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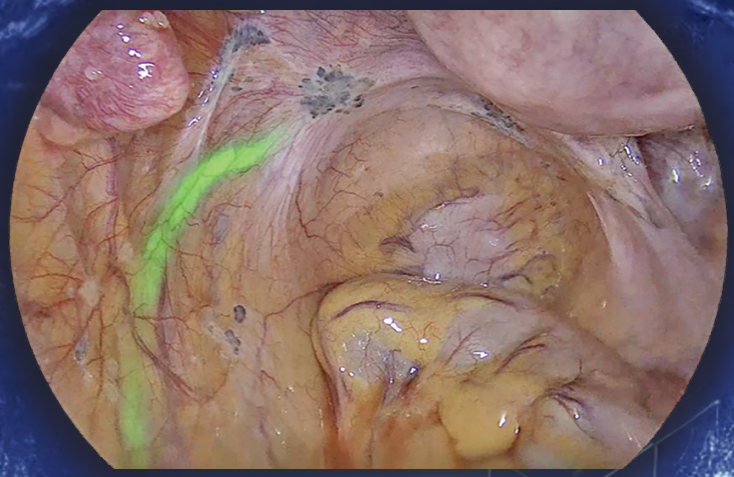

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ERRATUM

EDITORIAL

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Functional intrauterine surgery: restoring uterine potential to enable natural fertility

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Keywords: Intrauterine surgery, hysteroscopy, uterus, fertility

Hysteroscopic surgery has long been established as the gold standard in managing intrauterine pathology. However, an evolution in conceptual understanding is now needed, namely that beyond the technical removal of lesions lies the broader clinical goal of restoring uterine function to enable natural fertility.

The uterus is not only a target for surgical access, but it is also a hormonally responsive, structurally complex, and functionally dynamic organ. Congenital and/or acquired uterine anomalies such as uterine septa, uterine dysmorphism, intrauterine adhesions, endometrial polyps, submucosal fibroids, focal adenomyosis, endometrial hyperplasia or early endometrial cancer and retained pregnancy tissue may impair fertility and reproductive outcomes. Following imaging, these pathologies are typically approached hysteroscopically for diagnostic clarification and treatment prior to assisted reproductive technology (ART). However, an increasing body of evidence supports the notion that surgical correction of uterine factors alone can lead to natural conception, particularly when the surgery is conducted with a "functional intent"—that is, intending to restore the endometrial environment in a way that supports embryo implantation and pregnancy maintenance.[1-5]

This shift in perspective gives rise to the emerging concept of functional intrauterine surgery—a discipline that brings together operative hysteroscopy, reproductive endocrinology, imaging-guided techniques, and fertility-oriented surgical decision-making. The goal is no longer simply anatomical normalisation, but reconstruction of a functional and receptive uterine cavity, while minimising trauma and preserving endometrial and myometrial integrity.

Several studies have demonstrated that hysteroscopic treatment of intrauterine pathologies may lead to significantly improved reproductive outcomes in women with unexplained infertility or repeated implantation failure.[2,5,6] For example, hysteroscopic resection of fibroids, polyps, and adhesions[7] has been shown to increase clinical pregnancy and live birth rates, both in spontaneous cycles and in women undergoing ART, although high-quality data are still scarce. Moreover, hysteroscopic metroplasty for uterine anomalies[3,4] may reduce miscarriage rates and improve take-home baby rates, although data are conflicting and debate still rages.[8-11]

Importantly, functional intrauterine surgery is not merely a preparatory step for ART. In many cases, it prevents or delays the need for ART entirely by restoring natural reproductive capacity. For women facing uterine factor infertility, functional surgical correction may represent an opportunity to conceive spontaneously—an option often overlooked in

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the current fertility care model that prioritises *in vitro* fertilisation. Beyond its medical implications, this approach also empowers women to pursue conception in a less invasive, more physiologically aligned way, with lower emotional and economic burdens.

The concept of elective uterine preservation[12] within the context of reproductive ageing further reinforces the importance of maintaining and restoring uterine function as part of a long-term reproductive health strategy. Much like elective oocyte cryopreservation, uterine care could become a pillar of proactive fertility medicine. In this scenario, the uterus is no longer treated only when symptomatic or overtly dysfunctional; rather, its reproductive potential is proactively evaluated, and carefully selected interventions are considered when a meaningful reproductive benefit is expected.

To translate this vision into practice, several challenges must be addressed. First, the field needs clear definitions of functional success. Anatomical correction is not always equivalent to restored function. Outcome measures should include spontaneous conception rates, time to pregnancy, and quality of the endometrial lining. Secondly, comparative studies are needed to assess whether functional intrauterine surgery offers superior outcomes to early referral to ART. Thirdly, interdisciplinary surgical training should incorporate fertility-preserving principles and functional objectives into hysteroscopic education.

This also requires a cultural shift: to consider the uterus not only in terms of pathology but in terms of potential—a restorable organ whose function can be actively rehabilitated. With technological advances in imaging, minimally invasive instruments, and personalised surgical planning, we now have the means to do so.

The next generation of intrauterine surgery must align with the broader goals of reproductive health: sustainability, personalisation, and restoration. Functional intrauterine surgery represents an evolution—not only in technique, but in purpose. It reframes surgical success as reproductive restoration rather than simply lesion removal. And in doing so, it broadens the possibilities for women to conceive, carry, and complete their reproductive goals—naturally.

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EDITORIAL

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Illuminating the surgical field: the expanding role of Indocyanine Green (ICG) in gynaecological surgery

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Keywords: Endometriosis, fluorescence imaging, hysterectomy, indocyanine green, stents, ureters

Innovation in gynaecological surgery has always been driven by one fundamental aim: to improve patient safety while enhancing surgical precision. From the introduction of laparoscopy to the refinement of robotic platforms, each technological advance has sought to minimise morbidity and maximise clarity within the operative field. In recent years, fluorescence-guided surgery using indocyanine green (ICG) has emerged as a powerful adjunct in this evolution.[1] What was once largely confined to oncological sentinel lymph node mapping is now finding a meaningful place in benign gynaecology.[2-4] The recent review in Facts, Views & Vision in ObGyn[5] provides a timely and comprehensive appraisal of this transition, highlighting both the promise and the practical considerations of incorporating ICG into everyday gynaecological practice.

ICG is a water soluble tricarbocyanine dye that fluoresces in the near-infrared (NIR) spectrum when excited by appropriate imaging systems.[1] ICG has a well-established safety profile and rapid hepatic clearance, it offers surgeons real time visualisation of vascular perfusion and anatomical structures that may otherwise remain indistinct under white light. Its application in gynaecology has expanded steadily, propelled by improvements in NIR-equipped laparoscopic and robotic platforms.[4] What distinguishes ICG from many other surgical adjuncts is its immediacy by transforming invisible physiological information into visible guidance at the point of care.

In benign gynaecological surgery, the prevention of iatrogenic injury remains paramount. Ureteric injury during hysterectomy or deep endometriosis surgery, though uncommon, carries significant morbidity and medicolegal consequence. Traditional preventive strategies include meticulous dissection, identification under direct vision, and, in selected cases, pre-operative stenting. However, these approaches are not infallible, particularly in the context of distorted pelvic anatomy. ICG instilled via ureteric catheters to facilitate dynamic ureteric visualisation in real time is an exciting alternative.[3] The capacity to delineate ureteric course under NIR imaging may not only reduce the incidence of injury but also shorten operative time otherwise spent on extensive dissection solely for identification.[2,3,5]

Currently, ICG for ureteric visualisation still requires cystoscopy and cannulation of the ureteric orifices to deliver the dye. This makes its invasiveness comparable to temporary intraoperative ureteric catheterisation with Pollack catheters, as it also

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involves cystoscopic placement of ureteric catheters and removal.[6] Ideally, ureteric identification would not require cystoscopy at all. An intravenously administered fluorescent agent that selectively highlights the ureters throughout surgery would represent a major advance, providing continuous visualisation without cannulation. While such agents are under investigation, none are yet validated for routine use. A safe, reliable, and non-invasive method therefore remains an important unmet need, particularly in complex gynaecological surgery where ureteric injury risk is highest.

