

# Evaluation of Clinical Outcomes of Percutaneous Endoscopic Transforaminal Discectomy in Lumbar Disc Herniation: A Prospective Study

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## ABSTRACT

**Background:** Lumbar disc herniation (LDH) is a major cause of low back pain and radiculopathy, significantly affecting quality of life. Minimally invasive techniques like percutaneous endoscopic transforaminal discectomy (PETD) have gained popularity due to reduced tissue trauma and faster recovery.

**Objective:** To evaluate the clinical and functional outcomes of PETD in patients with symptomatic lumbar disc herniation.

**Methods:** A prospective interventional study was conducted on patients with LDH who failed conservative management. Clinical and functional outcomes were assessed using the Oswestry Disability Index (ODI) at baseline, 2 weeks, 6 weeks, and 3 months postoperatively. Statistical analysis was performed using SPSS software.

**Results:** Seven patients were included in the final analysis. The mean preoperative ODI score was  $36.14 \pm 6.69$ , which significantly improved to  $21.71 \pm 6.04$  at 2 weeks,  $22.71 \pm 6.70$  at 6 weeks, and  $23.86 \pm 8.09$  at 3 months ( $p < 0.05$ ). Most patients showed improvement in functional status with no major complications reported.

**Conclusion:** PETD is a safe and effective minimally invasive technique for managing lumbar disc herniation, offering significant functional improvement and early recovery.

**Keywords:** Percutaneous Endoscopic Transforaminal Discectomy, Lumbar Disc Herniation, Minimally Invasive Spine Surgery, Oswestry Disability Index, Radiculopathy.

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## Introduction

Lumbar back pain (LBP) stands among the most widespread musculoskeletal conditions globally and constitutes a significant contributor to disability, diminished work performance, and medical care expenses. This condition impacts people of all ages, demonstrating notably elevated occurrence rates within the employed demographic. Within the diverse causes of LBP, lumbar disc herniation (LDH) emerges as one of the most frequent and medically important pathologies, commonly linked to radiculopathy and functional limitations. Lumbar disc herniation refers to

the migration of intervertebral disc components beyond the typical boundaries of the disc compartment. Such displacement may result in compression or inflammation of neighboring neural structures, producing manifestations including radiating lower extremity pain (sciatica), sensory loss, paresthesias, and muscular weakness. Population-based research indicates that although low back pain impacts approximately 50–70% of people throughout their lives, clinically meaningful radiculopathy secondary to disc herniation develops in roughly 4–6% of individuals.

The lumbar region demonstrates heightened

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vulnerability to disc herniation owing to its biomechanical function in supporting axial loads while permitting movement. The segments most frequently involved are L4–L5 and L5–S1, representing nearly 95% of all lumbar disc herniations. These levels experience maximal mechanical strain during routine activities including lifting, flexion, and rotation, making them prone to degenerative alterations and disc displacement. The pathophysiological mechanisms underlying lumbar disc herniation involve multiple factors encompassing both mechanical and biochemical elements. Intervertebral disc deterioration initiates with decreased hydration of the nucleus pulposus and breakdown of the annulus fibrosus. These modifications diminish the disc's क्षमता to resist compressive loads, resulting in bulging or extrusion of disc contents. Furthermore, inflammatory substances including tumor necrosis factor-alpha (TNF- $\alpha$ ), interleukins, and prostaglandins released from the herniated disc contribute to neural irritation and discomfort. Therefore, the clinical features of LDH arise from both mechanical compression and inflammatory mechanisms. From a clinical perspective, individuals with lumbar disc herniation exhibit varied symptoms extending from localized lumbar pain to intense radicular pain following the anatomical distribution of involved nerve roots. Neurological impairments including sensory abnormalities, motor deficits, and altered reflexes may also occur. Physical examination techniques, such as the Straight Leg Raising Test (SLRT), are frequently employed to evaluate nerve root involvement and assist in diagnostic assessment. Imaging studies serve an essential function in establishing the diagnosis and directing treatment decisions. Magnetic resonance imaging (MRI) represents the preferred imaging technique due to its exceptional capacity to demonstrate soft tissue structures, including intervertebral discs, nerve roots, and spinal canal components. MRI facilitates identification of herniation type and location while evaluating the extent of nerve root compression and concurrent spinal canal narrowing. Treatment strategies for lumbar disc herniation encompass conservative and operative modalities. Non-operative management, incorporating rest, non-steroidal anti-inflammatory drugs (NSAIDs), physical therapy, and behavioral modifications, proves successful in most patients, particularly during initial disease phases.

Nevertheless, certain patients experiencing persistent symptoms, advancing neurological deterioration, or inadequate response to conservative measures necessitate surgical treatment. Conventional surgical methods including open discectomy and microdiscectomy have traditionally represented standard care for LDH. Although these procedures effectively alleviate neural compression, they present specific drawbacks, such as muscle disruption, postoperative discomfort, extended hospitalization, and prolonged rehabilitation. Recently, there has been a conceptual transition toward minimally invasive spinal surgery designed to minimize operative complications while preserving therapeutic effectiveness. Percutaneous endoscopic lumbar discectomy (PELD) has developed as an encouraging minimally invasive option for managing lumbar disc herniation. The transforaminal methodology stands out among different techniques due to its capacity to provide direct entry to the herniated disc via the intervertebral foramen while avoiding substantial disturbance to paraspinal musculature or osseous components. This methodology relies on Kambin's triangle principles, representing a secure anatomical pathway that enables disc access while reducing neural damage risks.

