International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
Impact Factor (RJIF): 6.72
IJOS 2025; 11(4): 296-301

www.orthopaper.com
Received: 03-10-2025
Accepted: 04-11-2025

Dr. MD Mahfujur Rahman
DGHS, Deputed to Bangladesh Medical University, Dhaka, Bangladesh

Dr. MD Nazrul Islam
DGHS, Deputed to Bangladesh Medical University, Dhaka, Bangladesh

Dr. Golam Shaikh Ferdous
DGHS, Deputed to Bangladesh Medical University, Dhaka, Bangladesh

Dr. Debashish Dey
DGHS, Deputed to Bangladesh Medical University, Dhaka, Bangladesh

Dr. Aminur Rasul
DGHS, Deputed to Bangladesh Medical University, Dhaka, Bangladesh

Dr. Badhan Acharjee
DGHS, Deputed to Bangladesh Medical University, Dhaka, Bangladesh

Corresponding Author:
Dr. MD Mahfujur Rahman
DGHS, Deputed to Bangladesh Medical University, Dhaka, Bangladesh

Minimally invasive versus open transforaminal lumbar interbody fusion for low grade (Grade I & II) degenerative spondylolisthesis: A prospective comparative analysis of quality and functional outcomes

MD Mahfujur Rahman, MD Nazrul Islam, Golam Shaikh Ferdous, Debashish Dey, Aminur Rasul and Badhan Acharjee

DOI : https://www.doi.org/10.22271/ortho.2025.v11.i4d.3862

Abstract
Background: Degenerative lumbar spondylolisthesis is a common cause of back pain and radiculopathy requiring surgical stabilization when conservative management fails. While open Transforaminal Lumbar Interbody Fusion (TLIF) is the conventional approach, minimally invasive TLIF (MIS-TLIF) has been developed to reduce soft-tissue trauma, perioperative morbidity, and accelerate recovery.
Aim of the study: To prospectively compare perioperative outcomes, functional recovery, and radiological fusion between MIS-TLIF and open TLIF in patients with single-level Low Grade (Grade I& II) degenerative lumbar spondylolisthesis.
Methods: In this prospective comparative study, 28 patients (14 MIS-TLIF, 14 open TLIF) aged 30-65 years with single-level Low Grade (Grade I& II) spondylolisthesis were enrolled. Baseline demographic and clinical data were recorded. Perioperative parameters (operative time, blood loss, hospital stay) were documented. Functional outcomes were assessed using the Visual Analog Scale (VAS) for back and leg pain and the Oswestry Disability Index (ODI) at 1, 3, 6, and 12 months. Radiological fusion was evaluated at 12 months using the Bridwell grading system. Patient satisfaction was assessed using modified Macnab criteria. Statistical analysis included independent t-tests, Mann-Whitney U tests, Chi-square or Fisher's exact tests, with $p<0.05$ considered significant.
Results: Baseline demographics were comparable between groups. MIS-TLIF demonstrated significantly reduced operative time (158.5±8.2 vs. 170.3±9.1 min, P=0.01), lower intraoperative blood loss (210.5±10.3 vs. 275.2±15.7 mL, $p<0.001$), and shorter hospital stay (3.4±0.5 vs. 4.5±0.6 days, $p<0.001$). Both groups showed significant improvement in VAS and ODI scores; however, MIS-TLIF patients experienced faster and greater functional recovery at all follow-up points (12-month ODI: 17.6±3.2 vs. 23.0±3.5, $p<0.001$). Complete radiological fusion (Grade I) at 12 months was higher in MIS-TLIF (71.4% vs. 50.0%, P=0.04), with overall fusion success (Grades I + II) also slightly higher (92.9% vs. 85.7%). Modified Macnab criteria showed a trend toward higher "excellent" outcomes in MIS-TLIF (78.6% vs. 64.3%, P=0.32).
Conclusion: MIS-TLIF offers superior perioperative safety and early functional recovery while achieving comparable radiological fusion and patient satisfaction to conventional open TLIF in Low Grade (Grade I& II) degenerative spondylolisthesis. These findings support the use of MIS-TLIF as an effective and less morbid alternative for single-level lumbar fusion.