Beyond ureteric mapping, fluorescence imaging has shown value in assessing tissue perfusion during complex pelvic procedures. In cases requiring bowel resection for severe endometriosis, ensuring adequate vascular supply to an anastomosis is critical to reducing the risk of leak. While clinical judgement and visual cues have long guided surgeons, ICG provides an objective adjunct to confirm perfusion adequacy.[7] The ability to visualise perfusion gradients may influence resection margins and intraoperative decision making, potentially reducing postoperative complications. Importantly, this application bridges benign and oncological practice, underscoring how technological advances often transcend subspecialty boundaries.[1]

Endometriosis surgery represents another domain where ICG may enhance operative precision.[8] Deep infiltrating endometriosis frequently distorts normal anatomy, obscuring planes and vital structures. Although white light laparoscopy remains the standard, fluorescence imaging may assist in differentiating vascularised endometriotic lesions from surrounding fibrotic tissue.[7] While current evidence is heterogeneous and largely observational, early reports suggest that ICG may aid in lesion detection and in confirming adequate perfusion after excision. However, distinguishing between improved visualisation and improved clinical outcomes remains essential, and ongoing research is critical to clarifying clinical benefit.

The utility of ICG also extends to bladder endometriosis and multidisciplinary collaboration.[9] Cystoscopic administration can demarcate bladder nodules prior to laparoscopic excision, offering a clear visual boundary between diseased and healthy tissue. In collaborative settings, this shared fluorescence guidance may enhance communication and operative planning. The integration of gynaecological and urological expertise is increasingly important in complex pelvic surgery, and ICG may serve as a practical tool to facilitate this cooperation.

Despite these promising applications, several challenges must be addressed before ICG can be considered standard of care in benign gynaecology. There is a lack of universally accepted protocols regarding dosing, timing, and route of administration. Intravenous bolus doses vary across studies, and the optimal concentration for ureteric or bladder instillation remains under investigation. Without standardisation, reproducibility and comparison of outcomes become difficult.

Until recently, most studies have been observational or proof of concept rather than adequately powered comparative trials. This evidence gap has hindered definitive conclusions on clinical outcomes. Addressing this, the ICE trial[10] (ICG vs. conventional ureteric stenting in endometriosis surgery) represents one of the first randomised feasibility studies directly comparing ICG guided ureteric identification with traditional stenting in deep endometriosis surgery. Funded by the NIHR's Research for Patient Benefit programme and recruiting across UK sites including Birmingham Women's and Children's NHS and University Hospitals of North Midlands, this pilot trial aims to evaluate whether ICG can reduce operative time, post-operative pain, and stent-related morbidity compared with conventional stent methods.

The ICE trial builds on the recognition that while ureteric stenting has been a longstanding protective strategy, it is not without drawbacks, including post-operative discomfort and urinary symptoms. By using a small catheter to deliver ICG dye into the ureters, surgeons can visualise ureteral anatomy with NIR imaging, potentially reducing reliance on stents and improving patient experience without compromising safety.

Early insights from this work are expected to inform larger, multicentre trials and could establish a new evidence base for fluorescence guidance in benign gynaecological practice. The ICE trial exemplifies the type of comparative research needed to move beyond feasibility and towards evidence-based adoption, addressing a critical knowledge gap.

Cost and accessibility represent additional considerations. NIRcapable imaging systems are increasingly common in tertiary centres but may not be universally available. The financial implications of acquiring and maintaining such platforms, along with the cost of consumables, must be balanced against potential reductions in complication related expenditure. A thorough cost effectiveness analysis will be important in informing policy and

procurement decisions, especially within publicly funded healthcare systems.

Fluorescence imaging introduces a new visual modality into surgical practice. Surgeons must become proficient not only in the technical aspects of dye administration but also in the interpretation of fluorescence patterns. Over reliance without critical judgement could be as problematic as underutilisation. Structured training modules and inclusion in advanced laparoscopic curricula may support safe and effective adoption.

Ethical considerations further shape the discourse. Patients should be counselled regarding the use of ICG, including its rare but potential allergic reactions. Transparency about the evolving evidence base is essential. As with any adjunct technology, shared decision-making grounded in accurate information preserves patient autonomy and trust.

Looking ahead, the integration of fluorescence imaging with emerging technologies such as artificial intelligence and augmented reality offers intriguing possibilities. Real time quantitative perfusion analysis or automated ureteric tracking may further enhance the objectivity of intraoperative assessment. While these developments remain largely conceptual, they underscore the trajectory toward increasingly data driven surgery.

The broader question, however, is not merely whether ICG works, but how it reshapes surgical philosophy. Fluorescence guidance represents a shift from reliance on static anatomical knowledge toward dynamic physiological visualisation. It aligns with a precision-medicine paradigm in which intraoperative decisions are informed by immediate, patient-specific information. In this sense, ICG is emblematic of a wider transformation in surgical practice.

ICG is not a fleeting innovation but a tool with tangible potential to enhance safety and precision in benign gynaecology. Yet its promise will only be realised through collaborative research, thoughtful implementation, and continued reflection on outcomes. As surgical platforms evolve and imaging capabilities expand, the responsibility rests with clinicians to ensure that technology serves patient welfare rather than novelty.

In illuminating anatomical structures and perfusion patterns, ICG quite literally brings light into the operative field. More importantly, it symbolises the illumination of surgical decision-making through innovation grounded in evidence. The challenge now lies in transforming fluorescence from an adjunct used selectively by enthusiasts into a standardised, evidence-based component of high quality gynaecological care. If this can be achieved, the glow of NIR imaging may offer not only clearer vision in theatre but also a brighter future for patient safety and surgical excellence.

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EDITORIAL

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In outpatient hysteroscopy, experience matters

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Keywords: Hysteroscopy, ambulatory care, patient education as topic, patient participation, patient-centered care

Eisenberg-Kogan et al.[1] are to be congratulated on their randomised controlled trial published in this issue of Facts Views and Vision in Gynaecology highlighting an important yet sometimes underestimated aspect of outpatient hysteroscopy: preparation. As awake hysteroscopy is now established as routine practice across the United Kingdom, how we prepare women matters as much as the procedure itself. Standardised, effective, and compassionate information, such as pre-procedure videos, can shape expectations, influence anxiety, and ultimately affect the overall experience.

In this randomised trial of 100 women undergoing awake diagnostic and operative hysteroscopy, an explanatory animated video was compared with verbal preparation. Pre-operative anxiety was low in 72 women, moderate in 25, and high in three. There were no significant demographic, gynaecological, or procedural differences between women with low anxiety and those with moderate to high anxiety. Unsurprisingly, higher pre-procedure anxiety correlated with higher post-procedure visual analogue scale (VAS) pain scores.[1]

The animated video reduced moderate/high anxiety compared with verbal counselling. However, post-procedure pain scores did not differ between groups. A pre-procedure video is easy to implement in routine care and can be shared in advance, allowing time for reflection and the option to decline awake hysteroscopy if preferred.

The increasing emphasis on patient-reported outcomes is appropriate. Pain and anxiety are central to women's experience of hysteroscopy, and contemporary funders expect such outcomes in clinical trials. In procedures like hysteroscopy, experience is as important as technical success.

Awake hysteroscopy is now ubiquitous in National Health Service (NHS) practice. Miniature instruments, vaginoscopic approach, and morcellation systems enabling single-pass procedures have transformed theatre-based surgery into a walk-in, walk-out intervention suitable for most women. NHS England's "Getting It Right First Time" programme recommends that a high proportion of hysteroscopies are performed awake. Yet this shift exists within a tension field. Clinicians and managers aim for cost-effective, minimally invasive, efficient, and safe care. Many women prefer avoiding general anaesthesia and the convenience of outpatient treatment. However, a subset report significant pain and, in some cases, emotional distress or trauma. Advocacy groups such as Women Against Painful Hysteroscopy have highlighted the need to prioritise comfort, choice, and informed consent.

