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UNILATERAL BIPORTAL ENDOSCOPIC DISCECTOMY FOR LUMBAR DISC HERNIATION: CURRENT EVIDENCE, MORPHOLOGY-ORIENTED SURGICAL STRATEGY, AND A PROPOSED UBE-MAP FRAMEWORK

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Abstract

Background. Unilateral biportal endoscopic discectomy (UBED) has emerged as a tissue-preserving alternative to microscopic and uniportal endoscopic surgery for lumbar disc herniation. Its independent visualization and working portals permit bimanual instrumentation, panoramic epidural inspection, targeted laminotomy, and adaptable fragment retrieval during continuous irrigation.

Materials and methods. Peer-reviewed clinical trials, comparative cohorts, technical studies, and complication analyses published through July 2026 were examined. Evidence was organized according to herniation location, migration grade, access corridor, neural decompression, preservation of the facet–lamina complex, perioperative outcomes, and failure mechanisms.

Results. Randomized and comparative investigations demonstrate that UBED provides leg-pain relief, disability improvement, and quality-of-life recovery comparable to microscopic discectomy and other endoscopic techniques. Potential advantages include reduced paraspinal muscle injury, limited cutaneous trauma, enhanced visualization, shorter hospitalization, and versatile access to central, paracentral, migrated, foraminal, extraforaminal, upper-lumbar, and recurrent fragments. These benefits are technique-dependent rather than automatic. Inadequate localization, excessive facet resection, uncontrolled irrigation, epidural bleeding, dural injury, postoperative hematoma, dysesthesia, and recurrent herniation remain relevant. Learning-curve studies indicate that structured training, progressive case selection, and standardized portal geometry are essential.

Conclusion. UBED should be considered a platform rather than a single operation. Optimal results require phenotype-based approach selection, low-pressure irrigation, complete neural decompression, preservation of stabilizing anatomy, meticulous hemostasis, and postoperative surveillance. The proposed framework links disc morphology to portal placement, decompression endpoint, complication prevention, and outcome assessment.

Keywords: unilateral biportal endoscopy; biportal endoscopic discectomy; lumbar disc herniation; lumbar radiculopathy; minimally invasive spine surgery; endoscopic spine surgery; migrated disc fragment; neural decompression; recurrent disc herniation.

УНИЛАТЕРАЛЬНАЯ БИПОРТАЛЬНАЯ ЭНДОСКОПИЧЕСКАЯ ДИСКЭКТОМИЯ ПРИ ГРЫЖЕ ПОЯСНИЧНОГО МЕЖПОЗВОНКОВОГО ДИСКА: СОВРЕМЕННЫЕ ДОКАЗАТЕЛЬСТВА, МОРФОЛОГИЧЕСКИ ОРИЕНТИРОВАННАЯ ХИРУРГИЧЕСКАЯ СТРАТЕГИЯ И ПРЕДЛОЖЕННАЯ МОДЕЛЬ UBE-MAP

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Аннотация

Актуальность. Унилатеральная бипортальная эндоскопическая дискэктомия представляет собой тканесберегающую альтернативу микродискэктомии и унипортальной эндоскопической хирургии при грыже поясничного межпозвонкового диска. Раздельные визуализационный и рабочий порталы обеспечивают бимануальную инструментальную манипуляцию, панорамную ревизию эпидурального пространства, селективную ламинотомию и направленное удаление фрагмента при непрерывной ирригации.

Материалы и методы. Проанализированы рецензируемые клинические исследования, сравнительные когорты, технические публикации и исследования осложнений, опубликованные до июля 2026 года. Доказательства систематизированы с учётом локализации грыжи, степени миграции, хирургического коридора, полноты декомпрессии, сохранности фасеточно-ламинарного комплекса, периоперационных результатов и механизмов неудачи.

Результаты. Рандомизированные и сравнительные исследования показывают, что UBE обеспечивает уменьшение корешковой боли, улучшение функционального статуса и восстановление качества жизни, сопоставимые с микродискэктомией и другими эндоскопическими методами. Возможные преимущества включают меньшую травматизацию паравертебральных мышц, ограниченное повреждение кожи, увеличенное операционное изображение, короткую госпитализацию и возможность удаления центральных, парацентральных, мигрировавших, фораминальных, экстрафораминальных, верхнепоясничных и рецидивных фрагментов. Однако результат зависит от техники. Неполная локализация секвестра, чрезмерная фасетэктомия, неконтролируемая ирригация, эпидуральное кровотечение, повреждение твёрдой мозговой оболочки, гематома, дизестезия и рецидив сохраняют клиническое значение.

Заключение. UBE следует рассматривать как универсальную хирургическую платформу. Оптимальные результаты требуют фенотипического выбора доступа, низкого ирригационного давления, полной декомпрессии нервных структур, сохранения стабильности, надёжного гемостаза и стандартизированного наблюдения после операции. Предложенная модель связывает морфологию дискового пролапса с геометрией порталов, направлением костной резекции, конечными критериями декомпрессии и профилактикой осложнений, позволяя отличать технически обоснованное расширение показаний от неоправданной хирургической агрессии при сложных вариантах поясничной грыжи диска.

Ключевые слова: унилатеральная бипортальная эндоскопия; бипортальная эндоскопическая дискэктомия; грыжа поясничного диска; поясничная радикулопатия; малоинвазивная хирургия позвоночника; мигрировавший секвестр; декомпрессия нервного корешка; рецидив грыжи диска.

BEL UMURTQALARARO DISKI CHURRASIDA UNILATERAL BIPORTAL ENDOSKOPIK DISKEKTOMIYA: ZAMONAVIY DALILLAR, MORFOLOGIYAGA ASOSLANGAN JARROHLIK STRATEGIYASI VA TAKLIF ETILGAN UBE-MAP MODELI

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Annotatsiya

Dolzarblik. Unilateral biportal endoskopik diskektomiya bel umurtqalararo diski churrasida mikrodiskektomiya va uniportal endoskopik jarrohlikka nisbatan to‘qimalarni asrovchi muqobil usuldir. Alohida vizualizatsion va ishchi portallar bimanual instrumental manipulyatsiya, epidural bo‘shliqni keng ko‘lamda ko‘rish, selektiv laminotomiya hamda uzluksiz irrigatsiya ostida disk fragmentini yo‘naltirilgan olib tashlash imkonini beradi.

