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Minimally Invasive vs. Open Techniques in Spine Surgery: Long-Term Neurological and Functional Outcomes

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Abstract

Background: Minimally invasive spine surgery (MISS) has gained popularity due to reduced tissue trauma and faster recovery. However, its long-term neurological and functional superiority over open spine surgery (OSS) remains debated.

Objective: To compare long-term neurological and functional outcomes between MISS and OSS in patients undergoing surgery for degenerative lumbar spine disease.

Methods: A prospective observational study was conducted on 100 patients (50 MISS, 50 OSS) over 24 months. Outcomes assessed included Visual Analog Scale (VAS), Oswestry Disability Index (ODI), neurological recovery, complications, and reoperation rates.

Results: Both groups showed significant improvement in VAS and ODI scores ($p<0.001$). At 24 months, no statistically significant difference was found between MISS and OSS in functional outcomes (ODI: 18.4 vs. 19.6; $p=0.42$). MISS demonstrated lower blood loss and shorter hospital stay ($p<0.001$), but similar long-term neurological recovery ($p=0.67$). Reoperation rates were slightly higher in MISS (8% vs. 4%; $p=0.34$).

Conclusion: MISS offers short-term perioperative benefits but demonstrates comparable long-term neurological and functional outcomes to OSS.

Keywords: Minimally invasive spine surgery, open spine surgery, neurological outcomes, functional outcomes, lumbar spine.

Introduction

With the advent of minimally invasive methods to lower surgical morbidity, spine surgery has undergone substantial change [1]. Although direct visibility is possible with traditional open spine surgery (OSS), it is linked to significant muscle dissection, higher blood loss, and a longer recovery period.

Tubular retractors and percutaneous instruments are used in minimally invasive spine surgery (MISS) to minimize tissue injury [2]. It has been linked to quicker healing, less blood loss, and shorter hospital stays. But issues with limited visibility, partial decompression, and long-term efficacy still exist.

MISS does not significantly outperform OSS in terms of long-term functional results or pain alleviation, according to a number of randomized trials and meta-analyses. Additionally, comparable results between MISS and OSS in spinal fusion surgeries are suggested by long-term follow-up investigations [3].

With an emphasis on long-term neurological healing and functional outcomes, this study attempts to present a prospective comparison of MISS and OSS in 100 patients.

The MI technique has advanced significantly over the past ten years, providing noteworthy advantages like less pain and increased functionality following surgery, quicker recovery, less blood loss, less damage to soft tissues, and preservation of the paraspinal region's structural integrity while reducing the formation of scar tissue [4-5]. These advantages are especially important when treating spondylolisthesis because an open approach may worsen the instability of the muscles, ligamentous structures, and facet joints, all of which are essential for providing support [6].

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Multiple studies have examined the perioperative, functional, and pain outcomes of minimally invasive (MI) versus OS for the treatment of common lumbar degenerative conditions including spinal stenosis, disk disease, and spondylolisthesis. As far as we know, only one review on spondylolisthesis has investigated the disparities in pain, function, and perioperative results between MI and OS [7-9].

Materials and Methods

Study Design: Prospective comparative observational study conducted at Multiple Tertiary care center over 2 years.

Sample Size: 100 patients:

MISS group: 50 patients

OSS group: 50 patients

Inclusion Criteria

Age 18–70 years

Degenerative lumbar disc disease

Failed conservative treatment ≥6 weeks

Exclusion Criteria

Previous spine surgery

Trauma, tumor, infection

Multilevel deformity

Surgical Techniques

MISS: Microdiscectomy or minimally invasive TLIF

OSS: Conventional open discectomy or fusion

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Outcome Measures

Pain: Visual Analog Scale (VAS)

Function: Oswestry Disability Index (ODI)

Neurological status: Motor/sensory recovery

Perioperative variables

Complications and reoperation

Follow-up

3 months

6 months

12 months

24 months

Statistical Analysis

SPSS v25

Student t-test, Chi-square test

Significance: $p < 0.05$

Results

Table 1: Demographic and Clinical Profile

Variable	MISS (n=50)	OSS (n=50)	p-value
Mean Age (years)	45.2 ± 10.3	47.1 ± 9.8	0.36
Male (%)	60%	58%	0.84
BMI (kg/m²)	26.4 ± 3.2	27.1 ± 3.5	0.29
Symptom duration (months)	8.2 ± 2.1	8.5 ± 2.3	0.52
Level involved (L4-L5 %)	56%	60%	0.68

No significant baseline differences.

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Table 2: Operative and Hospital Parameters

Parameter	MISS	OSS	p-value
Operative time (min)	120 ± 25	105 ± 20	0.01*
Blood loss (ml)	110 ± 40	350 ± 90	<0.001*
Hospital stay (days)	3.2 ± 1.1	6.5 ± 2.0	<0.001*
Time to ambulation (days)	1.2 ± 0.5	2.8 ± 1.0	<0.001*

MISS significantly reduced blood loss and hospital stay but had longer operative time.

Table 3: VAS and ODI Scores

Outcome	MISS	OSS	p-value
Pre-op VAS	8.2 ± 0.9	8.0 ± 1.0	0.34
24-mo VAS	2.1 ± 0.8	2.3 ± 0.9	0.28
Pre-op ODI	62.5 ± 8.2	63.1 ± 7.9	0.71
24-mo ODI	18.4 ± 6.5	19.6 ± 7.1	0.42

Both groups improved significantly; no long-term difference.

