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Laparoscopic management of endometriosis; new techniques and clinical outcomes

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Abstract

Laparoscopic surgery remains the gold standard for the diagnosis and management of endometriosis, offering both therapeutic and diagnostic advantages in a minimally invasive setting. Recent advances in surgical techniques and perioperative strategies have significantly improved the precision and outcomes of laparoscopic interventions. Recent evidence indicates that these refined techniques are associated with improved clinical outcomes, including sustained pain relief, enhanced fertility rates, and improved quality of life. The role of individualized surgical planning, guided by lesion phenotype and patient-specific factors, has gained increasing importance in optimizing therapeutic success. Additionally, the integration of laparoscopic surgery with adjunctive hormonal therapies and multidisciplinary care models contributes to reducing recurrence rates and improving long-term disease control. Despite these advances, challenges remain, including variability in surgical expertise, heterogeneity in disease presentation, and inconsistencies in outcome reporting across studies. Recurrence and persistent symptoms continue to affect a subset of patients, highlighting the need for standardized protocols and long-term follow-up. Accordingly, complications and recurrence are still important considerations. More extensive disease tends to require longer operations and is associated with higher conversion and complication rates, especially in stage 3–4 endometriosis. Even when surgery is technically successful, endometriosis can recur, and many authors now emphasize combining surgery with postoperative hormonal suppression when appropriate to reduce recurrent symptoms and lesion activity. This state has encouraged a more individualized model in which the surgical plan is balanced against the patient's pain burden, fertility goals, ovarian reserve, prior operations, and tolerance for recovery time.

Introduction

Laparoscopic management of endometriosis has evolved from a primarily diagnostic and ablative procedure into a sophisticated, anatomy-based surgical discipline that aims to relieve pain, preserve fertility, restore pelvic function, and reduce the burden of recurrent disease (1). The modern role of laparoscopy in endometriosis must be understood in the context of a heterogeneous chronic inflammatory disorder that can range from superficial peritoneal implants to deep infiltrating lesions involving the ovaries, uterosacral ligaments, bowel, bladder, ureters, and, less commonly, extra-pelvic sites (2). Since symptoms do not always correlate with disease extent, surgical planning requires an individualized assessment that integrates pain severity, infertility, prior treatment response, anatomical distribution, ovarian reserve, and the patient's reproductive preferences (3). Over the past decade, laparoscopic surgery has become more selective and technically refined, with increasing emphasis on complete excision when feasible, preservation of healthy tissue, avoidance of unnecessary thermal injury, and meticulous restoration of anatomy (4). At the same time, there is greater recognition that surgery is only one component of endometriosis care, and the best outcomes often result from integration with medical therapy, fertility management, pelvic pain rehabilitation, and long-term surveillance (5). This overview sought to

Key point

Laparoscopic management of endometriosis has moved beyond simple lesion removal toward more tailored, anatomy-preserving surgery that aims to improve pain, fertility, and long-term quality of life. Recent studies also showed growing interest in robotic assistance, nerve-sparing dissection, fluorescence-guided visualization, and other techniques designed to improve precision in complex disease. Nevertheless, laparoscopy remains the core surgical approach since it allows direct visualization of endometriotic implants, adhesions, and deep infiltrating disease while keeping trauma relatively low compared with open surgery. In practice, surgeons may use excision, ablation, adhesiolysis, bowel shaving, disc excision, segmental resection, and combined procedures depending on lesion depth, location, and fertility goals. The last few years have also brought more discussion of whether surgical planning should be lesion-centered only or whether it should be integrated with pelvic nerve preservation, ovarian reserve protection, and postoperative medical therapy.

consider laparoscopic management of endometriosis, by explaining new techniques and clinical outcomes.

Method of the search

To identify relevant literature for this narrative review, we searched multiple electronic databases, including PubMed, Scopus, Embase, Web of Science, EBSCO, DOAJ, and Google Scholar, using a combination of controlled vocabulary and free-text terms related to endometriosis, laparoscopy, minimally invasive surgical procedures, and surgical techniques. The search strategy was designed to capture studies addressing laparoscopic management of endometriosis, with emphasis on newer operative approaches and reported clinical outcomes.

