



Functional Recovery Following Surgical Intervention for Multilevel Lumbar Spinal Stenosis: A Prospective Cohort Analysis

Sangmeshwar Siddheshwar¹,
Shailesh Hadgaonkar¹,
Ajay Kothari¹,
Siddhart Aiyer¹,
Pramod Bhilare¹,
Darshan Sonawane¹,
Ashok Shyam¹,
Parag Sancheti¹

¹Sancheti Institute of Orthopaedics and Rehabilitation PG College, Sivaji Nagar, Pune, Maharashtra, India.

Address of Correspondence

Dr. Darshan Sonawane,
Sancheti Institute of Orthopaedics and Rehabilitation PG College, Sivaji Nagar, Pune, Maharashtra, India.

Email: researchsior@gmail.com.

Abstract

Background: Multilevel degenerative lumbar spinal stenosis produces neurogenic claudication and radicular pain with marked functional limitation. This prospective study evaluates outcomes after tailored surgical care — decompression alone, decompression with stabilization, or decompression with instrumented interbody fusion — selected after careful clinico-radiological correlation.

Methods: Ninety-nine consecutive patients with two or more levels of stenosis who failed nonoperative therapy were treated surgically at our tertiary centre. Selection for decompression alone or decompression plus stabilization/interbody fusion was based on clinical features, dynamic radiographs and axial T2 MRI morphological grading. Functional outcomes were measured using the Oswestry Disability Index (ODI), Visual Analog Scale (VAS) and Short Form-36 (SF-36) preoperatively and at six months and one year.

Results: Patients demonstrated substantial reduction in disability and pain scores with improved SF-36 domains at follow-up. Complications were infrequent and manageable.

Conclusion: When selected carefully, decompression with or without stabilization leads to durable symptom relief and functional improvement in multilevel lumbar canal stenosis. Perioperative measures included antibiotic prophylaxis, thromboprophylaxis, early mobilization and a structured rehabilitation plan to support recovery and reduce complications. Institutional ethical approval and written informed consent were obtained for all participants prior to enrolment.

Keywords: lumbar spinal stenosis; decompression; fusion; Oswestry Disability Index; neurogenic claudication

Introduction

Degenerative lumbar spinal stenosis most commonly results from progressive disc degeneration, facet joint hypertrophy, ligamentum flavum thickening and osteophyte formation that, in combination, narrow the spinal canal and encroach upon neural elements [1]. Multilevel involvement typically affects adjacent motion segments and is frequently encountered in routine clinical practice; patients often present

with neurogenic claudication characterized by leg pain and paresthesia provoked by walking or standing and relieved by sitting or forward flexion [2]. Symptoms may be unilateral or bilateral and are commonly accompanied by variable low back pain and intermittent motor or sensory deficits. Radiological assessment with high-resolution axial T2 magnetic resonance imaging is central to diagnosis and permits morphological grading of canal compromise to help correlate clinical findings



Dr. Shailesh Hadgaonkar



Dr. Ajay Kothari



Dr. Siddhart Aiyer



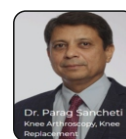
Dr. Pramod Bhilare



Dr. Darshan Sonawane



Dr. Ashok Shyam



Dr. Parag Sancheti

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with imaging [3]. Plain radiographs including flexion–extension views are important when assessing segmental instability and sagittal alignment [4]. Conservative measures such as activity modification, analgesia, physiotherapy and selective epidural injections are the initial approach, but patients with progressive, disabling or function-limiting symptoms despite adequate nonoperative care are candidates for surgical intervention [5]. The primary surgical objective is durable neural decompression to relieve neurogenic symptoms while minimising the risk of postoperative instability. Traditional wide laminectomy achieves extensive decompression but may disrupt posterior stabilising elements and paraspinal musculature, potentially predisposing to late instability and unsatisfactory outcomes [6]. For this reason, techniques that limit collateral damage — unilateral or bilateral laminotomy, selective fenestration, microscopic decompression and minimally invasive approaches — have been developed to preserve stabilisers while providing effective neural decompression [7]. Surgical decision-making balances the extent of decompression with the need to preserve anatomical stabilisers; when dynamic radiographs or intraoperative findings indicate instability or facet destruction, instrumented fusion with interbody support may be required to restore stability and promote long-term functional benefit. Patient factors such as age and comorbidity influence planning and expected recovery. Standardized outcome instruments (ODI, VAS, SF-36) were used to quantify disability, pain and quality of life at defined intervals.

