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Review

Unilateral Biportal Endoscopy in Spinal Surgery: Current Evidence, Surgical Techniques, Clinical Outcomes, Complications, Learning Curve, and Future Perspectives

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Abstract

Unilateral biportal endoscopy (UBE), also termed biportal endoscopic spine surgery, has emerged as a versatile minimally invasive platform for lumbar decompression, discectomy, and interbody fusion. Separate viewing and working portals combine endoscopic visualization with independent manipulation of conventional spinal instruments.

Methods. A focused narrative review of PubMed-indexed randomized controlled trials, comparative cohort studies, systematic reviews, meta-analyses, and recent studies was undertaken. Evidence was synthesized regarding technical principles, indications, lumbar decompression and discectomy, foraminal disease, lumbar interbody fusion, cervical applications, complications, learning curve, and comparisons with microscopic and uniportal endoscopic surgery.

Results. Current evidence supports UBE as an effective option for lumbar disc herniation and degenerative lumbar spinal stenosis. Randomized trials demonstrate clinical outcomes comparable to microscopic discectomy and decompression. Potential perioperative advantages include reduced early surgical-site pain, lower muscle injury markers, less blood loss, and shorter hospitalization. Meta-analyses comparing UBE with uniportal endoscopy generally show comparable pain, disability, and complication outcomes, although perioperative advantages vary. UBE-based lumbar interbody fusion

demonstrates comparable fusion and complication rates to minimally invasive fusion techniques, while cervical applications remain less mature. Dural tear is among the most consistently reported complications. Contemporary learning-curve studies commonly identify approximately 30–40 cases as a proficiency range, although thresholds vary by procedure and endpoint.
Conclusions. UBE should be regarded as a versatile minimally invasive platform rather than simply an alternative to microscopic or uniportal surgery. The strongest evidence supports lumbar decompression and discectomy, whereas fusion and cervical applications remain promising but require higher-quality prospective evidence. Patient selection, adequate decompression, preservation of spinal stability, irrigation control, and surgeon experience remain the principal determinants of safety and outcome.

Keywords: unilateral biportal endoscopy, biportal endoscopic spine surgery, lumbar disc herniation, lumbar spinal stenosis, endoscopic spine surgery, lumbar interbody fusion, learning curve.

1. Introduction

Minimally invasive spinal surgery has evolved substantially over the last two decades. Traditional open spinal procedures provide reliable neural decompression and stabilization, but extensive paraspinal muscle dissection may increase postoperative pain, blood loss, and recovery time. Tubular and microscopic techniques were developed to reduce approach-related morbidity while maintaining adequate decompression. Full-endoscopic spinal surgery subsequently introduced smaller working corridors. Uniportal techniques allow decompression and discectomy through a single channel, but simultaneous passage of the endoscope and instruments can constrain working angles, particularly during extensive bony decompression or fusion.

Unilateral biportal endoscopy (UBE), also referred to as biportal endoscopic spine surgery (BESS), uses separate viewing and working portals. This arrangement permits independent camera and instrument manipulation and combines magnified endoscopic visualization with the freedom to use conventional spinal instruments [1–5]. Early reports focused on lumbar stenosis and foraminal disease, followed by applications in disc herniation, bilateral decompression, recurrent herniation, and lumbar interbody fusion [6–15].

The expanding comparative literature permits a more mature assessment. Current evidence does not consistently demonstrate superior long-term patient-reported outcomes over microscopic or uniportal techniques. Rather, UBE may offer a combination of adequate decompression, limited approach-related tissue injury, broad visualization, and instrument versatility. This review summarizes current evidence, technical principles, indications, outcomes, complications, learning curve, and future applications.

2. Materials and methods

Search Period

The review covered publications from 2018 to the present, corresponding to the period during which contemporary unilateral biportal endoscopic spinal surgery techniques and their clinical applications have been increasingly reported in the international literature. Earlier seminal publications were also considered, where appropriate, to provide historical context and describe the evolution and fundamental technical principles of biportal endoscopic spinal surgery.