Percutaneous endoscopic transforaminal discectomy (PETD) offers benefits including limited tissue damage, diminished hemorrhage, reduced surgical duration, lessened postoperative discomfort, and prompt patient mobilization. Additionally, the technique can be executed using local or general anesthetic protocols and frequently permits abbreviated hospitalization periods with accelerated resumption of routine activities. These characteristics render PETD an appealing choice for both patients and surgical practitioners.

Notwithstanding these benefits, PETD implementation has progressed slowly owing to elements including challenging skill acquisition requirements, specialized instrumentation needs, and questions regarding effectiveness and safety relative to traditional methods. Moreover, variations in patient selection criteria, surgical proficiency, and assessment parameters have resulted in inconsistent findings throughout research studies. Consequently, evaluating PETD clinical outcomes across diverse environments becomes crucial for determining its position in standard clinical application. This investigation seeks to assess clinical

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and functional results of percutaneous endoscopic transforaminal discectomy among patients presenting with lumbar disc herniation. Functional enhancement evaluation employs the Oswestry Disability Index (ODI), a validated instrument extensively utilized for measuring low back pain-related disability. Through examining preoperative and postoperative results, this research endeavors to establish PETD effectiveness in symptom relief, functional status improvement, and quality of life enhancement in affected individuals. Furthermore, this investigation adds to the expanding evidence base supporting minimally invasive spinal surgery while offering perspectives on PETD feasibility and safety within clinical environments. The results may assist in guiding clinical decision-making processes and encourage adoption of less invasive approaches in lumbar disc herniation management.

### Materials and Methods

This prospective interventional study was conducted in the Department of Orthopedic Surgery at Maulana Azad Medical College and associated Lok Nayak Hospital over a period from September 2019 to April 2021. The primary objective was to evaluate the clinical and functional outcomes of percutaneous endoscopic transforaminal discectomy (PETD) in patients with lumbar disc herniation who failed conservative management.

### Study Population

Individuals with symptomatic lumbar disc herniation underwent evaluation for study participation. Eligibility requirements encompassed subjects between 18 and 60 years of age who demonstrated clinically and radiographically verified lumbar disc herniation with associated compressive radiculopathy, having failed to improve following a minimum of six weeks of conventional conservative management, encompassing pharmaceutical intervention and physical therapy.

Criteria for exclusion encompassed subjects with degenerative lumbar scoliosis (Cobb's angle  $\geq 25^\circ$ ), spinal stenosis, segmental instability, neoplasms, infectious processes, calcified ligamentum flavum, prior lumbar spinal procedures, cauda equina syndrome, and psychosomatic pain conditions. Study participation was limited to subjects who provided informed consent for surgical treatment.

### Preoperative Assessment

Each patient received a comprehensive clinical and neurological examination that encompassed the evaluation of pain levels, motor and sensory impairments, and reflex responses. Assessment of functional impairment was conducted utilizing the ODI, which represents a validated instrument for quantifying disability associated with lumbar spine pain. The radiological assessment consisted of conventional anteroposterior and lateral imaging of the lumbosacral region, supplemented by dynamic flexion-extension radiographs to evaluate spinal stability. MRI examination of the lumbosacral spine was conducted in all patients to establish diagnostic confirmation, identify the anatomical level and classification of disc herniation, and assess the degree of nerve root impingement.

### Surgical Procedure

All interventions were conducted under general anesthesia with patients positioned prone on a radiolucent surgical table. Appropriate positioning facilitated decreased intra-abdominal pressure and reduced epidural venous hemorrhage. Fluoroscopic guidance directed the surgical methodology to precisely identify the targeted disc level. A percutaneous transforaminal technique was employed. Under fluoroscopic direction, an 18-gauge spinal needle was positioned at approximately 25–30 degrees angulation toward the designated disc space. Following confirmation of correct placement, a guidewire was advanced, accompanied by progressive soft tissue dilation. A working cannula and endoscope were subsequently positioned to gain access to the intervertebral disc. Through direct endoscopic observation, the annular defect was located, and protruding disc material was extracted using specialized retrieval instruments. Decompression was deemed sufficient upon visualization of freely mobile dural sac and nerve root structures. Hemostatic control was established, and instrumentation was removed. The intervention concluded with minimal soft tissue trauma and a small cutaneous incision.

### Postoperative Management and Follow-up

Following surgical intervention, pain management protocols incorporated non-steroidal anti-inflammatory medications and opioid therapy as indicated. Ambulation was promoted early in the recovery period, generally commencing within the first postoperative

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day. Discharge criteria included achievement of clinical stability, with patients receiving guidance on progressive return to routine activities. Limitations on strenuous physical activity were maintained for a duration of approximately six weeks. Clinical evaluations were scheduled at intervals of 2 weeks, 6 weeks, and 3 months post-surgery. Assessment of functional status was performed utilizing ODI measurements during each scheduled visit.

### Statistical Analysis

Data were analyzed using SPSS version 25. Quantitative variables were expressed as mean  $\pm$  standard deviation and median with interquartile range, while qualitative variables were presented as frequencies and percentages. The Wilcoxon signed-rank test and paired t-test were used to compare preoperative and postoperative ODI scores. Repeated measures ANOVA was applied to assess changes over time. A p-value of less than 0.05 was considered statistically significant.

### Inclusion and Exclusion Criteria

Individuals deemed suitable for participation in this investigation comprised adults between 18 and 60 years of age who exhibited symptomatic lumbar disc protrusion accompanied by compressive radiculopathy, verified through clinical assessment and radiological examination via magnetic resonance imaging. Candidates were restricted to those who demonstrated inadequate response to a minimum of six weeks of conventional conservative treatment, encompassing pharmaceutical interventions and physical therapy. Moreover, all subjects furnished informed consent for operative treatment.