Aims and objectives

The primary aim was to evaluate functional outcome following surgical management of multilevel lumbar canal stenosis. Specific objectives were to

- (1) Quantify change in ODI, VAS and SF-36 at six months and one year;
- (2) Record perioperative and early postoperative complications; and
- (3) Analyse the relationship of functional recovery with morphological MRI grade, number of levels and patient age to better inform surgical selection and patient counselling at a tertiary referral centre in India.

Review of literature

The surgical literature emphasises balancing adequate neural decompression with preservation of posterior stabilising structures [8]. Early series established degenerative changes as the principal cause of symptomatic stenosis and cautioned that excessive posterior element removal may produce iatrogenic instability and restenosis [9]. Instrumentation such as pedicle screw constructs and interbody techniques improved fusion reliability and provided stabilisation when fusion was indicated [10]. Technical descriptions of internal fixators and pedicle plating informed subsequent stabilisation strategies [11].

Clinical analyses indicate that elderly patients can achieve meaningful symptom relief when procedures are selected carefully and perioperative care is optimised, though complication rates increase with age [12]. Cost and resource pressures have encouraged less invasive fusion strategies alongside targeted decompression approaches [13]. Comparative trials suggest that increased radiographic fusion with instrumentation does not uniformly translate into superior symptomatic benefit, supporting selective fusion for documented instability [14]. Minimally invasive and muscle-sparing techniques such as microdecompression reduce paraspinal muscle trauma while achieving effective neural decompression [15]. Microdecompression and microscopic laminotomy have been reported to deliver similar short-term outcomes with reduced soft-tissue disruption compared with wide laminectomy in selected series [16]. Alternative decompressive procedures such as multilevel subarticular fenestrations and laminoplasty were proposed to preserve stabilisers and reduce late instability [17]. Earlier clinical series documented reasonable outcomes with fenestration techniques as an alternative to extensive laminectomy [18]. Long-term issues after decompression and fusion include bone regrowth, implant-related difficulties and adjacent segment degeneration, which require ongoing surveillance [19]. Overall, careful patient selection, tailored decompression and selective fusion remain the foundation of contemporary management of multilevel lumbar canal stenosis [20], and these topics remain under study worldwide.

Materials and Methods

This prospective study enrolled ninety-nine consecutive patients between October 2016 and October 2017 who presented with clinical and radiological evidence of lumbar canal stenosis affecting two or more levels and who failed conservative treatment. Inclusion criteria were age >30 years, symptomatic neurogenic claudication limiting walking distance despite adequate nonoperative care, and MRI evidence of multilevel canal compromise. Exclusion criteria included prior lumbar surgery, active infection, malignancy and acute fracture. Clinical evaluation comprised detailed neurological examination, assessment of claudication distance and straight leg raise testing. Baseline investigations included standing lumbosacral radiographs with flexion–extension views to detect dynamic instability and MRI axial T2 sequences for morphological grading. Treatment was individualised: decompression alone was performed when clinical and radiological features showed no instability; decompression with posterolateral fusion or decompression with instrumented transforaminal lumbar interbody fusion (TLIF) was used where dynamic films or facet destruction indicated instability. Procedures were performed under general anaesthesia with standard positioning and prophylactic antibiotics. Meticulous microsurgical technique was used to preserve posterior tension

bands while achieving neural release; pedicle screw constructs and interbody cages were employed where indicated. Perioperative data were recorded and complications tracked. Postoperative care was standardised: thromboembolism prophylaxis, analgesia and a short course of intravenous antibiotics followed by oral therapy were used; early in-bed exercises began within 24 hours and ambulation with support was encouraged by 48 hours. Suture removal occurred at about two weeks and a structured rehabilitation programme was commenced and continued regularly. Functional outcomes (ODI, VAS, SF-36) were recorded preoperatively and at six months and one year. Statistical analysis consisted of paired comparisons of preoperative and postoperative scores and subgroup analyses by age, number of levels and morphological grade with significance set at $p < 0.05$.