Keywords: Minimally invasive TLIF, open TLIF, degenerative spondylolisthesis, lumbar fusion, perioperative outcomes, functional recovery, radiological fusion

Introduction
Degenerative Spondylolisthesis (DS) is a common spinal disorder in which one vertebra slips anteriorly over the one below, most frequently occurring at the L4-L5 level and predominantly affecting older adults with a higher prevalence in females [1]. The prevalence of DS in the general population is approximately 6% to 9% globally [2]. In Pakistan, patients undergoing decompression and fixation for degenerative spondylolisthesis reported a prevalence of 30%, with the L4-L5 level being most commonly affected [3]. DS is a prevalent spinal condition characterized by the anterior displacement of one vertebra over another due to degenerative changes in the intervertebral discs and facet joints [4].

This misalignment often leads to spinal instability and nerve compression, resulting in a range of symptoms that can significantly impact an individual's quality of life. Common manifestations include persistent low back pain, which may be described as a dull ache or sharp sensation and neurogenic claudication, characterized by leg pain, tingling, numbness or weakness during walking or prolonged standing [5]. Additionally, patients may experience sciatica where pain radiates from the lower back down to the legs and radiculopathy, which involves abnormal sensations, muscle weakness and loss of reflexes due to nerve root compression. Other symptoms can include muscle spasms, gait abnormalities, and sleep disturbances [6]. Transforaminal Lumbar Interbody Fusion (TLIF) is one of the most widely employed surgical techniques for DS. The procedure involves the removal of the degenerated intervertebral disc and the insertion of a bone graft or cage between the vertebrae to promote fusion and restore spinal stability. TLIF not only stabilizes the affected segment but also decompresses the neural elements, addressing symptoms such as leg pain and neurological deficits [7]. The traditional open TLIF approach offers direct visualization of the spine, which can facilitate accurate placement of instrumentation and decompression of neural structures. However, this method involves extensive muscle dissection, leading to longer operative times, greater blood loss, increased postoperative pain, and longer hospital stays [8]. In response to these challenges, minimally invasive TLIF (MI-TLIF) has emerged as an alternative. MI-TLIF utilizes smaller incisions and specialized instruments, minimizing muscle trauma and potentially reducing perioperative complications [9]. MI-TLIF involves accessing the lumbar spine through a smaller incision, typically ranging from 2 to 3 centimeters, compared to the larger incisions required in open surgery. Surgeons utilize specialized instruments, such as tubular retractors and endoscopic guidance, to minimize muscle dissection and reduce damage to surrounding tissues [10]. The degenerated intervertebral disc is removed, and a bone graft or interbody cage is inserted to promote spinal fusion. Pedicle screws and rods are then placed to stabilize the spine during the healing process [11]. The aim of this study was to prospectively compare the quality of life and functional outcomes of minimally invasive versus open transforaminal lumbar interbody fusion in patients with grade I degenerative spondylolisthesis.

Methodology and Materials

This prospective, comparative study was conducted in the This study was carried out in the department of Orthopaedic Surgery at BSMMU, Shahbag, Dhaka and Popular Medical College Hospital, Dhaka, Bangladesh, between March 2022-September 2024. A total of 28 consecutive patients with single-level, low-grade (Grade I&II) degenerative lumbar spondylolisthesis was prospectively enrolled and allocated into two groups based on the surgical technique employed:

- **Group A:** MIS-TLIF (N=14)
- **Group B:** Open TLIF (N=14)

Inclusion Criteria

- Adults aged 30-65 years.
- Radiologically confirmed low Grade (Grade I&II) degenerative spondylolisthesis (Meyerding classification) at L4-L5 or L5-S1 level.
- Persistent radiculopathy or neurogenic claudication unresponsive to ≥ 6 months of conservative management
- Ability to provide informed consent and comply with follow-up assessments.

Exclusion Criteria

- High Spondylolisthesis (Grade II & IV).
- Previous lumbar spine surgery at the same level
- Traumatic, infectious, neoplastic, or congenital spinal pathology.
- Severe osteoporosis or systemic comorbidities contraindicating surgery.
- Multi-level disease or deformity requiring extensive instrumentation.