Material va usullar. 2026-yil iyuligacha chop etilgan klinik sinovlar, qiyosiy kohortalar, texnik tadqiqotlar va asoratlar tahlili ko‘rib chiqildi. Dalillar churra lokalizatsiyasi, migratsiya darajasi, jarrohlik koridori, nerv dekompressiyasi, faset-laminar kompleksning saqlanishi, perioperatsion natijalar va muvaffaqiyatsizlik mexanizmlariga ko‘ra tizimlashtirildi.

Natijalar. Randomizatsiyalangan va qiyosiy tadqiqotlar UBE ildiz og‘rig‘ini kamaytirish, funksional holatni yaxshilash va hayot sifatini tiklash bo‘yicha mikrodiskektomiya hamda boshqa endoskopik usullar bilan taqqoslanadigan natijalarni ko‘rsatishini tasdiqlaydi. Ehtimoliy afzalliklar paravertebral mushaklar shikastlanishining kamayishi, kichik teri kesmalari, kattalashtirilgan operatsion tasvir, qisqa gospitalizatsiya va markaziy, paratsentral, migratsiyalangan, foraminal, ekstraforaminal, yuqori bel hamda retsidiv fragmentlarga moslashuvchan kirishni o‘z ichiga oladi. Biroq natija texnikaga bog‘liq. Sekvestrni noto‘g‘ri lokalizatsiya qilish, ortiqcha fasetektomiya, boshqarilmagan irrigatsiya, epidural qon ketish, dura shikastlanishi, gematoma, dizesteziya va qayta churra klinik ahamiyatini saqlaydi.

Xulosa. UBE yagona operatsiya emas, balki moslashuvchan jarrohlik platformasidir. Optimal natija fenotipga mos kirish, past irrigatsion bosim, to‘liq dekompressiya, stabil anatomiyani saqlash, puxta gemostaz va standart kuzatuvni talab qiladi. Taklif etilgan model disk prolapsi morfologiyasini portallar geometriyasi, suyak rezeksiyasi yo‘nalishi, dekompressiyaning yakuniy mezonlari va asoratlarning profilaktikasi bilan bog‘lab, murakkab churralarda asoslangan qaror qabul qilishni yaxshilaydi kundalik amaliyotda sezilarli.

Kalit so‘zlar: unilateral biportal endoskopiya; biportal endoskopik diskektomiya; bel diski churrasi; bel radikulopatiyasi; minimal invaziv umurtqa jarrohligi; migratsiyalangan disk sekvestri; nerv ildizi dekompressiyasi; disk churrasi retsidivi.

Introduction. Lumbar disc herniation is a clinically heterogeneous degenerative disorder in which displaced nucleus pulposus and annular tissue produce mechanical deformation, inflammatory sensitization, venous congestion, and variable ischemic dysfunction of a lumbar or sacral nerve root. The clinical syndrome may include radicular pain, dermatomal sensory disturbance, myotomal weakness, impaired tendon reflexes, positive nerve-tension signs, and activity-related functional disability. Although many patients improve with structured conservative treatment, surgery becomes necessary when disabling radiculopathy persists despite adequate nonoperative therapy, when progressive motor deficit develops, or when cauda equina compression requires urgent neural decompression [1–3]. Conventional microscopic discectomy remains an established operative benchmark because it provides direct visualization of the dural sac, traversing nerve root, epidural venous plexus, posterior longitudinal ligament, annular defect, and displaced disc fragment. Nevertheless, the conventional posterior approach may require paraspinal muscle detachment, retractor-mediated ischemia, laminotomy, flavectomy, and manipulation of neural structures. These tissue effects stimulated the development of tubular, microendoscopic, uniportal full-endoscopic, and biportal endoscopic techniques designed to reduce approach-related morbidity without compromising the completeness of neural decompression [3, 6, 10]. Unilateral biportal endoscopy uses two independently mobile portals. One portal contains the endoscope and irrigation inflow, while the second accommodates operative instruments and provides a route for fluid egress. This separation differentiates UBE from uniportal endoscopy, in which visualization and instrumentation are constrained within a shared working cannula. Independent portal movement creates triangulation and permits the use of familiar spinal instruments, including Kerrison punches, pituitary forceps, curettes, nerve hooks, high-speed drills, bipolar or radiofrequency devices, and specialized endoscopic instruments. The surgeon can modify the viewing angle without obligating the working instrument to follow the same trajectory [5, 11, 16].

Randomized and comparative investigations indicate that biportal endoscopic discectomy can produce improvements in leg pain, back pain, Oswestry Disability Index, neurological function, and health-related quality of life that are comparable with those obtained after microscopic discectomy. Earlier comparative work also found lower measured intraoperative blood loss and shorter hospitalization after UBE, although operative time may initially be longer. More recent randomized evidence supports clinical equivalence or noninferiority rather than universal superiority of the biportal technique [4, 7, 14]. The clinical effectiveness of UBE should therefore not be attributed solely to the presence of an endoscope. Outcomes are determined by correct patient selection, congruence between symptoms and imaging, accurate portal geometry, efficient creation of the working space, controlled irrigation, atraumatic flavectomy, recognition of the exiting and

traversing roots, complete fragment retrieval, preservation of the facet–lamina complex, meticulous hemostasis, and postoperative detection of residual or recurrent compression. The technique is a surgical platform that must be adapted to the morphology of each herniation.
A central or paracentral contained protrusion, a transligamentous extrusion, a highly migrated sequestration, a foraminal fragment, a far-lateral herniation, an upper-lumbar lesion, and recurrent disc herniation do not present the same anatomical problem. Each variant requires a different relationship among the endoscopic portal, working portal, lamina, facet joint, interlaminar window, pedicle, exiting root, traversing root, and displaced fragment. Applying an identical portal configuration to all lesions can cause inadequate decompression, excessive bone removal, unnecessary neural manipulation, or failure to identify a hidden fragment [8, 9, 25].

