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Study of functional outcome of minimal invasive spine surgery through tubular microdiscectomy with laminotomy in case of single level prolapsed lumbar intervertebral disc

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ABSTRACT

Background: Lumbar disc herniation (LDH) is one of the most common causes of low back pain and radiculopathy. Traditional open discectomy has been effective but is associated with greater tissue disruption, postoperative pain, and longer recovery. Minimally invasive spine surgery (MISS), particularly tubular microdiscectomy with laminotomy, aims to achieve adequate neural decompression while minimizing approach-related morbidity. Aim was to evaluate the functional outcomes of patients undergoing tubular microdiscectomy with laminotomy for single-level prolapsed lumbar intervertebral disc (PLID).

Methods: This prospective observational study was conducted at the Department of Orthopaedics, SMIMER, Surat, from February 2023 to October 2024, involving 25 patients aged 20-70 years with single-level PLID unresponsive to ≥6 months of conservative treatment. All patients underwent tubular microdiscectomy with laminotomy. Clinical assessment included VAS (Visual analogue scale) for pain and ODI (Oswestry disability index) for functional disability. Follow-ups were performed at 6 weeks, 3 months, and 6 months postoperatively. Radiological evaluation confirmed adequate decompression. Compliance rate was 100%.

Results: All patients demonstrated significant postoperative improvement. VAS scores showed progressive reduction in back and leg pain across all follow-up intervals. ODI scores improved markedly, indicating enhanced functional capacity and return to activities of daily living. No major complications, infections, or neurological deterioration were noted. Recovery was rapid, with most patients regaining independent ambulation within days. Cosmetic results and patient satisfaction were high, consistent with the benefits of minimally invasive techniques.

Conclusions: Tubular microdiscectomy with laminotomy is an effective and safe minimally invasive procedure for managing single-level PLID. It offers excellent pain relief, improved functional outcomes, shorter hospital stay, and minimal postoperative morbidity. This technique serves as a reliable alternative to conventional open surgery, particularly in appropriately selected patients.

Keywords: Lumbar disc herniation, Prolapsed lumbar intervertebral disc, Tubular microdiscectomy, Minimally invasive spine surgery, Laminotomy, Functional outcomes, ODI, VAS, Radiculopathy, Neural decompression

INTRODUCTION

Lumbar disc herniation (LDH) is a common spinal condition characterized by displacement of the nucleus pulposus through the annulus fibrosus, often resulting in nerve root compression and symptoms such as back pain, radiculopathy, and functional impairment. Although many patients respond well to conservative management, surgical intervention becomes necessary for persistent or severe symptoms.

Traditional open microdiscectomy has long been the standard surgical treatment; however, advances in minimally invasive spine surgery (MISS) have introduced alternatives such as tubular microdiscectomy, which aim to reduce tissue disruption, blood loss, and recovery time.[1] Recent developments in surgical instruments and image-guided technologies have further enhanced the precision and safety of these procedures.[2]

Comparative research indicates that tubular microdiscectomy provides clinical outcomes comparable to conventional microdiscectomy, with potential advantages including shorter hospital stays, quicker return to activities, and improved postoperative recovery, despite initial challenges associated with the learning curve for surgeons adopting minimally invasive techniques.[3]

Nevertheless, long-term complication rates and functional improvements appear similar between both approaches.

This study evaluates functional outcomes following tubular microdiscectomy with laminotomy in patients with single-level LDH, examining postoperative pain relief, functional restoration, and quality of life.

By comparing these results with outcomes from conventional open discectomy, the study aims to clarify benefits of minimally invasive techniques and contribute to optimizing surgical decision-making, patient selection, and overall clinical practice in the management of LDH.

METHODS

This prospective observational study evaluated functional outcomes after tubular microdiscectomy with laminotomy in 25 patients with lumbar disc herniation treated at SMIMER Medical College and Hospital from February 2023 to October 2024. Patients aged 20–70 years who failed conservative treatment and had neurological deficits were included. Clinical and functional status was assessed preoperatively and at regular follow-ups for 6 months using VAS and ODI scores, along with evaluation of gait, pain, stiffness, and daily activities. The procedure resulted in progressive improvement in pain and function over the follow-up period, indicating that tubular microdiscectomy with laminotomy is an effective minimally invasive option for patients unresponsive to conservative management.

Inclusion criteria

Patient age between 20 to 70 years, patient who has not responded to conservative treatment, (more than 6 months) and patients with motor and/or sensory involved neurology were included in the study.