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Previous difficult gynaecological experiences can make awake procedures less tolerable.[2] Awake hysteroscopy is not right for every woman. Nonetheless, for those choosing it, any intervention that reduces pre-procedure anxiety deserves attention.

The absence of an effect on pain in this study should not detract from its importance. Pain during hysteroscopy is multifactorial. Patient-related factors include menopause, nulliparity,[3] abnormal uterine angles,[4] chronic pelvic pain, or a history of trauma. Procedural duration and complexity, as well as operator experience also contribute. Anxiety is only one component of this complex interplay. The finding that modifying anxiety did not reduce pain scores does not diminish its relevance.

Crucially, procedural pain does not automatically equate to an unacceptable experience. Mahmud et al.[5] reported that 82% of women described outpatient hysteroscopy positively and only 7% negatively, despite 35.5% reporting VAS pain scores between 70–100 mm. Pain is a physical sensation; acceptability is broader, encompassing communication, trust, dignity, and perceived control.

Pain is easier to tolerate when patients feels informed, safe, and respected. Education before a procedure fosters psychological safety. Many hysteroscopists recognise the scenario of an anxious woman who leaves the clinic visibly relieved after a straightforward procedure. Reducing anxiety may enhance satisfaction even without lowering pain scores. Inclusion of validated satisfaction measures would have strengthened the study's assessment of overall experience.

The finding that video information reduced anxiety more effectively than verbal counselling raises important questions. The content and standardisation of the verbal briefing are not described. Was pain explicitly discussed? Was the script consistent across clinicians? A key advantage of video is standardisation—eliminating inter- and intra-operator variability in wording, tone, and emphasis. In busy clinics with rotating staff, this consistency may be invaluable.

Generational shifts may also play a role. Visual explanations that illustrate anatomy and instruments may resonate more with Gen Z and Millennials accustomed to digital media. With artificial intelligence–supported translation tools, high-quality video counselling can also be made accessible to women who do not speak English as a first language.

Having led a team of filmmakers, researchers, and clinicians to co-develop an educational animation for awake hysteroscopy (Figure 1), I found it fascinating to compare our approach with the video used in this trial.

Figure 1. BSGE accredited information video on awake hysteroscopy co-produced with women with lived experience.

Co-development with women with lived experience introduced priorities clinicians might overlook. These included explicit emphasis on conscious choice, reassurance that awake hysteroscopy is optional, and clear scripting on how to withdraw consent if the procedure becomes unacceptable.

Women involved in our workshops were particularly concerned about how the hysteroscope was depicted. They did not want imagery suggesting impalement or exaggerated scale. They stressed accurate portrayal of the outpatient setting and inclusive representation across age and culture.

The most powerful lesson from co-development was the centrality of control. Explicit phrases such as "stop means stop," alongside agreed non-verbal cues like raising a hand, were highlighted as an important pre-procedure agreement between patient and healthcare professional. Although withdrawal of consent is uncommon, knowing that one can stop at any time is empowering. That sense of agency may itself reduce anxiety.

The co-development process also revealed variation in United Kingdom practice, including deviations from vaginoscopic technique, lapses in dignity, and instances where requests to stop were dismissed. These accounts underscore the need for reflective practice as well as better information. Hysteroscopists must comply with standards of care[6,7] and will benefit from studying patient information themselves, particularly the expectation of a vaginoscopic approach. An educational video on techniques to minimise discomfort in vaginoscopy will soon be available for professional training for healthcare professionals.

User involvement in developing patient information can add peer narratives of how it feels to experience the procedure. The gold standard for future patient information on medical procedures should be co-development with women who have lived experience. This aligns with shared decision-making and patient-centred care.

Ultimately, we should ask ourselves what standard of preparation for a medical procedure we would like to receive for ourselves or our families. Adequate preparation can make or break the experience of awake hysteroscopy. This study demonstrates that a simple, scalable intervention can reduce anxiety. That alone is worthwhile.

Future research could explore co-developed video content and include validated satisfaction measures. Reducing anxiety may not abolish pain, but it may transform the experience. In outpatient hysteroscopy, experience matters.

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OPINION PAPER

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A proposed MRI classification of junctional zone morphology based on reproductive performance: the JZ-MRI ReproClass

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ABSTRACT

We propose the junctional zone- magnetic resonance imaging (JZ-MRI) ReproClass, a four-tiered MRI-based classification for describing JZ morphology, developed from more than a decade of clinical experience in women with recurrent implantation failure or pregnancy loss despite normal embryo quality. The system characterises the spectrum of JZ appearances -from normal architecture to complete loss of differentiation- and is particularly informative when ultrasound and hysteroscopy appear normal. By standardising MRI assessment of the JZ, the ReproClass may help identify morphological patterns associated with impaired reproductive performance and support more individualised diagnostic reasoning. It provides a foundation for future research into the role of JZ architecture in fertility outcomes.

Keywords: Fertility, infertility, MRI, magnetic resonance imaging, pregnancy, women

Introduction

The inner myometrium is increasingly recognised as a critical structure in reproductive medicine.[1] Functionally distinct from the outer myometrium, it originates embryologically from the Müllerian ducts and plays a key role in sperm transport, embryo implantation, and placentation through its hormone-responsive peristaltic activity.[2,3,4]

With the advent of magnetic resonance imaging (MRI), our understanding of uterine architecture has deepened significantly. MRI allows for a clear visualisation of three distinct uterine layers: the endometrium, the inner myometrium, and the outer myometrium. During the 1980s, T2-weighted MRI revealed a distinct low-signal intensity band between the endometrium and the outer myometrium, which was subsequently defined as the junctional zone (JZ).[5] Importantly, the JZ is not a discrete histological entity and cannot be clearly delineated from the outer myometrium using conventional light microscopy. Similarly, the JZ visualised on ultrasound -as described in the Morphological Uterus Sonographic Assessment (MUSA) criteria[6]- does not correspond to the JZ seen on MRI. Harmsen et al.[7] recently emphasised the poor agreement between MRI, ultrasound, and histology in evaluating the JZ, highlighting that each modality assesses fundamentally different structural or functional features. On MRI, the JZ is characterised by its distinct tissue composition: higher smooth muscle cell density, reduced extracellular matrix, lower water content, higher iron concentrations, and concentric fibre orientation; features that collectively give rise to its low signal intensity on T2-weighted images.[8,9]

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Despite this improved anatomical delineation, several questions remain unresolved. What constitutes a normal JZ on MRI? What degree of variation is physiological, and how do hormonal fluctuations influence its appearance?[9-13] While numerous studies have investigated JZ thickness and its association with adverse reproductive outcomes[14-17] -particularly in assisted reproduction- no standardised classification system currently exists to characterise JZ morphology on MRI. This lack of a unified approach creates inconsistency in clinical interpretation, limits cross-study comparisons, and hampers prospective validation of JZ-related risk factors.

Over the past decade, we have systematically incorporated pelvic MRI into the evaluation of all women entering our egg donation program.[17] This accumulated clinical and imaging experience suggests that variations in JZ morphology -ranging from subtle irregularities to complete loss of differentiation- may be associated with impaired implantation and differences in reproductive performance, even when ultrasound and hysteroscopy are unremarkable. Although the aetiology of these abnormalities is likely multifactorial, proposed contributing factors include chronic inflammation, hormonal dysregulation (e.g., prolonged oestrogen exposure), prior uterine trauma, and early or subclinical adenomyosis.[18] These mechanisms may disrupt the normal contractile and receptive functions of the JZ, thereby compromising implantation and placentation.

Our observation has highlighted a critical diagnostic gap: while the JZ can be visualised reliably on MRI, we currently lack a universally accepted classification system to define what is normal, borderline, or pathological in the context of reproduction. To move the field forward, a reproducible, intuitive, and clinically meaningful framework is urgently needed -one that can help stratify reproductive risk and guide future prospective studies.

