those operated by unilateral approach. At 6 months follow-up, VAS values were very similar (2.6) and (2.3) respectively. All patients presented functional recovery evaluated with the ODI scale that showed continuous improvement at 6 months (26%) and (23%) respectively.

Farzad *et al.* [11] reported in a retrospective comparative study comparing unilateral fenestration to conventional laminectomy that intergroup comparison showed that patient satisfaction rate and the mean improvement in VAS and ODI was comparable between the studied groups and that no group had a superior outcome compared to the other group.

Regarding intraoperative complications in our study, only one incidental durotomy happened in group of conventional laminectomy. It was approached by primary repair. It was not obviously related to postoperative morbidity, but was related to increased duration of surgery and augmented EBL. In that case, no subsequent postoperative CSF fistula was detected. When the complication rates were compared, the difference was not statistically significant. This signifies that the unilateral fenestration approach does not bring extra risk of durotomy in patients of lumbar canal stenosis.

Henky *et al.* [14] reported the results of 62 patients with canal stenosis treated with unilateral laminotomy for bilateral decompression. They reported accidental durotomy in 3.2%. **Oertel *et al.*** [15] in a retrospective study of 102 patients treated with unilateral laminotomy reported that the incidence of complications was 9.8% including incidental durotomy and deep wound infection. **Weinstein *et al.*** [16], in an observational cohort study conducted on 304 patients suffering from LSS, treated with conventional laminectomy, they reported a dural tear incidence of 10%.

Regarding perioperative mortality in our study, we did not have perioperative deaths of totally operated 36 patients. This may be due to adequate selection, preoperative preparation and postoperative care of patients with exclusion of those who were generally unfit for surgery and those with general illness. **Weinstein *et al.*** [16], in an observational cohort study conducted on 304 patients suffering from LSS, treated with conventional laminectomy, they reported a death rate of 1%.

In the current study, analysis of outcome was based on the VAS for pain and the ODI for disability. Surgeon-based outcome measures were not considered. More importantly, however, the randomized study strategy minimized theoretical errors in the comparison of outcomes among groups. In our study, a minimum follow-up period of 12 weeks was obtainable for all patients. Symptoms and scores continued stable during that period. Yet, long-term follow up data is recommended.

CONCLUSION

Unilateral fenestration allows acceptable and safe decompression of the spinal canal in patients with degenerative lumbar stenosis. This was accompanied by a major benefit in most outcome factors during a minimum follow-up period of three months and is a current method with no instability effect, which offers sufficient decompression in the degenerative stenosis and increases patient comfort in the postoperative stage.

Unilateral fenestration causes less paraspinal muscle damage than conventional laminectomy and allows for better healing of muscles and rapid recovery from postoperative low back pain.

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