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Original Article

Surgical outcome of multiple level laminotomies in patients with lumbar canal stenosis at multiple level: A prospective hospital based interventional study

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ABSTRACT

Background: Lumbar canal stenosis (LCS) is a common degenerative spinal disorder characterized by neurogenic claudication, low back pain, radiculopathy, and functional disability. Multilevel laminotomy has emerged as a motion-preserving decompressive technique that aims to achieve adequate neural decompression while minimizing postoperative spinal instability. The purpose of this study was to evaluate the functional and clinical outcomes of multilevel laminotomies in patients with multilevel degenerative lumbar canal stenosis.
Methods: Twenty patients diagnosed with multilevel degenerative lumbar canal stenosis underwent decompressive multilevel laminotomies without fixation. Functional outcome and pain relief were assessed using the Self-Paced Walk Test (SPWT), Oswestry Disability Index (ODI), and Visual Analog Scale (VAS) for leg and back pain. Patients were followed up at 6 weeks, 6 months, and 9 months postoperatively.
Results: Mean SPWT improved drastically from 124.92±131.09 meters pre-operatively to 1482±127.28 meters post- operatively after 9 months. This drastic improvement in SPWT was statistically significant (p-value <0.001). The mean ODI score improved from 57.32 ± 11.99 preoperatively to 7.48 ± 6.07 at final follow-up ($p < 0.001$). Mean VAS leg pain improved from 7.44 ± 1.11 to 0.86 ± 1.43, while VAS back pain improved from 5.96 ± 1.86 to 1.10 ± 1.34 at 9 months postoperatively ($p < 0.001$). No significant postoperative spinal instability was observed on dynamic radiographs.
Conclusion: Multilevel laminotomy is a safe, effective, and motion-preserving surgical technique for the management of multilevel lumbar canal stenosis. It provides significant improvement in functional capacity, disability status, and pain relief while preserving spinal stability.

Keywords*: Lumbar canal stenosis, Multilevel laminotomy, Neurogenic claudication, Lumbar decompression, Functional outcome, Motion-preserving surgery.*

INTRODUCTION

Lumbar spinal stenosis is defined as a narrowing of the spinal canal resulting in compression of neural elements traversing the lower back into the lower limbs. It is predominantly a degenerative condition affecting individuals over 60 years of age. Degenerative lumbar spinal stenosis represents a progressive disorder involving the entire spinal motion segment and is best explained by the "degenerative cascade" described by Kirkaldy-Willis et al. (1978), consisting of three stages: dysfunction, relative instability and restabilization. (1) Degeneration of the intervertebral disc leads to segmental instability and increased facet joint mobility. Progressive disc space narrowing increases load transmission to the facet joints, promoting hypertrophy of the superior articular process. Over time, joint degeneration may culminate in local ankylosis. Concurrently, hypertrophy and calcification of the ligamentum flavum further contribute to canal narrowing. (2) These combined changes ultimately reduce spinal canal dimensions, resulting in compression of neural structures. Venous congestion and increased intrathecal pressure are believed to underlie the hallmark symptom of intermittent neurogenic claudication. (3) Degenerative lumbar spinal stenosis is a major cause of low back pain and lower extremity disability in the elderly population. Common clinical features include back pain (95%), sciatica (91%), sensory disturbances (70%), motor weakness (33%), and urinary dysfunction (12%). A critical clinical distinction must be made between neurogenic and vascular claudication, neurogenic claudication typically improves with lumbar flexion, stooping, sitting or lying, though relief may take up to 20 minutes. Degenerative lumbar spinal stenosis has become one of the common indications for spine surgery in patients older than 65 years. (2,4) Radiological evaluation plays an important role in diagnosis, although imaging findings do not always correlate with clinical symptoms. (5) Magnetic resonance imaging (MRI) is the preferred modality for assessing canal morphology and neural compression. (6) Anatomically, a normal lumbar canal has a midsagittal diameter greater than 13 mm. Relative stenosis is defined by a diameter of 10–13 mm, while absolute stenosis is present when the diameter is ≤10 mm. (7) Notably, radiographic evidence of stenosis may be asymptomatic, necessitating careful clinical correlation. Management strategies include both non-surgical and surgical approaches. Conservative treatment consists of analgesics (e.g., acetaminophen, NSAIDs), physical therapy, and lifestyle modifications. However, sustained improvement with non-operative measures is often limited. (8) Surgical intervention is indicated primarily in patients with persistent or worsening pain unresponsive to conservative therapy. Decompressive procedures aim to relieve neural compression and include conventional laminectomy, bilateral or unilateral laminotomy, partial facetectomy, and laminoplasty techniques. The choice of procedure depends on the severity, chronicity, and anatomical location of stenosis. (9) According to Zaina et al, overall evidence is inconclusive whether non-surgical or surgical treatment is the better for lumbar spinal stenosis. (10) Surgical outcomes are generally favourable, particularly for relief of neurogenic claudication, with reported improvement rates ranging from 64% to 91%. (11) However, relief of back pain is more variable, and some residual symptoms often persist due to underlying degenerative changes. (3) Variability in surgical indications and procedure rates across regions highlights the need for standardized clinical decision-making. The purpose of this study was to evaluate the effectiveness of surgery for the management of patients with multiple level lumbar canal stenosis by multiple level laminotomies. In this study, we analysed the outcome of multi-level laminotomies without fixation and assessed the stability of the spine post-operatively.