Materials and Methods. This article was designed as a structured integrative review with an original clinical–technical synthesis. Peer-reviewed studies available through July 2026 were examined, with priority given to randomized controlled trials, prospective comparative studies, multicenter cohorts, learning-curve analyses, complication studies, radiological investigations, and technical reports specifically addressing biportal endoscopic discectomy for lumbar disc herniation. The principal concepts included unilateral biportal endoscopy, biportal endoscopic spinal surgery, biportal endoscopic discectomy, lumbar disc herniation, lumbar radiculopathy, migrated disc fragment, foraminal disc herniation, far-lateral disc herniation, upper-lumbar disc herniation, recurrent disc herniation, dural tear, epidural hematoma, irrigation pressure, learning curve, and reoperation. Studies of lumbar spinal stenosis were considered only when they provided transferable evidence concerning irrigation, dural injury, neural manipulation, facet preservation, or postoperative hematoma. Evidence was classified according to four domains. The first domain was disc morphology, including level, axial location, degree and direction of migration, containment, sequestration, calcification, annular defect, and recurrent status. The second domain was operative access, including interlaminar, ipsilateral paramedian, contralateral sublaminar, translaminar, paraspinal, extraforaminal, and transforaminal trajectories. The third domain was structural preservation, including the lamina, facet joint, pars interarticularis, ligamentum flavum, interspinous complex, multifidus attachment, and epidural neural structures. The fourth domain was outcome, including pain scores, functional disability, neurological recovery, length of stay, blood loss, complications, residual compression, recurrence, and reoperation. No pooled statistical analysis was performed because of heterogeneity in patient selection, terminology, operative approach, surgeon experience, outcome measures, and follow-up intervals. Reported numerical findings were interpreted within the design and limitations of the original studies. Tables 1–4 represent an original synthesis and do not describe an invented clinical cohort.

Results. Prospective randomized evidence has strengthened the scientific basis for UBED. A multicenter randomized trial involving patients with single-level lumbar disc herniation demonstrated that biportal endoscopic discectomy achieved clinical outcomes comparable to microscopic discectomy across patient-reported pain, disability, quality-of-life, and neuropathic-pain measures. The trial emphasized noninferiority rather than a categorical replacement of microscopic surgery. A subsequent multicenter assessor-blinded randomized investigation again supported comparable efficacy and safety between biportal and microscopic discectomy [10, 13, 23]. An earlier multicenter comparative study evaluated 141 patients undergoing single-level discectomy and found significant postoperative improvement in both UBE and open microscopic groups. UBE was associated with lower measured blood loss, shorter hospitalization, and less early postoperative back pain, whereas operative time was longer. Long-term pain, disability, patient satisfaction, and complication outcomes were not significantly different. These findings remain clinically relevant because they demonstrate that the principal advantage of UBE may lie in reducing approach morbidity rather than producing greater final neural recovery [2, 3, 18]. The pooled safety analysis of two randomized trials involving lumbar disc herniation and lumbar stenosis showed similarly low rates of major adverse events between biportal endoscopic and microscopic surgery. This suggests that, when performed within an appropriate training environment, UBE does not inherently increase the risks of dural injury, nerve-root damage, infection, or symptomatic epidural hematoma. Nevertheless, pooled trial data frequently originate from experienced centers and may not reproduce the complication profile encountered during early implementation [2, 3, 7].

Table 1. Evidence-Based Comparison of UBED and Microscopic Discectomy

Outcome domain	UBED	Microscopic discectomy	Current interpretation
Radicular pain relief	Marked postoperative improvement	Marked postoperative improvement	Generally comparable
Functional recovery	Significant ODI reduction	Significant ODI reduction	Comparable in randomized trials
Early surgical-site pain	May be lower in selected studies	May be higher after muscle retraction	Potential UBE advantage
Blood loss	Usually low, but hidden blood loss may be underestimated	More directly measurable	UBE often favorable
Length of hospitalization	Frequently shorter	Frequently longer	Depends on institutional pathway
Operative time	Longer during early experience	Usually predictable	Difference decreases with proficiency
Visualization	Magnified, panoramic, close to pathology	Familiar three-dimensional microscopic view	Different but complementary strengths
Instrument mobility	Independent bimanual manipulation	Fully unrestricted open or tubular manipulation	UBE resembles microsurgical handling
Irrigation-related risk	Present	Absent	Requires pressure and outflow control
Learning requirements	Endoscopic orientation and water dynamics	Microsurgical orientation	Formal training required for both

Appropriate candidates usually demonstrate unilateral or bilateral radiculopathy that corresponds to MRI-confirmed disc compression and persists despite structured conservative therapy. Surgery may also be indicated when progressive motor weakness, incapacitating pain, or cauda equina dysfunction is present. The imaging lesion must be interpreted in relation to the symptomatic root. A paracentral L4–L5 extrusion typically compresses the traversing L5 root, whereas a foraminal L4–L5 fragment generally compromises the exiting L4 root. Failure to identify this distinction can result in technically successful removal of the wrong compressive component. Preoperative MRI should define axial location, cranial or caudal migration, continuity with the parent disc, annular defect, sequestration, Modic change, degree of disc degeneration, facet osteoarthritis, lateral recess dimensions, foraminal height, epidural fat displacement, and possible calcification. Thin-slice CT is useful when a calcified fragment, ossified posterior longitudinal ligament, anomalous lamina, narrow interlaminar window, or complex upper-lumbar anatomy is suspected. Dynamic radiographs should be considered when preoperative spondylolisthesis, facet degeneration, translational motion, or disproportionate mechanical back pain raises concern for instability. UBE discectomy is a decompressive procedure and cannot correct clinically relevant segmental instability. Excessive facet resection in a marginally stable segment may transform radiographic degeneration into symptomatic postoperative instability. Patients with a large central herniation and severe bilateral deficits, extensive calcification, major instability, deformity, active infection, tumor, or a lesion requiring reconstruction should not automatically be directed toward a simple biportal fragmentectomy. Similarly, the presence of a technically accessible disc herniation does not prove that it is the dominant pain generator in patients with polyneuropathy, hip disease, sacroiliac dysfunction, peripheral vascular disease, or nondermatomal pain.