The JZ-MRI ReproClass: Toward A Standardised Framework for JZ Morphology

The proposed classification emerged from the cumulative interpretation of hundreds of high-quality T2-weighted MRI scans, each reviewed in parallel with detailed ultrasound and hysteroscopic assessments. Although it is not derived from a prospective dataset, the JZ-MRI ReproClass represents a structured synthesis of reproducible morphological patterns -ranging from normal JZ architecture to complete loss of differentiation between the JZ and outer myometrium- that appear to correlate with reproductive performance. Its development is rooted in extensive clinical experience within a high-performance egg donation program, where subtle deviations in JZ morphology aligned with implantation outcomes.

The primary goal of this framework is to facilitate more consistent communication between radiologists, gynaecologists, and fertility specialists, particularly in cases of unexplained infertility, recurrent implantation failure, or pregnancy loss in which conventional imaging fails to identify a clear abnormality. By offering a standardised language to describe JZ morphology, the JZ-MRI ReproClass may help bridge the diagnostic gap between structural appearance and reproductive function.

The JZ-MRI ReproClass includes four distinct categories: (A) Normal, (B) Subtle changes, (C) Focal pathology, and (D) Advanced or global disruption.

Class A: Normal

Class A is defined by a well-delineated JZ, clearly distinct from the outer myometrium. The JZ occupies no more than one-third of the total myometrial thickness and shows a smooth, continuous contour without interruption (Figure 1). This morphology is considered physiologically normal and reflects an intact, well-organised inner myometrium. Clinical experience consistently shows that a normal JZ is associated with optimal uterine function, without features suggestive of impaired implantation or reduced receptivity. Overall, Class A morphology appears to be a highly favourable marker of endometrial receptivity and uterine competence.

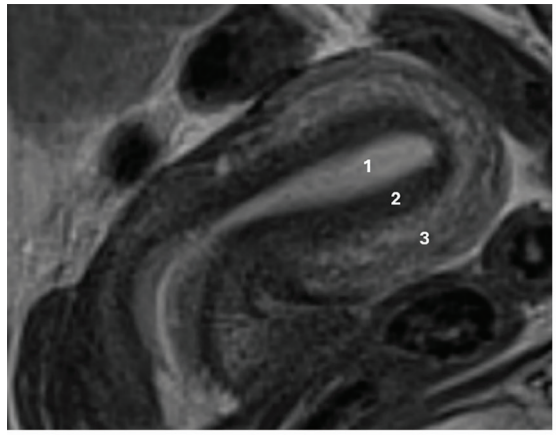

Figure 1. Example of JZ-MRI ReproClass A: a sharply demarcated, homogeneous low-signal intensity band on T2-weighted image, involving less than one-third of the total myometrial thickness (1; Endometrium, 2; junctional zone, 3; Outer myometrium). JZ-MRI: junctional zone- magnetic resonance imaging.

Class B: Subtle Changes

Class B represents a morphology similar to Class A but with certain precise changes. These include small focal changes such as microcysts (defined as cystic structures <5 mm), a mildly irregular contour, slight thickening of the JZ that remains below two-thirds of the myometrial thickness, or conversely hypotrophy, referring to a very thin or nearly absent JZ (Figure 2). These features are interpreted as early or borderline alterations, currently of unclear pathological significance. Introducing this category allows for a stricter definition of normality in Class A while separating out subtle deviations that may warrant closer observation. Class B thus functions as a buffer group for morphological variations of unclear clinical relevance, which may or may not influence reproductive outcome and warrant further study.

Class C: Focal Pathology

Class C is defined by the coexistence of normal and abnormal JZ segments. The abnormal areas are characterised by a complete loss of JZ differentiation and/or the presence of macrocysts (well defined cystic structures ≥5 mm). This category is thought to reflect localised dysfunction of the JZ and is generally associated with intermediate reproductive potential.

Initial clinical experience -across cases with both small and more extensive focal abnormalities- suggests that selected patients may benefit from targeted hysteroscopic resection. Smaller cystic or solid lesions can be removed using 5-fr instruments (Trophyscope XL, Figure 3), whereas larger focal pathology may require a more structured surgical approach with the 15-fr mini-resectoscope as previously described by our stepwise approach (Figure 4).[19] This technique promotes optimal postoperative healing and initial outcomes in terms of reproductive success appear promising, although formal validation is still needed.

Class D: Advanced or Global Disruption

Class D represents widespread architectural disruption of the JZ. It is defined by either a markedly hypertrophic JZ occupying more than two-thirds of the myometrial thickness or by a complete loss of JZ differentiation. In both presentations, the inner myometrium loses its normal layered organisation: this may occur through pronounced thickening or through homogenised low-signal intensity appearance in which the JZ can no longer be distinguished from the outer myometrium. Such uniform characteristics suggest that the tissue composition across the myometrial wall becomes

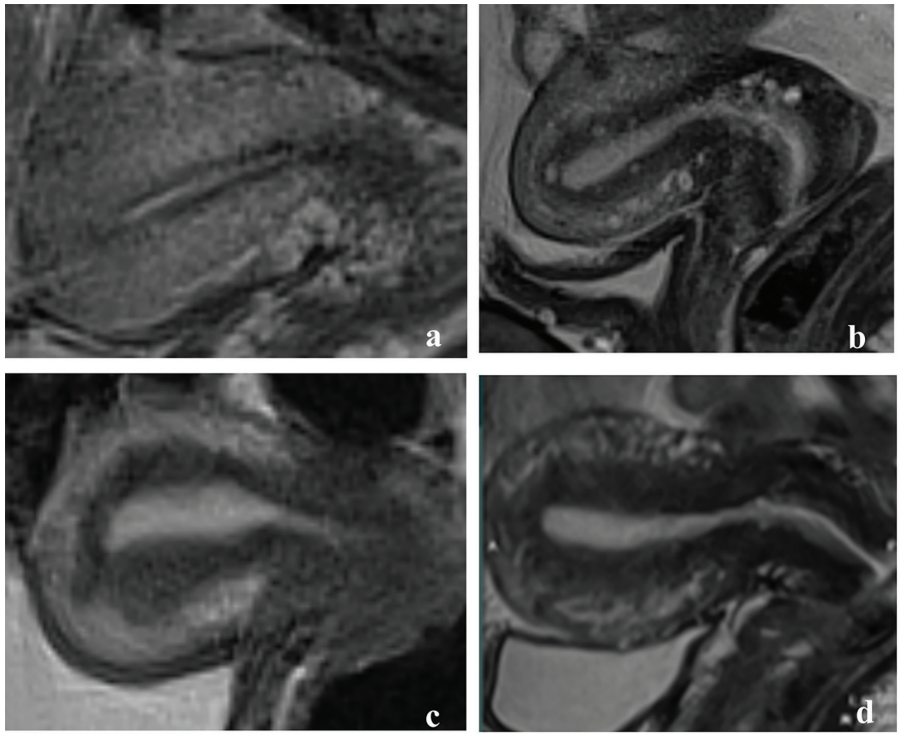

Figure 2. JZ-MRI ReproClass B subtle changes: hypotrophic JZ (a), Normal JZ with microcystic changes (b), Focal thickened JZ (c), Enlarged JZ occupying less than two-thirds of the total myometrial thickness (d). JZ-MRI: junctional zone- magnetic resonance imaging.

essentially identical -likely reflecting alterations in water and iron content together with loss of the typical zonal architecture. Clinically, Class D is associated with markedly reduced reproductive potential and appears to signify a severely compromised endo-myometrial environment. Importantly, these abnormalities may remain entirely undetected on standard ultrasound or hysteroscopy, highlighting the unique diagnostic value of MRI (Figure 5). Preliminary exploratory findings in this subgroup often reveal histological features consistent with adenomyosis, supporting the hypothesis of an inflammatory or non-functional JZ state. In such cases, hormonal suppression or targeted local anti-inflammatory strategies[20] may hold therapeutic potential, although these approaches require further systematic evaluation.

Discussion

In this article, we propose the JZ-MRI ReproClass, a four-tiered, morphology-based framework for describing JZ patterns on T2-weighted MRI. Developed from more than a decade of clinical experience in women with unexplained infertility, recurrent implantation failure, and recurrent pregnancy loss in the setting of normal embryo quality, the classification aims to provide a standardised way to describe JZ morphology in relation to reproductive performance (Figure 6). To our knowledge, this is the first classification system specifically designed to assess the JZ as a marker of uterine reproductive receptivity.