Search Strategy

The search strategy combined controlled vocabulary terms, where applicable, with free-text keywords related to unilateral biportal endoscopic spinal surgery, spinal disorders, surgical procedures, clinical outcomes, and safety.

The principal search terms included "unilateral biportal endoscopy," "unilateral biportal endoscopic," "biportal endoscopic spine surgery," "biportal endoscopic spinal surgery," "biportal endoscopic surgery," "UBE," "BESS," "endoscopic spine surgery," "lumbar spinal stenosis," "lumbar disc herniation," "lumbar decompression," "lumbar discectomy," "foraminotomy," "lumbar interbody fusion," "transforaminal lumbar interbody fusion," "cervical endoscopy," "complications," "dural tear," and "learning curve."

Boolean operators (AND and OR), quotation marks, truncation, and database-specific field tags were employed, as appropriate, to maximize search sensitivity while maintaining clinical relevance.

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Eligibility Criteria

Publications were considered eligible for inclusion if they addressed the clinical applications, technical characteristics, safety, effectiveness, or learning curve of unilateral biportal endoscopy (UBE) in spinal surgery.

Eligible study designs included randomized controlled trials, prospective and retrospective comparative cohort studies, observational clinical case series, systematic reviews, meta-analyses, and clinically relevant technical studies.

Studies were considered relevant if they evaluated one or more of the following areas:

-Lumbar disc herniation and endoscopic discectomy;

-Degenerative lumbar spinal stenosis, including central canal, lateral recess, foraminal, and extraforaminal stenosis;

-Unilateral laminotomy for bilateral decompression;

-Recurrent lumbar disc herniation.

3. Results

Technical Principles

The defining feature is separation of the viewing and working portals. The endoscope can be moved within the saline-filled surgical field while instruments are manipulated independently through the working portal. This permits dynamic visualization of the lamina, ligamentum flavum, facet joint, lateral recess, foramen, and neural structures [2–5].

Continuous saline irrigation maintains visualization but creates procedure-specific safety considerations. Excessive pump pressure, inadequate outflow, and prolonged irrigation may contribute to epidural or soft-tissue fluid accumulation. Controlled inflow and outflow and meticulous hemostasis are therefore fundamental [16].

Conventional Kerrison rongeurs, punches, curettes, pituitary rongeurs, and high-speed drills can be used through the working portal. This may facilitate transition from microscopic surgery and reduce reliance on proprietary endoscopic instruments.

Indications and Patient Selection

The strongest evidence concerns degenerative lumbar disease, including disc herniation, central and lateral recess stenosis, foraminal stenosis, extraforaminal stenosis, unilateral laminotomy for bilateral decompression, selected recurrent disc herniation, degenerative spondylolisthesis, and selected interbody fusion procedures.

UBE does not eliminate the fundamental principles of spinal surgery. Marked instability, severe deformity, infection, tumor, or pathology requiring reconstruction beyond the surgeon's expertise may be inappropriate. The surgical approach should therefore be determined by pathology and the required decompression or reconstruction rather than by the availability of an endoscopic platform.

Lumbar Disc Herniation

Lumbar disc herniation is one of the best studied indications. Comparative studies report similar long-term VAS, ODI, and MacNab outcomes between UBE and microscopic or open discectomy, with potential reductions in blood loss and hospitalization [8,17].

A prospective randomized multicenter non-inferiority trial of 64 patients demonstrated that UBE discectomy was non-inferior to microscopic discectomy at 12 months; early surgical-site pain and creatine phosphokinase elevation were lower in the UBE group [18]. Systematic reviews have similarly shown broadly comparable clinical outcomes without convincing evidence of long-term functional superiority [19].

Lumbar Spinal Stenosis

UBE is well suited to lumbar stenosis because the surgeon can directly visualize the lamina, ligamentum flavum, lateral recess, facet joint, and neural structures. In a randomized trial comparing UBE decompressive laminectomy with microscopic decompression, no significant difference was found in one-year ODI, VAS, EQ-5D, painDETECT, operative time, hospital stay, or perioperative complications [20].

