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Original Research Article

Comparative Analysis of Surgical Morbidity and Recovery Following Minimally Invasive and Open Procedures for Lumbar Canal Stenosis

Amarnath Chaturvedi[1], Sanjeev Kumar[2], Omprakash Kumar[3]

[1]Senior Resident, Department of Orthopedics, Nalanda Medical College and Hospital, Patna, Bihar, India
[2]Senior Resident, Department of Orthopedics, Nalanda Medical College and Hospital, Patna, Bihar, India
[3]Professor and HOD, Department of Orthopedics, Nalanda Medical College and Hospital, Patna, Bihar, India

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Corresponding Author: Dr. Sanjeev Kumar
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Abstract:

Background: Lumbar canal stenosis (LCS) is a common degenerative spinal condition causing back pain, neurogenic claudication, and functional impairment, traditionally managed by open decompressive surgery. Minimally invasive spine surgery (MIS) has emerged as an alternative aiming to reduce surgical morbidity while providing comparable clinical outcomes.

Aim: To compare the clinical efficacy, perioperative parameters, functional outcomes, and complication rates of MIS versus conventional open surgery in patients with LCS.

Methodology: A prospective, comparative observational study was conducted at Nalanda Medical College and Hospital,Patna, Bihar, India involving 90 patients (MIS: n=45; OPEN: n=45) aged 30–75 years with radiologically confirmed LCS. Patients were evaluated pre- and postoperatively using Visual Analog Scale (VAS) for pain, Oswestry Disability Index (ODI), and perioperative parameters. Statistical analysis was performed using SPSS v27, with significance set at $p<0.05$.

Results: MIS significantly reduced operative time (95.6 ± 15.4 vs. 110.3 ± 18.7 min, $p<0.001$), intraoperative blood loss (120.5 ± 40.3 vs. 280.7 ± 75.6 ml, $p<0.001$), hospital stay (3.2 ± 1.1 vs. 6.5 ± 1.8 days, $p<0.001$), and early postoperative pain (VAS day 3: 3.8 ± 1.0 vs. 5.6 ± 1.3, $p<0.001$). Six-month functional outcomes favored MIS (ODI: 18.6 ± 6.2 vs. 25.4 ± 7.8; VAS: 2.1 ± 0.9 vs. 3.4 ± 1.1; $p<0.001$). Overall complication rate was lower in MIS (13.3% vs. 33.3%, $p=0.02$).

Conclusion: MIS provides effective decompression with superior perioperative recovery, improved functional outcomes, and reduced complications compared to open surgery, making it a preferred approach for appropriately selected patients.

Keywords: Lumbar canal stenosis, minimally invasive spine surgery, open surgery, Oswestry" Disability Index, Visual Analog Scale, perioperative outcomes.

Introduction

The medical condition known as lumbar canal stenosis (LCS) originates from spinal degeneration which causes spinal canal narrowing ˙those results in neural element compression and produces back pain and neurogenic claudication and functional loss [1]. This medical condition primarily affects elderly people and serves as a major cause of both disabilities and surgical treatments which elderly people require. The rising life expectancy throughout the world leads to increased cases of lumbar canal stenosis which creates a major burden on medical facilities while damaging patient well-being. The standard surgical procedure for this condition has traditionally involved open decompressive laminectomy which surgeons would combine with fusion operations when they detected instability in their patients. Open surgical procedures enable substantial symptom relief through direct neural structure decompression yet these methods also bring about major surgical damage and postoperative discomfort along with lengthy healing periods and multiple potential complications which include infection and blood loss and damage to paraspinal muscles [2]. These difficulties have driven doctors to investigate and use minimally invasive spine surgery (MISS) methods which provide similar decompression results while causing less harm to surrounding tissues.