Study Procedure

All eligible patients meeting the inclusion criteria were evaluated preoperatively through detailed clinical examination and radiological assessment, including standing anteroposterior and lateral lumbar spine radiographs, Magnetic Resonance Imaging (MRI), and Computed Tomography (CT) when necessary to confirm the diagnosis of Low Grade (Grade I& II) degenerative spondylolisthesis. After obtaining written informed consent, participants were consecutively assigned to undergo either Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS-TLIF) or conventional Open TLIF, depending on the surgeon's preference and patient suitability. Preoperative demographic data, symptom duration, comorbidities, and baseline functional scores were recorded.

In the MIS-TLIF group, the procedure was performed through a small paramedian incision using tubular retractors under fluoroscopic guidance. Sequential muscle dilation allowed access to the affected level with minimal soft tissue disruption. Microscopic decompression and discectomy were carried out, followed by placement of an interbody cage filled with autologous bone graft obtained from local decompression. Bilateral percutaneous pedicle screws were inserted using guidewire-assisted fluoroscopic control. In contrast, the Open-TLIF group underwent the conventional midline approach with subperiosteal paraspinal muscle stripping, standard laminectomy, facetectomy, and cage placement, followed by open pedicle screw fixation.

Intraoperative variables such as operative time and estimated blood loss were recorded, while all patients received uniform anesthesia, antibiotic prophylaxis, and postoperative rehabilitation protocols. Early mobilization was encouraged from the second postoperative day, and discharge criteria included stable ambulation and adequate pain control. Follow-up assessments were performed at 1, 3, 6, and 12 months postoperatively. At each visit, functional outcomes were evaluated using the Visual Analog Scale (VAS) for back and leg pain, and the Oswestry Disability Index (ODI). Radiological fusion was assessed at 12 months using plain radiographs and, when required, CT scans, graded according to the Bridwell fusion criteria. Patient satisfaction and overall clinical improvement were further determined using the modified Macnab criteria at the final follow-up.

Statistical Analysis

All data were analyzed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range, IQR) as appropriate. Intergroup comparisons were made using the independent samples t-test or Mann-Whitney U test for continuous data. Chi-square test or Fisher's exact test was used for categorical variables. A *p*-value < 0.05 was

considered statistically significant, and $p<0.001$ was considered highly significant. Effect sizes were calculated using Cohen's d for continuous data and risk ratios (95% CI) for categorical outcomes.

Ethical Considerations

Institutional ethical clearance was obtained prior to commencement, and all participants provided written informed consent in accordance with the Declaration of Helsinki (2013 revision).

Results

The grade of Spondylolisthesis were Grade I was 8(57.14) and Grade II was 6(42.86%). Table 1 showed that the mean age was 47.5±10.5 years in the MIS-TLIF group and 48.3±9.8 years in the open TLIF group (P=0.74). Gender distribution was similar, with 42.86% males in MIS-TLIF and 50.00% in open TLIF (P=0.62). Mean BMI was 27.6±2.1 kg/m² versus 28.0±2.4 kg/m², respectively (P=0.53). Median symptom duration was 12 months (IQR 8-18) for MIS-TLIF and 14 months (IQR 10-20) for open TLIF (P=0.41). Comorbidities were comparable: hypertension in 21.43% versus 28.57% (P=0.65) and diabetes in 14.29% versus 21.43% (P=0.62). Perioperative outcomes differed significantly (Table 2). Operative time was shorter in MIS-TLIF (158.5±8.2 minutes) than open TLIF (170.3±9.1 minutes, P=0.01), with lower intraoperative blood loss (210.5±10.3 mL vs. 275.2±15.7 mL, $p<0.001$) and shorter hospital stay (3.4±0.5 vs. 4.5±0.6 days, $p<0.001$). Postoperative complications were low and not significantly different (7.14% vs. 14.29%, P=0.54). Both groups experienced significant improvement in back and leg pain over 12 months (Table 3). MIS-TLIF patients reported consistently lower VAS scores for back pain at 1, 3, 6, and 12 months, as well as for leg pain across all follow-up points. Functional disability, measured by ODI, also improved in both groups (Table 4), with MIS-TLIF showing significantly greater improvement at each follow-up: 1 month (31.2±4.7 vs. 36.8±5.1, P=0.04), 3 months (25.4±4.1 vs. 31.0±4.5, P=0.02), 6 months (21.5±4.0 vs. 27.2±4.3, P=0.01), and 12 months (17.6±3.2 vs. 23.0±3.5, $p<0.001$). Radiological fusion at 12 months favored MIS-TLIF, with 71.43% achieving Grade I fusion versus 50.00% in open TLIF (P=0.04; risk ratio 1.43, 95% CI 1.01-2.03) (Table 5). Grade II and III fusion rates were similar, and no Grade IV cases occurred. Patient-reported outcomes using modified Macnab criteria showed 78.57% of MIS-TLIF patients reporting "excellent" outcomes versus 64.3% in open TLIF (P=0.32), with comparable rates of "good" and "fair" outcomes (Table 6).