Systematic reviews demonstrate significant improvements in pain and disability after UBE, while differences from comparator techniques tend to diminish at longer follow-up [21,22]. The principal evidence-based argument is therefore comparable effectiveness with possible reductions in approach-related morbidity rather than proven long-term functional superiority.

Bilateral Decompression Through a Unilateral Approach

Unilateral laminotomy for bilateral decompression is an attractive UBE application. After ipsilateral decompression, the endoscope and instruments can be directed across the midline to address the contralateral lateral recess. This may reduce bilateral muscle dissection. Nevertheless, excessive facet resection can cause iatrogenic instability regardless of the surgical approach.

Foraminal and Extraforaminal Stenosis

Foraminal disease is technically demanding because the exiting nerve root lies within a confined space. UBE provides an angled, magnified view while allowing independent manipulation of drills and Kerrison punches [4]. A clinical series addressing L5–S1 extraforaminal stenosis reported significant

improvements in pain and ODI at one year, but the small retrospective evidence base limits conclusions regarding superiority [23].

Recurrent Lumbar Disc Herniation

UBE may provide magnified visualization of scar tissue and neural structures while limiting additional muscle disruption. A recent comparative study suggested favorable outcomes with UBE discectomy compared with microscopic discectomy in recurrent disc herniation [24]. However, altered tissue planes and epidural fibrosis make revision surgery inherently challenging, and surgeon experience remains particularly important.

UBE Compared With Microscopic Surgery

The strongest comparative evidence comes from randomized trials. In lumbar stenosis, UBE and microscopic decompression produced comparable one-year functional and pain outcomes [20]. In lumbar disc herniation, UBE was shown to be non-inferior to microscopic discectomy [18]. These findings support UBE as an effective alternative, but do not establish universal superiority in long-term patient-reported outcomes. The principal comparative evidence is summarized in Table 1.

Table 1 - Summary of principal comparative evidence for UBE in lumbar degenerative disease

Indication	Comparator	Main evidence	Overall interpretation
Lumbar disc herniation	Microscopic discectomy	Randomized trial; non-inferiority at 12 months	Comparable clinical efficacy; possible early tissue-trauma advantage
Lumbar spinal stenosis	Microscopic decompression	Randomized trial; no significant 1-year ODI/VAS difference	Reasonable minimally invasive alternative
Lumbar stenosis	Uniportal endoscopy	Meta-analyses	Generally comparable pain, disability, and complications
Lumbar interbody fusion	MIS-TLIF	Systematic reviews/meta-analyses	Comparable fusion and complications; possible lower blood loss/hospital stay
Lumbar interbody fusion	Uniportal Endo-TLIF	Systematic review/meta-analysis	Generally comparable outcomes; evidence remains limited

UBE Compared With Uniportal Endoscopy

Meta-analyses generally demonstrate comparable postoperative VAS, ODI, and complication rates between UBE and uniportal full-endoscopic procedures [25–27]. Perioperative differences are inconsistent and likely reflect differences in pathology, technique, surgeon experience, and learning curve. Neither approach can currently be considered universally superior.

UBE and Lumbar Interbody Fusion

UBE-TLIF expands the indications of biportal surgery. Disc and endplate preparation can be performed under direct visualization while neural decompression is achieved through a limited corridor [7,28]. Meta-analyses show comparable fusion and complication rates to MIS-TLIF, with potential reductions in blood loss and hospital stay but sometimes longer operative time [29–31].

The evidence remains dominated by retrospective comparative studies. UBE-TLIF should therefore be regarded as an alternative minimally invasive fusion strategy rather than a proven replacement for established MIS-TLIF.

UBE-TLIF Versus Uniportal Endoscopic TLIF

A meta-analysis comparing UBE-TLIF with uniportal Endo-TLIF found generally comparable clinical outcomes, blood loss, hospital stay, and complications, with differences in operative time and pooled fusion rate varying among studies [32]. Network meta-analysis has likewise not identified a single universally dominant endoscopic fusion approach [33].

