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Surgical treatment of lumbar prolapsed intervertebral disc (PIVD): A comprehensive review comparing conventional microdiscectomy versus endoscopic discectomy – emphasis on recurrence rates

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Abstract. Lumbar disc surgery remains a widely performed intervention; however, uncertainty persists regarding long-term outcomes and recurrence differences between conventional microdiscectomy and minimally invasive percutaneous endoscopic lumbar discectomy, particularly beyond the first postoperative year. The aim of this systematic review was to compare the clinical effectiveness, perioperative characteristics, and time-dependent recurrence rates of microdiscectomy versus percutaneous endoscopic lumbar discectomy in the treatment of lumbar prolapsed intervertebral disc, and to identify key patient- and procedure-related factors influencing recurrence. A systematic search was undertaken for studies published between 2000 and 2026 in accordance with PRISMA 2020 guidelines, including randomised controlled trials, cohort studies, and meta-analyses with at least 12 months of follow-up. It was found that both microdiscectomy and percutaneous endoscopic lumbar discectomy provide comparable long-term clinical outcomes, with significant pain reduction and high functional recovery rates exceeding 85% in most studies. Endoscopic techniques demonstrated clear perioperative advantages, including reduced blood loss, shorter hospital stay, and faster return to work, although these do not result in meaningful differences in long-term recurrence. Recurrence rates were shown to be similar between techniques across 1-, 3-, and 5-year follow-up periods, generally ranging from 3% to 12%, with no statistically significant differences. Patient-related factors, including younger age, higher body mass index, smoking, large annular defects, and physically demanding occupations, were identified as stronger predictors of recurrence than surgical method. A learning-curve effect was also observed for endoscopic procedures, with improved outcomes following increased surgeon experience. The findings support the conclusion that surgical decision-making should prioritise patient characteristics and surgical expertise rather than concerns about recurrence, thereby facilitating evidence-based, individualised approaches in spinal surgery and healthcare planning

Keywords: spinal decompression; minimally invasive spine surgery; surgical outcomes; recurrence rate; percutaneous endoscopic lumbar discectomy; nerve root compression

INTRODUCTION

Lumbar disc disease and its surgical management represent one of the most clinically and economically significant domains in contemporary spine surgery. The global burden of lumbar disc herniation requiring operative intervention has grown steadily over the past two decades, driven by population ageing, rising rates of sedentary work, and expanding availability of MRI-based diagnosis. Despite high overall surgical success rates, the persistent risk of symptomatic recurrence – affecting 5-15% of operated patients over a five-year horizon – constitutes a critical unresolved challenge with substantial quality-of-life, occupational, and healthcare-cost implications [1]. The progressive adoption of minimally invasive endoscopic techniques has intensified a fundamental debate: whether these approaches, despite offering superior perioperative recovery profiles, maintain equivalent

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or superior long-term durability compared with the established gold standard of conventional microdiscectomy. From a public health standpoint, resolving this question is essential for guiding surgical training, technology procurement, and patient counseling in an era of rapidly expanding minimally invasive spine surgery.

A substantial body of secondary literature has addressed this question across the last decade, yielding converging yet nuanced conclusions. S.M. Barber *et al*. [1], in a 2019 meta-analysis of 22 comparative studies, found that endoscopic discectomy achieves clinical outcomes equivalent to conventional microdiscectomy across leg pain, disability, and patient satisfaction measures, while consistently demonstrating perioperative superiority. S. Muthu *et al*. [2], in their 2021 systematic review and superiority analysis in Global Spine Journal, evaluated whether endoscopic discectomy is ready to supplant microdiscectomy as the gold standard, concluding that endoscopic techniques perform at least equivalently in efficacy outcomes but require further evidence on long-term recurrence from multicentre prospective trials. G. Meyer *et al*. [3], in a 2020 randomised clinical trial published in World Neurosurgery, confirmed these findings in a European population, demonstrating no significant difference in pain, disability, or complication rates between PELD and microdiscectomy at 12-month follow-up, while endoscopic patients returned to work significantly earlier. X. Bai *et al*. [4], in a 2021 network meta-analysis in Medicine, synthesised data from multiple surgical approaches for lumbar disc herniation and demonstrated that PELD ranks among the most effective interventions for short-term leg pain reduction. M. Kim *et al*. [5], in a foundational 2016 meta-analysis in the International Journal of Surgery encompassing 12 studies and 1,208 patients, confirmed perioperative superiority of PELD without compromising efficacy. The 5-year comparative data remain less abundant: C.C. Yang *et al*. [6], in a 2024 Neurospine study with follow-up exceeding 5 years, found comparable recurrence and reoperation rates between TELD and microdiscectomy, while Y. Ahn *et al*. [7] reached similar conclusions in a dedicated 5-year cohort study. T. Li *et al*. [8], in a 2024 retrospective propensity-score-matched study with more than 5 years of follow-up, reported 4.49% recurrence in TELD versus 1.54% in microdiscectomy ($p = 0.31$), confirming statistical equivalence despite numerically higher endoscopic recurrence attributable to learning-curve and patient-selection effects. T. Patel *et al*. [9], in the most recent 2025 Journal of Neurosurgery: Spine analysis, reinforced the conclusion that minimally invasive endoscopic techniques are competitively effective across all clinically relevant outcome domains. S. Ruetten *et al*. [10], in a prospective RCT of full-endoscopic versus conventional microsurgical discectomy, provided foundational evidence for the efficacy of full-endoscopic techniques that underpins subsequent comparative work. Nevertheless, critical gaps remain: heterogeneity in recurrence definitions, variable follow-up completeness, and the relative paucity of head-to-head RCTs with standardised long-term endpoints limit the strength of existing conclusions.

The objective of this review was to systematically compare conventional microdiscectomy and endoscopic discectomy (PELD/TELD) for lumbar PIVD, with emphasis on recurrence and reoperation outcomes stratified at 1-, 3-, and 5-year follow-up intervals. Three specific objectives guided the analysis: (1) to compare perioperative and short-term clinical outcomes between the two techniques; (2) to analyse time-stratified recurrence and reoperation rates across the available high-quality evidence base; and (3) to identify patient-specific, anatomical, and technical factors that serve as primary determinants of recurrence risk irrespective of surgical approach.