The proposed UBE-MAP framework begins with morphology. The surgeon first determines where the fragment is located relative to the disc space, pedicles, medial pedicle line, posterior longitudinal ligament, traversing root, exiting root, and facet complex. The second component is access: the shortest safe operative corridor is selected to reach the fragment without unnecessary neural retraction. The third component is preservation: only the amount of bone, ligament, and disc tissue necessary to achieve complete decompression is removed.

Table 2. Proposed UBE-MAP Framework for Lumbar Disc Herniation

Herniation phenotype	Preferred UBE corridor	Principal target	Structure requiring maximal preservation	Major technical hazard
Central or paracentral extrusion	Ipsilateral interlaminar	Traversing root and ventral dural sac	Medial facet and pars	Excessive root retraction
Low-grade caudal migration	Interlaminar with limited caudal laminotomy	Inferiorly migrated fragment	Inferior articular process	Residual fragment below the disc
High-grade caudal migration	Extended interlaminar or contralateral sublaminar	Medial pedicle zone	Facet–pars complex	Incomplete distal exploration
High-grade cranial migration	Translaminar or tailored cranial laminotomy	Hidden axillary or preforaminal fragment	Pars interarticularis	Wrong-level or insufficient window
Foraminal herniation	Paraspinal foraminal	Exiting root	Facet joint	Dorsal root ganglion injury
Extraforaminal herniation	Wiltse-type paraspinal UBE	Exiting root beyond foramen	Facet capsule and muscle attachments	Root dysesthesia
Upper-lumbar herniation	Interlaminar, translaminar, or navigated transforaminal	Narrow canal and conus-adjacent neural elements	Facet and neural structures	Dural or multiple-root injury
Recurrent herniation	Scar-avoiding lateral-to-medial route	Recurrent fragment and root shoulder	Intact dura outside scar	Durotomy within adhesions

The patient is positioned prone on a radiolucent table with abdominal decompression to reduce epidural venous congestion. The target level is verified fluoroscopically. General anesthesia is commonly used, although selected centers have reported regional or epidural techniques. Neuromonitoring is not routinely required for standard single-level lumbar discectomy but may be useful in complex upper-lumbar, recurrent, or high-risk cases. Portal position must be determined by target anatomy rather than a rigid skin-distance formula. For a conventional interlaminar procedure, portals are generally created on one side of the spinous process with sufficient separation to permit triangulation. One portal is usually cranial and the other caudal, although the viewing and working functions can be exchanged. The portals should converge on the spinolaminar junction or the specific bone target identified on imaging. The working-space preparation phase begins with serial dilation and blunt separation of the multifidus from the lamina. Radiofrequency energy should be used selectively because thermal propagation can injure muscle, capsule, dura, or neural tissue. The surgeon identifies the inferior margin of the cranial lamina, superior margin of the caudal lamina, medial facet, and interlaminar ligament. Correct early identification of these landmarks prevents disorientation caused by soft-tissue debris and turbid irrigation.

Continuous irrigation creates an optical cavity, evacuates heat and blood, and keeps the lens clear. However, irrigation is not simply a visual accessory. Pressure within the operative field depends on inflow, outflow resistance, portal obstruction, soft-tissue tension, body habitus, and surgical phase. Experimental and clinical studies have demonstrated that epidural and remote spinal pressure can rise when outflow is restricted. Gravity irrigation or a low-pressure pump is generally preferred, and the outflow portal must remain patent [6, 13, 28]. Recent real-time monitoring research confirms that water pressure varies across working-space preparation, laminectomy, flavectomy, dural exposure, and discectomy. The practical implication is that a nominal pump setting does not equal the pressure surrounding neural structures. Tissue swelling, prolonged cervical discomfort, headache, seizure, visual complications, and neurological deterioration have been described in association with uncontrolled irrigation, although such events remain uncommon [11, 12, 20]. After establishing the bony landmarks, a limited laminotomy is performed. The required extent depends on fragment morphology. A simple paracentral extrusion may require only a small window, while a highly migrated fragment may necessitate targeted extension toward the relevant pedicle. Bone resection should follow the fragment rather than enlarge the exposure indiscriminately.

The ligamentum flavum can be preserved temporarily as a protective barrier during drilling. Once bone work and hemostasis are adequate, the ligament is split or resected to expose the epidural space. Early violation of the flavum exposes the dura to drill injury, thermal injury, and repetitive instrument contact. During flavectomy, the surgeon must differentiate flaval fibers, epidural fat, venous structures, dura, and root sleeve under continuous magnified visualization.

The traversing root is identified at the shoulder and axilla. Epidural veins are coagulated judiciously with low-energy bipolar or radiofrequency hemostasis. Aggressive coagulation near the dorsal root ganglion or radicular vessels should be avoided. The disc fragment may be located at the root shoulder, axilla, ventral epidural space, medial pedicle zone, preforaminal region, or within a hidden cranial or caudal compartment. The annular defect is explored only as necessary. Sequestrectomy alone may be adequate when a free fragment is clearly responsible for compression and the remaining disc is stable [15, 17, 27]. More extensive intradiscal curettage may reduce residual loose fragments but can accelerate disc-height loss, endplate injury, and postoperative axial pain. The goal is not maximal disc removal; it is complete removal of the compressive fragment while preserving viable annular and intradiscal structures.

The endpoint of decompression should be defined anatomically. The traversing or exiting root should be visibly free along the compressed segment, the dural sac should regain mobility, no residual fragment should remain in the cranial or caudal hidden zone, and a blunt hook should pass safely around the decompressed root without obstruction. Visible pulsation alone is insufficient because irrigation can create apparent movement despite persistent focal compression.