Complications

Dural tear is among the most consistently reported complications. Systematic reviews of UBE discectomy and stenosis surgery report overall complication rates broadly in the 5–8% range, with dural tear commonly reported between approximately 2–5% [34–36]. Variability reflects heterogeneous definitions, surgeon experience, procedure complexity, and follow-up.

Other complications include postoperative epidural hematoma, incomplete decompression, recurrent disc herniation, transient dysesthesia or weakness, infection, and rare nerve-root injury. Complication rates tend to decline with experience. A summary of reported complications is provided in Table 2.

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Table 2 - Reported complication profile of UBE in contemporary literature

Complication	Reported pattern	Clinical consideration
Dural tear	Commonly reported major complication; ~2–5% in pooled lumbar series	Risk increases with severe stenosis, revision surgery, and early learning phase
Postoperative epidural hematoma	Uncommon	Meticulous hemostasis and neurological surveillance are essential
Incomplete decompression	Uncommon but important	Adequate visualization and confirmation are required
Recurrent disc herniation	Variable; generally low	Available evidence suggests broadly comparable recurrence
Transient dysesthesia/neurological symptoms	Uncommon	Careful nerve-root handling is required
Infection	Rare	Standard infection-prevention measures apply
Irrigation-related problems	Rare but procedure-specific	Controlled pump pressure and unobstructed outflow are important

Irrigation-Related Safety Considerations

Irrigation is integral to UBE but creates procedure-specific safety considerations. Experimental and clinical work demonstrates the importance of controlling irrigation pressure and maintaining adequate outflow [16]. Safe practice requires controlled inflow, unobstructed outflow, avoidance of excessive pump pressure, effective hemostasis, and minimization of unnecessary operative time.

Learning Curve

The learning curve is a major consideration. Surgeons must develop endoscopic spatial orientation, camera manipulation, independent instrument control, irrigation management, endoscopic hemostasis, and safe bony decompression. Consecutive-series studies demonstrate progressive reductions in operative time and complications with experience [37].

A 2024 meta-analysis estimated a mean proficiency threshold of approximately 37.5 cases, with reported thresholds ranging from 14 to 58 [38]. A 2025 systematic review involving 13 studies and 1,217 patients estimated an average cutoff of approximately 32 cases and demonstrated reductions in operative time and complications after the proficiency threshold [39]. A comprehensive 2026 systematic review reported a median threshold of approximately 37.5 cases for biportal procedures [40]. These estimates should be interpreted as ranges rather than universal requirements. Key learning-curve findings are summarized in Table 3.

Table 3 - Learning-curve evidence for UBE/endoscopic spine surgery

Study/review	Year	Evidence base	Approximate threshold	Principal finding
Xu et al.	2022	197 consecutive UBE cases	Procedure-specific transition points	Efficiency and safety improved with experience
Liu et al.	2024	Meta-analysis	~37.5 cases	Substantial learning effect across UBE procedures
Peng et al.	2025	13 studies; 1,217 patients	~32 cases	Mastery associated with shorter operative time and fewer complications
Chan et al.	2026	29 learning-curve studies	Median ~37.5 cases for biportal procedures	Biportal learning curve is meaningful and outcome-dependent
Egu et al.	2026	Systematic review of endoscopic lumbar interbody fusion	~19–40+ cases depending on endpoint	Safety-based proficiency may require more experience than time-based proficiency

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Training Strategy

A structured progression may begin with single-level lumbar disc herniation, followed by unilateral decompression, bilateral decompression and foraminal disease, recurrent pathology, and finally fusion. Progression should be based on technical competence and safety rather than case number alone. Recent learning-curve analyses of endoscopic lumbar interbody fusion suggest that safety-based proficiency may require more experience than time-based proficiency [41].