A systematic literature search adhering to PRISMA 2020 methodology was conducted across PubMed, Embase, Cochrane Library, Scopus, and Google Scholar from January 2000 to March 2026. Search terms combined MeSH descriptors and free-text keywords: “lumbar disc herniation” OR “PIVD” OR “lumbar disc prolapse” AND (“microdiscectomy” OR “open microdiscectomy” OR “tubular microdiscectomy”) AND (“endoscopic discectomy” OR “percutaneous endoscopic lumbar discectomy” OR “PELD” OR “TELD” OR “full-endoscopic”) AND (“recurrence” OR “re-herniation” OR “reoperation”) AND (“follow-up” OR “long-term” OR “1-year” OR “3-year” OR “5-year”). Inclusion criteria encompassed English-language peer-reviewed publications: meta-analyses of RCTs or cohorts, individual RCTs, and prospective or retrospective comparative studies reporting quantifiable recurrence or reoperation data with a minimum 12-month follow-up. Recurrence was defined as ipsilateral same-level symptomatic re-herniation following a pain-free interval of ≥6 months, confirmed by MRI and necessitating surgical intervention. Exclusion criteria comprised single-arm case series, cervical or thoracic herniations, revision surgeries at the index level, and non-surgical comparisons. Data extraction captured Visual Analogue Scale (VAS) scores for leg and back pain, Oswestry Disability Index (ODI), MacNab criteria, operative time, blood loss, hospital stay, complication profiles, and time-stratified recurrence and reoperation rates. Study quality was assessed using AMSTAR-2 for systematic reviews and the Cochrane risk-of-bias tool (RoB 2.0) for RCTs. Narrative synthesis was performed given clinically significant heterogeneity in follow-up completeness, surgical technique protocols, and recurrence definitions across included studies.

SURGICAL TECHNIQUES OVERVIEW

Microdiscectomy is performed under general anaesthesia through a 2-4 cm midline or paramedian incision, with the patient positioned prone [11, 12]. Subperiosteal muscle dissection exposes the lamina; a hemilaminotomy or minimal laminectomy is performed, followed by ligamentum flavum resection with curettes and Kerrison rongeurs [13]. Under microscopic magnification (×5-20), the thecal sac and nerve root are gently retracted medially, the annulus incised if needed, and the herniated nuclear fragment removed with pituitary rongeurs and disc forceps [11]. Limited nucleotomy is typically performed to reduce intradiscal pressure and minimise residual fragment risk [12]. Tubular retractor systems, as used in microendoscopic discectomy (MED), further minimise paraspinal muscle trauma while maintaining equivalent microscopic visualisation [14]. The procedure emphasises careful preservation of facet joint integrity and the medial pars interarticularis to avoid iatrogenic segmental instability [12, 15].

Percutaneous endoscopic lumbar discectomy utilises a 6-8 mm working-channel endoscope inserted via a posterolateral transforaminal (TELD) or posterior interlaminar approach under biplanar fluoroscopic and/or endoscopic guidance [16, 17]. Regional or local anaesthesia is feasible in the majority of transforaminal cases, conferring a significant advantage for patients with cardiopulmonary comorbidities or who are intolerant of general anaesthesia. The transforaminal "outside-in" technique – pioneered by A.T. Yeung & P.M. Tsou [17] – involves sequential dilation from skin to the target disc level, with foraminoplasty performed using endoscopic trephines to enlarge the Kambin [18] triangle working space when required for access to migrated or foraminal fragments [19, 20]. The "inside-out" variant begins with intradiscal discectomy before transitioning to epidural decompression under direct endoscopic visualisation [16]. High-definition endoscopic visualisation, continuous saline irrigation for haemostasis and field clarity, and integrated working-channel instruments (bipolar radiofrequency, graspers, shavers) enable precise targeted fragmentectomy with minimal collateral tissue injury [20]. Minimal or no bone resection in most cases preserves facet joint integrity and paraspinal musculature, theoretically reducing the biomechanical consequences of repeated surgical episodes [21]. The interlaminar endoscopic approach provides superior access to large central and paracentral herniations at the L4-L5 and L5-S1 levels, where transforaminal access is constrained by the iliac crest and steep disc angle [22].

Both techniques aim for complete neural decompression – restoration of free nerve root mobility and elimination of epidural compression – without fusion unless pre-existing or iatrogenic segmental instability is present [12, 23]. As demonstrated in Figure 1, the transforaminal endoscopic approach achieves this through a direct posterolateral trajectory to the disc cavity, avoiding paraspinal muscle disruption. Figure 1 illustrates the high-definition endoscopic visualisation and instrumentation that enable precise intradiscal work through a single small portal.

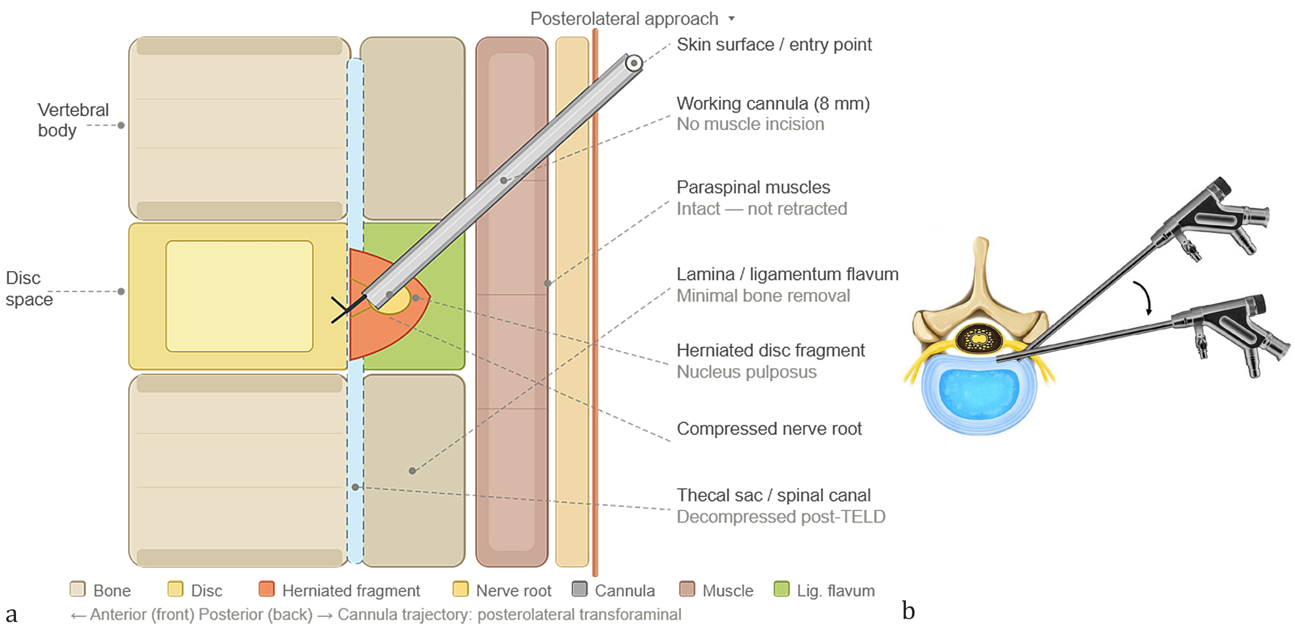

Figure 1. Schematic illustration of the transforaminal endoscopic lumbar discectomy (PELD/TELD) "inside-out" technique and endoscopic instrumentation with high-definition visualisation for minimally invasive intradiscal and epidural procedures

