Functional and Neurological Recovery Patterns Following Discectomy with Laminotomy for Prolapsed Lumbar Intervertebral Disc

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ABSTRACT

Background: Prolapsed lumbar intervertebral disk (PLID) remains a prominent cause of impairment in working-age people, necessitating surgical surgery when conservative treatment fails. This study aimed to assess functional and neurological recovery patterns after discectomy with laminotomy for PLID. **Methods & Materials:** This study was conducted at the Department of Orthopedic Surgery, Dhaka Medical College Hospital, from July 2019 to June 2021, on 28 radiologically confirmed PLID patients. Patients with nerve root compression and predominant leg pain unresponsive to conservative management were included. Outcome was measured using VAS, Modified Macnab criteria, and straight leg raising. **Results:** Males comprised 67.9% of the patients, and 39.3% were between the ages of 31 and 40. 67% of the patients were manual laborers. The L5 dermatome was most commonly affected by preoperative sensory impairments (57.1%), whereas the extensor hallucis longus was most commonly affected by motor weakness (57.1%). The mean VAS ratings dropped by 92%, from 3.00±0.00 before surgery to 0.24±0.64 at the last follow-up (p<0.001). The improvement in straight leg raising was from 42.63±6.30 degrees to 89.30±2.60 degrees (p<0.001). Neurological recovery revealed that 85.7% of patients had complete motor recovery and 89.3% had complete sensory recovery. The Modified Macnab criteria showed that only one superficial problem (3.6%) was documented, whereas 96.4% of patients had excellent or good results. 3.82±2.39 days was the average length of hospital stay following surgery. **Conclusion:** Excellent functional and neurological recovery with minor issues is demonstrated by discectomy combined with laminotomy for PLID. Significant pain relief, the ability to raise one's leg straight again, and a high incidence of full neurological recovery are all provided by the treatment, especially for L5 and S1 nerve root involvement.

Keywords: *Lumbar disc herniation, Discectomy, Laminotomy, Neurological recovery, Visual Analog Scale*

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INTRODUCTION

Lumbar intervertebral disc herniation (LDH) is a frequently encountered spinal disorder, in which the nucleus pulposus herniates, giving rise to nerve root compression, lower back pain, and radiculopathy that may cause substantial functional impairment. The rationale for surgical treatment of LDH is failure of conservative management and the progression of neurological deficits. However, discectomy with laminotomy has remained a classic surgical modality for LDH, in which the aim of decompression of the involved nerve roots is accomplished by excising the herniated portion of the disc via a small bony window to maintain spinal integrity. Long-term follow-up studies of LDH surgery, whether classical discectomy or its modified procedures in association with laminotomy, have shown good to excellent functional outcomes in 78% of the overall patient population [1, 2]. Postoperative functional recovery is assessed using patient-reported outcome measures, including the Visual Analogue Scale for pain and the Oswestry Disability Index for disability. There have been statistically significant changes in the Oswestry Disability Index and Visual Analogue Scale scores, reflecting the extent to which patients have had relief in the pain in the lower parts of the back and the legs, as well as in the patients' functional capability. For example, the five-year follow-up measurements in patients undergoing transforaminal full-endoscopic lumbar discectomy have shown significant changes in the Visual Analogue Scale scores for leg pain and Oswestry Disability Index scores, reflecting changes in the patients' pain and functional capability, from severe to mild disability [3]. Neurological recovery, defined as improvement in motor strength, sensory function, and reflexes, is a key outcome in patients presenting with preoperative deficits. Large longitudinal studies of simple lumbar discectomy show that many patients with preoperative motor weakness or reflex abnormalities achieve full or near-complete neurological recovery on long-term follow-up. In a one-cohort study followed for over two decades, 60% of patients with abnormal reflexes and 75% with motor weakness demonstrated normal neurological findings at long-term review and the majority reported minimal disability and high satisfaction [4]. TELD and full endoscopic discectomy have appeared safe, effective, and capable of generating significant functional and pain improvements at both short- and long-term follow-up. Among a cohort of patients undergoing transforaminal endoscopic discectomy, there was a significant postoperative decrease in both VAS and ODI scores at 1 year and beyond, coupled with low complication rates and durable outcomes. The above illustrates the theme that less invasive approaches achieve comparable recovery patterns to traditional open surgery [5,6,7]. Preoperative symptom duration, severity of neurological deficits, and comorbidities such as obesity and diabetes significantly influence the rate and extent of postoperative functional recovery. The longer the existing duration of symptoms before surgery, the less the likelihood of improvement in disability measures, underlining the need for proper selection and timing of surgery in individual patients [8, 9]. According to population-level analysis, reoperations occurring in association with primary LDH surgery have been shown to range from 4% to more than 10% at intermediate follow-up in terms of recurrence of LDH, which may be responsible for chronic disability in some cases [9,10]. The study aims to assess the functional and neurological progression of patients who have undergone discectomy with laminotomy due to a prolapsed lumbar intervertebral disc.