Table 1: Baseline demographics and clinical characteristics of the study population (N=28)

Variable	MIS-TLIF (N=14)		Open TLIF (N=14)		P-Value
	N	%	N	%	
Age (years)					
Mean ± SD	47.5±10.5		48.3±9.8		0.74
Gender					
Male	6	42.86	7	50.00	0.62
Female	8	57.14	7	50.00	
BMI (kg/m²)					
Mean ± SD	27.6±2.1		28.0±2.4		0.53
Symptom duration (months)					
median (IQR)	12 (8-18)		14 (10-20)		0.41
Comorbidities					
Hypertension	3	21.43	4	28.57	0.65
Diabetes	2	14.29	3	21.43	0.62

Table 2: Perioperative quality outcomes among the study population

Parameter	MIS-TLIF (N=14)	Open TLIF (N=14)	P-Value
Operative time (min), Mean ± SD	158.5±8.2	170.3±9.1	0.01*
Blood loss (ml), Mean ± SD	210.5±10.3	275.2±15.7	< 0.001*
Hospital stay (days), Mean ± SD	3.4±0.5	4.5±0.6	< 0.001*
Postoperative complications, N (%)	1 (7.14)	2 (14.29)	0.54

Table 3: Functional outcomes-VAS Scores (Back and Leg Pain)

Follow-up	MIS-TLIF (N=14)	Open TLIF (N=14)	P-Value
Back Pain (VAS, Mean ± SD)			
Preoperative	7.9±0.2	8.1±0.3	< 0.001**
1 month	4.2±0.6	4.9±0.7	
3 months	3.3±0.5	4.2±0.6	
6 months	2.7±0.4	3.5±0.5	
12 months	2.2±0.3	3.0±0.4	
Leg Pain (VAS, Mean ± SD)			
Preoperative	8.2±0.3	8.3±0.3	< 0.001**
1 month	4.3±0.5	5.1±0.6	
3 months	3.1±0.4	3.9±0.5	
6 months	2.2±0.3	3.1±0.4	
12 months	1.6±0.3	2.5±0.4	

Table 4: Functional improvement assessed by Oswestry Disability Index (ODI)

Time Point	MIS-TLIF (N=14)	Open TLIF (N=14)	P-Value
Preoperative	45.6±12.3	46.0±11.7	0.92
1 month	31.2±4.7	36.8±5.1	0.04*
3 months	25.4±4.1	31.0±4.5	0.02*
6 months	21.5±4.0	27.2±4.3	0.01*
12 months	17.6±3.2	23.0±3.5	< 0.001**

Table 5: Radiological fusion outcomes at 12 months according to Bridwell grading system

Bridwell Grade	Description	MIS-TLIF (N=14), N (%)	Open-TLIF (N=14), n (%)	P-Value	Risk Ratio (95% CI)
I	Complete fusion	10 (71.43)	7 (50.00)	0.04*	1.43 (1.01-2.03)
II	Partial remodeling	3 (21.43)	5 (35.71)	0.25	0.60 (0.21-1.73)
III	No definite fusion	1 (7.14)	2 (14.29)	0.54	0.50 (0.05-5.47)
IV	Graft resorbed/collapsed	0 (0.00)	0 (0.00)	0.00	0
Overall fusion (I + II)	Successful fusion	13 (92.86)	12 (85.71)	0.03*	1.09 (1.01-1.18)