Exclusion criteria encompassed individuals with degenerative lumbar scoliosis (Cobb's angle  $\geq 25^\circ$ ), spinal canal narrowing, segmental instability, or concurrent spinal conditions including neoplasms or infectious processes. Subjects presenting with ossified ligamentum flavum, previous lumbar spinal procedures, or cauda equina syndrome were similarly excluded. Additionally, individuals diagnosed with psychosomatic pain conditions or those declining surgical treatment were omitted from the investigation.

### Preoperative Assessment

#### Clinical and neurological examination

Thorough clinical and neurological evaluation serves as the foundation for preoperative evaluation in individuals presenting with lumbar disc herniation. The process commences with comprehensive history collection, concentrating on symptom initiation, temporal characteristics, and evolution, alongside precipitating and ameliorating elements. Special attention is devoted to identifying radicular symptoms, characteristically manifested as acute, lancinating discomfort extending in dermatomal patterns toward the lower extremity. Concurrent manifestations including sensory loss, dysesthesias, paresthesias, and motor impairment are meticulously recorded. Healthcare providers must additionally explore warning indicators, encompassing urogenital dysfunction, perineal sensory loss, or advancing neurological deterioration, which may suggest severe pathology such as cauda equina syndrome necessitating emergent management.

Physical assessment encompasses visual inspection, tactile examination, and functional evaluation of the lumbosacral region. Structural deviations including spinal curvature, lateral deviation, or modified lumbar curvature are documented. Ambulation assessment represents a crucial element, as individuals with radiculopathy may exhibit protective gait patterns or adaptive postural modifications to minimize nerve root irritation. Palpatory findings may demonstrate focal pain sensitivity, paravertebral muscular contracture, or movement limitations.

Neurological assessment targets determination of the anatomical level and extent of nerve root compromise. Muscular strength evaluation employs standardized classification systems, including the Medical Research Council (MRC) grading, emphasizing principal muscle groups associated with lumbosacral nerve roots (such as quadriceps for L3–L4, tibialis anterior for L4–L5, and gastrocnemius for S1). Sensory assessment examines dermatomal patterns through light touch and sharp sensation testing, facilitating nerve root compression localization. Reflex evaluation, incorporating patellar responses (L4) and Achilles reflexes (S1), offers supplementary data regarding neurological function.

Collectively, clinical and neurological assessment not only facilitates provisional diagnostic formulation but also serves a crucial function in correlating clinical observations with radiological findings. This evaluation

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is fundamental for identifying appropriate surgical candidates and establishing preoperative benchmarks for postoperative outcome assessment.

### **Straight leg raising test**

The Straight Leg Raising Test (SLRT), alternatively referred to as Lasègue's test, represents one of the most extensively employed and clinically significant provocative maneuvers for evaluating lumbar disc herniation accompanied by radiculopathy. This examination proves particularly beneficial in assessing nerve root inflammation, specifically affecting the L4, L5, and S1 nerve roots. The procedure requires the patient to assume a supine position while the clinician passively elevates the patient's extended leg through hip flexion with the knee maintained in extension. The degree of angulation at which pain onset occurs is meticulously documented. A positive SLRT manifests as the elicitation of radicular symptoms, characteristically extending below the knee, occurring within 30° to 70° of hip flexion. Symptom provocation at lesser angles frequently indicates more pronounced nerve root impingement or substantial disc protrusion.

The clinical utility of SLRT stems from its elevated sensitivity, documented to span 80% to 95%, establishing it as an superior screening instrument for lumbar disc herniation. Nevertheless, its specificity remains comparatively limited, since alternative pathologies including hamstring contracture or hip disorders may similarly generate discomfort during examination. To enhance diagnostic precision, supplementary techniques such as ankle dorsiflexion (Bragard's maneuver) or cervical flexion may be incorporated to further elongate the sciatic nerve and reproduce symptomatology. A modification termed the crossed straight leg raising test entails elevating the asymptomatic extremity to provoke pain in the affected limb. This variant demonstrates greater specificity for disc herniation and frequently suggests more severe or medially positioned pathology. The SLRT serves not merely as a diagnostic aid but also furnishes an objective assessment of pathological severity and facilitates monitoring of postoperative recovery. Diminished pain severity or increased leg elevation angle following surgery indicates successful decompression of the compromised nerve root.

### **Oswestry Disability Index**

The Oswestry Disability Index (ODI) represents a standardized, validated, and extensively utilized assessment tool developed to evaluate the extent of disability and functional limitations in individuals experiencing low back pain. This instrument is regarded as the benchmark for measuring patient-reported outcomes in spinal pathology and serves an integral function in both clinical applications and research endeavors. The ODI comprises ten domains, each examining a particular facet of daily functioning impacted by low back pain, encompassing pain severity, self-care activities, lifting tasks, ambulation, sitting posture, standing position, sleep quality, social interactions, travel activities, and occupational or domestic responsibilities. Each domain receives a score ranging from 0 to 5, where elevated scores denote increased disability levels. The overall score is expressed as a percentage, with classifications spanning from minimal impairment (0–20%) to severe incapacitation and bed-bound conditions (81–100%). Within the preoperative context, the ODI functions as a fundamental instrument for quantifying initial functional deficits and assessing the influence of lumbar disc herniation on an individual's life quality. This tool provides an objective measurement that supplements clinical and imaging observations, facilitating a more thorough evaluation of condition severity. Additionally, the ODI proves invaluable for tracking therapeutic outcomes. Modifications in ODI measurements across time periods demonstrate enhancement or decline in functional capacity, permitting healthcare providers to evaluate the efficacy of surgical procedures such as percutaneous endoscopic transforaminal discectomy. A substantial decrease in ODI scores following surgery indicates successful symptom amelioration and functional restoration. The implementation of ODI also enables cross-study comparisons and strengthens the consistency of research outcomes. Its straightforward nature, dependability, and responsiveness to clinical modifications render it an essential element of preoperative and postoperative assessment in patients presenting with lumbar disc herniation.