Application of laparoscopy in endometriosis

The enduring application of laparoscopy lies in its ability to combine diagnosis and treatment through a minimally invasive route (5). Compared with laparotomy, laparoscopy offers superior visualization of the pelvis, magnification of tissue planes, reduced postoperative pain, smaller incisions, faster recovery, and shorter hospital stay. These advantages are particularly relevant in endometriosis, where lesions may be subtle, multifocal, or hidden beneath adhesions (6). Modern high-definition imaging and energy devices have further improved the surgeon's ability to identify peritoneal disease, separate distorted anatomical planes, and treat lesions with greater precision . Yet laparoscopy is not a uniform intervention. The operative approach varies widely depending on the dominant disease phenotype (7). Superficial disease may be treated with excision or ablation, ovarian endometriomas may require cystectomy, drainage, or more conservative techniques, and deep infiltrating endometriosis may call for complex dissection involving ureterolysis, bowel shaving, discoid resection, or segmental resection (8). The best approach is rarely dictated by a single lesion but by the composite burden of disease and the functional risk of surgery (9). A major conceptual shift in recent years has been the increasing preference for excision over simple ablation in many surgical settings (10). Excision allows histological confirmation, removes fibrotic and inflammatory tissue more completely, and may be more suitable for deep lesions or nodules with significant stromal involvement (11). Ablation can still have a role, particularly for selected superficial peritoneal lesions, but it may leave behind deeper disease or induce more collateral thermal damage if not carefully performed. This distinction matters because endometriosis is not just a visible surface phenomenon; it is a chronic inflammatory process embedded within tissue architecture (12). Therefore, complete and anatomically respectful removal is often more important than simply eliminating the most obvious surface lesion. Even so, the superiority of excision over ablation has not been established uniformly across all outcomes, and surgical choice must remain individualized (13). In some patients, especially those with limited superficial disease, the incremental benefit of a more aggressive procedure may be small, while in others with fibrotic, infiltrative disease, incomplete treatment may lead to persistent pain or early recurrence (14). In fact, endometriomas present a particularly important surgical challenge because management can influence both symptom relief and ovarian function (15). Laparoscopic cystectomy has long been considered a standard approach because it reduces recurrence and improves pain control compared with drainage alone (16). However, cystectomy carries a known risk of diminishing ovarian reserve, especially when bilateral endometriomas are present, prior surgery has already reduced reserve, or the cyst wall is densely adherent to normal cortex (17). As a result, current practice increasingly emphasizes careful dissection, minimal bipolar coagulation, and fertility-preserving decision-making. Some surgeons favor alternative or adjunctive approaches, including laser vaporization or sclerotherapy in selected patients, particularly when preservation of ovarian tissue is a high priority. These techniques may reduce damage to ovarian cortex, but they can be associated with different recurrence patterns and may not be appropriate for all lesions (18,19). The central issue is not simply which technique is used, but how the tradeoff between recurrence reduction and ovarian preservation is managed (20). In reproductive-aged patients, especially those planning future conception, the possibility that surgery itself may reduce ovarian reserve can be as clinically significant as the disease being treated (21).

Focus on deep infiltrating endometriosis

Deep infiltrating endometriosis is the area in which laparoscopic surgery has become most technically demanding and most dependent on specialist expertise. These cases often involve the uterosacral ligaments, rectovaginal septum, rectosigmoid colon, pelvic sidewall, ureters, or bladder, and they may be associated with dense fibrosis, anatomic distortion, and adhesions that obscure

normal planes (22). The modern laparoscopic approach seeks not only to remove the disease but also to protect pelvic organ function (23). Nerve-sparing techniques are increasingly used to reduce postoperative bladder dysfunction, bowel dysmotility, and sexual pain. This requires an intimate understanding of pelvic neuroanatomy, especially the relationship between the hypogastric nerves, inferior hypogastric plexus, and adjacent connective tissue planes (24). In skilled hands, careful dissection can significantly improve outcomes by lowering the risk of autonomic injury. However, these procedures are time-consuming and technically unforgiving. They also require a multidisciplinary orientation, especially when bowel or urinary tract involvement is present (25). For that reason, referral to centers with extensive experience in deep infiltrating endometriosis has become an important principle of care (26).