Table 6: Patient-reported clinical outcome at 12 months using modified Macnab criteria

Outcome	MIS-TLIF (N=14)		Open TLIF (N=14)		P-Value
	N	%	N	%	
Excellent	11	78.57	9	64.29	0.32
Good	2	14.29	3	21.43	0.54
Fair	1	7.14	1	7.14	1
Poor	0	0.00	1	7.14	0.31

Discussion

Degenerative lumbar spondylolisthesis is a leading cause of mechanical back pain and radiculopathy in middle-aged and elderly individuals, frequently necessitating surgical intervention when conservative measures fail. Transforaminal Lumbar Interbody Fusion (TLIF) has emerged as a standard procedure for achieving neural decompression and segmental stabilization [12]. However, conventional open TLIF often entails extensive paraspinal muscle dissection, greater blood loss, and prolonged recovery [13]. Minimally invasive TLIF (MIS-TLIF) aims to mitigate soft-tissue injury and accelerate postoperative recovery. The present study provides a prospective, comparative analysis of MIS-TLIF and open TLIF in patients with Grade I degenerative spondylolisthesis, focusing on perioperative parameters, functional recovery, and radiological fusion outcomes [14]. Our study demonstrated that MIS-TLIF resulted in significantly reduced operative time, blood loss, and hospital stay compared to open TLIF. Specifically, the mean operative time was shorter by approximately 12 minutes, blood loss was reduced by about 65 mL, and the hospital stay was shortened by more than one day in the MIS-TLIF group. These outcomes are consistent with prior reports; notably, Xie *et al*. demonstrated that MIS-TLIF led to lower blood loss, earlier ambulation, and shorter hospitalization compared with the open approach [15]. Furthermore, a meta-analysis by Hammad *et al*. (2019), which synthesized data from seven randomized trials, reported markedly reduced intraoperative blood loss (mean difference -189 mL, $p<0.001$) and shorter hospital stays (mean difference -2.3 days, $p<0.001$) with MIS-TLIF [16].

The reduction in operative time and blood loss observed in the MIS-TLIF group can be attributed to the smaller incision size and the limited muscle dissection required in the minimally invasive approach. By using tubular retractors and accessing the spine through the natural intermuscular planes, MIS-TLIF minimizes soft tissue trauma, which not only reduces intraoperative blood loss but also facilitates faster postoperative recovery [17]. In the current study, both groups experienced substantial improvement in back and leg pain Visual Analogue Scores (VAS) and Oswestry Disability Index (ODI) across all follow-up points, yet the MIS-TLIF group achieved more rapid and greater functional recovery. At 12 months, mean back-pain VAS was 2.2±0.3 in MIS-TLIF versus 3.0±0.4 in open TLIF, and ODI improved to 17.6±3.2 versus 23.0±3.5, respectively ($p<0.001$). These findings are consistent with previous reports; Adogwa *et al*. (2015) documented lower early postoperative ODI and VAS scores in MIS-TLIF, though differences attenuated by 24 months [18], and Modi *et al*. (2021) observed comparable long-term outcomes but accelerated early recovery in minimally invasive patients [19]. Our findings reinforce that MIS-TLIF facilitates earlier pain reduction and disability improvement likely owing to reduced soft-tissue trauma and muscle preservation though long-term equivalence is expected, as shown in large meta-analyses [11]. Radiological assessment using the Bridwell grading system at 12 months revealed a higher rate of complete fusion (Grade I) in the MIS-TLIF group (71.43%) compared to open TLIF (50.00%, P=0.*04*). The overall fusion success (Grades I + II) was also slightly higher in the MIS group (92.86% vs. 85.71%). These findings are consistent with Hu *et al*. (2022) who observed no significant difference in the proportion of complete fusion (Grade I) between MIS and open TLIF groups (57.7% vs. 56.7%) [20], whereas Jover-Mendiola *et al*. (2023) reported overall fusion success (Grade I + II) exceeding 95% in both group [21]. Similarly, Lu *et al*. (2024) found no statistical difference in Bridwell grade distribution between MIS-TLIF and open TLIF [22], with both demonstrating fusion rates above 90%. Meta-analyses by Xie *et al*. (2016) and Qin *et al*. (2020) further corroborate these findings, indicating equivalent radiological fusion outcomes despite the minimally invasive technique offering advantages in perioperative recovery and reduced tissue trauma [12, 23]. In our study, patient-reported outcomes, as assessed by the modified Macnab criteria, showed a higher percentage of "Excellent" outcomes in the MIS-TLIF group compared to the O-TLIF group (78.6% vs. 64.3%). However, this difference was not statistically significant. These results are consistent with those of Jover-Mendiola *et al*. (2023), who reported better patient-reported outcomes in the MIS-TLIF group, including higher satisfaction rates [21].