MATERIALS AND METHODS

This study was a prospective, open labelled, hospital based interventional study. The study was carried out in Department of Orthopedic Government Medical College and Hospital, Jammu from 1st November 2021 to 31st October 2022. This study was conducted with approval from the Institutional Ethical Committee of our hospital after taking consent from patients **(IEC/GMC/2022/954).** The diagnosis of LCS was established based on history, clinical symptoms, local examination, neurological examination, plain radiography and MRI. Surgical decompression was done in all the patients with multilevel laminotomies and assessment of pain relief and disability was measured by SPWT test, ODI score and VAS score. Post-operative spinal stability was assessed by radiographs of the lumbo-sacral spine in flexion and extension. The primary outcome was measured by pain intensity (back pain or leg pain) using VAS. Disability status was measured by ODI score and quality of life by SPWT. Informed written consent was taken from all the patients before their inclusion in the study. Following are the inclusion and the exclusion criteria of this study-

INCLUSION CRITERIA

- Degenerative Multiple level lumbar canal stenosis with radiological evidence of LCS with (mid sagittal diameter of the canal < 10cm) on MRI.
- Either gender
- Patient not able to walk for >500 meters (Neurogenic Claudication)
- Patients who are medically fit and willing for surgery
- Patients without any lumbar canal instability (Pre operatively)

EXCLUSION CRITERIA

- Single level lumbar stenosis
- Previous spinal surgery (Failed back syndrome)
- Patient with co-morbidities like uncontrolled T2 Diabetes Mellitus
- Primary canal stenosis (Congenital)
- Canal stenosis secondary to trauma or tumor

PROCEDURE -Patients after admission in ward was managed according to following protocol. All patients after the completion of the clinical and radiographic examination were assessed for pain and functional disability using Oswestry Scale, self-paced walk test and VAS score.

1) **History:** Patients was asked about duration of back pain, pain radiation, difficulties in performing daily activities and walking ability were enquired.
2) **General Physical Examination and systemic examination**: General physical examination included measurement of pulse rate and blood pressure. Later CNS, CVS and respiratory examinations were performed to rule out any underlying abnormality.

3) **Local examination:** included a thorough back examination for any visible deformity, tenderness on palpation, sensory and motor examination were also done.
4) **Investigations:** Basic investigation included coagulation profile, serology and assessment of blood sugar fasting.
5) X ray Lumbar Spine flexion and extension view
6) **MRI** was done in all patients.