Results

Ninety-nine patients completed one-year follow-up. The cohort comprised 43 males and 56 females with ages ranging from 32 to 82 years; most (61) were aged 50–70. Two-level stenosis was present in 49 patients, three-level disease in 37 and four or more levels in 13. Morphological grading on axial MRI demonstrated a range from moderate to severe central canal compromise. Functional outcomes improved markedly: mean preoperative ODI was 53.07 (SD 5.93), improving to 20.91 (SD 9.93) at six months and 14.48 (SD 11.97) at one year, representing a clinically important reduction in disability. Median VAS for leg pain fell from 9 preoperatively to 3 at six months and 1 at one year. SF-36 domains showed statistically and clinically meaningful gains, especially in physical functioning and bodily pain. Subgroup analyses by age, number of levels treated and morphological grade did not reveal significant differences in one-year ODI or SF-36 outcomes. Complications were uncommon: dural tear was the most frequent intraoperative event and was managed intraoperatively without persistent morbidity; isolated cases of implant loosening, transient neurological deficit and adjacent segment symptoms occurred. Most patients were discharged within three to five days. Early mobilization aided recovery, and the sustained improvements at one year reflect durable symptomatic relief and functional recovery in the majority, with low reoperation rates.

Discussion

This prospective series demonstrates that carefully planned surgical decompression, with stabilization or fusion reserved for demonstrable instability, provides meaningful and sustained improvement in pain, disability and overall quality of life for patients with multilevel lumbar canal stenosis. The magnitude of improvement in ODI, VAS and SF-36 in this cohort confirms that appropriate decompression remains the foundation of effective surgical care for neurogenic claudication and radicular pain. The lack of significant

difference in one-year outcomes between age groups, numbers of levels treated and morphological grades suggests that multilevel involvement alone should not preclude consideration of surgery when symptoms and functional limitation warrant intervention. Complications were relatively infrequent and manageable; dural tear was the commonest intraoperative event and was addressed promptly without long-term consequence in this series. Implant-related issues and adjacent segment symptoms were limited to a small minority and were managed according to standard practice. Early mobilisation, standardised perioperative prophylaxis and a structured rehabilitation pathway likely contributed to low morbidity and rapid functional gains. Limitations include single-centre recruitment and one-year follow-up; longer observation is needed to characterise the durability of benefit and the incidence of late adjacent segment degeneration. Objective metrics such as gait analysis and longer-term imaging correlation would strengthen understanding of structural evolution after decompression and fusion. Future multicentre studies with extended follow-up will help refine indications and improve shared decision-making with patients and health policy too. Overall, a pragmatic strategy that provides adequate neural decompression tailored to symptoms and imaging, preserves stabilising structures when possible and reserves fusion for demonstrable instability maximises benefit while minimising unnecessary instrumentation.

Conclusion

In this prospective cohort of ninety-nine patients with multilevel lumbar canal stenosis, individualized decompression informed by careful clinico-radiological assessment produced substantial and sustained reductions in disability and pain and improved quality of life at one year. Functional measures showed statistically and clinically important gains. Complication rates were acceptable, with dural tear the most frequently encountered intraoperative event; implant problems and adjacent segment symptoms were uncommon. Outcomes were not markedly influenced by age, number of levels treated or morphological grade, supporting the principle that multilevel involvement alone is not a contraindication to surgery when clinical indications exist. Continued clinical surveillance and longer-term studies will clarify durability and late adjacent segment effects.

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Institute where Research was Conducted: Sancheti Institute of Orthopaedics and Rehabilitation PG College, Sivaji Nagar, Pune, Maharashtra, India

University Affiliation: Maharashtra University of Health Sciences (MUHS), Nashik, Maharashtra, India.

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