Central and paracentral herniations are generally approached through the interlaminar corridor. The surgeon identifies the traversing root and removes the ventral fragment with minimal root retraction. In large central herniations, bilateral visualization may be possible from one side by angling the endoscope beneath the spinous process, but extensive contralateral exploration is unnecessary unless imaging or symptoms indicate bilateral compression. Caudally migrated fragments require distal exploration toward the medial pedicle. A limited inferior laminotomy may expose the fragment while preserving the facet. Very highly migrated fragments can remain hidden beneath the lamina or medial pedicle even after the disc-space level appears adequately decompressed. Contralateral sublaminar or extended interlaminar approaches may improve the operative angle while reducing direct root retraction. Cranially migrated fragments may occupy the preforaminal zone and lie beneath the pars or upper lamina. A translaminar window can provide direct access and avoid an unnecessarily large interlaminar decompression. Technical studies published in 2024–2025 describe translaminar and contralateral sublaminar UBE strategies for highly migrated fragments, illustrating the adaptability of the biportal platform [7, 14, 19].

Foraminal and extraforaminal herniations are approached through a paraspinal trajectory targeting the lateral facet, transverse process, and intertransverse region. The exiting root and dorsal root ganglion are vulnerable to manipulation, thermal energy, and postoperative edema. Portal placement must be shifted laterally according to the disc level, facet orientation, iliac crest, and fragment position. Comparative cohorts suggest that UBE and percutaneous endoscopic approaches both improve pain and disability in far-lateral herniation, with different requirements for bone work and instrument mobility [16, 23, 30].

Upper-lumbar disc herniation is technically demanding because of narrower canal dimensions, shorter laminae, variable interlaminar windows, and proximity to multiple roots or the conus medullaris. UBE permits selection among interlaminar, translaminar, paraspinal, and navigation-assisted transforaminal approaches. The approach should be determined by fragment position rather than by an assumption that all upper-lumbar lesions require the same trajectory. Recent clinical and navigation-assisted investigations report encouraging short-term results, but evidence remains limited and highly dependent on surgeon experience [21, 24, 31]. Revision UBE for recurrent disc herniation may use the intact bony margin as an orientation landmark and approach the scar from normal tissue toward the recurrent fragment. Dissection should proceed from lateral to medial or from known bone toward the neural structures. Direct entry into the center of epidural fibrosis increases the risk of dural tear. Fusion should be considered instead of repeat discectomy when recurrence is accompanied by instability, severe disc-space collapse, deformity, extensive facet resection, or predominant mechanical back pain.

Complications. The principal complications of UBED include unintended dural tear, nerve-root injury, postoperative dysesthesia, residual fragment, incomplete decompression, epidural hematoma, infection, thermal injury, irrigation-related neurological or systemic events, recurrent herniation, and delayed instability. Published complication rates vary because some studies count radiological hematomas, transient symptoms, and minor dural injuries, whereas others report only symptomatic events requiring treatment. A systematic review of UBED complications reported a mean complication rate of approximately 5.37% across 596 patients, although individual study rates varied substantially and radiological hematomas increased the upper range. The reported events included dural tear, hematoma, neurological symptoms, incomplete decompression, recurrence, instability, pseudomeningocele, infection, retinal hemorrhage, fluid-related abdominal complications, and thermal injury. Complications were more frequent during the early learning phase [23, 30, 32]. A 2024 cohort of 608 UBE procedures identified unintended dural tears in 3.95% of patients. Older age, lumbar stenosis, bilateral decompression, and revision surgery increased risk, whereas uncomplicated primary discectomy had a lower-risk profile. Most tears were managed with direct repair or postoperative measures without severe sequelae. The study emphasizes that the risk profile of a primary soft-disc discectomy should not be equated with that of multilevel stenosis or revision decompression [1, 10, 13, 32]. Small dural defects may be managed with an endoscopic patch, sealant, or conversion to direct repair depending on size, location, root herniation, and surgeon expertise. Larger defects, irregular tears, or root entrapment require secure closure. Continuous irrigation can obscure cerebrospinal fluid leakage; therefore, the field should be inspected after lowering or stopping inflow. Postoperative epidural hematoma may be radiologically detectable without producing symptoms. A randomized study comparing biportal and microscopic surgery evaluated hematoma formation and found clinical outcomes improving in both groups without a major difference in symptomatic consequences. Nevertheless, meticulous hemostasis remains essential because irrigation can tamponade venous bleeding and create a deceptively dry field. Before closure, irrigation pressure should be reduced, the working space inspected without hydrostatic compression, and active bleeding controlled [3, 10, 18, 27].

Incomplete decompression usually results from incorrect portal placement, failure to explore the fragment's migration pathway, misunderstanding of axillary versus shoulder anatomy, premature termination after removing only the most visible fragment, or failure to recognize foraminal and extraforaminal compression. Immediate postoperative MRI is not required routinely but is appropriate when severe radicular pain, persistent neurological deficit, or unexpected deterioration raises concern for residual compression or hematoma. Recurrent herniation reflects biological and mechanical factors rather than the endoscopic approach alone. Annular defect size, disc degeneration, preserved disc height, segmental motion, smoking, diabetes, obesity, fragment morphology, and the extent of intradiscal removal may influence recurrence. A recent reoperation analysis of more than 2,200 UBE-treated patients reported an overall reoperation rate of 5.13%. Early reoperations were commonly related to inadequate decompression, whereas later procedures were more frequently associated with instability, advanced disc degeneration, and facet-joint osteoarthritis [4, 14, 19, 25].