SURGICAL TECHNIQUE- DECOMPRESSIVE LUMBAR LAMINOTOMY

PREOPERATIVE PREPARATION AND POSITIONING

The patient was placed in the prone position on a radiolucent operating table. Adequate padding was provided under the chest, pelvis and legs to ensure a free abdomen and minimize venous congestion. All monitoring lines and tubes were carefully secured and positioned to maintain an unobstructed operative field. A fluoroscopic C-arm was introduced prior to sterile draping to confirm the operative level. High-quality anteroposterior and lateral images were obtained to ensure accurate localization.

OPERATIVE PROCEDURE

- ✓ The procedure was performed under general endotracheal anaesthesia with administration of a single preoperative dose of prophylactic antibiotics.
- ✓ A midline longitudinal skin incision was made over the level of stenosis, guided by anatomical landmarks and fluoroscopy. Dissection was carried down through subcutaneous tissue to expose the lumbar fascia, which was incised just lateral to the spinous processes.
- ✓ Subperiosteal dissection was performed using a Cobb elevator or similar instrument to detach the paraspinal muscles from the spinous processes and laminae, extending laterally to the facet joints.
- ✓ The spinous processes at the operative levels were excised using a rongeur or bone cutter along with the supraspinous and interspinous ligaments. Residual soft tissue was cleared using curettes or bone nibblers to expose the underlying lamina.
- ✓ Decompression begins at the interlaminar space. Partial resection of the lamina and hypertrophied ligamentum flavum was performed using Kerrison rongeurs. Care was taken to preserve portions of the lamina and the base of the spinous processes, maintaining a posterior bony-ligamentous bridge to support spinal stability.
- ✓ Further decompression was achieved by undercutting the lamina and resecting the ligamentum flavum beneath this bridge. The decompression was extended laterally to visualize the dura and lateral recesses.
- ✓ The exiting nerve roots were identified, probed and confirmed to be freely mobile within the lateral recess and neural foramina. Facet joints and pars interarticularis were preserved as much as possible with only minimal resection of hypertrophied synovium or osteophytes when necessary to achieve adequate decompression.

CLOSURE AND POSTOPERATIVE CARE

The surgical field was irrigated with normal saline and meticulous haemostasis was achieved. The wound was closed in anatomical layers over a suction drain. Early mobilization was encouraged, typically beginning on the first postoperative day. The suction drain was usually removed within 24 hours, depending on output.

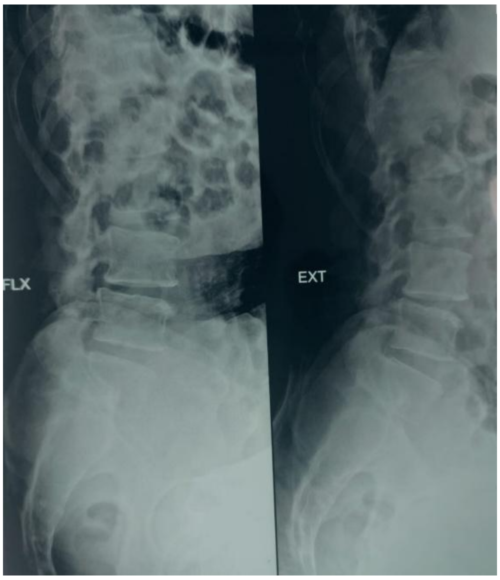
Preoperative X ray and MRI

INTRAOPERATIVE IMAGES

Intraoperative images showing multiple level laminotomies

FOLLOW-UP AND OUTCOME ASSESSMENT

Patients were evaluated clinically at **6 weeks, 6 months, and 9 months postoperatively**. At the completion of the study, all data were compiled and subjected to statistical analysis using appropriate methods. Following tests were used for the assessment of the outcomes-



Follow up x ray dynamic view (flexion and extension) at 9 months

SELF-PACED WALK TEST (SPWT)

The Self-Paced Walk Test (SPWT) was used to assess functional walking capacity. It measured the distance a patient with degenerative lumbar canal stenosis could walk on a level surface at a self-selected pace without support until symptoms (e.g., neurogenic claudication) necessitate stopping. The SPWT was considered a reliable and reproducible functional outcome. The SPWT was categorized as poor (less than 100 m), fair (between 100 m and 800 m), good (between 800 m and 1,600 m) and very good (more than 1,600 m).