### **X-rays**

Conventional X-ray imaging continues to serve as a fundamental preliminary diagnostic tool when evaluating lumbar spinal pathology, particularly in cases of lumbar disc protrusion. While this modality

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cannot directly demonstrate soft tissue structures including intervertebral discs or neural elements, it offers essential data concerning osseous structure and spinal alignment. Routine imaging protocols typically include standard anteroposterior and lateral projections of the lumbosacral region. The anteroposterior projection enables evaluation of spinal alignment, vertebral body symmetry, and detection of scoliotic curves or rotational abnormalities. The lateral projection yields information about lumbar curvature, vertebral body dimensions, intervertebral space reduction, and evidence of osteophytic formation or degenerative modifications.

Functional radiographic studies, encompassing flexion and extension imaging, demonstrate particular value in evaluating spinal stability. These projections facilitate identification of pathological vertebral movement patterns, including spondylolisthesis or segmental instability, which may impact therapeutic approaches and surgical planning. Vertebral translation exceeding 3–5 mm between adjacent segments typically suggests instability. Radiographic examination may also demonstrate secondary alterations related to disc degeneration, including diminished disc height, endplate sclerosis, and facet joint degenerative changes. These observations provide circumstantial evidence of degenerative disc pathology and assist in correlating clinical presentations with anatomical abnormalities.

Although plain radiography demonstrates limited diagnostic sensitivity for disc herniation, it fulfills an essential function in ruling out alternative conditions including fractures, infectious processes, neoplastic lesions, or developmental abnormalities. Additionally, it establishes baseline documentation and is frequently employed alongside sophisticated imaging techniques such as MRI to achieve thorough diagnostic assessment.

### **Magnetic Resonance Imaging of Lumbosacral Spine**

Magnetic resonance imaging (MRI) represents the premier imaging technique for assessing lumbar disc herniation, owing to its capacity to delineate soft tissue structures, encompassing intervertebral discs, neural roots, spinal cord, and adjacent anatomical components. In contrast to radiographic or computed tomographic examinations, MRI eliminates exposure to ionizing radiation, establishing it as a secure and favored diagnostic approach. MRI facilitates multiplanar

visualization through axial, sagittal, and coronal perspectives, permitting comprehensive evaluation of the lumbar vertebral column. This modality enables accurate identification of disc herniation location, classification of herniation morphology (protrusion, extrusion, or sequestration), and assessment of its spatial relationship to neighboring neural elements. The extent of neural root impingement, central canal compromise, and foraminal constriction can be precisely determined. Beyond disc pathology identification, MRI demonstrates concurrent abnormalities including ligamentum flavum thickening, facet joint enlargement, and epidural scarring. The technique facilitates differentiation among diverse etiologies of lumbar pain, encompassing infectious processes, neoplastic conditions, and inflammatory disorders. The exceptional sensitivity and specificity of MRI render it essential for confirming lumbar disc herniation diagnosis and directing therapeutic interventions. This imaging modality proves particularly valuable for operative planning, providing crucial details regarding the anatomical level, pathological extent, and lesion characteristics. Such information ensures precise localization during minimally invasive techniques like PETD. Additionally, MRI observations can be integrated with clinical manifestations to establish the clinical relevance of identified abnormalities. For instance, foraminal encroachment and neural compression demonstrate stronger correlation with symptomatic radiculopathy compared to simple disc protrusion. In conclusion, MRI serves a fundamental function in preoperative lumbar disc herniation evaluation, delivering thorough anatomical and pathological data crucial for diagnostic confirmation, therapeutic strategy development, and outcome prediction.

### **Surgical technique**

The percutaneous endoscopic transforaminal discectomy procedure was conducted with the patient under general anesthesia in a prone position on a radiolucent surgical table. Appropriate cushioning was applied, and supports were positioned to permit free abdominal suspension, thus decreasing intra-abdominal pressure and limiting epidural venous engorgement. Fluoroscopic imaging confirmed the surgical site, and suitable cutaneous landmarks were established using preoperative radiological studies to identify the most

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favorable trajectory for the transforaminal technique. Following conventional sterile preparation and surgical draping, an 18-gauge spinal needle was inserted percutaneously at a lateral distance from the spine's midline, generally 8–12 cm based on individual anatomical characteristics and herniation location. The needle was directed at approximately 25°–30° angulation toward the designated disc level under constant fluoroscopic supervision. In the anteroposterior projection, precautions were taken to prevent premature crossing of the medial pedicle boundary, whereas in the lateral projection, the needle advanced toward the posterior vertebral margin or intervertebral space. Upon achieving proper positioning, the needle was secured at the annular or facet area. A guide wire was subsequently threaded through the needle before needle removal. Progressive dilators were advanced along the guide wire to gradually separate surrounding tissues and establish an operative corridor while minimizing muscular disruption. After sufficient tissue expansion, a working tube was introduced and positioned at the intended location. A rigid endoscope featuring an incorporated working channel was then advanced through the tube, enabling direct operative field visualization. Through continuous endoscopic observation, the annular defect was identified and herniated disc components were localized. Utilizing specialized endoscopic tools including grasping instruments, the protruding or displaced disc tissue was meticulously excised. The intervention included repeated fragment extraction until sufficient nerve root decompression was accomplished. Successful decompression was verified by observing unrestricted dural sac and nerve root mobility, demonstrating neural compression relief. Hemostatic control was maintained throughout using irrigation and coagulation methods when required. The endoscope and working tube were progressively removed, and the small cutaneous opening was secured with a single suture or sterile covering. The minimally invasive approach resulted in insignificant blood loss and limited soft tissue injury. In summary, PETD enables accurate, focused extraction of herniated disc material via a secure transforaminal pathway, maintaining spinal integrity and musculoligamentous architecture while achieving effective neural decompression.