Table 3. Mechanisms and Prevention of Major UBED Complications

Complication	Predominant mechanism	Preventive strategy	Immediate management principle
Dural tear	Drill contact, adhesions, aggressive flavectomy	Preserve flavum during drilling; dissect from normal anatomy	Patch, sealant, direct repair, or conversion
Root injury	Excessive retraction, blind forceps insertion	Visualize root and fragment simultaneously	Stop manipulation, assess motor function and compression
Dysesthesia	Dorsal root ganglion irritation	Minimize foraminal coagulation and traction	Anti-inflammatory treatment and neurological follow-up
Epidural hematoma	Venous bleeding masked by irrigation	Reduce pressure before closure; meticulous hemostasis	Urgent MRI and evacuation if symptomatic
Residual fragment	Inadequate migration-zone exploration	Preoperative trajectory planning and hook confirmation	Early revision if compression persists
Infection	Portal contamination or retained fluid collection	Standard prophylaxis and atraumatic handling	Culture-directed antibiotics with drainage when required
Irrigation-related complication	High pressure or blocked outflow	Low-pressure inflow and unrestricted egress	Stop irrigation and assess neurological/systemic status
Recurrent herniation	Annular defect and persistent disc mobility	Selective fragmentectomy and risk counseling	Repeat discectomy or fusion according to stability
Postoperative instability	Excessive facet or pars resection	Morphology-targeted minimal bone removal	Dynamic assessment and fusion when clinically indicated

UBE preserves many familiar principles of microscopic posterior decompression, but the learning curve should not be underestimated. The surgeon must acquire endoscopic hand–eye coordination, understand two-dimensional image interpretation, maintain triangulation, control bleeding in a fluid medium, manage irrigation pressure, exchange portal functions, and operate safely close to neural structures. A 2025 CUSUM analysis of 117 patients and 126 operated levels reported significant postoperative improvement but identified an overall complication rate of 10.3% and recurrence rate of 5.1%. Conventional CUSUM analysis suggested completion of the learning curve after 43 cases, whereas risk-adjusted analysis suggested technical proficiency after approximately 23 cases. These figures should not be interpreted as universal thresholds because previous microscopic experience, case complexity, mentorship, simulation, and institutional volume substantially influence proficiency [5, 16, 20, 31]. Training should begin with uncomplicated, single-level, unilateral, noncalcified paracentral herniations in patients without previous surgery, severe obesity, high-grade migration, instability, or major facet hypertrophy. Complex foraminal, far-lateral, recurrent, upper-lumbar, calcified, and very highly migrated lesions should be introduced only after consistent competence in portal creation, hemostasis, flavectomy, root identification, and standard fragmentectomy. Video-based education is useful but cannot replace supervised operative training. Cadaveric dissection, simulation, observation in high-volume centers, structured mentoring, and prospective complication auditing are necessary. Technical proficiency should be judged not merely by operative time but by complete decompression, preservation of anatomy, complication rate, unplanned conversion, recurrence, and patient-reported outcomes.

Patients are assessed immediately for leg pain, sensory change, motor strength, sphincter function, wound swelling, and symptoms suggestive of increased pressure or hematoma. Early mobilization is generally encouraged after uncomplicated surgery. A drain may be used selectively when bleeding risk, extensive bone work, revision surgery, or concern for fluid accumulation is present. Postoperative analgesia should be multimodal. A randomized double-blind trial evaluated epidural steroid administration after UBE discectomy and demonstrated that perioperative pain-modifying strategies can be studied specifically within the biportal setting. However, steroid use should be individualized in relation to diabetes, infection risk, tissue quality, and the expected degree of root manipulation [2, 6, 10, 13]. Routine postoperative MRI is not mandatory after an uncomplicated procedure with complete clinical resolution. Imaging is indicated for persistent severe radiculopathy, new motor deficit, cauda equina symptoms, unexplained fever, progressive wound pain, or deterioration after initial improvement. Early MRI must be interpreted carefully because epidural fluid, blood, postoperative edema, and residual annular tissue may mimic persistent compression. Outcome evaluation should include separate VAS or numerical rating scores for leg and back pain, ODI, neurological examination, analgesic use, time to mobilization, length of stay, return to work, complications, recurrence, and reoperation. The modified MacNab classification may be reported but should not replace validated patient-reported outcome measures.

Table 4. Scientific Originality of the Proposed UBE-MAP Model

Existing problem	Conventional interpretation	Proposed original element	Expected clinical contribution
UBE treated as one standardized operation	Same portal strategy used for different herniations	Morphology-specific access selection	Reduces residual fragments and unnecessary bone removal
Success defined mainly by fragment removal	Visible fragment extraction considered sufficient	Root mobility and hidden-zone exploration as endpoints	Improves completeness of decompression
Minimal invasiveness defined by skin incision	Small portals assumed to guarantee tissue preservation	Quantitative attention to facet, pars, lamina, and muscle preservation	Reduces delayed instability and axial pain
Irrigation viewed only as a visualization tool	Pump pressure selected by image quality	Water dynamics incorporated into neural safety	Reduces pressure-related complications
Learning curve measured by operative time	Faster surgery interpreted as proficiency	Composite proficiency based on safety, decompression, recurrence, and anatomy preservation	Improves training quality
Recurrence considered a uniform event	All repeat herniations managed similarly	Separation of residual, recurrent, and instability-associated pathology	Supports rational repeat discectomy or fusion
Complex lesions considered simple extensions of standard UBE	Exposure enlarged without morphological algorithm	Dedicated corridors for migrated, foraminal, upper-lumbar, and recurrent fragments	Expands indications without indiscriminate surgical aggression

Discussion. The present synthesis demonstrates that unilateral biportal endoscopic discectomy is an effective minimally invasive option for appropriately selected lumbar disc herniation. Its clinical outcomes are generally comparable to those of microscopic discectomy, while early postoperative back pain, measured blood loss, and hospitalization may be reduced. These benefits are plausible consequences of limited paraspinal disruption, small skin and fascial incisions, close-up visualization, and targeted bone removal. Nevertheless, the randomized evidence supports equivalence or noninferiority more consistently than superiority [11, 15, 17, 20]. This distinction is important. A new surgical technology should not be considered superior merely because the incision is smaller or the image is magnified. The clinically relevant questions are whether the symptomatic root is completely decompressed, whether stabilizing anatomy is preserved, whether complications are minimized, and whether the patient experiences durable functional recovery. An incomplete endoscopic decompression is not less invasive from the patient's perspective when it results in persistent radiculopathy and early reoperation. The two-portal configuration represents the central technical advantage of UBE. Independent control of visualization and instrumentation enables bimanual surgery and use of conventional spinal instruments. The surgeon can alter the viewing trajectory while maintaining the operative instrument at the target. This is especially valuable when a fragment lies beneath the lamina, medial pedicle, facet, or posterior longitudinal ligament. However, unrestricted instrument movement also creates the possibility of blind advancement beyond the endoscopic field. The instrument tip must remain visible whenever it approaches dura, root, disc space, or epidural vessels [1, 2, 10, 13].