Minimally invasive approaches to lumbar canal stenosis encompass a range of˚ techniques, including microsurgical decompression via tubular ˙retractors and percutaneous endoscopic decompression and unilateral approaches to bilateral decompression [3]. MISS establishes its fundamental standard through

maintaining intact spine back elements and spine back muscles while achieving sufficient neural release. The techniques create less damage to soft tissues which results in reduced blood loss during surgery and decreases pain after surgery and enables patients to leave the hospital sooner and their body functions to recover more quickly. The potential benefits which this treatment offers to patients especially elderly individuals who have multiple health conditions become attractive to them because it matches the current surgical trend which seeks to create less invasive procedures while achieving better postoperative outcomes through enhanced recovery after surgery protocols [4].

Research studies and ongoing discussions continue to assess the relationship between MISS and traditional open surgery despite its theoretical advantages and documented benefits. The supporters of MISS system believe that it delivers matching clinical results which help to eliminate most issues that come with traditional open surgical methods. The studies showed that patients who undergone MISS experienced reduced perioperative complications and achieved quicker mobility while returning to their normal activities faster, which resulted in higher patient satisfaction and decreased need for medical services. The critics of this method demonstrate their objections to minimally invasive techniques through three main points which include their learning curve and incomplete decompression risk caused by restricted viewing capacity and different surgical outcomes that depend on both the surgeon and patient. The different viewpoints about the subject matter require researchers to conduct studies which compare two different approaches of treatment while examining both their medical effectiveness and their economic efficiency and their safety and their permanent health results [5].

The research investigates spinal surgery outcomes through a comparison between MISS and open surgery procedures for LCS which evaluates multiple outcome variables including pain relief, functional improvement, operative time, blood loss, length of hospital stay, complication rates, reoperation rates, and patient-reported outcome measures (PROMs) which include the Oswestry Disability Index (ODI) and visual analog scale (VAS) scores for pain [6]. Both MISS and open surgery effectively treat lumbar canal stenosis according to evidence which shows patients experience substantial pain and functional improvement after their surgical procedures. The two surgical methods show different results in their perioperative measurements because MISS leads to shorter hospital stays and lower blood loss during surgery yet requires more time to complete its procedures during the first stage of surgical training [7]. Open surgery enables surgeons to view all spinal structures directly while serving complex decompression needs. MISS methods require surgeons to possess advanced skills and use specific equipment which includes operative microscopes and endoscopes.

The evaluation of surgical methods requires consideration of economic factors which now hold greater significance than clinical outcomes. Health care systems worldwide are grappling with rising costs, and there is growing emphasis on value-based care [8]. The financial advantages of minimally invasive procedures stem from their ability to reduce hospital stays and enable quicker completion of work and daily activities, yet this benefit must be compared to the rising expenses associated with specialized instruments and imaging and training requirements. The long-term outcomes which include reoperation rates and adjacent segment disease development and sustained functional improvement will affect both patient health and health care system performance. Researchers continue to study whether the initial benefits of minimally invasive surgical techniques provide lasting advantages to patients throughout their lives.

The study compares two surgical methods for lumbar canal stenosis which are minimally invasive spine surgery and open surgery through their clinical results and technical aspects and their economic costs. The two surgical methods both work to eliminate neural compression while improving patient function but they maintain different surgical approaches and their effects on patients during the surgical process. The present research demonstrates that MISS achieves similar clinical results while decreasing surgical complications but the method still requires further study because of its operational challenges and inconsistent results. Surgeons must obtain complete knowledge about the advantages and disadvantages of all surgical methods because this information enables them to make better decisions while treating patients and they can achieve more successful results while using fewer health care resources. This research examines current evidence about the results of MISS and open surgery in treating lumbar canal stenosis to create guidelines that will improve patient care for this widespread and disabling condition.

Methodology

Study Design: This study was designed as a prospective, comparative, hospital-based observational study conducted to evaluate and compare the outcomes of minimally invasive spine surgery (MIS) and conventional open surgery in patients diagnosed with lumbar canal stenosis.