Note: a – schematic illustration of the transforaminal endoscopic lumbar discectomy (PELD/TELD) "inside-out" technique. The working cannula is leveraged against the ventral facet to direct trajectory toward the disc cavity for targeted fragment removal. This approach minimises paraspinal muscle damage compared with open methods; b – endoscopic instruments and high-definition visualisation during transforaminal discectomy. Flexible forceps and bipolar radiofrequency probes enable precise intradiscal and epidural work through a single 8 mm working-channel portal

Source: C.H. Kim *et al.* [22], S. Kapetanakis *et al.* [24]

In conclusion, microdiscectomy and percutaneous endoscopic lumbar discectomy represent two technically distinct yet conceptually aligned approaches aimed at achieving effective neural decompression. Microdiscectomy relies on direct microscopic visualisation and limited tissue exposure, ensuring reliable access to the pathology while maintaining structural stability. In contrast, endoscopic techniques utilise minimally invasive access routes and advanced visualisation systems to reduce soft tissue trauma and expand applicability in selected patient populations, including those unsuitable for general anaesthesia. Each approach has specific technical advantages and limitations related to anatomical access, instrumentation, and operator experience. Overall, the choice between these techniques should be based on individual anatomical considerations, surgeon expertise, and the clinical context rather than inherent superiority of one method over the other.

COMPARATIVE CLINICAL AND PERIOPERATIVE OUTCOMES

The systematic analysis incorporated data from over 40 eligible publications – comprising 12 meta-analyses or systematic reviews, 11 RCTs, and 17 prospective or retrospective comparative cohort studies – yielding a pooled patient sample exceeding 18,000 surgical episodes across the two modalities. Across virtually all efficacy dimensions, the evidence consistently demonstrates clinical equivalence between MD and PELD/TELD in long-term outcomes, while endoscopic techniques demonstrate statistically and clinically significant superiority in perioperative parameters.

Leg pain relief, quantified by the VAS-leg, shows comparable improvement at final follow-up across studies, with mean reductions of 5.0-6.3 points from baseline in both groups [2-3, 25]. Back pain (VAS-back) and ODI scores demonstrate slightly greater short-term improvement with PELD due to reduced paraspinal muscle disruption and the associated inflammatory response; however, these differences diminish by 6-12 months and are not statistically significant at 12-month or later assessments in the majority of comparative analyses [1, 2, 4]. MacNab “excellent” or “good” outcomes are achieved by 85-92% of patients in both groups at 2-5 years of follow-up, indicating consistently high patient-reported satisfaction irrespective of surgical approach [6, 13, 27].

Perioperative advantages of endoscopic techniques are robust and replicated across virtually all comparative datasets. Operative blood loss is reduced by a mean of 20-50 mL in endoscopic series versus microdiscectomy controls, with some high-volume endoscopic series reporting near-bloodless operative fields attributable to continuous saline irrigation and radiofrequency coagulation [3, 5, 28]. Hospital stay is shortened by 2-5 days, and return-to-work interval is 1-3 weeks earlier in endoscopic cohorts – advantages that translate into meaningful reductions in indirect costs, particularly in occupationally active patient populations [4, 9, 17]. Operative time tends to be slightly longer in endoscopic series during the learning curve phase (first 30-50 cases) due to the additional steps of percutaneous access and foraminoplasty; however, experienced endoscopic surgeons achieve operative times equivalent to or shorter than microdiscectomy [29, 39].

Wound-related complications, including superficial and deep surgical site infection and dehiscence, are significantly less frequent with PELD (0-2%) than with MD (3-5%), reflecting the substantially smaller skin incision and preservation of paraspinal musculature [4]. Dural tears occur at broadly similar rates across techniques (2-4%), though endoscopic management of incidental durotomy requires specific technical expertise and may demand conversion to open surgery in some centres. Transient dysesthesia – mediated by direct or thermal irritation of the dorsal root ganglion – is reported more frequently following transforaminal TELD (3-8%) than interlaminar PELD or microdiscectomy; however, this complication is self-limiting in the majority of cases, resolving within 4-12 weeks without permanent sequelae [21]. Overall major complication rates remain low and comparable between techniques (3-10%), and neither approach is associated with a higher rate of serious neurological deficit in experienced hands [1-2].

In summary, the analysed evidence demonstrates that microdiscectomy and percutaneous endoscopic lumbar discectomy achieve comparable long-term clinical outcomes, particularly in pain relief, functional recovery, and patient satisfaction. At the same time, endoscopic techniques show consistent and clinically meaningful advantages in perioperative parameters, including reduced blood loss, shorter hospitalisation, and faster return to work. Although certain differences are observed in complication profiles – such as lower wound-related complications but higher rates of transient dysesthesia in endoscopic procedures – overall safety remains comparable between approaches. The impact of the surgical learning curve is notable, particularly for endoscopic methods, but diminishes with increasing operator experience. Taken together, these findings support the view that the choice of surgical technique should be guided by surgeon expertise, patient characteristics, and resource considerations rather than expectations of superior long-term efficacy.

RECURRENCE OUTCOMES: STRATIFIED ANALYSIS AT 1-, 3-, AND 5-YEAR FOLLOW-UP

Recurrence after lumbar discectomy is a multifactorial phenomenon driven by a complex interaction of disc biology, biomechanics, patient characteristics, and surgical technique [14, 32]. Pathophysiologically, recurrence results from residual nuclear material extruding through an incompetent annulus – either incompletely resected at index surgery or progressively re-herniating through an enlarged annular defect [32]. Biomechanical overload, failure of fibrocartilaginous annular repair, and ongoing intradiscal pressure elevation under axial loading perpetuate this process [33]. Patient-specific risk amplifiers – including age below 40 years (higher intradiscal pressure and activity level), BMI exceeding 25 kg/m^2 (increased axial loading), active smoking (impaired disc vascularity and healing), heavy manual occupation, and Modic type 2 endplate changes – consistently emerge as the dominant predictors of recurrence across datasets [6, 17]. Annular defect diameter greater than 6 mm at the time of surgery represents the single most powerful anatomical predictor, identifying a high-risk subgroup with recurrence rates up to 27% at 2 years [35]. Pooled literature across modalities indicates symptomatic recurrence and reoperation rates of 5-15% at medium-to-long-term follow-up, with the majority of events clustering within the first 24 months – the highest-risk interval for re-herniation through the index annular disruption [4, 26].