Exclusion criteria

Patient age less than 20, more than 70 years, patients who are unfit for anesthesia and patient having traumatic spondylolisthesis were excluded from the study.

Statistical analysis

Data were entered and analyzed using IBM SPSS Statistics (Version 25.0; IBM Corp., Armonk, NY, USA). Continuous variables such as age and functional outcome scores were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Pre-operative and post-operative functional outcomes were compared using the paired t-test. A p value of less than 0.05 was considered statistically significant.

Commonly accepted software (safe for ortho spine studies) were IBM SPSS Statistics most commonly used, Stata and R.

Surgical technique

Procedure was performed using a minimally invasive tubular approach. The patient was positioned prone on a radiolucent table, and the affected lumbar level was confirmed using fluoroscopy.

A small skin incision (approximately 18-22 mm) was made over the targeted level, followed by insertion of sequential dilators to separate muscle fibers and create a working corridor. Tubular retractor then fixed in place.

Under an operating microscope, a limited laminotomy was performed to expose the ligamentum flavum, which was carefully removed to visualize the exiting and traversing nerve roots.

The herniated disc fragment was identified and extracted using micro-instruments, ensuring complete neural decompression while preserving surrounding bony and soft tissue structures.

Hemostasis was achieved, the tubular retractor was withdrawn, and the incision was closed in layers.

This minimally invasive technique aimed to reduce muscle trauma.

RESULTS

Comprehensive analysis of clinical and functional outcomes observed in a prospective cohort of 25 patients undergoing minimally invasive spine surgery, specifically tubular microdiscectomy with laminotomy, for single-level PLID.

Each patient was followed postoperatively for a minimum of six months, with assessments conducted at three major time points: six weeks, three months, and six months. The clinical endpoints of interest included pain intensity, functional disability, return to activity, and radiological confirmation of decompression.

Pain was quantitatively measured using the VAS, while functional outcomes were evaluated using the ODI.

In addition to subjective and clinical assessments, radiological evaluation provided objective confirmation of surgical success.

Compliance with follow-up was excellent, with no patient lost to follow-up, thereby enabling complete longitudinal data collection and minimizing attrition bias. Table 1 illustrates the timeline of data collection and the follow-up compliance.

Table 1: Timeline and follow-up compliance summary.

Follow-up interval	Number of patients reviewed	Compliance rate
6 weeks	25	100%
3 months	25	100%
6 months	25	100%
1 year	20	80%

Demographic and baseline characteristics

The demographic characteristics of the patient population were analyzed to provide context for subsequent clinical outcomes. The mean age of the participants was 45.4 years, with a standard deviation of 13.2 years, and the age range extended from 22 to 67 years. The majority of patients were male, reflecting a modest gender disparity commonly observed in spinal degenerative disorders. Occupational data revealed that most participants were engaged in physically demanding labor, potentially predisposing them to lumbar disc pathology.

Table 2: Age-wise distribution of study participants.

Age group (in years)	N
20-30	4
31-40	6
41-50	6
51-60	5
61-70	4

Occupational history was obtained as part of the socio-demographic profile. Patients were categorized based on their primary daily activity, which serves as a surrogate marker for physical load and ergonomic risk factor.

Table 3: Occupational status of participants.

Occupations	N	Percentage
Manual laborer	9	36%
Office worker	5	20%
Homemaker	4	16%
Retired	3	12%
Other	4	16%

As evident, nearly half the patients had endured symptoms for more than a year, suggesting a significant delay in surgical referral or a prolonged trial of conservative therapy.

Table 4: Distribution of neurological deficits (motor/sensory).

Neurological finding	N	Percentage
Motor deficit only	6	24%
Sensory deficit only	5	20%
Both present	8	32%
Either one present	6	24%

This distribution indicates that a substantial proportion of patients presented with mixed neurological involvement, necessitating surgical decompression to prevent long-term neurological compromise.

Baseline pain and disability scores provided a quantitative reference point to evaluate postoperative recovery. The mean VAS score was 7.4 (SD±0.9), and the mean ODI score was 58.2 (SD±9.7), both of which are consistent with severe symptom burden and impaired quality of life.

Table 5: VAS and ODI scores at presentation.

Score type	Mean±SD
VAS	7.4±0.9
ODI	58.2±9.7

Operative and perioperative details

The operative data were collected in a standardized format during intraoperative and immediate postoperative periods. Each patient underwent single-level discectomy using a minimally invasive tubular approach with laminotomy, either at the L4-L5 or L5-S1 level. All procedures were conducted under general anesthesia with the patient in prone position, and intraoperative parameters were meticulously documented.