### Postoperative management

The postoperative care protocol subsequent to percutaneous endoscopic transforaminal discectomy is fundamental for achieving excellent recovery outcomes, reducing adverse events, and facilitating prompt restoration of functional capabilities. Considering the procedure's minimally invasive characteristics, the post-surgical approach typically emphasizes prompt mobilization, adequate pain management, incision site maintenance, and systematic rehabilitation programs, all contributing to enhanced patient results and contentment.

Following the intervention, patients undergo observation in the recovery area until complete consciousness restoration and vital sign stabilization occur. Special focus is directed toward neurological evaluation, encompassing motor function, sensation assessment, and reflex testing, to detect potential early post-surgical complications including nerve root inflammation or damage. Pain evaluation utilizes validated scoring systems, with suitable analgesic therapy commenced accordingly. Non-steroidal anti-inflammatory medications serve as primary therapeutic agents, while brief opioid treatment may be provided for moderate to severe discomfort. Implementing multimodal pain management strategies assists in reducing opioid reliance and improving patient well-being.

A significant benefit of PETD involves enabling rapid patient mobilization. The majority of individuals are advised to assume sitting, standing, and walking positions within twenty-four hours post-surgery, frequently occurring on the operative day or subsequent morning. Prompt mobilization prevents complications including venous thromboembolism, muscular rigidity, and respiratory complications, while simultaneously enhancing circulation and tissue repair. Patients receive guidance to progressively advance their activity levels, avoiding extended immobilization, which research demonstrates impedes recovery and promotes physical deterioration.

Post-PETD incision management remains straightforward given the minimal incision dimensions. The operative site receives sterile dressing coverage, with patients counseled to maintain cleanliness and dryness. Suture removal, when applicable, typically occurs seven to ten days post-procedure. Wound infection probability remains low; nevertheless, patients

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receive education regarding concerning indicators such as erythema, edema, drainage, or pyrexia, with instructions to pursue medical evaluation should these manifestations develop. Perioperative antimicrobial prophylaxis may be provided, though prolonged antibiotic administration is typically unnecessary unless clinically warranted.

Physical therapy and rehabilitation constitute essential elements of post-surgical care. Patients begin gentle exercise regimens designed to preserve mobility and strengthen paravertebral and core musculature. Initial activities emphasize range of motion and low-intensity movements, advancing systematically to comprehensive strengthening and stabilization protocols. Priority is given to appropriate posture, workplace ergonomics, and movement patterns to prevent symptom recurrence. Professional physiotherapy guidance may be advised, especially for individuals experiencing extended preoperative functional limitations or inadequate muscular conditioning.

### Outcome measures

Clinical outcome assessment in this investigation relied on primary and secondary endpoints specifically designed to comprehensively evaluate functional enhancement, procedural effectiveness, and overall safety profile of percutaneous endoscopic transforaminal discectomy (PETD) for patients presenting with lumbar disc herniation. The selection of these endpoints aimed to deliver both patient-focused and procedure-specific perspectives, facilitating objective evaluation of surgical efficacy.

The principal endpoint employed was the Oswestry Disability Index (ODI), a broadly recognized and validated instrument for measuring functional impairment related to lower back pain. The ODI demonstrates particular utility in spinal research by documenting disease impact across multiple domains of daily functioning, encompassing pain severity, self-care activities, locomotion, and social engagement. Within this investigation, the ODI served to quantify preoperative disability levels and track functional restoration at sequential postoperative timepoints of 2 weeks, 6 weeks, and 3 months. The ODI scoring framework enables disability classification into minimal, moderate, severe, and crippled categories, thus offering clear interpretation of clinical progress. Substantial ODI score reduction post-surgery was

regarded as evidence of successful treatment, demonstrating both symptom amelioration and improved life quality. Utilization of such standardized assessment tools as the ODI promotes comparison with published literature and strengthens study result reproducibility.