OSWESTRY QUESTIONNAIRE SCALE

The self-completed questionnaire contained ten topics concerning intensity of pain, lifting, ability to care for oneself, ability to walk, ability to sit, sexual function, ability to stand, social life, sleep quality, and ability to travel. Each topic cat egory was followed by 6 statements describing different potential scenarios in the patient's life relating to the topic. The patien t then checked the statement which most closely resembles their situation. Each question was scored on a scale of 0 -5 with the first statement being zero and indicated the least amount of disability and the last statement was scored 5 indicated most severe disability. The scores for all questions answered were summed up and then multiplied by two to obtain the index (range 0 to 100). Zero is equated with no disability and 100 is the maximum disability possible.

VAS LEG PAIN AND BACK PAIN SCORING

The VAS (Visual Analog Scale) is a common method used to measure the intensity of pain, including leg pain and back pain. It is used to monitor improvement after treatment and to compare pre- and post-operative pain.

X RAY OF LUMBOSACRAL SPINE AP AND LAT

Flexion and extension views were done to rule out instability. White and Panjabi defined criteria for diagnosing instability from flexion-extension radiographs as sagittal plane translation greater than 4.5 or greater than 15% of the vertebral body width or sagittal plane rotation of greater than 15 at L1/L2, L2 /L3 L3/L4, greater than 20 at L4/L5, or greater than 25 L5/ S1. Measurements of sagittal plane translation and rotation were made using methods described by White and Panjabi. Sagittal plane rotation for each motion segment was calculated as the difference between the Cobb angle measurements taken in the flexion and extension positions. Sagittal plane translation was assessed for both the flexion and extension radiographs. The magnitude of the translation at each segment was calculated by measuring the displacement of the superior vertebra as a percentage of vertebral body width of the inferior vertebra. This method avoids inaccuracies related to the criteria of White and Panjabi for determining rotational or translational instability.

STATSTICAL ANALYSIS

The statistical analysis was done by an experienced statistician. SPSS programme version 2.0 was used for statical analysis of the data.