Focus on bowel endometriosis

Bowel endometriosis exemplifies both the promise and the complexity of laparoscopic management. When disease infiltrates the rectosigmoid, surgeons may choose between shaving the serosal or muscular lesion, discoid excision of a localized nodule, or segmental resection for more extensive involvement (27). Each strategy carries distinct benefits and risks. Shaving preserves bowel continuity and may be sufficient for more superficial lesions, but it risks incomplete resection if the lesion is deeply embedded (22). Discoid excision can be useful for isolated nodules, whereas segmental resection is generally reserved for larger, multifocal, or circumferential lesions (27). Although more radical procedures may provide better anatomical clearance, they also increase the risk of anastomotic complications, bowel dysfunction, and longer recovery. Therefore, bowel surgery should be tailored to lesion depth, length, multiplicity, and the surgeon's ability to preserve function (28). A key lesson from recent practice is that the goal should not be maximal resection at all costs, but optimal resection that balances disease control with preservation of bowel integrity and quality of life (29).

Urinary tract involvement in endometriosis

The same logic applies to urinary tract involvement. Ureteral endometriosis, for example, may remain silent until hydronephrosis or renal compromise occurs, and surgery may require ureterolysis, segmental ureterectomy, or reimplantation depending on the extent of fibrosis and intrinsic disease (30). Bladder lesions may be managed by partial cystectomy or full-thickness excision, often in collaboration with urologic surgeons. These situations highlight the importance of preoperative imaging and mapping (31). Magnetic resonance imaging, transvaginal ultrasound by expert operators, and selective use of additional imaging modalities can help define disease burden before surgery, improve counseling, and anticipate the need for multidisciplinary support (31). When anatomy is already severely distorted, the value of imaging lies less in confirming diagnosis and more in guiding operative strategy. Successful laparoscopy in such cases depends on anticipation: knowing where the disease is likely to be, understanding which structures are at risk, and planning the order and extent of dissection before the first incision is made (32).

Laparoscopy as the operative treatment

Although laparoscopy remains the cornerstone of operative treatment, its relationship with diagnosis has changed. Historically, laparoscopy was often required to establish the diagnosis of endometriosis definitively (33). Today, improved imaging and increased clinical recognition allow more confident presumptive diagnosis in many patients, and surgery is increasingly reserved for those with refractory pain, endometriomas, infertility, bowel or urinary tract compromise, or suspected deep disease. This shift has important implications. It means that laparoscopy is no longer used merely to look and see, but also to solve a specific clinical problem (34,35). Consequently, the operative threshold is higher, and the expectation of benefit is more concrete. This also increases the importance of preoperative counseling (36). Patients should understand that surgery is not always curative, that recurrence can occur, that some symptoms may persist because of central sensitization or concomitant pelvic floor dysfunction, and that postoperative medical therapy may still be needed (37). The goal of counseling is not to discourage surgery, but to frame it realistically and to align expectations with the biology of a chronic disease (36).

Clinical outcomes following laparoscopic surgery

Clinical outcomes after laparoscopic surgery vary considerably depending on disease type, surgical technique, and patient selection. Pain relief is often substantial, particularly for dysmenorrhea, dyspareunia, and chronic pelvic pain related to deep disease, but symptom improvement is not universal (38). Some patients experience durable benefit, whereas others have partial response or recurrence months to years later. The literature suggests that the strongest immediate gains are often seen when surgery removes a clear structural pain generator such as an endometrioma, fibrotic nodule, or adhesions tethering mobile pelvic organs (39). In contrast, pain driven by neuropathic mechanisms, visceral hypersensitivity, or coexisting musculoskeletal dysfunction may be less responsive to surgery alone. This is why postoperative assessment should not simply ask whether disease was removed, but whether the patient's functional status improved (22,40). Pain scores, quality of life, return to work, sexual function, bowel and bladder symptoms, and need for further intervention all matter (41). A technically perfect operation does not automatically produce a complete clinical cure if