METHODS & MATERIALS

This is a prospective study, which was performed in the Department of Orthopedic Surgery, Dhaka Medical College Hospital, from July 2019 to June 2021. 28 consenting adults with clinically and radiologically proven prolapsed lumbar intervertebral disc, selected through purposive sampling. Inclusion criteria were patients suffering from predominant radicular leg pain and having objective signs of nerve root pressure, disc prolapse confirmed on MRI, and failure of conservative management for a period of three to six weeks. Cases of traumatic disc prolapse, patients with cauda equina syndrome, spinal tumors, infection, and previous lumbar surgery on the same level were excluded. Discectomy with laminotomy under general anesthesia through a standard posterior midline approach was conducted on all the participants. Early ambulation, routine physiotherapy, and restriction of activities were the post-operative measures followed, as per the institutional protocol. The patients were followed up at pre-specified intervals for a period of a maximum of 16 months. The efficacy-evaluating parameters included functional and neurological outcome according to the Visual Analog Scale for pain, straight leg raising test, and Modified Macnab criteria. The data were entered and analyzed using SPSS version 26. Continuous variables were expressed as mean ± SD, while categorical variables were presented as frequencies and percentages. Longitudinal changes in pain scores and straight leg raising were evaluated by repeated-measures analysis, and associations between neurological deficits and functional outcomes were assessed using Fisher's exact test and logistic regression as

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appropriate. A p-value of < 0.05 was considered statistically significant.

RESULTS

Table I shows the demographic and preoperative data of 28 patients. The age distribution reveals a predominance of the 31-40 year group (39.3%), followed by younger patients ≤30 years (28.6%). Males made up about two-thirds of the cohort (67.9%). Occupational research found that manual workers made up the majority (60.7%), followed by housewives (21.4%) and sedentary workers (17.9%).

Table I
Age, sex, occupation, and preoperative neurological status of patients (*n* = 28).

Variable	Category	(n)	(%)
Age (Years)	≤30	8	28.6
	31–40	11	39.3
	41–50	6	21.4
	≥51	3	10.7
Sex	Male	19	67.9
	Female	9	32.1
Occupation	Manual worker	17	60.7
	Sedentary worker	5	17.9
	Housewife	6	21.4

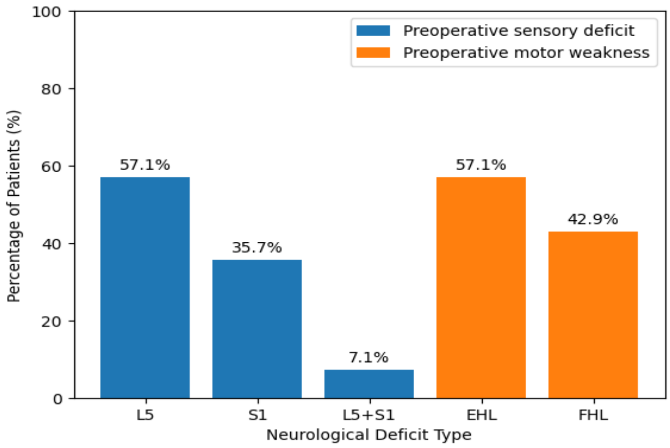

Figure 1 Patients' preoperative neurological condition.

Sensory impairments were most common in the L5 dermatome (57.1%), followed by S1 (35.7%), with only 7.1% involving both. Motor weakness examination found that 57.1% of patients had extensor hallucis longus (EHL) involvement, whereas 42.9% had flexor hallucis longus (FHL). This pattern of neurological involvement is typical of L4-L5 and L5-S1 disc herniations, the most prevalent locations of lumbar disc prolapse, and corresponds to the anatomical distribution of nerve root compression (*Figure 1*).

