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Research Article

Comparative Study of Functional Outcomes in Single-Level versus Multi-Level Lumbar Canal Stenosis

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Abstract: ***Introduction:*** Lumbar canal stenosis is a common degenerative spinal disorder causing back pain, neurogenic claudication, radiculopathy, and functional disability. The extent of stenosis may influence clinical presentation and postoperative recovery. Comparison of functional outcomes between single-level and multi-level lumbar canal stenosis remains clinically important for treatment planning and prognostication. **Aim:** To compare the functional outcomes in patients with single-level and multi-level lumbar canal stenosis. **Materials and Methods:** A hospital-based comparative observational study was conducted in the Department of Orthopaedics of a tertiary care teaching hospital. A total of 200 patients diagnosed with lumbar canal stenosis were included, comprising 97 patients with single-level stenosis and 103 patients with multi-level stenosis. Demographic, clinical, radiological, and functional outcome data were collected. Functional assessment was performed using the Visual Analog Scale (VAS), Oswestry Disability Index (ODI), Japanese Orthopaedic Association (JOA) score, and walking distance. Preoperative and postoperative outcomes were compared within and between groups. Statistical analysis was performed using Student's t-test, paired t-test, and Chi-square test, with $p<0.05$ considered statistically significant. **Results:** Multi-level stenosis patients were significantly older (60.4 ± 8.8 vs. 56.9 ± 7.9 years; p=0.004), had higher BMI (p=0.007), longer symptom duration (p<0.001), and greater prevalence of motor weakness (p=0.011) and sensory deficits (p=0.031). Both groups demonstrated significant postoperative improvement in VAS back pain, VAS leg pain, ODI, JOA score, and walking distance (all p<0.001). Comparison of functional improvement showed significantly greater JOA score improvement (12.3 ± 4.2 vs. 10.9 ± 4.5; p=0.024) and walking distance improvement (475.7 ± 186.4 m vs. 394.9 ± 172.8 m; p=0.002) in the single-level group. Excellent/good outcomes were achieved in 84.5% of single-level patients compared with 68.9% of multi-level patients (p=0.009). **Conclusion:** Both single-level and multi-level lumbar canal stenosis patients experienced significant postoperative functional improvement. However, single-level stenosis was associated with better neurological recovery, greater walking capacity improvement, and higher rates of favorable outcomes compared to multi-level stenosis. Early diagnosis and appropriate surgical intervention may improve overall functional outcomes.

Keywords: Lumbar Canal Stenosis; Functional Outcome; Oswestry Disability Index.

INTRODUCTION

Lumbar canal stenosis (LCS) is one of the most common degenerative disorders of the spine and a leading cause of pain, disability, and reduced quality of life among middle-aged and elderly individuals. It is characterized by narrowing of the spinal canal, lateral recesses, or neural foramina, resulting in compression of the neural elements. Degenerative changes such as intervertebral disc degeneration, facet joint hypertrophy, ligamentum flavum thickening, and osteophyte formation contribute significantly to the development of lumbar canal stenosis. Patients commonly present with low back pain, neurogenic claudication, lower limb pain, numbness, weakness, and functional limitations that interfere with daily activities.[1]

The prevalence of lumbar canal stenosis has increased substantially due to rising life expectancy and the growing elderly population. It is estimated that lumbar canal stenosis affects approximately 11–39% of adults above 60 years of age and represents one of the most frequent indications for spinal surgery. The disease may involve a single lumbar level or multiple lumbar levels. Single-level stenosis commonly affects the L4–L5 segment, whereas multilevel stenosis may involve two or more adjacent segments, resulting in more extensive neural compression and potentially greater functional impairment.[2]

Assessment of functional outcomes in lumbar canal stenosis is essential for evaluating disease severity, planning treatment, and monitoring postoperative recovery. Several validated tools, including the Oswestry Disability Index (ODI), Visual Analog Scale (VAS), and Japanese Orthopaedic Association (JOA) score, are commonly used to assess pain, disability, and functional status. Previous studies have demonstrated significant improvement in functional outcomes following decompressive surgery; however, the extent of recovery may vary depending on the number of levels involved.[3] Single-level lumbar canal stenosis is generally associated with localized pathology and may have relatively favorable surgical outcomes due to limited tissue

involvement and shorter operative times. In contrast, multilevel lumbar canal stenosis often presents with more severe symptoms, extensive degenerative changes, longer operative duration, increased blood loss, and potentially prolonged rehabilitation. Understanding the differences in functional outcomes between these two groups is important for patient counseling, surgical planning, and prognostication.[4]

Although numerous studies have evaluated surgical outcomes in lumbar canal stenosis, limited data are available comparing functional recovery between single-level and multilevel disease in the Indian population. Therefore, the present study was undertaken to compare the functional outcomes of patients with single-level and multi-level lumbar canal stenosis using standardized clinical and radiological assessments. The findings of this study may help clinicians optimize treatment strategies and improve patient outcomes in lumbar canal stenosis.[5]

AIM

To compare the functional outcomes in patients with single-level and multi-level lumbar canal stenosis.