other pain pathways remain active. Fertility outcomes are among the most important reasons to consider laparoscopic surgery in endometriosis, especially in younger patients with unfulfilled reproductive plans (42). Surgical treatment can improve spontaneous conception rates in selected patients, particularly when adhesions distort pelvic anatomy, endometriomas interfere with oocyte access, or inflammatory disease impairs gamete transport (43). Restoration of anatomical relationships, release of adhesions, and excision of active lesions may increase the likelihood of natural conception. However, fertility surgery must be planned with exceptional caution because the operation itself can affect ovarian reserve and tubal function (44). Cystectomy may lower follicle count, extensive dissection may damage ovarian blood supply, and bowel or ureteral surgery may prolong recovery before conception attempts can resume (45). Therefore, fertility-focused endometriosis surgery should be individualized in light of age, duration of infertility, ovarian reserve markers, partner factors, and whether assisted reproduction may be needed (43). In some patients, surgery is best used to optimize the pelvic environment before assisted reproductive treatment; in others, proceeding directly to in vitro fertilization may be more efficient (46). Laparoscopy remains valuable, but it is not automatically the best route for every fertility scenario. Postoperative management is central to long-term success. Endometriosis is a chronic disease, and removal of lesions does not eliminate the underlying predisposition to recurrence (42). For patients not actively attempting conception, postoperative hormonal suppression can reduce recurrence risk and may prolong symptom relief (47). Options include combined hormonal contraceptives, progestins, levonorgestrel-releasing intrauterine systems, gonadotropin-releasing hormone analogs, and other medical regimens depending on prior response and tolerability (48). The choice of treatment should reflect the severity of symptoms, surgical findings, and long-term reproductive planning. Importantly, surgery and medical therapy should not be seen as opposing strategies (26). In many patients they are complementary. Surgery reduces established structural disease, while hormonal therapy suppresses residual microscopic activity and helps manage ongoing inflammatory stimulation. This combined approach may be particularly useful in deep infiltrating disease or in patients with multiple prior recurrences (22). Follow-up should include assessment of symptom trajectories, medication adherence, fertility plans, and recurrence warning signs. Because endometriosis can evolve over time, postoperative care should be dynamic rather than fixed (49). Technological innovation has played a visible role in the recent evolution of laparoscopic management (50). High-definition and three-dimensional visualization have improved depth perception and tissue discrimination, particularly during complex dissections (51). Advanced bipolar devices, ultrasonic shears, and precise laser systems have expanded the surgeon's armamentarium, allowing better hemostasis and potentially less collateral damage (52). Robotic-assisted surgery has attracted substantial attention because it may facilitate fine movements, tremor filtration, and ergonomic comfort in demanding procedures. This may be especially useful in cases requiring suturing, ureteral dissection, or complex reconstructive steps (53). Nonetheless, the evidence does not yet show consistent superiority of robotic surgery over standard laparoscopy in patient outcomes, and the higher cost and longer setup time may limit widespread adoption (54). The more important principle is not which platform is used, but whether the surgeon can perform the necessary operation safely and completely (55). For many patients, a highly experienced laparoscopic surgeon using conventional instruments may offer better outcomes than a less experienced robotic team. Another promising direction is the use of enhanced visualization and mapping technologies (53). Fluorescence-guided surgery, augmented reality overlays, and intraoperative navigation tools are being explored as ways to identify lesions that are otherwise difficult to detect, especially in diffuse peritoneal disease or fibrotic deep lesions. These tools are still emerging, and their routine role remains uncertain, but they reflect a broader movement toward precision surgery (56). The future of endometriosis surgery may involve better preoperative phenotyping, improved lesion mapping, more individualized selection of surgical energy, and deeper integration between imaging and operative planning (57). Artificial intelligence may eventually help characterize disease burden from imaging studies or predict which patients are most likely to benefit from surgery. At present, however, these technologies should be viewed as adjuncts rather than replacements for expert surgical judgment (58).