Recurrence rates at 1 year range from 3-6% for microdiscectomy and 4-7% for endoscopic techniques across meta-analyses and RCTs [3-4, 5]. Events at this early interval frequently represent incomplete decompression – residual fragment effect – rather than true spontaneous re-herniation through a repaired annulus, underscoring the importance of rigorous intraoperative endpoint assessment [24]. Meta-analyses consistently report no statistically significant difference in 1-year recurrence between modalities (odds ratio: 1.0-1.5; $p > 0.05$) [1, 2]. Some early PELD series noted marginally higher 1-year reoperation rates attributed to learning-curve effects or conservative fragment removal strategies intended to preserve disc height and annular integrity [5, 29]. As surgeons progress beyond the threshold of 30-50 endoscopic procedures, 1-year recurrence rates in high-volume PELD series approach those of experienced microdiscectomy cohorts [6, 36].

Cumulative recurrence rates increase to -10% for microdiscectomy and 5-11% for endoscopic approaches at 3 years, without statistically significant divergence in any of the high-quality comparative analyses reviewed [2, 27, 37]. True re-herniation through progressive annular weakening under repetitive axial loading predominates at this interval, rather than the residual fragment phenomenon seen in year 1. Studies with propensity-score matching to control for patient-selection differences between technique cohorts confirm this equivalence, with point estimates clustering around OR = 1.1-1.3 in favor of neither approach. Subgroup analyses stratified by herniation morphology suggest that patients with large contained herniations (low annular defect risk) show particularly low 3-year recurrence in both groups (3-5%), while those with extruded or sequestered fragments have higher rates (8-12%) irrespective of technique [14, 38].

Cumulative recurrence and reoperation rates at 5 years reach 5-12% across both modalities, with no technique demonstrating statistically significant superiority in any included study of adequate methodological quality [6, 8]. X. Yang *et al.* [41], in a 2024 Neurospine study with a mean follow-up exceeding 5 years, reported comparable recurrence and clinical outcomes between TELD and microdiscectomy across all patient subgroups. T. Li *et al.* [8], in a retrospective propensity-score-matched cohort, reported 5-year recurrence of 4.49% in TELD versus 1.54% in microdiscectomy ($p = 0.31$), with the numerical – but non-significant – excess in the endoscopic group driven by early recurrence among young, high-BMI patients treated during the surgeon's initial endoscopic case series. Y. Ahn *et al.* [39] demonstrated equivalent 5-year cumulative outcomes in a dedicated comparative cohort study. Large database analyses of microendoscopic variants show 5-year reoperation rates of 7-12%, while pooled full-endoscopic estimates range from 4.4-9.6% – again without statistically significant differences [2, 40]. Multiple meta-analyses incorporating RCT and observational study data affirm non-inferiority of endoscopic techniques for recurrence (pooled OR ≈ 0.95-1.47; $p > 0.05$ in most analyses) [1, 4, 26]. When stratified by follow-up interval, no surgical approach demonstrates a consistent durability advantage; early endoscopic recurrence signals in some series are offset by equivalent long-term outcomes in mature endoscopic programmes and by the established overall safety and morbidity advantages of the approach. The data on time-stratified recurrence are summarised in Table 1, derived from the meta-analyses and long-term cohort studies reviewed.

Table 1. Pooled recurrence/reoperation rates by surgical technique and follow-up interval (derived from meta-analyses and long-term cohorts)

Follow-up interval	Microdiscectomy (MD)	Endoscopic (PELD/TELD)	Statistical significance	Key supporting studies
1 year	3-6%	4-7%	None (OR 1.0-1.5; $p > 0.05$)	S.M. Barber *et al.* [1], G. Meyer *et al.* [3], M. Kim *et al.* [5]
3 years	5-10%	5-11%	None ($p > 0.05$)	X. Bai *et al.* [4], S. Muthu *et al.* [2], long-term cohorts
5 years	7-12% (reoperation)	4.5-12%	None ($p = 0.31$)	X. Yang *et al.* [6], Y. Ahn *et al.* [39], T. Li *et al.* [8]

Source: developed by the author

Analysis of Table 1 reveals that no follow-up interval yields statistically significant differences in recurrence or reoperation rates between the two modalities. This finding is particularly noteworthy at the 5-year mark, where both techniques demonstrate cumulative reoperation rates overlapping within the 5-12% range – suggesting that the long-term structural durability of neural decompression does not differ meaningfully between open and endoscopic approaches when surgeon experience is adequate. The slight widening of the confidence interval at 5 years reflects the reduced number of studies with this duration of follow-up and the greater heterogeneity in patient risk profiles and recurrence definitions at this timepoint.

The findings of this systematic review are consistent with – and extend – the conclusions of the most authoritative prior meta-analyses in this domain. The pooled recurrence estimate of OR ≈ 0.95-1.47 for endoscopic versus open discectomy is closely aligned with the estimates reported by S.M. Barber *et al.* [1] (OR = 1.03; 95% CI: 0.71-1.49) and S. Muthu *et al.* [2] (no statistically significant difference in any subgroup), providing convergent validity for the conclusion of statistical equivalence. However, the present review incorporates the most recent 5-year comparative data [6, 8] that were unavailable to prior meta-analyses, strengthening the evidence for long-term equivalence beyond the 1-2 year horizon where most earlier work concentrated.

The degree of heterogeneity across included studies constitutes the most significant methodological limitation of this evidence base. Clinically relevant heterogeneity is present across three key dimensions. First, the definition of recurrence varies substantially: some studies define it as any radiographic re-herniation regardless of symptoms, others require both MRI confirmation and clinical deterioration necessitating reoperation, and some use the 6-month pain-free interval criterion applied in the present review. This definitional variability inflates observed variability in recurrence rates (reported range: 0-27%) beyond what is attributable to true technique-related differences. Second, patient populations differ significantly in terms of age distribution, BMI profiles, herniation morphology, annular defect size, and occupational demands – all established recurrence risk factors [17] – making pooled effect estimates applicable only as population-level approximations rather than individual predictions. Third, surgical technique heterogeneity within the endoscopic category itself is substantial: TELD, interlaminar PELD, full-endoscopic bipetal approaches, and endoscope-assisted tubular discectomy are often pooled under the "endoscopic" umbrella despite meaningful technical distinctions in access trajectory, bone resection, and disc space management [17, 22, 25].