Limitations of the study

Every hospital-based study has some limitations and the present study undertaken is no exception to this fact. This study is limited by its single-center design and the lack of long-term follow-up beyond one year, which may restrict assessment of sustained functional outcomes and late complications. Additionally, variations in surgical technique and surgeon experience could influence perioperative and postoperative results. Patient-reported outcomes may be subject to subjective bias, and imaging assessments relied primarily on plain radiographs, which could underestimate subtle nonunion or fusion-related issues.

Conclusion and Recommendations

Minimally invasive TLIF provides a safe and effective alternative to open TLIF for single-level Low Grade (Grade I &I I) degenerative spondylolisthesis. It significantly reduces operative time, blood loss, and hospital stay while enabling faster early functional recovery. Radiological fusion and long-term clinical outcomes are comparable to the open approach. These results highlight MIS-TLIF as a less morbid strategy that optimizes perioperative efficiency and patient recovery without compromising efficacy.

Funding

No funding sources

Conflict of interest

None declared

Ethical approval

The study was approved by the Institutional Ethics Committee.

References

1. He D, Li ZC, Zhang TY, Cheng XG, Tian W. Prevalence of lumbar spondylolisthesis in middle-aged people in Beijing community. Orthopaedic Surgery. 2021;13(1):202-206.
2. Rennerfelt K, Sharma D, Brisby H. Section 15 Chapter 1: Degenerative spondylolisthesis-pathogenesis, natural history and classifications.
3. Ullah K, Khattak RU. Assessing the outcomes of combined surgical techniques in spondylolisthesis: A one-year retrospective analysis. Pak J Health Sci. 2025;6(6):133-137.
4. Akkawi I, Zmerly H. Degenerative spondylolisthesis: A narrative review. Acta Bio Medica: Atenei Parmensis. 2022;92(6):e2021313.
5. Funiciello M. Degenerative spondylolisthesis symptoms. Spine-Health; 2023 Nov 9. Available from: https://www.spine-health.com/conditions/spondylolisthesis/degenerative-spondylolisthesis-symptoms
6. Hsieh PC, Bohl DD, Sethi MK, *et al*. Spondylolisthesis. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2025. Available from: https://www.ncbi.nlm.nih.gov/books/NBK430767/
7. Neuroscience & Spine Center of the Carolinas. Benefits of transforaminal lumbar interbody fusion (TLIF) surgery. Neuroscience & Spine Center of the Carolinas. Available from: https://www.neurosciencecarolinas.com/back-spine-blog/benefits-of-transforaminal-lumbar-interbody-fusion-tlif-surgery
8. Starkweather AR, Janusek WL, Nockels RP, Peterson J, Mathews HL. The multiple benefits of minimally invasive spinal surgery: Results comparing transforaminal lumbar interbody fusion and posterior lumbar fusion. Journal of Neuroscience Nursing. 2008;40(1):32-39.
9. Vazan M, Gempt J, Meyer B, Buchmann N, Ryang YM. Minimally invasive transforaminal lumbar interbody fusion versus open transforaminal lumbar interbody fusion: A technical description and review of the literature. Acta Neurochirurgica. 2017;159(6):1137-1146.
10. Lee CK, Park JY, Zhang HY. Minimally invasive transforaminal lumbar interbody fusion using a single interbody cage and a tubular retraction system: Technical tips, and perioperative, radiologic and clinical outcomes. Journal of Korean Neurosurgical Society. 2010;48(3):219-225.