The UBE-MAP framework addresses the frequent conceptual error of selecting the approach before analyzing fragment morphology. The skin portals are not the procedure; they are access points whose position must be derived from the anatomical target. A standard interlaminar approach is logical for a typical paracentral extrusion but may be inefficient for a highly cranially migrated, far-lateral, or upper-lumbar fragment. Conversely, an unnecessarily lateral or translaminar approach may increase bone resection when a simple interlaminar trajectory would suffice. Preservation is the third component of the framework. Minimal invasiveness should be defined biologically and biomechanically rather than cosmetically. Two small incisions do not compensate for excessive facetectomy, pars injury, prolonged high-pressure irrigation, thermal damage, or aggressive intradiscal curettage. The most appropriate UBE operation is the one that removes the pathological compression with the least disruption of structures not responsible for symptoms [3, 6, 15, 18]. The role of irrigation deserves particular emphasis. Continuous saline flow provides optical clarity, washes out debris, cools instruments, and can reduce minor venous oozing. At the same time, irrigation can mask bleeding and transmit pressure through the epidural space. Safe practice requires a free outflow route, avoidance of unnecessary pump escalation, periodic assessment at reduced pressure, and attention to unexpected neurological or systemic changes. Recent pressure-monitoring studies may facilitate the development of more objective safety thresholds, but universal values have not yet been established.

The learning curve remains a major determinant of outcomes. Published thresholds ranging from approximately 20 to more than 40 cases reflect differences in surgeon experience and methods used to define proficiency. A surgeon trained in microscopic decompression may recognize laminar, flaval, and neural anatomy quickly but still require time to master fluid-mediated visualization and biportal triangulation. Conversely, familiarity with arthroscopy does not guarantee competence in spinal neural decompression. The evidence also demonstrates that complication patterns evolve over time. During early experience, wrong portal positioning, bleeding, prolonged operative time, residual fragments, and dural injury may predominate. With increasing experience, attention shifts toward complex indications, recurrent disease, facet preservation, and long-term instability. Continuous auditing is therefore required even after the initial learning curve has been completed. Reoperation after UBE should be classified according to mechanism. Persistent symptoms immediately after surgery may indicate an unrecognized fragment, wrong-level intervention, incomplete foraminal decompression, root injury, or hematoma. Recurrent symptoms after a pain-free interval suggest new extrusion through the annular defect. Later mechanical pain with translation or progressive foraminal collapse may represent instability or degenerative progression rather than simple recurrent herniation. These conditions require different treatments. The principal limitation of current evidence is heterogeneity [5, 11, 16, 20]. UBE terminology is not fully standardized, and studies include different portal configurations, irrigation systems, anesthetic techniques, herniation morphologies, and surgeon experience. Follow-up is often limited, and many studies originate from high-volume Asian centers with substantial endoscopic expertise. Cost, training resources, equipment availability, and reproducibility in lower-volume institutions require further evaluation. Future research should include multicenter registries that record disc morphology, portal trajectory, irrigation parameters, extent of bone removal, surgeon experience, neurological outcomes, residual compression, recurrence, return to work, and cost. Randomized trials should distinguish primary paracentral herniation from migrated, foraminal, far-lateral, upper-lumbar, and recurrent disease. Radiological preservation of the facet and multifidus should be correlated with long-term axial pain and instability.

Conclusion. Unilateral biportal endoscopic discectomy is a versatile tissue-preserving surgical platform for lumbar disc herniation. Randomized and comparative evidence indicates that it provides pain relief, functional improvement, and neurological recovery comparable to microscopic discectomy, with potential reductions in early approach-related morbidity, blood loss, and hospitalization. The effectiveness of UBE is not guaranteed by the endoscope or by two small portals. Successful treatment requires precise correlation between clinical radiculopathy and imaging, morphology-specific portal selection, controlled creation of the working space, low-pressure irrigation with unobstructed outflow, complete neural decompression, preservation of the facet–lamina complex, and meticulous hemostasis. The proposed UBE-MAP framework integrates Morphology, Access, and Preservation. It separates standard paracentral herniation from migrated, foraminal, extraforaminal, upper-lumbar, and recurrent lesions and assigns each phenotype an appropriate operative corridor and structural preservation objective. This framework may reduce incomplete decompression, unnecessary facetectomy, neural manipulation, irrigation-related complications, recurrence, and delayed instability. UBE should be introduced through structured training and progressive case selection. Standard single-level paracentral herniations are appropriate early cases, whereas calcified, recurrent, upper-lumbar, far-lateral, and very highly migrated fragments should be reserved for surgeons with established biportal proficiency. Further multicenter randomized studies and long-term registries are required to define cost-effectiveness, learning standards, recurrence patterns, and the durability of anatomical preservation.