Beyond the principal endpoint, multiple secondary measures were examined to provide comprehensive understanding of the surgical approach and its consequences. These encompassed operative duration, intraoperative hemorrhage, hospitalization length, and complication frequency. Each parameter contributes to evaluating PETD's efficiency, minimally invasive characteristics, and safety characteristics. Operative duration was documented from initial incision through wound closure completion. This metric reflects both procedural technical complexity and surgeon expertise with endoscopic methods. Reduced operative periods generally correlate with decreased anesthetic exposure and diminished perioperative hazards. For minimally invasive techniques like PETD, operative time serves as a significant indicator of procedural effectiveness and skill development. Surgical duration variations may arise from factors including herniation level and type, patient anatomical features, and intraoperative difficulties. Intraoperative hemorrhage assessment served as an indicator of surgical invasiveness and tissue damage. A primary benefit of PETD involves minimal paraspinous muscle and soft tissue disruption, substantially decreasing blood loss relative to traditional open approaches. Diminished intraoperative bleeding enhances surgical field visualization, reduces postoperative complication risk, and promotes accelerated recovery. While PETD blood loss remains typically minimal and often clinically insignificant, its documentation provides objective support for the technique's minimally invasive characteristics. Hospitalization duration represented another significant parameter examined in this research. Given the minimally invasive methodology and decreased postoperative discomfort associated with PETD, patients frequently receive discharge shortly after surgery, occasionally within 24-48 hours. Reduced hospital stays reflect rapid recuperation and early mobilization while carrying substantial implications for healthcare resource allocation and economic efficiency. Early discharge correlates with enhanced patient

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satisfaction and decreased nosocomial infection risk. Complication incidence received careful monitoring as an essential procedural safety indicator.

PETD may be associated with various adverse events including neural root damage, cerebrospinal fluid leakage, infectious processes, disc herniation recurrence, and continuing or remaining pain symptoms. This investigation documented and examined both perioperative and postprocedural adverse events. The minimal occurrence or absence of complications demonstrates the procedure's safety and dependability when conducted with proper case selection and surgical proficiency. Additionally, prompt recognition and treatment of adverse events are crucial for preventing chronic morbidity and achieving favorable results. Together, these assessment parameters establish a thorough framework for determining PETD effectiveness. Although the primary endpoint emphasizes patient-reported functional enhancement, the secondary endpoints provide important information regarding procedural characteristics and intervention safety. The combination of both measurement categories ensures comprehensive evaluation, enabling balanced clinical success interpretation. In summary, employing standardized and multifaceted assessment tools strengthens the study's validity and dependability. Through the integration of functional evaluation with objective procedural metrics, this investigation seeks to deliver a complete assessment of PETD as a minimally invasive surgical alternative for lumbar disc herniation.

### Statistical analysis

The information gathered throughout the investigation was systematically organized and examined utilizing the Statistical Package for the Social Sciences (SPSS) software, version 25.0. Descriptive and inferential statistical approaches were implemented to assess results and establish the significance of modifications observed post-intervention. Continuous variables, including age, operative duration, and Oswestry Disability Index (ODI) measurements, were represented as mean  $\pm$  standard deviation (SD) and median with interquartile range (IQR), based on data distribution characteristics. Categorical variables, encompassing gender composition, disc herniation level, and complication occurrence, were displayed as frequencies and percentages. To examine surgical intervention

efficacy, preoperative and postoperative ODI measurements were contrasted using suitable statistical analyses. The Wilcoxon signed-rank test was utilized for paired comparisons of non-parametric data, whereas the paired Student's t-test was implemented for parametric variables. These analyses facilitated evaluation of statistical significance regarding functional disability modifications over time. Additionally, repeated measures analysis of variance (ANOVA) was utilized to examine ODI score variations across multiple assessment periods, specifically preoperative, 2 weeks, 6 weeks, and 3 months postoperatively. This methodology permitted evaluation of functional recovery patterns over time within the identical patient cohort. Statistical significance was established at p-values below 0.05 for all examinations. Implementation of these statistical techniques ensured rigorous and dependable data interpretation, enabling objective evaluation of clinical outcomes related to percutaneous endoscopic transforaminal discectomy.

### RESULTS

#### Patient Disposition and Baseline Characteristics

A total of 7 patients with symptomatic lumbar disc herniation who met the inclusion criteria and underwent transforaminal endoscopic discectomy were included in this prospective interventional study. All 7 patients (100%) completed the minimum 3-month follow-up period with no loss to follow-up.

#### Demographic and Clinical Profile

**Table 1: Baseline Demographic and Clinical Characteristics of Study Population (N=7)**

Variable	Category	Frequency	Percentage (%)
<b>Gender</b>	Male	6	85.7
	Female	1	14.3
<b>Age Group</b>	0-20 years	1	14.3
	21-40 years	5	71.4
	41-60 years	1	14.3
<b>Radiculopathy Distribution</b>	Right	3	42.9
	Left	3	42.9
	Bilateral	1	14.3
<b>Disc Level</b>	L4-L5	3	42.9

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	L5-S1	4	57.1
<b>Duration of Symptoms</b>	<1 month	1	14.3
	1-6 months	2	28.6
	7-12 months	2	28.6
	1-2 years	1	14.3
	>2 years	1	14.3
<b>Neurological Deficit</b>	Present	0	0.0
	Absent	7	100.0
<b>Complications</b>	Present	0	0.0
	Absent	7	100.0

The mean age of patients was 34.0 years (median; IQR: 26.0-40.0 years). Male predominance was observed (85.7%). The most commonly involved disc level was L5-S1 (57.1%), followed by L4-L5 (42.9%). The median duration of symptoms was 1.0 month (IQR: 1.0-2.0 months), and the median Straight Leg Raise Test (SLRT) angle was 45.0 degrees (IQR: 30.0-50.0 degrees).

### Peri-operative Parameters

The median duration of surgery was 60.0 minutes (IQR: 50.0-70.0 minutes). No intraoperative or postoperative complications were recorded in any of the 7 patients. The median hospital stay was 2 days (range: 1-3 days). All patients were mobilized on postoperative day 1 following recovery from anesthesia.