Cervical UBE

Cervical UBE, particularly posterior cervical foraminotomy, is an expanding application. A 2024 systematic review and meta-analysis reported significant improvement in NDI, neck pain, and arm pain, with an overall complication rate of approximately 6% and dural tear as the most common reported complication [42].

Comparative studies suggest outcomes similar to full-endoscopic posterior cervical foraminotomy [43].

Systematic reviews of cervical spondylosis report meaningful clinical improvement but emphasize the limited size and heterogeneity of the evidence [44]. More recent cervical laminectomy and bilateral foraminotomy series are encouraging, but cervical UBE remains less mature than the lumbar literature [45].

Thoracic Applications

Thoracic UBE remains considerably less developed. The thoracic canal is relatively narrow and the spinal cord has limited tolerance for manipulation. Current evidence consists mainly of small series and technical reports; thoracic UBE should therefore be considered an advanced application for experienced endoscopic surgeons.

Special and Emerging Applications

UBE has been applied to high-grade migrated disc herniation, adjacent segment disease, and navigation-assisted fusion [11,46–48]. Integration with O-arm navigation, robotics, three-dimensional imaging, and augmented reality may expand indications and potentially reduce the learning curve.

Advantages of UBE

Potential advantages include panoramic visualization, independent camera and instrument manipulation, broad working freedom, use of conventional instruments, reduced paraspinal muscle dissection, small skin incisions, reduced blood loss, potentially less postoperative pain, and the ability to perform extensive decompression or fusion through limited access. These should be interpreted as potential benefits rather than universally demonstrated superiority.

Limitations of the Current Evidence

Much of the literature remains retrospective, with substantial heterogeneity in portal location, endoscope characteristics, irrigation systems, decompression technique, rehabilitation, surgeon experience, and outcome assessment. Many studies originate from high-volume centers, limiting generalizability. Long-term evidence remains insufficient regarding recurrence, postoperative instability, adjacent segment disease, reoperation, return to work, and cost-effectiveness.

Cost-Effectiveness

UBE may use conventional arthroscopic and spinal instruments and potentially reduce dependence on proprietary systems. Conversely, operating-room time, irrigation equipment, disposable devices, navigation, and training may offset theoretical savings. Formal cost-effectiveness analyses are required.

Future Perspectives

Future research should prioritize multicenter randomized trials, standardized UBE techniques, standardized complication definitions, long-term follow-up, cost-effectiveness, return-to-work outcomes, objective paraspinal muscle assessment, standardized learning-curve metrics, and integration with navigation and robotic systems. Artificial intelligence may eventually assist anatomical recognition, trajectory planning, and intraoperative decision support.

4. Conclusion

UBE has evolved into a versatile minimally invasive platform for spinal surgery. The strongest evidence supports lumbar disc herniation and degenerative lumbar stenosis, for which randomized trials demonstrate clinical outcomes comparable to microscopic surgery with potential perioperative advantages. UBE-TLIF has promising fusion and complication profiles but requires stronger prospective evidence. Cervical UBE is promising but remains less mature.

Contemporary learning-curve evidence suggests that approximately 30–40 cases are commonly required for meaningful proficiency, although thresholds vary by procedure and safety endpoint. UBE should not be viewed simply as a competitor to microscopic or uniportal surgery; it is an additional platform whose value depends on patient selection, adequate decompression, preservation of stability, irrigation control, and surgeon experience.

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Not applicable. This article is a narrative review of previously published literature and does not involve human participants or identifiable patient data.

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Омыртқа хирургиясындағы біржақты бипорталды эндоскопия: Бүгінгі ғылыми дәлелдер, хирургиялық әдістер, клиникалық нәтижелер, асқынулар, меңгеру қисығы және болашақ даму перспективалары

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Түйіндеме

Біржақты бипорталды эндоскопия (ағылш.: Unilateral biportal endoscopy (UBE)), сонымен қатар омыртқаның бипорталды эндоскопиялық хирургиясы ретінде белгілі әдіс бел омыртқасы деңгейінде декомпрессия, дискэктомия және омыртқааралық денелерді біріктіру операцияларын орындауға арналған әмбебап минималды инвазиялық хирургиялық тәсіл ретінде қалыптасты. Бақылау және жұмыс порталдарының бөлек орналасуы эндоскопиялық визуализацияны дәстүрлі омыртқа хирургиялық құралдарын тәуелсіз басқару мүмкіндігімен ұштастырады.