Table II summarizes the follow-up length and hospital stay data. The average follow-up period was 9.46±3.94 months, with 42.9% of patients followed for up to 6 months, 21.4% for 7-9 months, and 35.7% for 10 months or beyond, allowing for accurate assessment of surgical results. The average preoperative hospital stay was 11.29±5.94 days, which included evaluation and conservative care prior to surgery. The treatment was minimally invasive, resulting in a shorter postoperative hospital stay of 3.82±2.39 days. This promotes early discharge and lowers healthcare expenses.

Table II
Duration of follow-up and hospital stay (*n* = 28).

Parameter	Category	n (%) / Mean ± SD
Follow-up duration (months)	Up to 6 months	12 (42.9)
	7-9 months	6 (21.4)
	≥10 months	10 (35.7)
	Mean± SD	9.46 ± 3.94
Hospital stays (days)	Preoperative	11.29 ± 5.94
	Postoperative	3.82 ± 2.39

Table III shows a gradual improvement in discomfort and straight leg lifting. Preoperatively, all patients reported moderate discomfort (VAS=3). By the third postoperative visit, 92.9% were pain-free, and the mean VAS decreased from 3.00±0.00 to 0.24±0.64, a 92% reduction (p<0.001). Straight leg raising significantly improved from 42.63±6.30 degrees preoperatively to 89.30±2.60 degrees at end follow-up (p<0.001), representing a 109.5% increase. This progressive enhancement demonstrates efficient neural decompression, which results in the gradual resolution of nerve root inflammation and the restoration of biomechanical function over time.

Table III
Distribution of pain score and straight leg raising (SLR) during follow-up (*n* = 28).

A. Pain score distribution (VAS)

Pain score	Preoperative	1st visit	2nd visit	3rd visit
	n (%)	n (%)	n (%)	n (%)
Absent (0)	0 (0)	0 (0)	16 (57.1)	26 (92.9)

Occasional (1)	0 (0)	2 (7.1)	5 (17.9)	0 (0)
Mild (2)	0 (0)	25 (89.3)	7 (25)	2 (7.1)
Moderate (3)	28 (100)	1 (3.6)	0 (0)	0 (0)

B. Mean VAS score

Stage	Mean ± SD
Preoperative	3.00 ± 0.00
Postoperative 1st visit	1.79 ± 0.62
Postoperative 2nd visit	1.07 ± 0.84
Postoperative 3rd visit	0.24 ± 0.64

C. Straight Leg Raising

Visit	Mean ± SD
Preoperative	42.63 ± 6.30
Postoperative 1st visit	75.0 ± 5.77
Postoperative 2nd visit	83.6 ± 4.88
Postoperative 3rd visit	89.3 ± 2.60

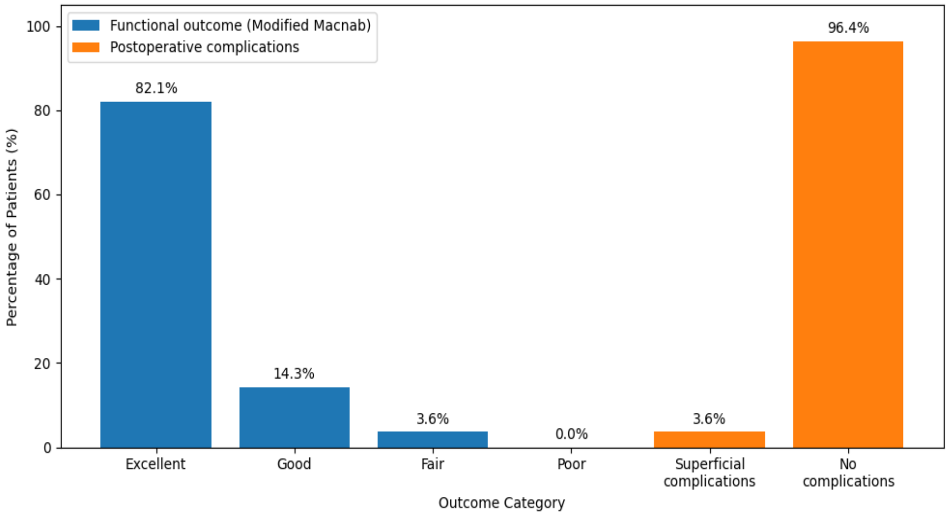

Figure 2 Final functional outcomes and complications.

Using Modified Macnab criteria in conjunction with VAS scores, 82.1% achieved excellent outcomes, 14.3% good outcomes, and 3.6% fair outcomes, with no poor results. This amounts to 96.4% favorable results (excellent/good), indicating a high surgical success rate. issue study indicated only one superficial issue (3.6%), whereas 96.4% had no complications. The low complication rate highlights the procedure's safety profile, while the large proportion of favorable outcomes confirms discectomy with laminotomy as a viable therapy method for symptomatic prolapsed lumbar intervertebral disc (*Figure 2*).