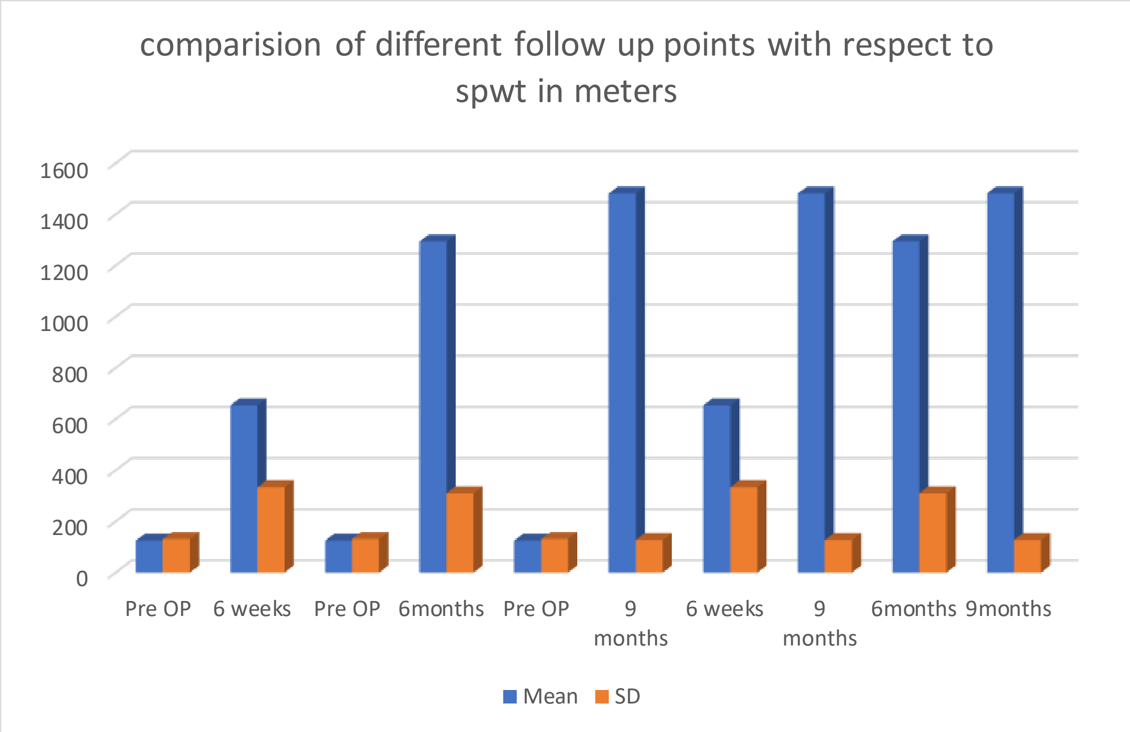
RESULTS -

There were 12 males (58%) & 8 females (42%). Male and female ratio was 1.5:1. Mean age of patients in the present study was 56.5±9.76 years. 80% of the patients were aged between 50 to 70 years.

SPWT (SELF PACED WALK TEST)

The mean baseline SPWT of the study participants was 124.92±131.09 meters pre-operatively. The mean SPWT at 6 weeks post-operatively in the patients improved to 653.70±333.5 meters and this improvement was statistically significant (P-value <0.001). At final follow-up at 9 months post-operatively, the mean SPWT in the study participants improved drastically from 124.92±131.09 meters pre-operatively to 1482±127.28 meters. This drastic improvement in SPWT was statistically significant (p-value <0.001).

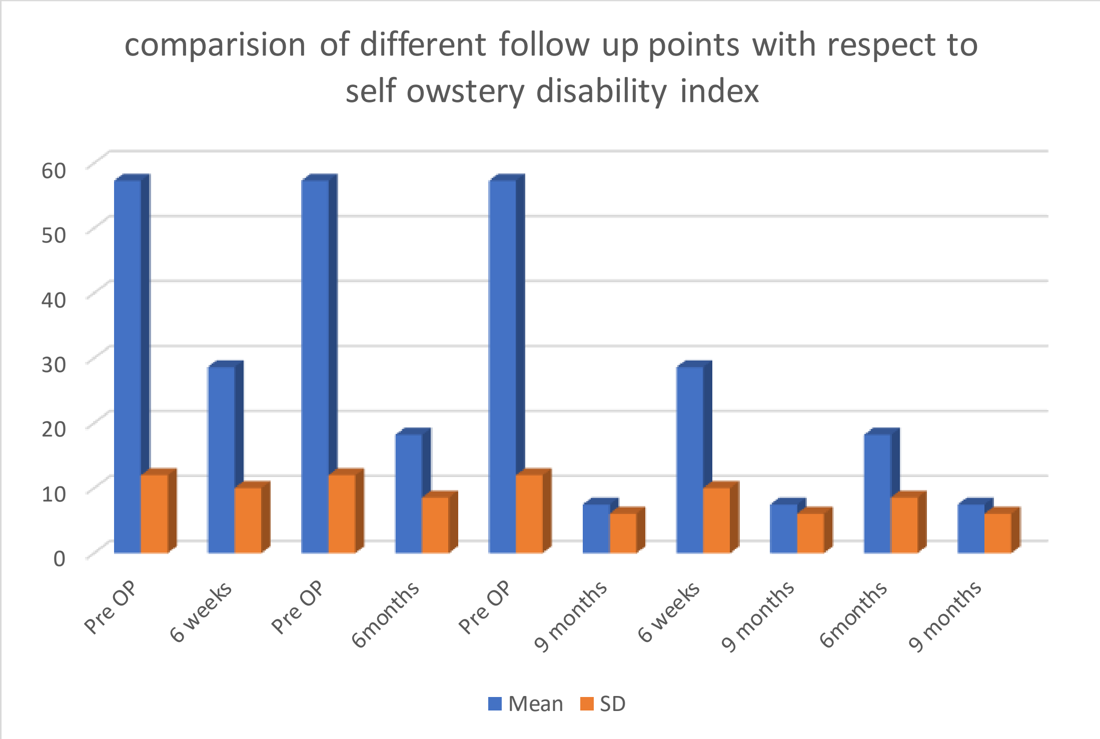
Time Points	Mean SPWT	SD	Mean Diff.	SD Diff.	% of effect	Paired t	P-value
Pre OP	124.92	131.09	-528.78	303.83	-423.29	-12.3064	<0.001
6 weeks	653.70	333.55					
Pre OP	124.92	131.09	-1169.36	296.52	-936.09	-27.8851	<0.001
6months	1294.28	309.87					
Pre OP	124.92	131.09	-1357.08	175.02	-1086.36	-54.8282	<0.001
9 months	1482.00	127.28					
6 weeks	653.70	333.55	-828.30	326.04	-126.71	-17.9637	<0.001
9 months	1482.00	127.28					
6months	1294.28	309.87	-187.72	284.96	-14.50	-4.6581	<0.001
9months	1482.00	127.28					