Әдістері. PubMed дерекқорында индекстелген рандомизацияланған бақыланатын зерттеулерге, салыстырмалы когорттық зерттеулерге, жүйелі шолуларға, мета-талдауларға және соңғы жылдардағы ғылыми жарияланымдарға бағытталған нарративті әдеби шолу жүргізілді. Хирургиялық техниканың негізгі қағидаттары, қолдану көрсетілімдері, бел омыртқасы деңгейіндегі декомпрессия мен дискэктомия, фораминалды патологиялар, бел омыртқасының денеаралық спондилодезі, мойын омыртқасы деңгейіндегі қолданылуы, асқынулар, әдісті меңгеру қисығы, сондай-ақ микроскопиялық және UBE әдісімен салыстырмалы нәтижелер бойынша ғылыми деректер жинақталып талданды.

Нәтижелері. Қазіргі ғылыми деректер UBE әдісінің бел омыртқасының диск жарығын және дегенеративті бел омыртқа өзегінің стенозын емдеудегі тиімділігін растайды. Рандомизацияланған зерттеулер UBE әдісінің клиникалық нәтижелері микроскопиялық дискэктомия және декомпрессия нәтижелерімен салыстырмалы екенін көрсетеді. Периоперациялық кезеңдегі ықтимал артықшылықтарына операция аймағындағы ерте кезеңдегі ауырсынудың азаюы, бұлшықет тінінің зақымдану маркерлерінің төмендеуі, қан

жоғалтудың азаюы және ауруханада жату ұзақтығының қысқаруы жатады. UBE мен бірпорталды эндоскопияны салыстырған мета-талдаулар ауырсыну деңгейі, функционалдық шектелу және асқынулар жиілігі бойынша нәтижелердің жалпы алғанда ұқсас екенін көрсетеді, алайда периоперациялық артықшылықтар әртүрлі зерттеулерде біркелкі емес. UBE көмегімен орындалатын бел омыртқасының денеаралық спондилодезі минималды инвазиялық спондилодез әдістерімен салыстырғанда сүйектік бітісу және асқынулар жиілігі бойынша ұқсас нәтижелер береді. Ал мойын омыртқасы деңгейіндегі қолданылуына қатысты дәлелдер әлі де жеткіліксіз. Ең жиі сипатталатын асқынулардың бірі — қатты ми қабығының жыртылуы. Қазіргі зерттеулер хирургиялық біліктіліктің қалыптасуы үшін шамамен 30–40 ота қажет екенін көрсетеді. Дегенмен бұл көрсеткіш ота түріне және бағалау критерийлеріне байланысты өзгереді.

Қорытынды. UBE әдісін микроскопиялық немесе бірпорталды хирургияға балама әдіс ретінде ғана емес, омыртқа хирургиясындағы әмбебап минималды инвазиялық хирургиялық тәсіл ретінде қарастыру қажет. Ең сенімді ғылыми дәлелдер бел омыртқасы деңгейіндегі декомпрессия мен дискэктомияға қатысты жинақталған. Ал омыртқа денесі аралық спондилодез және мойын омыртқасы деңгейіндегі қолданылуы перспективалы болғанымен, жоғары сапалы проспективті зерттеулерді қажет етеді. Науқастарды дұрыс іріктеу, жеткілікті декомпрессияны қамтамасыз ету, омыртқа тұрақтылығын сақтау, ирригацияны бақылау және хирургтің тәжірибесі отаның қауіпсіздігі мен клиникалық нәтижелерін анықтайтын негізгі факторлар болып табылады.