Table IV measures temporal variations in pain severity and straight leg lifting. Pain intensity improved consistently throughout all follow-up periods, with mean VAS reductions of 1.21 points (40.3%) at first visit, 1.93 points (64.3%) at second visit, and 2.76 points (92%) at third visit ($p < 0.001$). At each visit, straight leg raising improved by an average of 32.37 degrees (75.9%), 40.97 degrees (96.1%), and 46.67 degrees (109.5%) ($p<0.001$). The progressive trend of improvement suggests that brain repair, inflammation resolution, and tissue healing are continuing, with the greatest increases occurring during the first three months after surgery.

Table IV
Change in pain intensity and improvement in straight leg raising over time.

A. Change in Pain Intensity (VAS Score) Over Time

Time point	Mean ± SD	Mean change from baseline	% Reduction from baseline	p-value
Preoperative	3.00 ± 0.00	-	-	<0.001
Postoperative 1st visit	1.79 ± 0.62	-1.21	40.3%	
Postoperative 2nd visit	1.07 ± 0.84	-1.93	64.3%	
Postoperative 3rd visit	0.24 ± 0.64	-2.76	92.0%	

B. Improvement in Straight Leg Raising (SLR) Angle Over Time

Time point	Mean ± SD (degrees)	Mean improvement from baseline	% Improvement	p-value
Preoperative	42.63 ± 6.30	-	-	<0.001
Postoperative 1st visit	75.00 ± 5.77	+32.37	75.9%	
Postoperative 2nd visit	83.60 ± 4.88	+40.97	96.1%	
Postoperative 3rd visit	89.30 ± 2.60	+46.67	109.5%	

Table V compares neurological healing trends based on nerve root involvement. Complete sensory recovery was achieved in 93.8% of L5, 90% of S1, and 50% of combined L5+S1 deficiency patients, with the remainder demonstrating partial recovery and none reporting no recovery. Motor recovery resulted in complete resolution in 87.5% of EHL and 83.3% of FHL weakening cases, with 12.5% and 16.7% demonstrating partial recovery, respectively ($p=0.68$). The high percentages of complete neurological recovery corroborate the efficacy of early surgical decompression, but the absence of statistical significance between groups indicates that recovery potential is equivalent regardless of specific nerve root involvement.

Table V
Combined Sensory and Motor Neurological Recovery Pattern at Final Follow-up After Discectomy with Laminotomy.

Preoperative Neurological Profile	Complete Recovery n (%)	Partial Recovery n (%)	No Recovery n (%)	p-value
Sensory deficit	-	-	-	-
L5 (n=16)	15 (93.8)	1 (6.2)	0 (0.0)	0.21
S1 (n=10)	9 (90.0)	1 (10.0)	0 (0.0)	
L5 + S1 (n=2)	1 (50.0)	1 (50.0)	0 (0.0)	
Motor weakness	-	-	-	-
EHL (n=16)	14 (87.5)	2 (12.5)	0 (0.0)	0.68
FHL (n=12)	10 (83.3)	2 (16.7)	0 (0.0)	

Table VI shows a logistic regression study of the factors for great functional outcomes. Although younger patients (≤40 years) had superior outcomes (OR=2.10), with 89.5% having good results compared to 77.8% in older patients, the difference was not statistically significant (p=0.44). Similarly, male gender (OR=1.38), manual occupation (OR=0.92), and longer follow-up ≥10 months (OR=2.67) showed favorable tendencies but did not reach statistical significance. The lack of significant indicators shows that discectomy with laminotomy produces consistently positive results across varied patient populations, regardless of demographic or vocational characteristics.

Table VI
Logistic regression analysis of factors associated with excellent functional outcome.