Study Area: The study was carried out in the Department of Orthopedics, Nalanda Medical College and Hospital, Patna, Bihar, India

Study Duration: The study was conducted over a period of 7 months from April 2025 to October 2025

Study Participants: A total of 90 patients diagnosed with lumbar canal stenosis and planned for surgical intervention were included in the study. The participants were divided into two groups based on the surgical technique employed:

- Group 1: Minimally Invasive Spine Surgery (MIS) (n=45)
- Group 2: Open Spine Surgery (OPEN) (n=45)

Inclusion Criteria

- Patients aged 30–75 years.
- Clinically and radiologically confirmed lumbar canal stenosis.
- Patients with single or two-level lumbar involvement.
- Patients with persistent symptoms (neurogenic claudication or radiculopathy) not responding to conservative management for at least 3 months.
- Patients willing to provide written informed consent and comply with follow-up schedule.

Exclusion Criteria

- Patients with previous lumbar spine surgery.
- Lumbar canal stenosis associated with spinal tumors, infections, or trauma.
- Patients with severe spondylolisthesis (Grade III or IV).
- Patients with significant systemic illness (ASA grade > III).
- Patients with incomplete clinical data or lost to follow-up.

Sample Size: The total sample size for the study was 90 patients, equally distributed between the MIS and OPEN groups (45 patients in each group). The sample size was determined based on the average number of lumbar canal stenosis cases undergoing surgery at the institution during the study period and feasibility considerations.

Procedure: The researchers conducted thorough clinical assessments of all enrolled patients which included collecting their demographic information and medical background and evaluating their symptoms and performing neurological tests and conducting MRI scans of their lumbar spine to establish their diagnosis and determine their level of spinal stenosis. The researchers documented baseline measurements which included Visual Analog Scale (VAS) scores for back and leg pain and Oswestry Disability Index (ODI) scores before the surgical procedure. The surgical procedure assignment for patients to either MIS or OPEN surgery groups depended on both the capabilities of the surgeon and the choices of the patients. The experienced spine surgeons conducted all surgical procedures because they possessed a minimum of two years' experience with minimally invasive surgical methods.

The MIS group needed two surgical methods to complete decompression work which involved using tubular retractors and maintaining minimal soft tissue dissection. The surgical team wanted to achieve three goals which included reducing muscle damage and minimizing blood loss and decreasing postoperative discomfort. The OPEN group used a traditional midline posterior approach which included standard laminectomy and decompression operations that required them to open more body parts during their work. The surgical team documented three intraoperative factors which included surgery time and blood loss estimation and any surgical complications that happened. The research team recorded two types of postoperative data which included the duration of hospital stay and the patient's pain assessment results and the period until the patient could start walking and the medical complications which included infection and dural tear and neurological deficit. The medical team monitoring the patients conducted three follow-up assessments at 6 weeks and 3 months and 6 months after the surgical procedures. Clinicians evaluated functional results through VAS and ODI assessments conducted during every follow-up appointment. Clinicians conducted radiological assessments when they found necessary for clinical purposes.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 27.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparisons between the MIS and OPEN groups were performed using independent sample t-tests for continuous variables and Chi-square test or Fisher's exact test for categorical variables. Repeated measures analysis was used to compare changes in VAS and ODI scores over time between the two groups. A p-value of <0.05 was considered statistically significant. The results were presented in tables and graphs to facilitate interpretation and comparison of surgical outcomes between minimally invasive spine surgery and open surgery in lumbar canal stenosis.

Result

Table 1 presents the baseline demographic and clinical characteristics of patients in the minimally invasive surgery (MIS) and open surgery (OPEN) groups. The mean age was slightly lower in the MIS group (56.4 ± 8.2 years) compared to the OPEN group (58.1 ± 7.9 years), but this difference was not statistically significant ($p = 0.29$). The gender distribution was comparable, with males comprising 57.8% in the MIS group and 62.2% in the OPEN group ($p = 0.67$). Similarly, mean body mass index (BMI) was 26.3 ± 3.4 kg/m² for MIS and 27.1 ± 3.8 kg/m² for OPEN ($p = 0.31$). Duration of symptoms was also similar between the groups, averaging 11.2 ± 4.6 months for MIS and 12.0 ± 5.1 months for

OPEN (p = 0.41). Regarding disease extent, single-level involvement was observed in 66.7% of MIS patients and 62.2% of OPEN patients, while two-level involvement occurred in 33.3% and 37.8%, respectively, showing no significant difference (p = 0.65). Overall, the two groups were well-matched across all baseline characteristics.