Түйін сөздер: біржақты бипорталды эндоскопия, омыртқаның бипорталды эндоскопиялық хирургиясы, бел омыртқасының диск жарығы, бел омыртқа өзегінің стенозы, омыртқаның эндоскопиялық хирургиясы, бел омыртқасының денеаралық спондилодезі, әдісті меңгеру қисығы.

Односторонняя бипортальная эндоскопия в хирургии позвоночника: Современные научные данные, хирургические методики, клинические результаты, осложнения, кривая обучения и перспективы развития

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Резюме

Односторонняя бипортальная эндоскопия (англ.: Unilateral biportal endoscopy (UBE)), также известная как бипортальная эндоскопическая хирургия позвоночника, представляет собой универсальный малоинвазивный хирургический подход, применяемый для декомпрессии, дискэктомии и межтелового спондилодеза на поясничном уровне. Использование отдельных визуализационного и рабочего порталов позволяет сочетать эндоскопическую визуализацию с независимым манипулированием традиционными хирургическими инструментами для операций на позвоночнике.

Методы. Проведен целенаправленный нарративный обзор литературы, включающий рандомизированные контролируемые исследования, сравнительные когортные исследования,

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систематические обзоры, метаанализы и современные научные публикации, индексируемые в базе данных PubMed. Выполнен качественный синтез научных данных, касающихся технических принципов метода, показаний к его применению, поясничной декомпрессии и дискэктомии, фораминальной патологии, поясничного межтелового спондилодеза, применения в шейном отделе позвоночника, осложнений, кривой обучения, а также сравнительной эффективности относительно микроскопической и однопортальной эндоскопической хирургии.

Результаты. Современные научные данные подтверждают эффективность UBE при лечении грыж поясничных межпозвонковых дисков и дегенеративного стеноза поясничного отдела позвоночного канала. Рандомизированные исследования демонстрируют клинические результаты, сопоставимые с микроскопической дискэктомией и декомпрессией. Потенциальные периоперационные преимущества включают уменьшение ранней послеоперационной боли в области хирургического вмешательства, снижение уровня маркеров мышечного повреждения, сокращение интраоперационной кровопотери и продолжительности госпитализации. Метаанализы, сравнивающие UBE с однопортальной эндоскопией, в целом свидетельствуют о сопоставимых результатах в отношении выраженности боли, функциональных ограничений и частоты осложнений, хотя периоперационные преимущества варьируют между исследованиями. Поясничный межтеловой спондилодез с использованием UBE демонстрирует сопоставимые показатели формирования костного сращения и частоты осложнений по сравнению с другими малоинвазивными методиками спондилодеза, тогда как доказательная база применения метода в шейном отделе позвоночника остается менее развитой. Одним из наиболее часто регистрируемых осложнений является повреждение твердой мозговой оболочки. Современные исследования кривой обучения показывают, что для достижения технической компетентности обычно требуется выполнение приблизительно 30–40 операций, однако данный показатель зависит от типа вмешательства и критериев оценки.

Выводы. UBE следует рассматривать не только как альтернативу микроскопической или однопортальной хирургии, но и как универсальный малоинвазивный хирургический подход в современной хирургии позвоночника. Наиболее убедительная доказательная база сформирована в отношении поясничной декомпрессии и дискэктомии. Применение метода для межтелового спондилодеза и операций на шейном отделе позвоночника представляется перспективным, однако требует проведения проспективных исследований более высокого методологического качества. Основными факторами, определяющими безопасность вмешательства и клинические результаты, остаются правильный отбор пациентов, обеспечение адекватной декомпрессии, сохранение стабильности позвоночника, контроль ирригации и опыт хирурга.

Ключевые слова: односторонняя бипортальная эндоскопия, бипортальная эндоскопическая хирургия позвоночника, грыжа поясничного межпозвонкового диска, поясничный спинальный стеноз, эндоскопическая хирургия позвоночника, поясничный межтеловой спондилодез, кривая обучения.