Table 4: Clinical Outcomes and Complications

Outcome	MISS (%)	OSS (%)	p-value
Complete neurological recovery	88%	84%	0.57
Partial recovery	10%	12%	0.74
No recovery	2%	4%	0.56
Infection	4%	10%	0.26
Dural tear	6%	4%	0.65
Reoperation	8%	4%	0.34

Comparable neurological outcomes; MISS had fewer infections but slightly higher reoperation.

Discussion

In line with other research, this study shows that MISS and OSS offer comparable long-term neurological and functional effects.

A number of the studies that were included of this evaluation looked at patients who had comorbid conditions [10–12], which may have affected the functional and pain outcomes

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[13]. These measures will enable a better understanding of post-operative functional and pain outcomes in both MI and OS, according to subsequent study. When comparing the ODI and VAS data, this review found no statistically significant difference in the long-term functional or pain outcomes between spondylolisthesis patients treated with MI or OS [15–16].

Functional Results

Several RCTs with comparable long-term outcomes are consistent with no discernible difference in ODI and VAS at 24 months. Additionally, no difference in patient-reported outcomes after two years was confirmed by a meta-analysis [16].

Neurological Recovery

Neurological improvement was comparable in both groups, suggesting that adequate decompression can be achieved with either approach.

Perioperative Advantages

MISS showed clear benefits:

Reduced blood loss

Shorter hospital stay

Faster ambulation

These findings are widely supported in literature.

Complications

Lower infection rates in MISS are likely due to smaller incisions. However, slightly higher reoperation rates may reflect technical challenges and limited visualization.

Clinical Implications

MISS is beneficial for early recovery

OSS remains reliable for complex cases

Long-term outcomes should guide surgical choice rather than short-term benefits alone

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Limitations

Single-center study

Moderate sample size

Lack of randomization

Limited to lumbar degenerative disease

Conclusion

Minimally invasive spine surgery offers significant short-term advantages, including reduced blood loss and faster recovery. However, long-term neurological and functional outcomes are comparable to open spine surgery. Surgical approach should be individualized based on patient pathology, surgeon expertise, and resource availability.

References

1. McClelland S, Goldstein JA. Minimally invasive versus open spine surgery. J Neurosci Rural Pract. 2017;8(2):194–198.
2. Heemskerk JL, et al. Long-term outcomes of MIS vs open TLIF. Spine J. 2021;21(12):2049–2065.
3. Saber B, Agrawal DK. Long-term outcomes of MIS vs open fusion. J Spine Res Surg. 2025;7(1):18–25.
4. Saber B, Agrawal DK. Minimally invasive spinal fusion outcomes. PMC. 2025.
5. Phan K, et al. MIS vs open discectomy meta-analysis. Spine. 2014.
6. Phan K, et al. Comparative outcomes of MIS vs open discectomy. CMAJ. 2015.
7. Khan NR, et al. MIS vs open TLIF meta-analysis. Neurosurgery. 2015.
8. Lee YL, et al. Outcomes of MIS vs open lumbar fusion. Asian J Neurosurg. 2017.
9. Tarik M, Rahman M. Long-term functional outcomes after spinal decompression. TAJ. 2025.

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE5, 2024

10. Hartmann S, Lang A, Lener S, Abramovic A, Grassner L, Thomé C. Minimally invasive versus open transforaminal lumbar interbody fusion: A prospective, controlled observational study of short-term outcome. Neurosurg Rev 2022;45:3417-26.
11. Sulaiman WA, Singh M. Minimally invasive versus open transforaminal lumbar interbody fusion for degenerative spondylolisthesis grades 1-2: Patient-reported clinical outcomes and cost-utility analysis. Ochsner J 2014;14:32-7.
12. Dibble CF, Zhang JK, Greenberg JK, Javeed S, Khalifeh JM, Jain D, et al. Comparison of local and regional radiographic outcomes in minimally invasive and open TLIF: A propensity score-matched cohort. J Neurosurg Spine 2022;37:384-94.
13. Zawy Alsofy S, Nakamura M, Ewelt C, Kafchitsas K, Lewitz M, Schipmann S, et al. Retrospective comparison of minimally invasive and open monosegmental lumbar fusion, and impact of virtual reality on surgical planning and strategy. J Neurol Surg Part A Cent Eur Neurosurg 2021;82:399-409.
14. Le H, Anderson R, Phan E, Wick J, Barber J, Roberto R, et al. Clinical and radiographic comparison between open versus minimally invasive transforaminal lumbar interbody fusion with bilateral facetectomies. Global Spine J 2021;11:903-10.
15. Qin R, Wu T, Liu H, Zhou B, Zhou P, Zhang X. Minimally invasive versus traditional open transforaminal lumbar interbody fusion for the treatment of low-grade degenerative spondylolisthesis: A retrospective study. Sci Rep 2020;10:21851.
16. McGirt MJ, Parker SL, Mummaneni P, Knightly J, Pfortmiller D, Foley K, et al. Is the use of minimally invasive fusion technologies associated with improved outcomes after elective interbody lumbar fusion? Analysis of a nationwide prospective patient-reported outcomes registry. Spine J 2017;17:922-32.