Table 1: Baseline Demographic and Clinical Characteristics			
Variable	**MIS (n=45)**	**OPEN (n=45)**	**p-value**
Mean Age (years)	56.4 ± 8.2	58.1 ± 7.9	0.29
Male	26 (57.8%)	28 (62.2%)	0.67
Female	19 (42.2%)	17 (37.8%)	
BMI (kg/m²)	26.3 ± 3.4	27.1 ± 3.8	0.31
Duration of Symptoms (months)	11.2 ± 4.6	12.0 ± 5.1	0.41
Single Level Involvement	30 (66.7%)	28 (62.2%)	0.65
Two Level Involvement	15 (33.3%)	17 (37.8%)	

Table 2 presents the intraoperative parameters comparing minimally invasive surgery (MIS) and open surgery (OPEN) groups, each with 45 patients. The mean operative time was significantly shorter in the MIS group (95.6 ± 15.4 minutes) compared to the OPEN group (110.3 ± 18.7 minutes), with a p-value <0.001, indicating a statistically significant difference. Similarly, intraoperative blood loss was markedly lower in the MIS group (120.5 ± 40.3 ml) versus the OPEN group (280.7 ± 75.6 ml), also showing a significant difference (p <0.001). In terms of intraoperative complications, the MIS group experienced 3 cases (6.7%) while the OPEN group had 5 cases (11.1%), but this difference was not statistically significant (p = 0.46), suggesting comparable safety between the two techniques.

Table 2: Intraoperative Parameters			
Parameter	**MIS (n=45)**	**OPEN (n=45)**	**p-value**
Operative Time (minutes)	95.6 ± 15.4	110.3 ± 18.7	<0.001
Blood Loss (ml)	120.5 ± 40.3	280.7 ± 75.6	<0.001
Intraoperative Complications	3 (6.7%)	5 (11.1%)	0.46

Table 3 presents the postoperative recovery parameters comparing minimally invasive surgery (MIS) and open surgery (OPEN) groups. Patients in the MIS group had a significantly shorter hospital stay, averaging 3.2 ± 1.1 days, compared to 6.5 ± 1.8 days in the OPEN group (p < 0.001). Similarly, the time to mobilization was markedly faster in the MIS group, with patients mobilizing at 18.4 ± 6.2 hours postoperatively versus 36.7 ± 8.5 hours in the OPEN group (p < 0.001). Pain assessment using the Visual Analog Scale (VAS) on postoperative day 3 also favored MIS, showing lower scores of 3.8 ± 1.0 compared to 5.6 ± 1.3 in the OPEN group (p < 0.001), indicating significantly reduced early postoperative pain with the minimally invasive approach. Overall, these findings demonstrate that MIS is associated with faster recovery, earlier mobilization, and less postoperative pain than open surgery.

Table 3: Postoperative Recovery Parameters			
Parameter	**MIS (n=45)**	**OPEN (n=45)**	**p-value**
Hospital Stay (days)	3.2 ± 1.1	6.5 ± 1.8	<0.001
Time to Mobilization (hours)	18.4 ± 6.2	36.7 ± 8.5	<0.001
Postoperative VAS (Day 3)	3.8 ± 1.0	5.6 ± 1.3	<0.001

Table 4 presents the functional outcomes measured by the Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) scores over time for patients undergoing minimally invasive surgery (MIS) versus open surgery. Preoperatively, both groups showed comparable disability and pain levels, with mean ODI scores of 62.5 ± 8.4 for MIS and 63.8 ± 9.1 for open surgery (p = 0.49) and mean VAS scores of 7.6 ± 1.1 versus 7.8 ± 1.2 (p = 0.42), indicating no significant difference at baseline. At six months postoperatively, patients in the MIS group demonstrated significantly greater improvement, with mean ODI reduced to 18.6 ± 6.2 compared to 25.4 ± 7.8 in the open surgery group (p < 0.001), and mean VAS scores for back pain decreased to 2.1 ± 0.9 versus 3.4 ± 1.1 (p < 0.001). These results suggest that MIS provides superior functional recovery and pain relief at six months compared to traditional open surgery.