Predictor Variable	Excellent Outcome n (%)	OR	95% CI	p-value
Age ≤40 years (n=19)	17 (89.5)	2.10	0.32-13.6	0.44
Male (n=19)	16 (84.2)	1.38	0.21-9.12	0.74
Manual occupation (n=17)	14 (82.4)	0.92	0.14-6.11	0.93
Follow-up ≥10 months (n=10)	9 (90)	2.67	0.29-24.5	0.39

DISCUSSION

Prolapsed lumbar intervertebral disc is a major cause of disability in the population of the working age group, and surgery is indicated when conservative management fails to provide adequate relief to the patients [11]. This is a prospective analysis of functional and neurological recovery patterns in patients who underwent discectomy with laminotomy and shows excellent results with minimal complications. Our study demonstrated male predominance of 67.9% and a peak incidence in the 31-40-year age group, an epidemiological pattern for lumbar disc herniation. Manual workers constituted the majority of the subjects, 60.7%, showing the biomechanical stress and repetitive loading from heavy physical work [12]. This demographic distribution was corroborated by Bydon et al., in their large cohort of 500 patients who underwent lumbar laminectomy with similar patterns, emphasizing the occupational impact of degenerative lumbar diseases [13]. The pain control, as measured by VAS, showed significant improvement from 3.00±0.00 preoperatively to 0.24±0.64 at final follow-up, indicating a 92% reduction (p<0.001). This goes beyond the minimal clinically significant difference and is in tandem with studies presented by Tang et al., who showed significant pain reduction after unilateral laminotomy for bilateral decompression procedures [14]. The progressive stabilization of pain values at follow-up intervals indicates a gradual recovery of the nerve and cessation of inflammation following decompression procedures. Minamide et al. also showed pain control in their 5-year follow-up study of microendoscopic laminotomy in lumbar spinal stenosis patients [15]. Improvement in straight leg raising from 42.63±6.30 degrees before surgery to 89.30±2.60 degrees at final follow-up (p<0.001) signifies successful nerve root decompression and achievement of nerve mobility. The quantitative assessment of neurological function is well associated with subjective measures of pain relief and signifies a successful surgical procedure. Continued progression signifies healing and neurological adaptation post-decompression procedure [16]. The patterns of neurological recovery showed complete sensory recovery in 89.3% and complete motor recovery in 85.7% of the patients. These findings were better than those reported by Mariconda et al., in their long-term follow-up study, found the following patient recovery percentages among those with preoperative muscle weakness; 75% regained normal strength, and among those with abnormal preoperative reflexes, 60% regained full recovery [17]. Our better recovery may be due to earlier surgery and shorter preoperative neurological deficits. Results from the study of Lønne et al. showed favorable recovery among patients with limb paresis, with 75% of them regaining full recovery at 12 months postmicrodiscectomy, especially those with mild paresis compared to those with severe paresis [18]. There were no significant differences in nerve root-specific recovery in L5 vs. S1 dermatomes (p=0.21) or in EHL vs. FHL motor recovery (p=0.68), indicating equivalent recovery capacities despite divergent compression of specific nerve roots. This is in accordance with sufficient recovery despite anatomical levels of depression after appropriate decompression [19]. Nonetheless, in the only case presenting with both L5 & S1 involvement, recovery was only partial with respect to sensory or motor components. Functional outcome measures according to Modified Macnab criteria revealed 82.1% to be excellent, 14.3% to be good, and 3.6% to be fair, while 96.4% patients achieved satisfactory outcomes which is in line with Ahn et al. [20]. The complication rate of 3.6% (one superficial wound complication) is comparable with reports by Silverplats et al. [21]. The surgical-site infections were found to be 4.3%, whereas the overall complication rate varied between 10% in a report by Lequin et al. [22]. The very low rate of complications in our study substantiates the safety profile of discectomy with laminotomy. Logistic regression analysis showed non-significant factors for excellent outcomes, such as age, gender, occupation, and duration of follow-up. It indicates that discectomy with laminotomy has consistent favorable outcomes for varying patients.

LIMITATIONS

This study's limitations include a relatively small sample size and variable follow-up duration, which may limit statistical power and long-term outcome assessment.

CONCLUSION

Discectomy with laminotomy for prolapsed lumbar intervertebral discs results in excellent functional and neurological recovery with few problems. The technique provides great pain relief (92% reduction in VAS scores), restores straight leg raising from 42.63 to 89.30 degrees, and has a high incidence of complete neurological recovery. With 96.4% attaining excellent or good outcomes according to Modified Macnab criteria and only 3.6% experiencing complications, this surgical method remains an effective and safe therapeutic option for appropriately selected patients with PLID who have failed conservative care.

RECOMMENDATIONS

Future studies should incorporate larger multicenter cohorts with standardized long-term follow-up protocols extending beyond 2-5 years, and investigate specific patient-reported outcome measures to better identify prognostic factors and optimize patient selection criteria.

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CONFLICT OF INTEREST

None declared

ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee.

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