ODI SCORE (OSWESTRY QUESTIONNAIRE SCALE)

The mean baseline ODI score of the study participants was 57.3±11.9 pre-operatively. The mean ODI score at 6 weeks post-operatively in the patients improved to 28.62±10.03 and this improvement was statistically significant (P-value <0.001). At final follow-up at 9 months post-operatively, the mean ODI score in the study participants improved drastically from 57.32±11.9 pre-operatively to 7.48±6.07. This drastic improvement in ODI score was statistically significant (p-value <0.001).

Time points	Mean ODI score	SD	Mean Diff.	SD Diff.	% of effect	Paired t	P-value
Pre OP	57.32	11.99	28.70	12.10	50.07	16.7714	<0.001
6 weeks	28.62	10.03					
Pre OP	57.32	11.99	39.10	13.34	68.21	20.7319	<0.001
6months	18.22	8.55					
Pre OP	57.32	11.99	49.84	13.15	86.95	26.8072	<0.001
9 months	7.48	6.07					
6 weeks	28.62	10.03	21.14	8.55	73.86	17.4784	<0.001
9 months	7.48	6.07					
6months	18.22	8.55	10.74	7.09	58.95	10.7059	<0.001
9 months	7.48	6.07					



VAS LEG PAIN

The mean baseline leg pain VAS score of the study participants was 7.44±1.1 pre-operatively. The mean VAS score at 6 weeks post-operatively in the patients improved to 3.28±1.7 and this improvement was statistically significant (P-value <0.001). At final follow-up at 9 months post-operatively, the mean VAS score in the study participants improved drastically from 7.44±1.11 pre-operatively to 0.86±1.43. This drastic improvement in VAS score was statistically significant (p-value <0.001).