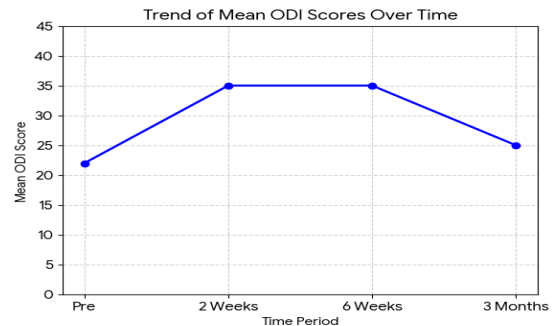
### Functional Outcomes (ODI Score)

#### Overall ODI Score Analysis

**Table 2: Comparison of Oswestry Disability Index (ODI) Scores at Pre-operative and Post-operative Time Points**

Time Point	Mean	Standard Deviation	Median	IQR (25%, 75%)	Minimum	Maximum
Pre-operative	36.14	6.694	38.0	(30.0, 40.0)	28	46
2 weeks	21.71	6.047	22.0	(20.0, 24.0)	14	32

post-op				24.0		
6 weeks post-op	22.71	6.701	24.0	(19.0, 28.0)	14	34
3 months post-op	23.86	8.092	22.0	(20.0, 30.0)	16	38



**Figure 1: Trend of Mean ODI Scores Over Time**

### Statistical Comparison of ODI Scores

**Table 3: Pairwise Comparison of ODI Scores at Different Time Points (Wilcoxon Signed-Rank Test)**

Comparison	Z-value	P-value	Significance
Pre-operative vs 2 weeks	-3.271	<0.001	Significant*
Pre-operative vs 6 weeks	-3.185	<0.001	Significant*
Pre-operative vs 3 months	-3.182	0.001	Significant*
2 weeks vs 6 weeks	-0.617	0.537	Not significant
2 weeks vs 3 months	-1.282	0.200	Not significant
6 weeks vs 3 months	-0.617	0.538	Not significant

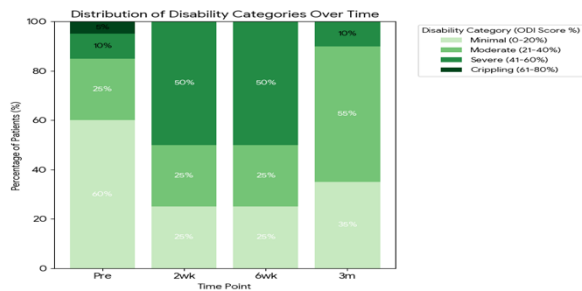
\*P-value <0.05 considered statistically significant

There was a statistically significant improvement in ODI scores from pre-operative to all post-operative time points (p<0.001 for 2 weeks and 6 weeks; p=0.001 for 3 months). However, there was no significant difference between successive post-operative follow-ups (p>0.05 for all inter-postoperative comparisons),

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indicating that maximum improvement was achieved by 2 weeks post-surgery and maintained through 3 months.

## Categorical Distribution of Disability



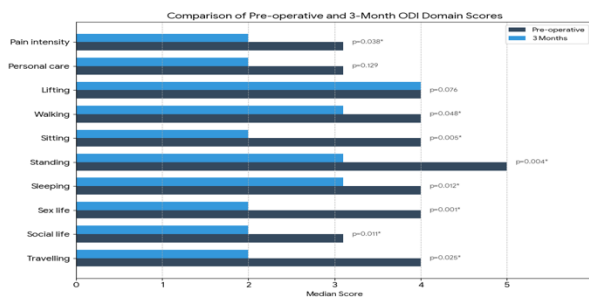
**Figure 2: Distribution of Disability Categories Over Time**

## Individual ODI Domain Analysis

**Table 4: Median Scores for Individual ODI Parameters at Each Time Point (Maximum score per domain = 5)**

ODI Parameter	Pre-operative	2 Weeks	6 Weeks	3 Months	P-value *
Pain intensity	3	2	2	2	0.038
Personal care	3	2	2	2	0.129
Lifting	4	1	4	4	0.076
Walking	4	2	3	3	0.048
Sitting	4	2	1	2	0.005
Standing	5	3	3	3	0.004
Sleeping	4	1	1	3	0.012
Sex life	4	3	3	2	0.001
Social life	3	2	2	2	0.011
Travelling	4	2	2	2	0.025

\*Friedman test for repeated measures; P-value <0.05 considered statistically significant



**Figure 3: Comparison of Pre-operative and 3-Month ODI Domain Scores**

## Discussion

This investigation assessed the clinical and functional results of percutaneous endoscopic transforaminal discectomy (PETD) in individuals with lumbar disc herniation and revealed substantial enhancement in postoperative functional capacity with minimal complications. These results contribute to the expanding evidence base that supports minimally invasive spinal procedures as a viable alternative to traditional open surgical methods. Lumbar disc herniation represents a frequent etiology of lower back pain and radicular symptoms, primarily impacting young and middle-aged populations. In this investigation, most participants were within the 21–40 years demographic, which corresponds with established epidemiological patterns indicating this pathology predominantly affects the economically active population. The greater proportion of male participants observed is also concordant with previously documented findings, potentially reflecting occupational and lifestyle elements that contribute to enhanced mechanical loading of the lumbar spine. The L5–S1 disc level was most commonly affected in this investigation, followed by L4–L5, which corresponds with the recognized biomechanical susceptibility of the caudal lumbar segments resulting from increased axial forces and motion. The lack of substantial preoperative neurological impairments in the study cohort indicates that PETD was primarily utilized in individuals experiencing radicular pain resistant to conservative management, rather than those presenting with severe neurological deterioration. A principal observation of this investigation was the substantial decrease in Oswestry Disability Index (ODI) scores after surgical treatment. The average ODI score demonstrated notable enhancement within two weeks post-surgery, with persistent improvements noted at 6 weeks and 3 months. This expedited functional restoration may be attributed to the minimally invasive characteristics of PETD, which maintains paraspinal muscle integrity and minimizes tissue damage. The early enhancement documented in this investigation is analogous to results from prior studies, which have described accelerated recovery and diminished postoperative discomfort with endoscopic methods compared to conventional open discectomy. The procedural benefits of PETD, encompassing minimal hemorrhage, abbreviated operative duration, and shortened hospitalization, were