OBJECTIVES

1. To assess the functional outcomes of patients with single-level lumbar canal stenosis using standardized outcome measures.
2. To assess the functional outcomes of patients with multi-level lumbar canal stenosis using standardized outcome measures.

MATERIALS AND METHODS

Source of Data

The data were collected from patients diagnosed with lumbar canal stenosis attending the Orthopaedics outpatient department and admitted to the Department of Orthopaedics at the study institution. Clinical, radiological, operative, and follow-up data were obtained from patient records and direct clinical evaluation.

Study Design

A hospital-based comparative observational study was conducted.

Study Location

The study was conducted in the Department of Orthopaedics of a tertiary care teaching hospital.

Study Duration

The study was conducted over a period of 24 months from the date of approval by the Institutional Ethics Committee.

Sample Size

A total of 200 patients diagnosed with lumbar canal stenosis were included in the study.

- Group A: Single-level lumbar canal stenosis (n = 100)
- Group B: Multi-level lumbar canal stenosis (n = 100)

Inclusion Criteria

- Patients aged 40 years and above.
- Patients diagnosed with lumbar canal stenosis based on clinical examination and MRI findings.
- Patients with symptomatic single-level or multi-level lumbar canal stenosis.
- Patients willing to participate and provide informed written consent.
- Patients undergoing conservative or surgical management with regular follow-up.

Exclusion Criteria

- Previous lumbar spine surgery.
- Congenital spinal canal stenosis.
- Lumbar spine trauma.
- Spinal infections such as tuberculosis.
- Spinal tumors or metastatic lesions.
- Inflammatory spinal disorders.
- Severe neurological disorders affecting gait and functional assessment.
- Patients unwilling to participate or lost to follow-up.

Procedure and Methodology

After obtaining Institutional Ethics Committee approval, eligible patients fulfilling the inclusion criteria were enrolled consecutively. Written informed consent was obtained from all participants. Detailed demographic information including age, sex, occupation, body mass index, duration of symptoms, and comorbidities was recorded.

A thorough clinical examination was performed, including neurological assessment, motor power evaluation, sensory examination, reflex assessment, and gait analysis. All patients underwent radiological evaluation using plain radiographs and magnetic resonance imaging (MRI) of the lumbosacral spine.

Based on MRI findings, patients were categorized into:

- Single-level lumbar canal stenosis group.
- Multi-level lumbar canal stenosis group.

Functional status was assessed using:

- Oswestry Disability Index (ODI)
- Visual Analog Scale (VAS) for back and leg pain
- Japanese Orthopaedic Association (JOA) Score (if applicable)

Baseline scores were recorded before treatment. Patients received treatment as per standard institutional protocol, including conservative management or surgical decompression with or without stabilization when indicated.

Follow-up assessments were performed at predefined intervals (6 weeks, 3 months, 6 months, and 12 months). Functional outcomes, pain scores, neurological improvement, complications, and return to daily activities were documented and compared between the two groups.

Sample Processing

All collected data were verified for completeness and accuracy. Clinical findings, radiological parameters, operative details, and follow-up outcome scores were entered into a predesigned case record form. Data were coded and transferred into Microsoft Excel before statistical analysis.

Statistical Methods

Statistical analysis was performed using SPSS software version 26.0 (IBM Corp., USA).

- Continuous variables were expressed as Mean ± Standard Deviation (SD).
- Categorical variables were expressed as frequencies and percentages.
- Independent Student's t-test was used to compare continuous variables between groups.
- Paired t-test was used to compare pre- and post-treatment outcomes within groups.
- Chi-square test or Fisher's exact test was used for categorical variables.
- Repeated measures ANOVA was used to assess changes in functional scores during follow-up.
- A p-value <0.05 was considered statistically significant.
- Results were presented with 95% confidence intervals wherever applicable.

Data Collection

Data were collected using a structured case record form containing:

- Demographic details.
- Clinical history and symptom duration.
- Neurological examination findings.
- MRI characteristics and levels involved.
- Treatment details.
- Oswestry Disability Index (ODI) scores.
- Visual Analog Scale (VAS) scores.
- JOA scores (where applicable).
- Post-treatment complications.
- Follow-up functional outcomes and recovery status.