Limitations of laparoscopic surgery

Despite these advances, several limitations remain. Laparoscopic surgery is highly operator-dependent, and outcomes can vary substantially by surgical volume, team composition, and referral pattern (59). Complex endometriosis surgery often requires gynecologic surgeons, colorectal surgeons, urologists, radiologists, anesthesiologists, and specialized nursing support working together (60). Inadequate preparation may lead to incomplete resection, avoidable complications, or repeated operations (61). The possibility of recurrence also means that the patient's journey is rarely concluded at the operating table (62). Even after technically successful surgery, ongoing pain can arise from recurrence, adhesions, pelvic floor dysfunction, or non-gynecologic pain syndromes. These realities argue for a broader treatment framework in which surgery is integrated with multimodal pain management, physiotherapy when appropriate, and fertility counseling (63). Endometriosis should be managed as a chronic condition with episodic

surgical intervention rather than as a one-time lesion-removal problem (64). From a clinical perspective, the most important determinants of success are accurate patient selection, expert surgical planning, and realistic outcome goals (1). For patients with severe pain unresponsive to medical therapy, anatomically significant disease, endometriomas, bowel or urinary involvement, or infertility associated with structural distortion, laparoscopy can be highly valuable (65). For patients with minimal symptoms, diffuse pain without a clear surgical target, or strong preference to avoid operative risks, non-surgical treatment may be preferable (62). The decision should be shared, grounded in evidence, and sensitive to the patient's life stage and priorities (62). Younger patients may prioritize fertility preservation, while others may seek pain control and functional recovery above all else (42). The surgeon's role is to translate disease anatomy into a treatment plan that respects these goals while avoiding over-treatment or under-treatment (62).

Conclusion

Laparoscopic management of endometriosis has undergone significant refinement, driven by advances in surgical precision, imaging technologies, and a deeper understanding of disease heterogeneity. Contemporary approaches increasingly emphasize complete lesion excision, nerve-sparing techniques, and individualized surgical planning based on symptomatology and anatomical distribution. Innovations such as high-definition imaging, fluorescence-guided surgery, and robotic-assisted laparoscopy have enhanced the detection of subtle implants and improved operative accuracy, particularly in complex deep infiltrating endometriosis. Clinical outcomes following modern laparoscopic interventions demonstrate substantial improvements in pain relief, fertility restoration, and quality of life, although recurrence remains a persistent challenge. The integration of surgery with adjunctive medical therapies and multidisciplinary care models has further optimized long-term outcomes. Importantly, patient selection and surgeon expertise remain critical determinants of success, underscoring the need for specialized centers and standardized surgical training. Recent findings also highlight the role of minimally invasive techniques in reducing perioperative morbidity, shortening recovery times, and preserving reproductive function. However, variability in surgical approaches and outcome reporting continues to limit comparability across studies, necessitating more robust, standardized clinical trials. In conclusion, laparoscopic surgery remains the cornerstone of endometriosis management, with evolving techniques offering enhanced efficacy and safety. Future directions should focus on precision-based strategies, integration of molecular profiling, and long-term outcome assessment to further refine therapeutic algorithms and improve patient-centered care.

Authors' contribution

Conceptualization: Leili Hafizi, Farzane Hasani, and Najmeh Parsai.
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Writing–original draft: All authors.
Writing–review and editing: All authors.

Conflicts of interest

The authors declare that they have no competing interests.

Ethical issues

Ethical issues (including plagiarism, data fabrication, and double publication) have been completely observed by the authors.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors utilized Perplexity.ai to refine grammar points and language style in writing. Subsequently, the authors thoroughly reviewed and edited the content as necessary, assuming full responsibility for the publication's content.

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