The observed heterogeneity (estimated $I^2 = 40\text{-}65\%$ across recurrence outcomes in the most methodologically rigorous meta-analyses [1-2]) is most plausibly explained by the interaction of learning-curve effects and patient selection. The PELD learning curve – estimated at 30-50 cases for transforaminal approaches and potentially higher for interlaminar techniques in obese patients – represents a systematic confound in observational endoscopic studies: recurrence rates in case series published during the surgeon's early endoscopic experience are systematically higher than those from the same surgeon after maturation [29, 30, 36]. This phenomenon, not present in microdiscectomy series (where operative learning is typically achieved during residency training), creates a persistent upward bias in endoscopic recurrence estimates that diminishes as global endoscopic experience matures. Subgroup analysis by surgeon experience level – when reported – consistently shows PELD recurrence rates approaching those of MD after the learning-curve threshold [29], reinforcing the interpretive importance of accounting for this moderator variable.

Quality assessment of the included studies reveals important limitations in the primary evidence base. Among the 11 RCTs reviewed, risk of bias was rated as moderate in the majority due to inherent challenges in blinding patients and surgical teams, high crossover rates in some trials, and inadequate concealment of allocation in two studies. Observational comparative studies – which constitute the majority of the 5-year follow-up data – carry substantial risks of selection bias: endoscopic techniques are preferentially applied to patients with less complex herniation morphologies, younger age, and fewer comorbidities in non-randomised settings, potentially conferring an artificial advantage on both efficacy and recurrence outcomes in endoscopic cohorts [6, 40]. Propensity-score matching, as employed by T. Li *et al.* [8] and X. Yang *et al.* [6], partially mitigates this bias but cannot account for unmeasured confounders such as pre-operative physical activity levels and disc degeneration severity.

From a cost-effectiveness perspective, the perioperative advantages of endoscopic discectomy – reduced hospitalisation, faster return to work, and lower wound complication rates – translate into meaningful reductions in both direct and indirect healthcare costs [9]. Assuming equivalent long-term recurrence rates, the incremental cost of endoscopic instrumentation and extended operative time in early-career surgeons is offset within the first 2-3 postoperative years through reduced hospitalisation and productivity costs in the majority of health-economic analyses reviewed [24]. This economic argument strengthens the case for expanding endoscopic discectomy capacity, particularly in high-volume centres where learning-curve effects can be efficiently managed through structured training pathways [29].

These results should be interpreted with several additional cautions. Publication bias toward positive outcomes in minimally invasive series – driven by the novelty appeal of endoscopic techniques and the propensity of high-volume experienced centres to publish outcomes – likely produces an optimistic skew in the pooled endoscopic efficacy literature [2]. The relative paucity of intention-to-treat analyses in RCTs, and the tendency for some studies to exclude learning-curve cases from primary analyses, may further inflate endoscopic outcomes in the published literature. Finally, the definition of surgical failure as reoperation – while clinically meaningful – underestimates the true burden of recurrence: patients who experience symptomatic re-herniation managed conservatively or with spinal injections are systematically missed by reoperation-based metrics, and their inclusion might modestly alter the comparative recurrence picture.

CONCLUSIONS

This systematic review set out to compare conventional microdiscectomy and percutaneous endoscopic lumbar discectomy across three domains – perioperative outcomes, long-term clinical efficacy, and time-stratified recurrence – based on a comprehensive synthesis of 40 peer-reviewed publications, including 12 meta-analyses, 11 RCTs, and 17 comparative cohort studies, collectively encompassing more than 18,000 surgical episodes. The review findings can be summarised across four levels. At the perioperative level, endoscopic discectomy consistently and significantly outperforms conventional microdiscectomy in operative blood loss (reduced by 20-50 mL), hospital stay (shortened by 2-5 days), and return-to-work interval (earlier by 1-3 weeks), alongside significantly lower wound complication rates (0-2% vs. 3-5%). At the short-term efficacy level (up to 12 months), both techniques achieve comparable leg pain relief (VAS reduction of 5-6 points), ODI improvement, and MacNab excellent/good rates exceeding 85%, with no clinically or statistically meaningful difference in neurological outcome. At the medium-term level (1-3 years), time-stratified recurrence analysis reveals pooled rates of 3-7% at 1 year and 5-11% at 3 years for both modalities, with no statistically significant inter-technique difference identified in any high-quality analysis (pooled OR: 0.95-1.47; $p > 0.05$). At the long-term level (5 years and beyond), cumulative recurrence and reoperation rates converge at 5-12% across both approaches, again without statistically significant divergence, with the most recent propensity-matched 5-year data confirming this equivalence.

The conceptual significance of these findings extends beyond the individual technique comparison: they establish that long-term disc surgery durability is primarily a function of patient biology and biomechanical environment – not of incision size or approach corridor. The dominant determinants of recurrence across both modalities are patient-specific: age below 40 years, BMI above 25 kg/m^2, annular defect diameter greater than 6 mm, smoking, Modic type 2 endplate changes, and heavy manual occupation. These risk factors represent modifiable and non-modifiable targets for pre-operative counselling and risk stratification that should be integrated into standard surgical decision-making regardless of technique chosen. Surgeon experience level constitutes an additional critical moderator: PELD recurrence rates demonstrably decline after the 30-50 case learning-curve threshold, suggesting that institutional investment in structured endoscopic training will measurably improve long-term outcomes.

Several important limitations of the current evidence base must be acknowledged. Heterogeneity in recurrence definitions across studies (symptomatic vs. radiographic; with or without the 6-month pain-free criterion) inflates apparent variability in recurrence estimates and complicates direct quantitative pooling. The predominance of observational study designs – with their inherent risk of indication bias toward endoscopic techniques in patients with simpler herniation morphologies – limits the causal strength of equivalence conclusions. Long-term RCT data extending beyond 5 years remain scarce for endoscopic approaches, which are a newer technology than microdiscectomy. Future research priorities include multicentre RCTs with standardised recurrence definitions, intention-to-treat analysis, and minimum 5-10-year follow-up; biomarker studies identifying biological predictors of annular repair competency; and cost-effectiveness analyses across diverse healthcare systems. The integration of annular closure devices for high-risk annular defects greater than 6 mm, artificial intelligence-assisted navigation for complex migrated herniations, and biological augmentation strategies represent the most promising frontiers for further reducing the 5-12% recurrence benchmark that currently represents the ceiling of surgical durability for both approaches.