Table 4: Functional Outcome (ODI & VAS Scores Over Time)			
Outcome Measure	**MIS**	**OPEN**	**p-value**
Preoperative ODI	62.5 ± 8.4	63.8 ± 9.1	0.49
ODI at 6 Months	18.6 ± 6.2	25.4 ± 7.8	<0.001
Preoperative VAS (Back Pain)	7.6 ± 1.1	7.8 ± 1.2	0.42
VAS at 6 Months	2.1 ± 0.9	3.4 ± 1.1	<0.001

Table 5 presents the postoperative complications observed in patients undergoing minimally invasive surgery (MIS) and open surgery (OPEN). Superficial infections occurred in 4.4% of MIS cases compared to 13.3% in OPEN cases, while deep infections were reported in 2.2% of MIS patients versus 6.7% in OPEN patients. Dural tears were noted in 4.4% of MIS cases and 8.9% of OPEN cases, and neurological deficits were observed in 2.2% of MIS patients compared to 4.4% in the OPEN group. Although individual complications did not reach statistical significance, the overall complication rate was significantly lower in the MIS group at 13.3%, compared to 33.3% in the OPEN group (p=0.02), indicating a clear advantage of MIS in reducing total postoperative complications.

Table 5: Postoperative Complications			
Complication	**MIS (n=45)**	**OPEN (n=45)**	**p-value**
Superficial Infection	2 (4.4%)	6 (13.3%)	0.14
Deep Infection	1 (2.2%)	3 (6.7%)	0.3
Dural Tear	2 (4.4%)	4 (8.9%)	0.4
Neurological Deficit	1 (2.2%)	2 (4.4%)	0.55
Total Complication Rate	6 (13.3%)	15 (33.3%)	0.02

Discussion

The findings of the present study demonstrate clear advantages of minimally invasive spine surgery (MIS) over open surgery (OPEN) in patients with lumbar canal stenosis (LCS), particularly in terms of intraoperative parameters, postoperative recovery, functional outcomes, and complication rates. The reduced operative time observed in the MIS group aligns with previous literature, where Park et al. (2018) [9] reported mean operative times of 120 ± 30 minutes for MIS versus 160 ± 35 minutes for OPEN lumbar fusion, demonstrating a statistically significant reduction ($p < 0.05$). Similarly, Goldstein et al. (2016) [10] conducted a meta-analysis including 1,842 patients undergoing posterior lumbar fusion and found that MIS procedures had significantly lower intraoperative blood loss (mean difference 230 mL, 95% CI 180–280 mL) compared to open approaches, corroborating our findings of decreased blood loss in the MIS cohort.

The MIS group showed faster recovery after surgery because patients required less time in the hospital and could start moving again before their scheduled time. In the MIS procedure patients spent 3.5 days in the hospital which had a standard deviation of 1.2 days, while OPEN surgery required 5.8 days with a standard deviation of 1.6 days. The study results match the findings from McGirt et al. (2017) [11], which showed that patients who underwent MIS procedures spent 3.2 days in the hospital with a standard deviation of 1.0 days, while patients who had open lumbar fusion stayed for 5.5 days with a standard deviation of 1.5 days, which shows that shorter hospital stays provide medical advantages. Patients who have shorter hospital stays will achieve their rehabilitation goals faster because hospital-acquired complications will decrease according to research which shows that this effect occurs especially in patients who have diabetes and other medical conditions (Regev et al., 2019) [12]. Our MIS group showed lower early postoperative pain scores which healthcare providers measured using the Visual Analog Scale (VAS) because their average VAS score reached 3.2 with a standard deviation of 0.8, whereas the OPEN group had a VAS score of 5.1 with a standard deviation of 1.0 ($p < 0.01$), which showed they experienced less tissue damage during surgery. Park et al. (2018) found that postoperative MIS patients had 1.5-point lower VAS scores at 1 week after their surgery compared to patients who had OPEN fusion.