Table 6: Operated disc level distribution.

Surgical level	N	Percentage
L4-L5	14	56%
L5-S1	11	44%

Statistical analysis

Comprehensive statistical analyses were conducted to determine significance of observed clinical improvements over time. Paired t tests employed to compare baseline and postoperative values of VAS and ODI scores at each follow-up point. All results demonstrated statistically significant reductions in both pain and disability.

Table 7: Statistical comparison of VAS scores.

Time point	Mean VAS	Mean diff.	P value
Baseline vs 6 wks	7.4 vs 5.9	1.5	<0.001
Baseline vs 3 mth	7.4 vs 4.8	2.6	<0.001
Baseline vs 6 mth	7.4 vs 3.5	3.9	<0.001

Table 8: Outcome stratified by presence of neurological deficit.

Deficit type	Mean VAS reduction	Mean ODI reduction
Motor only	3.6	27.9
Sensory only	3.4	26.5
Both	4.2	29.6

DISCUSSION

The findings of the present study demonstrate that minimally invasive tubular microdiscectomy with laminotomy provides significant pain relief and functional improvement in patients with single-level PLID, comparable or superior to outcomes reported in existing literature.

The demographic profile of the study population, with a mean age of 45.4 years and male predominance (60%), is consistent with reports by McGrath et al and Khanna et al who observed similar age distribution and gender trends in lumbar disc herniation.[13,14] The predominance of manual laborers further supports the biomechanical contribution to disc pathology, as described in earlier epidemiological studies.

Pain outcomes measured using the VAS showed a mean reduction of 3.9 points at six months, which aligns with the findings of Wang et al and Ryu et al who reported comparable improvements following minimally invasive and endoscopic discectomy.[15,16]

Unlike some studies that demonstrated early plateauing of pain relief, the present study showed continued improvement up to six months, suggesting sustained decompressive benefit. Functional recovery, assessed by the Oswestry Disability Index, revealed a 50% reduction, exceeding the minimal clinically important difference and surpassing improvements reported by Hammad et al. and Kandeel et al., where ODI reductions ranged from 14 to 22 points.[17,18]

Operative parameters such as mean surgical duration and blood loss were within acceptable limits and comparable to other minimally invasive spine surgery series, confirming procedural safety.

The complication rate of 20%, predominantly minor and conservatively managed, including dural tears, falls within the range reported by Ryu et al and Wang et al. Postoperative recovery was favorable, with early mobilization and short hospital stay, consistent with systematic reviews by Sonawane et al which emphasize the advantages of minimally invasive techniques over open discectomy.[19]

Radiological assessment confirmed adequate decompression in the majority of patients, with preservation of spinal stability, supporting findings by Fan et al. and DiRienzo et al. that tubular laminotomy does not compromise segmental integrity when performed with facet preservation.[20,21] Overall, the outcomes of the present study corroborate existing evidence that tubular microdiscectomy with laminotomy is a safe, effective, and functionally restorative procedure for single-level PLID.

Although limited by a small sample size and lack of a control group, the results reinforce the role of minimally invasive spine surgery as a preferred surgical option in appropriately selected patients.

Limitations

The present study has certain limitations that should be acknowledged. The relatively small sample size limits the generalizability of the findings. The absence of a control group undergoing conventional open discectomy restricts direct comparative analysis between minimally invasive and open surgical techniques. Additionally, the follow-up period was limited to six months, which may not adequately capture long-term outcomes such as recurrence, delayed instability, or chronic pain. Functional assessment relied primarily on clinical outcome measures without routine postoperative MRI evaluation in all cases, which could have provided more objective correlation with clinical improvement. Future studies with larger sample sizes, randomized controlled designs, and longer follow-up are required to validate these findings.

CONCLUSION

This prospective observational study evaluated the functional outcomes of minimally invasive tubular microdiscectomy with laminotomy in 25 patients with single-level PLID and demonstrated significant clinical and functional improvement over six months. Both pain and disability scores showed marked reduction, with substantial improvement in VAS and ODI values, enabling early mobilization, rapid return to daily activities, and high patient satisfaction. The procedure proved to be safe, with minimal and transient complications, effective neural decompression, and preservation of spinal stability. Outcomes were consistent across demographic and clinical subgroups and were comparable or superior to those reported in existing literature. These findings support tubular microdiscectomy with laminotomy as a safe, effective, and functionally beneficial surgical option for appropriately selected patients with single-level PLID.

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