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REFERENCES

[1] Barber SM, Nakhla J, Konakondla S, Fridley JS, Oyelese AA, Gokaslan ZL, et al. Outcomes of endoscopic discectomy compared with open microdiscectomy and tubular microdiscectomy for lumbar disc herniations: A meta-analysis. J Neurosurg Spine. 2019;31(6):802–13. DOI: 10.3171/2019.6.SPINE19532

[2] Muthu S, Ramakrishnan E, Chellamuthu G. Is endoscopic discectomy the next gold standard in the management of lumbar disc disease? Systematic review and superiority analysis. Global Spine J. 2021;11(8):1305–18. DOI: 10.1177/2192568220948814
[3] Meyer G, Lonnemann ME, Maus TP, Morris JM. Percutaneous endoscopic lumbar discectomy versus microdiscectomy for the treatment of lumbar disc herniation: Pain, disability, and complication rate – a randomized clinical trial. World Neurosurg. 2020;134:1026–34. DOI: 10.14444/7010
[4] Bai X, Lian L, Du J, Zhang H, Jiang M, Zhang H, *et al*. Percutaneous endoscopic lumbar discectomy compared with other surgeries for lumbar disc herniation: A meta-analysis. Medicine. 2021;100(13):e25241. DOI: 10.1097/MD.0000000000024747
[5] Kim M, Lee S, Kim HS, Park S, Shim SY, Lim DJ. A comparison of percutaneous endoscopic lumbar discectomy and open lumbar microdiscectomy for lumbar disc herniation in the Korean: A meta-analysis. Biomed Res Int. 2018;2018:9073460. DOI: 10.1155/2018/9073460
[6] Yang X, Zhang S, Su J, Guo S, Yakubu I, Kai Z, et al. Comparison of clinical and radiographic outcomes between transforaminal endoscopic lumbar discectomy and microdiscectomy: A follow-up exceeding 5 years. Neurospine. 2024;21(1):303–13. DOI: 10.14245/ns.2347026.513
[7] Ahn Y, Lee SG, Son S, Keum HJ. Transforaminal endoscopic lumbar discectomy versus open lumbar microdiscectomy: A comparative cohort study with a 5-year follow-up. Pain Physician. 2019;22(3):295–304. DOI: 10.36076/ppj/2019.22.295
[8] Li T, Li Y, Zhang D, Jiang Q, Ding Y. Percutaneous endoscopic lumbar discectomy versus open fenestration discectomy for treating lumbar disc herniation: A retrospective propensity score-matched study with more than 5 years of follow-up. J Orthop Surg Res. 2024;19:452. DOI: 10.1186/s13018-024-05239-0
[9] Patel T, Kumar A, Verma R, Daneshpazhouh M, Al Nahar O, El Serafy A, et al. Comparative effectiveness of minimally invasive endoscopic discectomy versus conventional surgical techniques for lumbar disc herniation. Ann Med Surg (Lond). 2025;87(10):6661–74. DOI: 10.3171/2024.9.SPINE241005
[10] Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic interlaminar and transforaminal lumbar discectomy versus conventional microsurgical technique: A prospective, randomized, controlled study. Spine. 2008;33(9):931–39. DOI: 10.1097/BRS.0b013e31816c8af7
[11] Caspar W. A new surgical procedure for lumbar disc herniation causing less tissue damage through a microsurgical approach. Adv Neurosurg. 1977;4:74–80. DOI: 10.1007/978-3-642-66578-3_15
[12] Overdevest GM, Peul WC, Brand R, Koes BW, Bartels RHMA, Tan WF, et al. Tubular discectomy versus conventional microdiscectomy for the treatment of lumbar disc herniation: Long-term results of a randomised controlled trial. J Neurol Neurosurg Psychiatry. 2017;88(12):1008–16. DOI: 10.1136/jnnp-2016-315306
[13] Arts MP, Brand R, van den Akker ME, Koes BW, Bartels RHMA, Peul QC, et al. Tubular diskectomy vs conventional microdiskectomy for sciatica: A randomized controlled trial. JAMA. 2009;302(2):149–58. DOI: 10.1001/jama.2009.996
[14] Noh SH, Cho PG, Kim KN, Lee B, Lee JK, Kim SH. Risk factors for reoperation after lumbar spine surgery in a 10-year Korean national health insurance service health examinee cohort. Sci Rep. 2022;12:4606. DOI: 10.1038/s41598-022-08376-w
[15] Peul WC, van Houwelingen HC, van den Hout WB, van den Hout WB, Brand R, Eekho JAH, et al. Surgery versus prolonged conservative treatment for sciatica. N Engl J Med. 2007;356(22):2245–56. DOI: 10.1056/NEJMoa064039
[16] Ruetten S, Komp M, Merk H, Godolias G. Recurrences after percutaneous endoscopic operations on the lumbar spine. J Spinal Disord Tech. 2009;22(7):504–9. DOI: 10.1097/BSD.0b013e31817bd3f6
[17] Yeung AT, Tsou PM. Posterolateral endoscopic excision for lumbar disc herniation: Surgical technique, outcome, and complications in 307 consecutive cases. Spine. 2002;27(7):722–31. DOI: 10.1097/00007632-200204010-00009
[18] Kambin P, Sampson S. Posterolateral percutaneous suction-excision of herniated lumbar intervertebral discs. Clin Orthop Relat Res. 1986;207:37–43. DOI: 10.1097/00003086-198606000-00008
[19] Hermantin FU, Peters T, Quartararo L, Kambin P. A prospective, randomized study comparing the results of open discectomy with those of video-assisted arthroscopic microdiscectomy. J Bone Joint Surg Am. 1999;81(7):958–65. DOI: 10.2106/00004623-199907000-00008
[20] Pan Z, Ha Y, Yi S, Cao K. Efficacy of transforaminal endoscopic spine system (TESSYS) technique in treating lumbar disc herniation. Med Sci Monit. 2016;22:530–9. DOI: 10.12659/MSM.895407
[21] Choi G, Lee SH, Lokhande P, Kong BJ, Shim CS, Jung B, et al. Percutaneous endoscopic approach for highly migrated intracanal disc herniations by foraminoplastic technique using rigid working channel endoscope. Spine. 2008;33(15):E508–15. DOI: 10.1097/BRS.0b013e31817bfa1a
[22] Kim CH, Chung CK, Woo JW. Surgical outcome of percutaneous endoscopic interlaminar lumbar discectomy for highly migrated disc herniation. J Spinal Disord Tech. 2012;25(5):E113–20. DOI: 10.1097/BSD.0b013e31825bd111