The collected data were analyzed to compare functional outcomes between patients with single-level and multi-level lumbar canal stenosis.

RESULTS

Table 1: Comparison of baseline characteristics between single-level and multi-level lumbar canal stenosis patients

Variable	Total (n=200)	Single-level (n=97)	Multi-level (n=103)	Test value	95% CI	p-value
Age (years)	58.7 ± 8.6	56.9 ± 7.9	60.4 ± 8.8	t=2.95	1.16 to 5.84	0.004*
Male	116 (58.0%)	61 (62.9%)	55 (53.4%)	χ^2=1.83	0.82 to 2.73	0.176
Female	84 (42.0%)	36 (37.1%)	48 (46.6%)	χ^2=1.83	0.37 to 1.22	0.176
BMI (kg/m²)	26.8 ± 3.7	26.1 ± 3.4	27.5 ± 3.8	t=2.73	0.39 to 2.41	0.007*
Duration of symptoms (months)	14.9 ± 6.3	12.8 ± 5.4	16.9 ± 6.6	t=4.78	2.41 to 5.79	<0.001*
Neurogenic claudication	139 (69.5%)	61 (62.9%)	78 (75.7%)	χ^2=3.82	1.01 to 3.41	0.051
Radicular pain	151 (75.5%)	68 (70.1%)	83 (80.6%)	χ^2=2.92	0.93 to 3.46	0.087
Motor weakness	67 (33.5%)	24 (24.7%)	43 (41.7%)	χ^2=6.51	1.19 to 4.05	0.011*
Sensory deficit	92 (46.0%)	37 (38.1%)	55 (53.4%)	χ^2=4.66	1.08 to 3.16	0.031*

***Statistically significant.**

Table 1 compares the baseline characteristics of patients with single-level and multi-level lumbar canal stenosis. The overall mean age of the study population was 58.7 ± 8.6 years. Patients with multi-level stenosis were significantly older than those with single-level stenosis (60.4 ± 8.8 vs. 56.9 ± 7.9 years; t=2.95, p=0.004). The gender distribution was comparable between the groups, with males constituting 58.0% of the total cohort and no statistically significant difference observed (p=0.176). Multi-level stenosis patients had a significantly higher mean BMI compared to single-level patients (27.5 ± 3.8 vs. 26.1 ± 3.4 kg/m²; p=0.007). Similarly, the duration of symptoms was significantly longer in the multi-level group (16.9 ± 6.6 months) than in the single-level group (12.8 ± 5.4 months) (p<0.001). Neurogenic claudication and radicular pain

were more frequent among multi-level stenosis patients, although the differences did not reach statistical significance (p=0.051 and p=0.087, respectively). Motor weakness and sensory deficits were significantly more common in patients with multi-level stenosis than in those with single-level disease (41.7% vs. 24.7%, p=0.011 and 53.4% vs. 38.1%, p=0.031, respectively).

Table 2: Functional outcomes in single-level lumbar canal stenosis patients (n=97)

Outcome measure	Preoperative Mean ± SD	Postoperative Mean ± SD	Mean difference	Test value	95% CI	p-value
VAS back pain score	7.2 ± 1.1	2.9 ± 1.2	4.3	t=26.84	3.98 to 4.62	<0.001*
VAS leg pain score	7.6 ± 1.0	2.6 ± 1.1	5.0	t=31.47	4.69 to 5.31	<0.001*
ODI score (%)	62.8 ± 9.4	24.7 ± 7.8	38.1	t=29.16	35.50 to 40.70	<0.001*
JOA score	11.6 ± 2.7	23.9 ± 3.1	12.3	t=27.93	11.43 to 13.17	<0.001*
Walking distance (meters)	218.6 ± 91.7	694.3 ± 162.8	475.7	t=25.11	438.1 to 513.3	<0.001*
Excellent/good outcome		82 (84.5%)		χ^2=46.23	76.1% to 90.7%	<0.001*

Table 2 presents the functional outcomes of patients with single-level lumbar canal stenosis. Significant postoperative improvements were observed across all outcome measures. The mean VAS back pain score decreased from 7.2 ± 1.1 preoperatively to 2.9 ± 1.2 postoperatively, representing a mean reduction of 4.3 points (p<0.001). Similarly, VAS leg pain scores improved significantly from 7.6 ± 1.0 to 2.6 ± 1.1, with a mean reduction of 5.0 points (p<0.001). Disability, assessed using the Oswestry Disability Index (ODI), showed marked improvement from 62.8 ± 9.4% to 24.7 ± 7.8%, corresponding to a mean reduction of 38.1 percentage points (p<0.001). The mean JOA score increased significantly from 11.6 ± 2.7 to 23.9 ± 3.1, indicating substantial functional recovery (p<0.001). Walking distance improved remarkably from 218.6 ± 91.7 meters preoperatively to 694.3 ± 162.8 meters postoperatively, with a mean increase of 475.7 meters (p<0.001). Overall, 82 patients (84.5%) achieved an excellent or good outcome.