The JZ is a hormonally responsive and functionally dynamic interface whose MRI appearance can be influenced by factors such as hormonal milieu, chronic inflammation, altered uterine peristalsis, prior microtrauma, parity, and possibly microbiome-related changes. Recent MRI literature has expanded our understanding of the JZ, yet most published classifications focus primarily on adenomyosis or its diagnostic criteria.[7,18,21] While valuable for disease identification, these systems do not capture the broader spectrum of JZ morphology that may hold relevance for uterine receptivity. The JZ-MRI ReproClass therefore serves a different purpose: it provides a descriptive, MRI-specific framework for characterising JZ patterns across reproductive contexts, including cases without overt adenomyosis. It is not intended as a diagnostic tool for adenomyosis, but rather as a

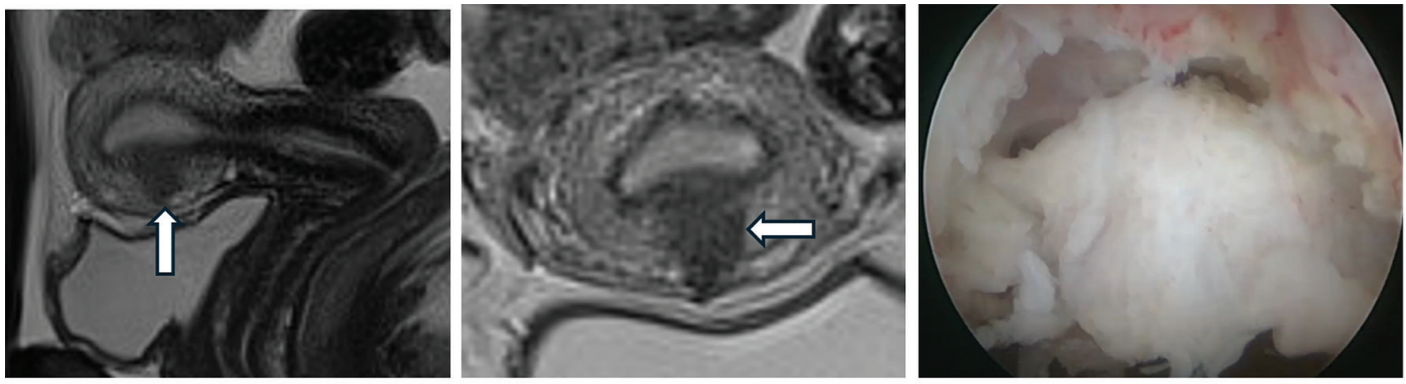

Figure 3. JZ-MRI ReproClass C small focal pathology corresponding with hysteroscopic view during excision. JZ-MRI: junctional zone-magnetic resonance imaging.

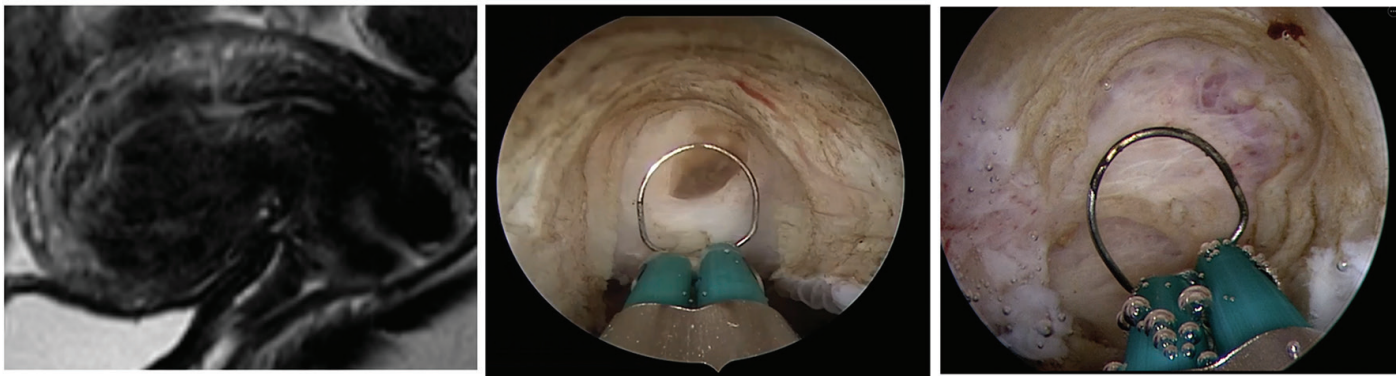

Figure 4. JZ-MRI ReproClass C large focal pathology with example of hysteroscopic cytoreductive surgery. JZ-MRI: junctional zone-magnetic resonance imaging.

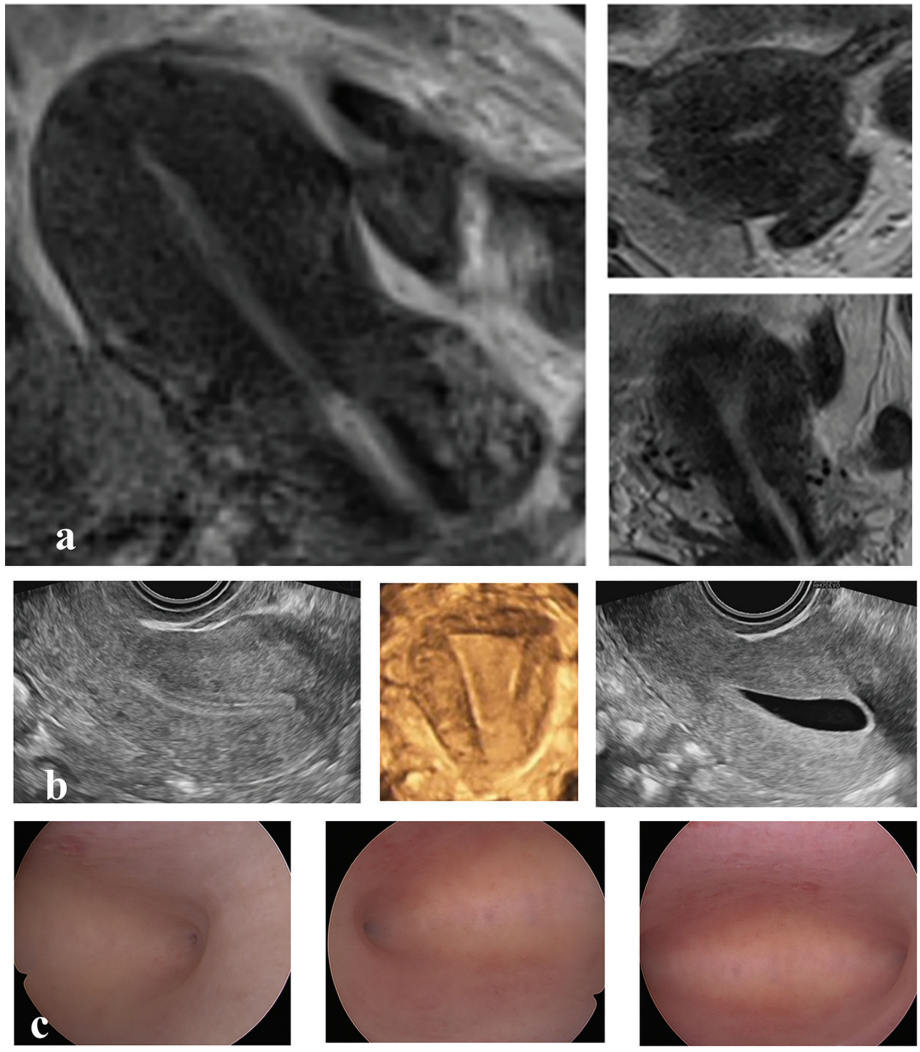

Figure 5. (a) Example of JZ ReproClass D with total loss of junctional zone differentiation. (b) Same patient with normal ultrasound and normal hysteroscopic findings (c).

phenotype-based approach to understanding intrinsic myometrial function.