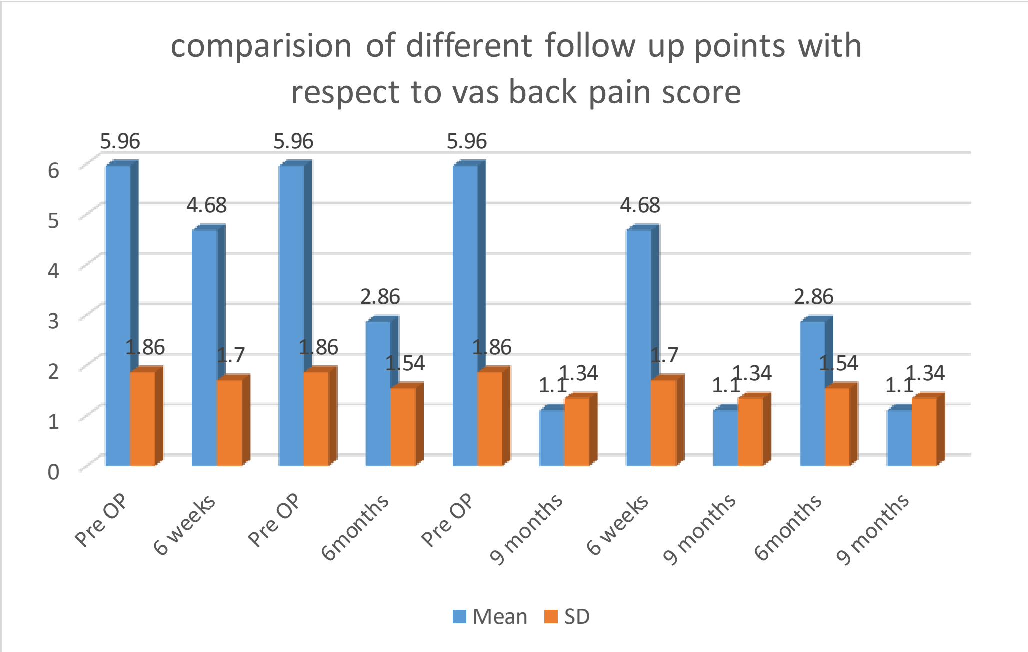
Time points	Mean VAS score	SD	Mean Diff.	SD Diff.	% of Effect	Z-value	P-value
Pre OP	7.44	1.11	4.16	2.06	55.91	6.0927	<0.001
6 weeks	3.28	1.70					
Pre OP	7.44	1.11	5.40	1.83	72.58	6.1540	<0.001
6months	2.04	1.52					
Pre OP	7.44	1.11	6.58	1.75	88.44	6.1540	<0.001
9 months	0.86	1.43					
6 weeks	3.28	1.70	2.42	2.19	73.78	5.1349	<0.001
9 months	0.86	1.43					
6months	2.04	1.52	1.18	1.57	57.84	4.2831	<0.001
9 months	0.86	1.43					

VAS BACK PAIN

The mean baseline back pain VAS score of the study participants was 5.96±1.86 pre-operatively. The mean VAS score at 6 weeks post-operatively in the patients improved to 4.68±1.7 and this improvement was statistically significant (P-value <0.001). At final follow-up at 9 months post-operatively, the mean VAS score in the study participants improved drastically from 5.96±1.86 pre-operatively to 1.1±1.34. This drastic improvement in VAS score was statistically significant (p-value <0.001).

Time points	Mean	SD	Mean Diff.	SD Diff.	% of effect	Z-value	P-value
Pre OP	5.96	1.86	1.28	2.18	21.48	3.7300	<0.001
6 weeks	4.68	1.70					
Pre OP	5.96	1.86	3.10	2.33	52.01	5.5938	<0.001

6months	2.86	1.54					
Pre OP	5.96	1.86	4.86	2.19	81.54	6.0308	<0.001
9 months	1.10	1.34					
6 weeks	4.68	1.70	3.58	1.79	76.50	6.0103	<0.001
9 months	1.10	1.34					
6months	2.86	1.54	1.76	1.56	61.54	5.2018	<0.001
9 months	1.10	1.34					



DISCUSSION

Lumbar canal stenosis (LCS) is a common degenerative spinal disorder predominantly affecting the elderly population, characterized by neurogenic claudication, radicular pain, and functional impairment. Surgical decompression remains the treatment of choice in patients who fail conservative management. In recent years, there has been a shift toward motion-preserving decompression techniques, such as multilevel laminotomies, which aim to achieve adequate neural decompression while minimizing iatrogenic instability. In the present study, the mean age of patients was 56.5 ± 9.76 years, with the majority (80%) between 50 and 70 years. This is consistent with previous literature, as degenerative changes such as ligamentum flavum hypertrophy, facet arthropathy, and disc degeneration increase with age (12,13). Similar demographic trends have been reported in recent studies on lumbar stenosis and minimally invasive decompression techniques.