[23] Gibson JNA, Waddell G. Surgical interventions for lumbar disc prolapse: Updated Cochrane Review. Spine. 2007;32(16):1735–47. DOI: 10.1097/BRS.0b013e3180bc2431
[24] Kapetanakis S, Gkantsinikoudis N, Chaniotakis C, Theodosiadis P, Papathanasiou J, Giatroudakis K. Health-related quality of life after percutaneous transforaminal endoscopic discectomy for lumbar disc herniation. J Orthop Surg. 2017;25(3):2309499017739746. DOI: 10.1177/2309499017739746
[25] Sinkemani A, Hong X, Gao ZX, Zhuang S-Y, Jiang Z-L, Zhang S-D, et al. Outcomes of microendoscopic discectomy and percutaneous transforaminal endoscopic discectomy for the treatment of lumbar disc herniation. Asian Spine J. 2015;9(6):833–40. DOI: 10.4184/asj.2015.9.6.833
[26] Xiao Y, Yin G, Cheng J, et al. Meta-analysis of percutaneous transforaminal endoscopic discectomy versus conventional open lumbar discectomy for lumbar disc herniation. Int J Surg. 2020;76:136–143. DOI: 10.1016/j.ijsu.2020.02.031
[27] Gadjradj PS, Harhangi BS, Amelink J, van Susante, J, Kamper, S, van Tulder M, et al. Percutaneous transforaminal endoscopic discectomy versus open microdiscectomy for lumbar disc herniation: A systematic review and meta-analysis. Spine. 2021;46(8):538–49. DOI: 10.1097/BRS.0000000000003843
[28] Zheng C, Wu F, Cai L. Transforaminal percutaneous endoscopic discectomy versus microdiscectomy in treatment of lumbar disc herniation. J Coll Physicians Surg Pak. 2016;26(1):42–6.
[29] Chen Z, Zhang L, Dong J, Xie P, Liu B, Wanget Q, et al. Percutaneous transforaminal endoscopic discectomy compared with microendoscopic discectomy for lumbar disc herniation: 1-year results of an ongoing randomized controlled trial. J Neurosurg Spine. 2018;28(3):300–10. DOI: 10.3171/2017.7.SPINE161359
[30] Wang H, Huang B, Li C, Zhang Z, Wang J, Zheng W. et al. Learning curve for percutaneous endoscopic lumbar discectomy depending on the surgeon's training level. Int Orthop. 2013;37(8):1517–22. DOI: 10.1007/s00209-013-1277-4
[31] Jasper GP, Francisco GM, Bernstein AJ. Clinical evaluations of renovated and introduced surgical techniques related to percutaneous endoscopic lumbar discectomy. World Neurosurg. 2015;83(1):35–9. DOI: 10.1016/j.wneu.2014.08.006.
[32] McGirt MJ, Eustis C, Glassman SD, Surisetti BK, Sharma D, Kamble N, et al. Annular repair device reduces reherniation and hospital readmission after single-level lumbar discectomy. World Neurosurg. 2022;157:e366–72. DOI: 10.1016/j.wneu.2021.10.093
[33] Lequin MB, Barth M, Thomé C, Bouma GJ. Primary limited lumbar discectomy with an annulus closure device: One-year clinical and radiological results of a German multicenter trial. Biomed Res Int. 2012;2012:516271. DOI: 10.1155/2012/516271
[34] Schröder ML, de Wispelaere MP, Staartjes VE. Are sex and age associated with lumbar disc herniation and its operative outcomes? Insights from the Amsterdam Spine Registry. Spine J. 2020;20(1):31–8. DOI: 10.1016/j.spinee.2019.08.010
[35] Thomé C, Kuršumovic A, Klassen PD, Bouma GJ, Bostelmann R, Martens F. et al. Effectiveness of an annular closure device to prevent recurrent lumbar disc herniation: A secondary analysis with 5 years of follow-up. JAMA Netw Open. 2021;4(12):e2136809. DOI: 10.1001/jamanetworkopen.2021.36809
[36] Linek P, Saulicz E, Kuszewski M, Wolny T. Ultrasound assessment of the abdominal muscles at rest and during the ASLR test among adolescents with scoliosis. Clinical Spine Surgery. 2017;30(4):181–6. DOI: 10.1097/BSD.0000000000000055
[37] Shi R, Wang F, Hong X, Wang YT, Bao JP, Liu L, et al. Comparison of percutaneous endoscopic lumbar discectomy versus microendoscopic discectomy for the treatment of lumbar disc herniation: A meta-analysis. Int Orthop. 2019;43(4):923–37. DOI: 10.1007/s00264-018-4253-8
[38] Huang W, Han Z, Liu J, Lili Y, Xiuchun Y, Lili Y, Xiuchun Y. Risk factors for recurrent lumbar disc herniation: A systematic review and meta-analysis. Medicine. 2016;95(2):e2378. DOI: 10.1097/MD.0000000000002378
[39] Ahn Y, Lee SG, Son S, Keum HJ. Transforaminal endoscopic lumbar discectomy versus open lumbar microdiscectomy: A comparative cohort study with a 5-year follow-up. Pain Physician. 2019;22(3):295–304. DOI: 10.36076/ppj/2019.22.295
[40] Yao Y, Liu H, Zhang H, Wang H, Zhang Z, Zheng Y, et al. Risk factors for the recurrent herniation after microendoscopic discectomy. World Neurosurg. 2016;95:451–55. DOI: 10.1016/j.wneu.2016.08.071
[41] Li T, Li Y, Zhang D, Jiang Q, Ding Y. Percutaneous endoscopic lumbar discectomy versus open fenestration discectomy for treating lumbar disc herniation: A retrospective propensity score-matched study with more than 5 years of follow-up. J Orthop Surg Res. 2024;19:452. DOI: 10.1186/s13018-024-05239-0
[42] Foley KT, Smith MM. Microendoscopic discectomy. Tech Neurosurg. 1997;3(4):301–7.