A key clinical observation underpinning the JZ-MRI ReproClass is the frequent discordance between ultrasound and MRI in assessing the JZ. Recent work by Harmsen et al.[7] similarly reported limited agreement between MRI- and ultrasound-based evaluations, highlighting that sonographic criteria cannot be directly translated to MRI. In our experience, women with recurrent implantation failure may show completely normal ultrasound and hysteroscopic findings, yet MRI reveals a total loss of JZ differentiation -an abnormality that would otherwise remain undetected (Figure 5). This discrepancy reflects fundamental differences between the modalities: ultrasound depicts macroscopic echotexture, whereas MRI captures tissue composition and microstructural organisation. The ability of MRI to reveal profound JZ disruption in patients with unexplained reproductive failure underscores the need for an MRI-specific descriptive framework and reinforces the clinical relevance of the JZ-MRI ReproClass.

Clinical Utility and Implications

The JZ-MRI ReproClass is intended as a functional imaging framework that captures a continuum of JZ morphology -from normal architecture to complete loss of differentiation (Figure 6). Its value is most evident in patients who present with unexplained implantation failure or pregnancy loss despite normal findings on ultrasound and hysteroscopy. In such situations, MRI can reveal intrinsic abnormalities of the inner myometrium that are not visible with other modalities.

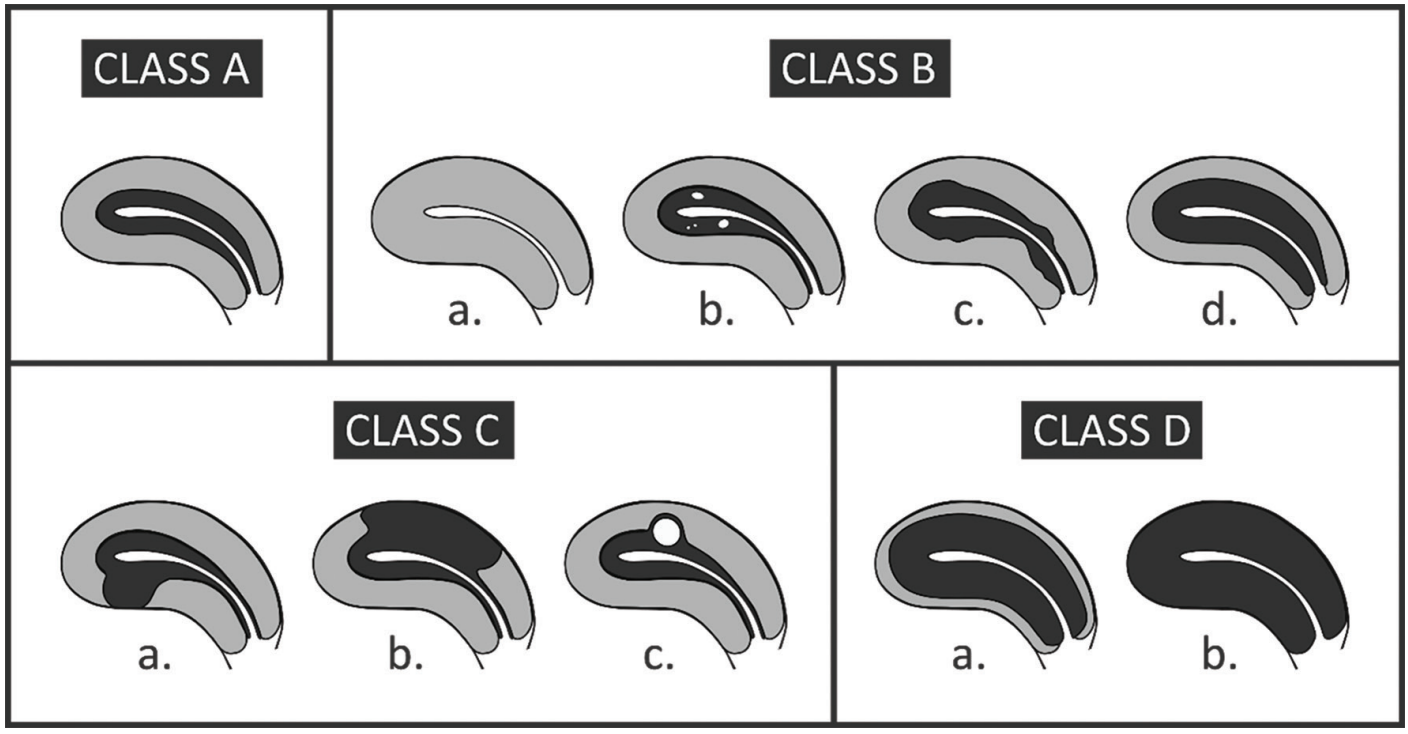

Figure 6. JZ-MRI ReproClass: a proposed classification system for JZ morphology based on reproductive performance. Class A: physiologically normal morphology, Class B: hypotrophic JZ (a), normal JZ with microcystic changes (b), focal thickened JZ (c), enlarged JZ occupying less than two-thirds of the total myometrial thickness (d); Class C: small focal pathology (a), large focal pathology (b), JZ macrocystic lesion (c); Class D: hypertrophic JZ occupying more than two-thirds of the myometrial thickness (a), total loss of JZ differentiation (b). JZ-MRI: junctional zone- magnetic resonance imaging.

By differentiating subtle, focal, and global patterns of JZ change, the classification can support more individualised clinical interpretation. It may assist with prognostic counselling, guide uterine preparation strategies, and help tailor embryo-transfer planning, particularly in assisted reproduction settings where embryo quality is known. The framework also facilitates clearer distinction between embryo-related and uterine-related contributors to implantation failure.

Although preliminary clinical experience suggests that focal abnormalities may respond to targeted hysteroscopic management and that diffuse disruption may warrant hormonal or anti-inflammatory approaches, such insights remain exploratory. Any therapeutic implications derived from the JZ-MRI ReproClass should therefore be regarded as hypothesis-generating. Above all, the classification provides a standardised descriptive language that enhances communication between radiologists and fertility specialists and lays the groundwork for more structured investigation of JZ-related reproductive dysfunction.

Strengths and Limitations

A key strength of the JZ-MRI ReproClass lies in its development within a comprehensive, multimodal diagnostic framework. All patients contributing to its conceptualisation were evaluated through a structured "one-stop uterine diagnosis" protocol incorporating transvaginal ultrasound, hysteroscopy, contrast sonography, and MRI. This integrative approach enabled direct cross-modal comparison and ensured that the classification emerged from clinically relevant correlations rather than isolated radiological interpretation.

The JZ-MRI ReproClass provides a clear and practical way to describe JZ morphology across the range of patterns encountered in reproductive medicine. By focusing on visual, phenotype-based features rather than strict quantitative measurements, the system avoids dependence on JZ thickness thresholds, which are known to vary with acquisition technique and show limited reproducibility. This morphology-driven approach aligns more closely with how clinicians interpret MRI in practice and offers a stable framework for characterising JZ appearance in a clinically meaningful way.

The JZ-MRI ReproClass has several important limitations. First, it is derived from consistent expert observation rather than from a prospectively collected or statistically modelled dataset. Although informal interobserver agreement has been high in our experience, the framework has not yet undergone formal validation across independent readers or centres. Standardisation of MRI acquisition protocols -particularly T2-weighted sequences, field strength, slice thickness, and assessment criteria- will be essential to ensure reproducibility and enable meaningful multicentre evaluation.

The classification also focuses specifically on intrinsic JZ abnormalities. In our cohort of women entering an egg donation program, intrinsic JZ-related changes were far more common than extrinsic myometrial disease, such as outer myometrial adenomyosis or deep infiltrating endometriosis. As a result, extrinsic pathology was not incorporated into the current framework. The relevance of extrinsic disease to reproductive outcomes may differ in other clinical populations,[22,23] and represents an important direction for future investigation.