References

1. Park SM, Lee HJ, Park HJ, Choi JY, Kwon O, Lee S, et al. Biportal endoscopic versus microscopic discectomy for lumbar herniated disc: a randomized controlled trial. Spine J. 2023;23(1):18–26. doi:10.1016/j.spinee.2022.09.003.
2. Park SM, Song KS, Ham DW, Kang MS, You KH, Park CK, et al. Comparing the efficacy and safety of biportal endoscopic discectomy with microscopic discectomy for lumbar herniated intervertebral disc: a multicentre, prospective, assessor-blinded, randomized controlled trial. Bone Joint J. 2025;107-B(5):529–539.
3. Park SM, Song KS, Ham DW, Kim HJ, Kang MS, You KH, et al. Safety profile of biportal endoscopic spine surgery compared to conventional microscopic approach: a pooled analysis of 2 randomized controlled trials. Neurospine. 2024;21(4):1190–1198. doi:10.14245/ns.2448718.359.
4. Kang T, Park SY, Kang CH, Lee SH, Park JH, Suh SW. Clinical comparison of unilateral biportal endoscopic technique versus open microdiscectomy for single-level lumbar discectomy: a multicenter, retrospective analysis. J Orthop Surg Res. 2018;13:22. doi:10.1186/s13018-018-0725-1.
5. Choi KC, Shim HK, Hwang JS, Shin SH, Lee DC, Jung HH, et al. Comparison of surgical invasiveness between microdiscectomy and three different endoscopic discectomy techniques for lumbar disc herniation. World Neurosurg. 2018;116:e750–e758.
6. Choi JY, Park HJ, Park SM, You KH, Kang MS, Hwang JY, et al. Biportal endoscopic discectomy versus tubular microscopic discectomy for treating single-level lumbar disc herniation in obese patients: a multicenter retrospective analysis. Eur Spine J. 2023.
7. Ham DW, Lee J, Kwon BT, Yoo Y, Park SM, Song KS. Comparison of postoperative epidural hematoma formation between biportal endoscopic spine surgery and conventional microscopic surgery: a randomized controlled trial. Int J Spine Surg. 2024;18(5):533–539. doi:10.14444/8578.

8. Yu D, Jeon I, Kim SW. Real-time water pressure monitoring in unilateral biportal endoscopic spine surgery. Neurospine. 2025;22(3):812–818. doi:10.14245/ns.2550648.324.
9. Kang MS, Park HJ, Hwang JH, Kim JE, Choi DJ, Chung HJ, et al. Water dynamics in unilateral biportal endoscopic spine surgery and its related factors: an in vivo proportional regression and proficiency-matched study. World Neurosurg. 2021.
10. Yin J, Jiang Y, Zheng Y, et al. Comparative study between unilateral biportal endoscopic discectomy and percutaneous interlaminar endoscopic discectomy for the treatment of L5/S1 disc herniation. World Neurosurg. 2025.
11. Shao J, et al. Unilateral biportal endoscopy for upper lumbar disc herniation. Pol Przegl Chir. 2025.
12. Liu C, et al. Unilateral biportal endoscopic discectomy via the translaminar approach for highly upward-migrated lumbar disc herniation: a technical note and preliminary treatment outcomes. 2024.
13. Yuan S, et al. Clinical outcomes of unilateral biportal endoscopic discectomy in patients with far-lateral lumbar disc herniation. 2025.
14. Yu H, Zhao Q, Lv J, Liu J, Zhu B, Chen L, et al. Unintended dural tears during unilateral biportal endoscopic lumbar surgery: incidence and risk factors. Acta Neurochir. 2024;166(1):95. doi:10.1007/s00701-024-05965-8.
15. Soliman HM. Complications of unilateral biportal endoscopic lumbar discectomy: a systematic review. World Neurosurg. 2023.
16. Ju CI, Lee SM. Complications and management of endoscopic spinal surgery. Neurospine. 2023;20:56–77.
17. Kim JE, Choi DJ, Park EJ. Risk factors of postoperative spinal epidural hematoma after biportal endoscopic spinal surgery. World Neurosurg. 2019.
18. Demirtaş OK, Özer Mİ. Unilateral biportal endoscopic discectomy for lumbar disc herniation: learning curve analysis with CUSUM analysis and clinical outcomes. Clin Neurol Neurosurg. 2025;249:108755. doi:10.1016/j.clineuro.2025.108755.
19. Shao J, et al. Learning curve and complications of unilateral biportal endoscopic surgery. J Orthop Surg Res. 2024.
20. Arunakul R, et al. Efficacy of epidural steroid in controlling pain after unilateral biportal endoscopic discectomy for single-level lumbar disc herniation: a randomized, double-blind, placebo-controlled trial. Int J Spine Surg. 2025;19(1):11–18. doi:10.14444/8655.
21. Shin JJ, et al. Radiologic and clinical predictors of reoperation following unilateral biportal endoscopic lumbar surgery. Yonsei Med J. 2026.
22. Han SY, et al. Feasibility of recurrent herniation surgery with biportal endoscopic surgery. 2026.
23. Lee DG, Park CK, Jang JW. Rationale and advantages of endoscopic spine surgery. Int J Spine Surg. 2021;15(Suppl 3):S11–S20.
24. Wakao N, et al. Technical development and anatomical applications of biportal endoscopic lumbar surgery. Neurospine. 2023.
25. De Antoni DJ, Claro ML, Poehling GG, Hughes SS. Translaminar lumbar epidural endoscopy: anatomy, technique, and indications. Arthroscopy. 1996;12(3):330–334.
26. Fisher, C. G., Dvorak, M. F., Fehlings, M. G., & Rampersaud, Y. R. (2010). Spine surgery: Current concepts and evidence-based practice. *The Spine Journal, 10*(5), 394–396.
27. Mummaneni, P. V., Kaiser, M. G., Matz, P. G., Anderson, P. A., Groff, M. W., Heary, R. F., Holly, L. T., Ryken, T. C., Choudhri, T. F., Vresilovic, E. J., & Resnick, D. K. (2009). Cervical surgical techniques for the treatment of cervical spondylotic myelopathy. *Journal of Neurosurgery: Spine, 11*(2), 130–141.
28. Усачёв, Д. Ю. (Ред.). (2022). *Нейрохирургия = Neurosurgery: Национальное руководство* (Т. 1). Москва: Национальный медицинский исследовательский центр нейрохирургии имени академика Н. Н. Бурденко.

29. Усачёв, Д. Ю. (Ред.). (2023). *Нейрохирургия = Neurosurgery: Национальное руководство* (Т. 3). Москва: Национальный медицинский исследовательский центр нейрохирургии имени академика Н. Н. Бурденко.
30. Усачёв, Д. Ю. (Ред.). (2025). *Нейрохирургия: Национальное руководство* (Т. 4). Москва: ГЭОТАР-Медиа.
31. Гусев, Е. И., Коновалов, А. Н., & Скворцова, В. И. (2022). *Неврология и нейрохирургия: Учебник: В 2 т.* (5-е изд., Т. 1). Москва: ГЭОТАР-Медиа.