A key finding of our study was the significant improvement in walking capacity, as assessed by the Self-Paced Walk Test (SPWT). The mean walking distance improved dramatically from 124.92 meters preoperatively to 653.70 meters at 6 weeks and further to 1482 meters at 9 months postoperatively ($p < 0.001$). This reflects effective relief of neurogenic claudication. Comparable improvements in functional mobility have been reported in both classical and recent literature. Malmivaara et al. and Weinstein et al. demonstrated that surgical decompression significantly improves functional outcomes compared to conservative treatment. (14,15) More recent studies evaluating unilateral laminotomy for bilateral decompression (ULBD) techniques have also shown marked improvements in walking tolerance and patient mobility. (16)

The Oswestry Disability Index (ODI) in our study improved significantly from 57.3 ± 11.9 preoperatively to 28.62 ± 10.03 at 6 weeks and further to 7.48 ± 6.07 at 9 months ($p < 0.001$), indicating a transition from severe disability to minimal disability. These findings are consistent with the SPORT trial (15) and other large cohort studies. Recent comparative studies have further confirmed that minimally invasive decompression techniques, including laminotomy, provide excellent functional outcomes with significant ODI improvement. Additionally, randomized trials such as the NORDSTEN study have demonstrated that different posterior decompression techniques yield comparable radiological and clinical improvements. (17)

Pain relief outcomes in our study were also highly significant. The VAS score for leg pain improved from 7.44 to 0.86, while the VAS score for back pain improved from 5.96 to 1.1 at final follow-up ($p < 0.001$). The greater improvement in leg pain compared to back pain is consistent with the pathophysiology of LCS, where nerve root compression is the primary contributor to radicular symptoms. Similar results have been reported by Postacchini (1999) and Kreiner et al. (2013) (18,19). Recent studies on endoscopic and microscopic laminotomy techniques have also shown significant reductions in VAS scores, confirming the efficacy of decompression in relieving radicular symptoms. (20)

One of the major concerns associated with multilevel decompression is postoperative spinal instability, particularly following conventional laminectomy. Multilevel laminotomy offers the advantage of preserving posterior spinal elements such as the spinous processes, interspinous ligaments, and portions of the lamina, thereby maintaining the posterior tension band. Biomechanical studies by Abumi et al. (1990) have demonstrated that preservation of these structures reduces the risk of instability. (21) Recent literature has increasingly focused on minimally invasive and endoscopic techniques, such as unilateral laminotomy for bilateral decompression (ULBD), which have shown comparable or superior outcomes to traditional open laminectomy. Hua et al. (2020, 2021) demonstrated that endoscopic laminotomy provides similar clinical outcomes to fusion procedures with reduced morbidity. (22,23)

The progressive improvement observed in our study—from early postoperative gains at 6 weeks to marked recovery at 9 months—highlights both short-term and mid-term efficacy of multilevel laminotomy. This is consistent with recent prospective and retrospective studies demonstrating sustained improvement in ODI, VAS, and functional outcomes following laminotomy-based decompression. (16) Furthermore, studies have shown that minimally invasive decompression techniques allow faster recovery, shorter hospital stay, and earlier return to daily activities.

LIMITTIONS OF THE PRESENT STUDY

- The relatively small sample size and lack of a control group limit the generalizability of the findings.
- Long-term radiological evaluation was not performed to assess spinal alignment and late instability.

Future studies with larger sample sizes, randomized controlled designs, and long-term follow-up are required to further validate these findings.

CONCLUSION

In conclusion, the present study demonstrates that multilevel laminotomy is a safe, effective, and motion-preserving surgical technique for the management of lumbar canal stenosis involving multiple levels. It provides significant improvement in walking capacity, functional disability, and pain relief, with sustained benefits up to 9 months postoperatively. These findings are consistent with both classical and recent literature, supporting laminotomy as a preferred alternative to conventional laminectomy in appropriately selected patients.

Conflict of interest

The authors declare that there is no conflict of interest.

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Data availability statement

All the data generated and analysed during this study are included in this article.

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