Finally, any therapeutic approaches associated with specific JZ-MRI ReproClass categories remain experience-based and exploratory. Their apparent utility in clinical practice should be regarded as hypothesis-generating rather than evidence-based, and confirmation through controlled prospective studies will be required.

Future Directions

Future work should prioritise the prospective validation of the JZ-MRI ReproClass. A multicentre study using standardised 2T MRI protocols and harmonised T2-weighted sequence parameters will be essential to evaluate interobserver reproducibility and the stability of the proposed categories. Blinded dual-reader assessment with κ-statistics would provide a robust measure of agreement, while secondary analyses could explore associations with implantation and live-birth outcomes. Establishing these methodological foundations is critical for broader clinical adoption.

Further research is also needed to clarify the hormonal, inflammatory, and biomechanical mechanisms that may underlie JZ dysfunction. A better understanding of why certain MRI phenotypes are associated with impaired receptivity could help identify patients who might benefit from targeted interventions. In parallel, therapeutic strategies -whether surgical, hormonal, or anti-inflammatory- should be examined within controlled prospective designs, as current impressions remain exploratory.

Incorporating the JZ-MRI ReproClass into assisted reproduction registries and future clinical trials may facilitate longitudinal data collection and allow progressive refinement of diagnostic thresholds. Ultimately, standardised imaging protocols, reproducible assessment criteria, and well-designed prospective studies will be essential to establish this classification as a reliable and clinically meaningful tool in reproductive medicine.

Conclusion

In conclusion, the JZ-MRI ReproClass provides a structured, phenotype-based framework for interpreting JZ morphology on MRI and offers a new way to conceptualise JZ-related uterine function in reproductive medicine. Grounded in extensive clinical experience, it captures the full spectrum of JZ appearances- from normal organisation to complete architectural loss- and highlights patterns that may hold functional relevance for implantation and pregnancy. By introducing a standardised descriptive language, the classification strengthens communication between radiologists and fertility specialists and supports more individualised diagnostic thinking, particularly in patients with unexplained implantation failure or miscarriage despite normal conventional imaging. Although therapeutic implications remain exploratory, the JZ-MRI ReproClass establishes a foundation on which future physiological studies, interobserver validation, and targeted interventions can be built. Developing a reproducible, MRI-specific approach to JZ assessment is an essential step toward a more coherent understanding of inner myometrial function. Ultimately, this framework aims to advance both clinical practice and research by providing a consistent point of reference for investigating the role of the JZ in reproductive performance.

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Data sharing: All data are available upon request from the corresponding author.

Transparency: The authors affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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OPINION PAPER

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The past, present and future of uterine fibroids

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ABSTRACT

Human evolution –specifically the development of bipedalism– altered the shape of the pelvis so that legs alone provided locomotion across the ground. As a result, the forelimbs were freed from locomotion. Though speculative, hands freed from locomotion may have led to the expansion of hand tool use and brain enlargement. With a pelvis no longer optimised for childbirth and with larger fetal brains, childbirth became more challenging. An "obstetrical dilemma" was created. How could large-headed babies be pushed through a narrowed, convoluted pelvis? More uterine muscle, a "neomyometrium," evolved in the uterus, to increase the force of contractions. Because fibroids develop from myometrial tissue, additional fibroids came along with the neomyometrium. Until recently, the fibroid burden that accompanied bipedalism did not become apparent until the advent of modern contraception. Mendelian randomisation studies have demonstrated causal links between women's reproductive histories and their risk of developing fibroids. Multiparity and infrequent menstruation, universally common until only recently, kept this fibroid risk hidden until socio-demographic changes and hormonal contraception unmasked fibroids that evolved with the neomyometrium. Simple therapeutic approaches that (i) periodically and temporarily emulate the clot formation that occurs within the blood vessels of the uterus following childbirth and that (ii) reduce the number of lifetime menstrual cycles may be able to reduce the current high incidence of fibroids.

Keywords: Birth rate, hormonal contraception, Mendelian randomisation, menstruation, myometrium, uterine fibroids

Introduction

In our previous paper,[1] we argued that in distinction from primates and distant hominin predecessors, childbirth in modern day humans requires a large-headed fetus to be propelled by powerful uterine contractions through a narrow, convoluted birth canal. This challenge can be traced back approximately 8 million years, to the evolution of walking and running upright on two feet which freed the forelimbs from climbing. With hands free, our ancestors devised and used tools which required additional computational power leading to the development of the neocortex. Thus, in parallel to the evolution of bipedalism, babies developed with bigger brains and heads (encephalisation) which led to two major problems –a restrictive birth canal and an enlarged fetal head –creating our modern-day obstetrical dilemma: cephalopelvic disproportion.

Among the many compensatory adaptations that permitted successful childbirth in the face of this dilemma, two important changes occurred within the human uterus (Figure 1): (i) through metaplasia and hyperplasia of adjacent connective tissue (mesenchyme), a thick outer myometrial layer,

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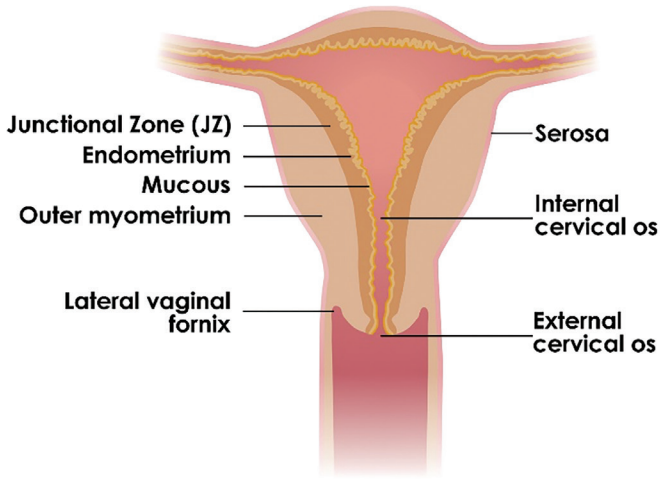

Figure 1. The human uterus-endometrium (yellow), archimetrium or magnetic resonance imaging junctional zone (tan), outer neomyometrium (peach), and serosal (pink) tissue layers. Mucous on the surface of the endometrium is shown in gold. Reproduced by permission from (Burbank).[33]

the neomyometrium, was added like an overcoat, to the archimetrium (junctional zone) and (ii) reflecting the origin of this new tissue, the entire uterus became primarily perfused by the uterine arteries instead of the ovarian arteries. We proposed that the evolution of the neomyometrium was the underlying genetically driven process that led to the high prevalence of fibroids in modern life.[1] How this risk remained hidden for so long, follows.

New fibroids appear from menarche to menopause, consistent with sex hormone-dependent proliferation. Their growth is modulated by progesterone for both cell proliferation and extracellular matrix deposition during the luteal phase of the menstrual cycle while oestrogen plays a supportive role, in part by inducing expression of progesterone receptors.[2] Though other mammals develop fibroids, current prevalence of fibroids in humans is remarkably high. By recent estimate, >75% of women develop fibroids at some point during their reproductive years.[3] Multiple fibroids within the same uterus are clonally unrelated, arising independently from myocytes or stem cells, which account for ~2% of myometrial cells.[4]

The Past

Reproductive Factors and Fibroid Development and Persistence

Fibroids, menstruation, fertility, and childbirth are interrelated. Women with fibroids have a reduced ability to conceive or maintain a pregnancy. Women with few or no prior pregnancies are at heightened risk of developing fibroids. Hence, an inverse relationship exists between parity and fibroid risk. Epidemiologic studies demonstrate that each childbirth leads to a ~20% decrease in fibroid risk, such that in women who have delivered 4 times or more, fibroids are rare.[5] Preterm pregnancies have no overall protective effect, suggesting that the process of term parturition itself, decreases fibroid risk.[6] Parity is inversely related to cumulative number of menstrual cycles, age at menarche, and age of menopause. Over the last 100 years, age of menarche has decreased radically (from 18 in 1840 to 12.7 presently) while age of menopause has only increased modestly (from 48.4 in 1960 to 49.9 in 2018).[7]

Menstruation and Fibroid Initiation

The formation of uterine fibroids including developmental origin and pathogenesis is genetically driven and involves multiple factors operating under certain conditions and circumstances as reported in a comprehensive review.[8] The initiating events and the cell of origin of uterine fibroids remain speculative. Whereas both fibroid and myometrial cells tolerate low levels of ischemia, only fibroid cells are induced to proliferate during hypoxia. This observation has led to the hypothesis that uterine hypoxia, during menstruation, promotes fibroid formation and growth.[9] If so, factors that increase a woman's cumulative number of menstrual cycles (early menarche, delayed menopause, low parity) would be predicted to lead to high fibroid incidence.