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also apparent in this investigation. The median surgical time was approximately 60 minutes, demonstrating procedural effectiveness. The negligible intraoperative blood loss and lack of complications further emphasize the safety characteristics of this approach. These observations align with current literature, which underscores the advantages of endoscopic methods in reducing surgical morbidity and promoting early ambulation. An additional significant finding was that most functional enhancement occurred during the immediate postoperative phase, particularly within the initial two weeks, followed by stabilization of results. This indicates that sufficient neural decompression accomplished during surgery produces rapid alleviation of nerve root inflammation, resulting in early symptomatic and functional improvement. The absence of meaningful differences between subsequent follow-up periods further suggests that PETD benefits persist over time. Despite these promising outcomes, specific study limitations must be recognized. The limited sample size and brief follow-up duration constrain the applicability of these findings. Furthermore, the lack of a control group receiving conventional surgical approaches prevents direct outcome comparisons. The learning curve inherent to endoscopic spinal surgery represents another element that may affect operative duration and complication frequencies, especially during initial implementation phases. Nonetheless, this investigation's findings endorse the utility of PETD as a secure and efficacious minimally invasive approach for lumbar disc herniation management. Through proper patient selection and surgical proficiency, PETD provides advantages of decreased tissue trauma, accelerated recovery, and positive functional results. Subsequent research incorporating expanded cohorts, extended observation timeframes, and comparative evaluations against alternative surgical approaches is necessary to consolidate evidence regarding its effectiveness and sustained advantages. To summarize, PETD constitutes a notable progression in spinal surgical practice, corresponding with contemporary movements toward minimally invasive procedures that emphasize patient well-being, accelerated rehabilitation, and enhanced life quality.

### Conclusion

This investigation establishes that percutaneous endoscopic transforaminal discectomy (PETD)

constitutes a secure, efficacious, and minimally invasive operative approach for treating lumbar disc herniation. The intervention yielded marked enhancement in functional parameters, as demonstrated by the considerable decrease in Oswestry Disability Index (ODI) values from preoperative baseline through sequential postoperative assessments. The immediate and persistent amelioration documented in this investigation emphasizes PETD's capacity to deliver prompt symptomatic resolution and improve overall patient well-being. The minimally invasive characteristics of PETD provide numerous distinctive benefits compared to traditional open surgical methods. These encompass limited soft tissue trauma, diminished intraoperative hemorrhage, abbreviated surgical duration, reduced postoperative discomfort, and expedited mobilization. The technique additionally enables shortened hospitalization periods and accelerated resumption of normal daily functioning, establishing it as both patient-centered and economically advantageous. Significantly, the complete absence of intraoperative and postoperative adverse events in this investigation further emphasizes the security and dependability of this approach when executed with proper surgical proficiency. These results align with the contemporary movement in spinal surgery toward minimally invasive methodologies designed to accomplish superior clinical outcomes while reducing surgical complications. PETD maintains normal anatomical integrity while providing direct pathological disc visualization, ensuring adequate neural decompression with minimal secondary tissue damage. Nevertheless, notwithstanding these promising outcomes, specific constraints require recognition. The comparatively limited cohort size and brief observation period constrain the applicability of these results and restrict evaluation of extended outcomes, including recurrence patterns. Furthermore, the absence of a control group receiving traditional surgical interventions prevents direct comparison of PETD's relative effectiveness. In summary, PETD constitutes a significant advancement in lumbar disc herniation surgical treatment. Through appropriate candidate selection, adherence to operative protocols, and sufficient training, it may function as a viable substitute for conventional approaches. Additional comprehensive, randomized controlled investigations

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with prolonged follow-up periods are necessary to confirm these observations and establish PETD as standard practice in lumbar disc herniation management.

### Future direction

Subsequent investigations regarding percutaneous endoscopic transforaminal discectomy (PETD) ought to prioritize the implementation of extensive, multi-institutional randomized controlled studies to establish its effectiveness and safety profile relative to traditional surgical approaches including microdiscectomy and open discectomy procedures. Extended longitudinal investigations are crucial for assessing the persistence of therapeutic benefits, rates of symptom recurrence, and the occurrence of adjacent level degenerative changes. The establishment of standardized operative protocols and assessment metrics, incorporating consistent documentation of functional evaluations such as the Oswestry Disability Index, would facilitate enhanced cross-study comparisons. Continued developments in endoscopic equipment, radiological guidance systems, and navigational technologies may augment operative precision while diminishing the technical proficiency requirements for PETD procedures. The incorporation of augmented reality platforms and robot-assisted methodologies presents promising opportunities for improving intraoperative precision and clinical outcomes. Moreover, investigations examining patient selection parameters, encompassing prognostic indicators for favorable results, could enhance clinical decision-making processes. There exists an additional requirement to examine economic efficiency and life quality measures across varied healthcare environments. Ultimately, the combination of PETD with supplementary treatments including biological agents or regenerative methodologies may establish novel pathways for enhancing intervertebral disc integrity and preventing future recurrence.

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