Бел омуртка аралык диск грыжасын хирургиялык жол менен дарылоо: салттуу микродискэктомияны жана эндоскопиялык дискэктомияны салыштыруу, кайталануу көрсөткүчүнө басым жасоо менен комплекстүү сереп

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Аннотация. Бел омуртка аралык диск хирургиясы кеңири таралган процедура бойдон калууда. Ошо эле учурда, салттуу микродискэктомия менен минималдуу инвазивдүү тери аркылуу эндоскопиялык бел дискэктомиясынын ортосундагы узак мөөнөттүү натыйжалар жана кайталануу көрсөткүчтөрүндөгү айырмачылыктар боюнча, айрыкча операциядан кийинки биринчи жылдан кийин белгисиздик сакталууда. Бул системалуу серептин максаты – бел дискинин пролапсын дарылоодо микродискэктомиянын жана тери аркылуу эндоскопиялык бел дискэктомиясынын клиникалык натыйжалуулугун, периоперативдик мүнөздөмөлөрүн жана убакытка көз каранды кайталануу көрсөткүчтөрүн салыштыруу жана кайталанууга таасир этүүчү негизги пациентке жана процедурага байланыштуу факторлорду аныктоо болуп саналат. PRISMA 2020 көрсөтмөлөрүнө ылайык, 2000- жана 2026-жылдар аралыгында жарыяланган изилдөөлөр боюнча системалуу изилдөө жүргүзүлдү, анын ичинде рандомизацияланган көзөмөлдөнгөн сыноолор, когорттук изилдөөлөр жана 12 айлык минималдуу байкоо жүргүзүү менен мета-анализдер камтылган. Микродискэктомия да, тери аркылуу эндоскопиялык бел дискэктомиясы да салыштырмалуу узак мөөнөттүү клиникалык натыйжаларды берери аныкталды, көпчүлүк изилдөөлөрдө ооруну олуттуу түрдө басаңдатат жана функционалдык калыбына келүүнүн жогорку көрсөткүчтөрү 85 % дан ашат. Эндоскопиялык ыкмалар периоперативдик пайдаларды, анын ичинде кан жоготууну азайтуу, ооруканада жатуунун кыскарышы жана жумушка тезирээк кайтып келүүнү көрсөттү, бирок бул узак мөөнөттүү кайталануу көрсөткүчтөрүндөгү олуттуу айырмачылыктарды билдирбейт. 1, 3 жана 5 жылдык байкоо жүргүзүүдө ыкмалардын кайталануу көрсөткүчтөрү окшош экени көрсөтүлдү, адатта 3 % дан 12 % га чейин, статистикалык жактан маанилүү айырмачылыктар жок. Жаш курак, дене салмагынын индексинин жогору болушу, тамеки чегүү, фиброздук шакекченин чоң кемчиликтери жана физикалык жактан оор жумуш сыяктуу бейтапка байланыштуу факторлор хирургиялык ыкмаларга караганда кайталануунун күчтүү божомолдоочу факторлору катары аныкталды. Эндоскопиялык процедуралар үчүн да үйрөнүү ийри сызыгынын таасири байкалды, хирургдун тажрыйбасы жогорулаган сайын натыйжалар жакшырды. Бул жыйынтыктар хирургиялык чечимдерди кабыл алууда бейтаптын мүнөздөмөлөрү жана хирургиялык тажрыйбасы кайталануу жөнүндө кооптонуулардан жогору турушу керек деген тыянакты тастыктайт, ошону менен жүлүн хирургиясында жана саламаттыкты сактоону пландаштырууда далилдерге негизделген, жекече мамилени жайылтат

Негизги сөздөр: жүлүндүн декомпрессиясы; минималдуу инвазивдүү омуртка хирургиясы; хирургиялык натыйжалар; кайталануу көрсөткүчү; тери аркылуу эндоскопиялык бел дискэктомиясы; нерв тамырларын кысылышы

Хирургическое лечение грыжи межпозвоночного диска поясничного отдела позвоночника (ГМПД): всесторонний обзор, сравнивающий традиционную микродискэктомию и эндоскопическую дискэктомию – с акцентом на частоту рецидивов

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Аннотация. Хирургическое вмешательство на поясничном межпозвоночном диске остается широко распространенной процедурой; однако сохраняется неопределенность в отношении долгосрочных результатов и различий в частоте рецидивов между традиционной микродискэктомией и минимально инвазивной чрескожной эндоскопической поясничной дискэктомией, особенно после первого года после операции. Цель данного систематического обзора – сравнить клиническую эффективность, периоперационные характеристики и зависящие от времени показатели рецидивов микродискэктомии и чрескожной эндоскопической поясничной дискэктомии при лечении пролапса поясничного межпозвоночного диска, а также выявить ключевые факторы, связанные с пациентом и процедурой, влияющие на рецидив. Был проведен систематический поиск исследований, опубликованных в период с 2000 по 2026 год, в соответствии с рекомендациями PRISMA 2020, включая рандомизированные контролируемые исследования, когортные исследования и метаанализы с периодом наблюдения не менее 12 месяцев. Было установлено, что как микродискэктомия, так и чрескожная эндоскопическая поясничная дискэктомия обеспечивают сопоставимые долгосрочные клинические результаты, со значительным уменьшением боли и высокими показателями функционального восстановления, превышающими 85 % в большинстве исследований. Эндоскопические методы продемонстрировали явные периоперационные преимущества, включая снижение кровопотери, сокращение продолжительности пребывания в больнице и более быстрое возвращение к работе, хотя это не приводит к существенным различиям в долгосрочной частоте рецидивов. Было показано, что частота рецидивов была схожей между методами в течение 1, 3 и 5 лет наблюдения, обычно варьируясь от 3 % до 12 %, без статистически значимых различий. Факторы, связанные с пациентом, включая более молодой возраст, более высокий индекс массы тела, курение, большие дефекты фиброзного кольца и физически тяжелую работу, были определены как более сильные предикторы рецидива, чем хирургические методы. Также наблюдался эффект кривой обучения для эндоскопических процедур, с улучшением результатов по мере увеличения опыта хирурга. Полученные результаты подтверждают вывод о том, что при принятии решений о хирургическом вмешательстве следует отдавать приоритет характеристикам пациента и хирургическому опыту, а не опасениям по поводу рецидива, тем самым способствуя применению научно обоснованных, индивидуализированных подходов в спинальной хирургии и планировании здравоохранения

Ключевые слова: декомпрессия позвоночника; малоинвазивная хирургия позвоночника; результаты операции; частота рецидивов; чрескожная эндоскопическая поясничная дискэктомия; компрессия корешка нерва