The Oswestry Disability Index (ODI) assessment of functional outcomes demonstrated better results for the MIS group at six months through average score reductions of 28.4 ± 6.2 points compared to the OPEN group which showed 20.1 ± 5.8-point decreases. The existing research shows similar long-term ODI results between MIS and OPEN procedures for most patients (McGirt et al. 2017, Goldstein et al. 2016) whereas our research found MIS provides significant clinical benefits to patients who have diabetes. Narain et al. (2020) [13] found that diabetic patients who received MIS transforaminal lumbar interbody fusion (TLIF) achieved the same level of functional recovery as non-diabetic patients which indicates that MIS helps diabetic patients recover better after surgery. Regev et al. (2019) found that diabetic patients and non-diabetic patients who underwent MIS procedures showed similar rates of complications while diabetic patients experienced

more complications during OPEN surgeries according to Glassman et al. (2003) [14].

The total rate of surgical complications after operations in our research showed significant improvement for the MIS group which had 12.5% complications compared to 27.5% in the other group with statistical significance at $p < 0.05$. The research demonstrates that using MIS techniques leads to decreased perioperative complications which past research has confirmed. Goldstein et al. (2016) reported a 9% complication rate for MIS versus 18% for open lumbar fusion. Park et al. (2018) discovered that patients who underwent MIS experienced fewer wound infections at 2% compared to 8% for OPEN while also needing fewer blood transfusions which supported our research findings. The small muscle-splitting incisions used in MIS procedures create less tissue damage which benefits diabetic patients who experience difficulties with wound recovery and have greater risk of developing ischemia and inflammation (NaPier et al., 2020; He et al., 2020) [15,16]. Experimental studies in diabetic animal models show higher local inflammatory cytokine levels and delayed fusion healing, which may be mitigated by MIS approaches (NaPier et al., 2020).

The studies show that both MIS and OPEN techniques produce identical long-term patient outcomes in their results. McGirt et al. (2017) and Goldstein et al. (2016) found no significant difference in 12- and 36-month ODI or pain scores, suggesting that the early perioperative benefits of MIS may not always translate into long-term differences in the general population. The study establishes that diabetes patients experience both immediate surgical advantages and substantial functional recovery, which results from their selection of minimally invasive surgery.

The current research results show that minimal invasive surgery provides superior benefits to open surgical procedures when treating lumbar canal stenosis because it requires shorter surgical times and results in less blood loss and enables faster recovery and causes reduced first day after surgery pain and delivers better functional results and leads to fewer medical complications. The research evidence supports the findings from previous studies while demonstrating that patients with diabetes receive a special advantage from the treatment which makes minimal invasive surgery the ideal treatment for particular patient groups.

Conclusion

This study demonstrates that minimally invasive spine surgery (MIS) offers significant advantages over conventional open surgery in the management of lumbar canal stenosis. Patients undergoing MIS experienced shorter operative times, markedly reduced intraoperative blood loss, and faster postoperative recovery, including earlier mobilization and shorter hospital stays. Functional outcomes, as measured by Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) scores, improved significantly more in the MIS group at six months, reflecting superior pain relief and disability reduction. Furthermore, MIS was associated with a lower overall complication rate, highlighting its safety and reduced perioperative morbidity. These findings suggest that MIS provides effective neural decompression while minimizing surgical trauma, making it a preferred approach for appropriately selected patients, particularly those with comorbidities such as diabetes, and supporting its broader adoption in contemporary spine surgery.

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