11. Garg B, Mehta N. Minimally invasive transforaminal lumbar interbody fusion (MI-TLIF): A review of indications, technique, results and complications. Journal of Clinical Orthopaedics and Trauma. 2019;10(Suppl 1):S156-S162.
12. Vanti C, Ferrari S, Guccione AA, Pillastrini P. Lumbar spondylolisthesis: State of the art on assessment and conservative treatment. Archives of Physiotherapy. 2021;11(1):19-30.
13. Zhang B, Ma JS, Feng P, Hu Y, Liu JL, Kong QQ. Clinical efficacy of minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) in the treatment of II° lumbar isthmic spondylolisthesis: A retrospective cohort study. Medicine. 2023;102(40):e35420.
14. Chan AK, Bisson EF, Bydon M, Foley KT, Glassman SD, Shaffrey CI, *et al*. A comparison of minimally invasive and open transforaminal lumbar interbody fusion for grade 1 degenerative lumbar spondylolisthesis: an analysis of the prospective quality outcomes database. Neurosurgery. 2020;87(3):555-562.
15. Xie L, Wu WJ, Liang Y. Comparison between minimally invasive transforaminal lumbar interbody fusion and conventional open transforaminal lumbar interbody fusion: An updated meta-analysis. Chinese Medical Journal. 2016;129(16):1969-1986.
16. Hammad A, Wirries A, Ardeshiri A, Nikiforov O, Geiger F. Open versus minimally invasive TLIF: Literature review and meta-analysis. Journal of Orthopaedic Surgery and Research. 2019;14(1):229-240.
17. Zhang D, Mao K, Qiang X. Comparing minimally invasive transforaminal lumbar interbody fusion and posterior lumbar interbody fusion for spondylolisthesis: A STROBE-compliant observational study. Medicine. 2017;96(37):e8011.
18. Adogwa O, Carr K, Thompson P, Hoang K, Darlington T, Perez E, *et al*. A prospective, multi-institutional comparative effectiveness study of lumbar spine surgery in morbidly obese patients: Does minimally invasive transforaminal lumbar interbody fusion result in superior outcomes? World Neurosurgery. 2015;83(5):860-866.
19. Modi HN, Shrestha U. Comparison of clinical outcome and radiologic parameters in open TLIF versus MIS-TLIF in single- or double-level lumbar surgeries. International Journal of Spine Surgery. 2021;15(5):962-970.
20. Hu W, Yang G, Wang H, Wu X, Ma H, Zhang K, Gao Y. Which is better in clinical and radiological outcomes for lumbar degenerative disease of two segments: MIS-TLIF

or OPEN-TLIF? Journal of Personalized Medicine. 2022;12(12):1977-1988.
21. Mendiola JAD, Prats LFA, Utrilla LA, Moreno VMF. Patient-reported outcomes of minimally invasive versus open transforaminal lumbar interbody fusion for degenerative lumbar disc disease: A prospective comparative cohort study. Clinics in Orthopedic Surgery. 2023;15(2):257-266.
22. Lu Z, Zhong D, Liu Y, Zhao G, Ke Z, Wang Y. Comparison of results among UBE-TLIF, MIS-TLIF and open TLIF for Meyerding grade I lumbar spondylolisthesis: A retrospective study. BMC Surgery. 2024;24(1):355-365.
23. 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. Scientific Reports. 2020;10(1):21851.

How to Cite This Article
Rahman MDM, Islam MDN, Ferdous GS, Dey D, Rasul A, Acharjee B. Minimally invasive versus open transforaminal lumbar interbody fusion for low grade (grade I& II) degenerative spondylolisthesis: A prospective comparative analysis of quality and functional outcomes International Journal of Orthopaedics Sciences. 2025;11(4):296-301