Table 3: Functional outcomes in multi-level lumbar canal stenosis patients (n=103)

Outcome measure	Preoperative Mean ± SD	Postoperative Mean ± SD	Mean difference	Test value	95% CI	p-value
VAS back pain score	7.8 ± 1.2	3.7 ± 1.4	4.1	t=23.42	3.75 to 4.45	<0.001*
VAS leg pain score	8.1 ± 1.1	3.4 ± 1.3	4.7	t=27.08	4.36 to 5.04	<0.001*
ODI score (%)	68.4 ± 10.1	32.6 ± 9.2	35.8	t=26.11	33.08 to 38.52	<0.001*
JOA score	10.2 ± 2.6	21.1 ± 3.6	10.9	t=24.37	10.01 to 11.79	<0.001*
Walking distance (meters)	176.9 ± 84.6	571.8 ± 148.7	394.9	t=23.18	361.1 to 428.7	<0.001*
Excellent/good outcome		71 (68.9%)		χ^2=14.78	59.4% to 77.0%	<0.001*

Table 3 shows the functional outcomes of patients with multi-level lumbar canal stenosis. Significant postoperative improvements were noted in all assessed parameters. The mean VAS back pain score decreased from 7.8 ± 1.2 to 3.7 ± 1.4, with a mean improvement of 4.1 points (p<0.001). Likewise, the mean VAS leg pain score improved from 8.1 ± 1.1 preoperatively to 3.4 ± 1.3 postoperatively, resulting in a mean reduction of 4.7 points (p<0.001). ODI scores improved significantly from 68.4 ± 10.1% to 32.6 ± 9.2%, with a mean reduction of 35.8 percentage points (p<0.001). Functional status assessed by the JOA score increased from 10.2 ± 2.6 to 21.1 ± 3.6, reflecting substantial neurological and functional recovery (p<0.001). Walking distance improved from 176.9 ± 84.6 meters to 571.8 ± 148.7 meters postoperatively, showing a mean gain of 394.9 meters (p<0.001). Overall, 71 patients (68.9%) achieved excellent or good outcomes.

Table 4: Comparison of postoperative functional improvement between single-level and multi-level lumbar canal stenosis patients

Improvement parameter	Single-level (n=97)	Multi-level (n=103)	Mean difference	Test value	95% CI	p-value

VAS back pain improvement	4.3 ± 1.6	4.1 ± 1.7	0.2	t=0.86	-0.26 to 0.66	0.391
VAS leg pain improvement	5.0 ± 1.5	4.7 ± 1.6	0.3	t=1.37	-0.13 to 0.73	0.172
ODI improvement (%)	38.1 ± 12.9	35.8 ± 13.7	2.3	t=1.22	-1.41 to 6.01	0.224
JOA score improvement	12.3 ± 4.2	10.9 ± 4.5	1.4	t=2.27	0.18 to 2.62	0.024*
Walking distance improvement (meters)	475.7 ± 186.4	394.9 ± 172.8	80.8	t=3.18	30.6 to 131.0	0.002*
Excellent/good outcome	82 (84.5%)	71 (68.9%)		χ^2=6.82	1.23 to 4.89	0.009*

***Statistically significant.**

Table 4 compares the magnitude of postoperative functional improvement between patients with single-level and multi-level lumbar canal stenosis. Improvements in VAS back pain, VAS leg pain, and ODI scores were numerically greater in the single-level group; however, these differences were not statistically significant (p=0.391, p=0.172, and p=0.224, respectively). In contrast, improvement in JOA scores was significantly greater among patients with single-level stenosis compared to those with multi-level disease (12.3 ± 4.2 vs. 10.9 ± 4.5; p=0.024). Similarly, the increase in walking distance was significantly higher in the single-level group (475.7 ± 186.4 meters) than in the multi-level group (394.9 ± 172.8 meters), with a mean difference of 80.8 meters (p=0.002). Furthermore, a significantly greater proportion of patients with single-level stenosis achieved excellent or good outcomes compared to those with multi-level stenosis (84.5% vs. 68.9%; χ^2=6.82, p=0.009).

DISCUSSION

In the present study, patients with multi-level lumbar canal stenosis were significantly older than patients with single-level disease (60.4 ± 8.8 years vs. 56.9 ± 7.9 years, p=0.004). This finding is comparable with Katz et al. (2008)[1] and Genevay et al. (2010)[2], who reported that lumbar canal stenosis is predominantly a degenerative disease of older age groups. Higher BMI was also observed in the multi-level group (27.5 ± 3.8 kg/m², p=0.007), suggesting that increased mechanical load may contribute to more extensive degenerative changes. Goni et al. (2014)[3] similarly observed that radiological severity of stenosis correlated with greater disability measured by ODI.

In our study, duration of symptoms was significantly longer in multi-level stenosis patients than in single-level stenosis patients (16.9 ± 6.6 vs. 12.8 ± 5.4 months, p<0.001). Motor weakness and sensory deficit were also significantly more common in the multi-level group (p=0.011 and p=0.031, respectively), indicating greater neurological compromise. Similar observations were reported by Nath et al. (2012)[4], who found that degenerative lumbar canal stenosis patients commonly presented with neurogenic claudication, radicular pain, sensory symptoms, and motor deficits.

Among single-level lumbar canal stenosis patients, significant postoperative improvement was observed in VAS back pain, VAS leg pain, ODI, JOA score, and walking distance (all p<0.001). The excellent/good outcome rate was 84.5%. These findings are consistent with Nath et al. (2012)[4], who reported excellent long-term functional results following operative treatment based on JOA scoring. Similarly, Murata et al. (2022)[5] found significant long-term improvement in JOA score, VAS, and ODI after decompressive procedures for lumbar stenosis.

In patients with multi-level lumbar canal stenosis, statistically significant improvement was also observed in all functional outcome parameters, including VAS back pain, VAS leg pain, ODI, JOA score, and walking distance (all p<0.001). However, the excellent/good outcome rate was lower in multi-level stenosis patients (68.9%) compared to single-level patients. Adilay et al. (2018)[6] also compared single-level and multilevel decompressive laminectomy and found that both groups improved postoperatively, although functional recovery may vary according to the extent of stenosis and decompression.

On direct comparison of postoperative improvement, VAS back pain, VAS leg pain, and ODI improvement were slightly better in the single-level group, but the differences were not statistically significant. However, improvement in JOA score (p=0.024), walking distance (p=0.002), and excellent/good outcome rate (p=0.009) were significantly better in single-level stenosis patients. This finding is supported by Ulrich et al. (2017)[7], who reported that single-level decompression may provide better symptom and function scores than multilevel decompression in multisegmental lumbar spinal stenosis. Joaquim et al. (2017)[8] also suggested that although both single-level and multilevel decompression improve symptoms, multilevel disease may be associated with less favorable functional outcomes.

CONCLUSION

The present study demonstrated that both single-level and multi-level lumbar canal stenosis patients

experienced significant postoperative improvement in pain, disability, neurological function, and walking capacity. Significant reductions were observed in VAS back pain scores, VAS leg pain scores, and Oswestry Disability Index scores, along with substantial improvement in JOA scores and walking distance in both groups. However, patients with single-level lumbar canal stenosis achieved superior functional outcomes compared to those with multi-level disease. Improvement in JOA scores, walking distance, and the proportion of excellent/good outcomes were significantly greater in the single-level group. Multi-level stenosis patients were generally older, had higher BMI, longer symptom duration, and greater neurological deficits at presentation, which may have contributed to comparatively lower functional recovery. Nevertheless, surgical management provided meaningful clinical benefit in both groups. Early diagnosis and timely intervention may help optimize postoperative outcomes, particularly in patients with multi-level lumbar canal stenosis.

LIMITATIONS OF STUDY

1. The study was conducted at a single tertiary care center, which may limit the generalizability of the findings to the broader population.
2. The follow-up duration was limited and may not reflect long-term functional outcomes, recurrence rates, or late postoperative complications.
3. Variations in the severity of stenosis, extent of neural compression, and radiological grading were not analyzed separately.
4. Different surgical techniques and surgeon-related factors were not evaluated independently, which could have influenced postoperative outcomes.
5. Potential confounding factors such as comorbidities, smoking status, osteoporosis, and rehabilitation compliance were not assessed in detail.
6. Functional outcomes were primarily based on clinical scoring systems and patient-reported measures, which may be subject to reporting bias.
7. Radiological postoperative assessment and correlation with functional recovery were not included in the study.
8. The observational study design limits the ability to establish causal relationships between the number of stenotic levels and functional outcomes.

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