The mechanistic link between menstrual history and fibroid risk is somewhat complex. Fibroid development has been proposed to represent a disordered form of wound healing.[10,11] As noted, uterine hypoxia, resulting from vasoconstrictive events during menstruation, may be the original trigger for fibroid formation.[9] Cumulative risk would therefore rise with each menstrual cycle; in the absence of term pregnancies and breastfeeding, the resulting fibroids would be expected to persist and grow throughout a woman's reproductive years. Continuous or extended dosing of progestin-based contraceptives may be another straightforward and potentially helpful intervention to reduce the number of menstrual cycles as will be discussed later.

With menarche at a later age (likely ~18 years), frequent childbirths (5 to 10), and a lifespan too short

for menopause be a consideration, women in ancestral societies probably experienced well under 100 menses in a lifetime and had no fibroids, compared to >400 menses for women today.

Pregnancy Reduces Fibroid Size and Prevalence

Contrary to widely held beliefs, pregnancy is associated with fibroid shrinkage not growth. Small fibroids detected in early pregnancy (<1 cm) typically only grow modestly during pregnancy, while fibroids ≥5 cm tend to shrink significantly, with a mean volume reduction of 2.1% per week.[12]

Parturition Reduces Fibroid Size and Viability

While pregnancy inhibits fibroid growth,[12] childbirth may complete the process by actively shrinking and even eliminating fibroids.[5,6,13-15] In a longitudinal, ultrasound study, Laughlin et al.,[13] demonstrated a general decrease in number and size of fibroid before and after pregnancy. This effect however, is neither universal nor linear since large or well-established fibroids frequently persist.

Fibroid devitalization following childbirth is best explained by widespread clot formation throughout the uterus and its adjacent arteries and veins following separation of the placenta away from the uteroplacental bed during vaginal or Caesarean delivery.[5,16] Following placental separation, clotting occurs quickly and widely throughout the uterine circulation and in adjacent veins, creating transient total uterine ischemia that affects fibroids as well as healthy myometrium. In healthy myometrium, the duration of this effect is short-lived; clots are degraded in a wave of fibrinolysis that peaks 3 hours post-partum.[17] Perfusion is thus restored to the uterus and it survives. Fibroids, on the other hand, which are not capable of efficient fibrinolysis, they devitalise and shrink.[5,16] At the extreme, fibroid degeneration and expulsion from the uterus following childbirth is well documented.[18]

The Present

Lifetime parity has declined steadily, worldwide, with a mean total fertility falling from 5.29 in the 1960s to 2.74 after 2010[19] and the total fertility rate (TFR) is now well under the stable replacement rate of 2.1 children per woman.[20,21] These trends show no sign of abating.[20,21] Extreme examples of low birth rate have been seen in economically advanced countries, notably Japan and South Korea. A similar pattern is evident in other countries; by 2100, only 6 countries are expected to maintain a fertility rate above maintenance. Projections indicate that the global population is likely to peak well before the end of the century and subsequently decline towards a TFR <1.5.[20,21]

As might be anticipated, recent surveys indicate that fibroids have become increasingly common globally,[3] with prevalence increasing 79% between 1990 and 2019. Mendelian randomisation studies confirm that reproductive factors like reduced parity and increased cumulative number of menstrual cycles contribute to this trend.[22,23] From studying isolated modern societies with unrestricted reproduction, it appears women's lifetime parity was likely between 5 and 10 live births reducing fibroid risk by 20% with each birth.[5,6] Postpartum clearance of fibroids, in response to clotting within the uterine vasculature, may be similar to the response of fibroids following uterine artery embolization/occlusion (UAE/UAO), medical procedures used to treat women with symptomatic fibroids.[5,16]

Which Came First, Fibroids Causing Decreased Fertility or Childbirth Devitalizing Fibroids?

It is not immediately clear which is cause and which effect. Do fibroids cause women to be less fertile, or are women who have few children predisposed to develop fibroids? To address this longstanding question, two groups have applied Mendelian randomisation to extract causal information from large databases. Mendelian randomisation begins by conducting genome-wide association studies, to identify genomic loci where polymorphisms are statistically associated with traits of interest (e.g., age at first birth, total number of births, and age at menarche and menopause) as well as their history of fibroids.

The same analysis can also be run in reverse, to ask if genetically predicted high risk of fibroids might be causally linked to genetically predicted early age of first birth (AFB)—another formally possible outcome. Causal findings derived from one database can also be re-examined in another database, to confirm the identify of genes of interest and to ask whether the causal arrow points in a consistent direction across different study populations.

Using Mendelian randomisation approach, Xiao et al.[22] found that two parameters that correspond to higher numbers of menstrual cycles (i.e., early menarche and late menopause) were each significantly and causally linked to higher likelihood of fibroids. Higher AFB likewise

predicted increased fibroid risk. These conclusions were based on analysis of large cohorts such as the publicly available FibroGENE consortium, with clinical and genetic data for approximately 300,000 women, predominantly of European ancestry.[22] Independently, Wang et al.[23] used a similar approach to look at reproductive parameters, using both the FibroGENE and a second large database from the FinnGen consortium, representing approximately 190,000 women. Their causal analysis reached similar conclusions: Genetically predicted early menarche and late menopause—both associated with increased numbers of menses—caused increased fibroid risk.[22,23] They also noted a remarkable 4-fold reduction in fibroid risk in women with higher numbers of live births; this effect was consistent and significant in each of databases analyzed.[22,23]

Both groups tested the reverse causal claim, whether fibroid risk might be causally linked to reproductive parameters like early or late AFB. In general, no such link was found, suggesting that the causal arrow points from women's reproductive history (e.g., many life-time menstrual cycles, delayed AFB, and fewer pregnancies) to high incidence of fibroids, and not in the reverse direction.[22,23] However, Wang et al.[23] found one interesting exception– a weak but significant finding that fibroids cause a reduced lifetime number of childbirths, implying that fibroids are also causally linked to reduced fertility. It must be pointed out however, that although Mendelian randomisation data predominantly support genetic predisposition as the primary driver of fibroid risk, the reproductive traits may act as modifiers rather than evidence of true bidirectionality.

Maternal Age at First Birth

Since the 1960s, in addition to reducing the number of children, couples have also chosen to delay the age of having a family trending to an increased AFB.[24] For example, in the US, the group of women with the largest share of first births in 1960 was 20 to 24 years old (43%). By 1990, the share experiencing a first birth among this age group had declined to 31%, but it was still the most common age group. In 2018, first births among women occurred most often between ages 25 to 29 (29%).[24] In Canada, the average age of first-time mothers increased from 23.2 years to 29.4 years between 1959 and 2019, rising to 31.6 years as of 2022.[25] Age at first birth limits parity and is related to more menstrual cycles both of which lead to increased fibroid risk.

The Future

Epidemiological and Mendelian randomisation studies support a causal basis of the well documented inverse relation between parity and fibroid risk.[5,6,14-17,22,23] In general, the more children a woman has, the fewer fibroids she is likely to face. Conversely, the fewer children she has, the more fibroids she is likely to experience. To emulate the biological process that devitalizes fibroids during childbirth, uterine ischemia and clot formations can be created with a transvaginal, Doppler-guided vascular clamp that causes temporary UAO.[26] Because this clamp system is temporary (<6 hours) and minimally invasive, such a procedure might be used, periodically, to substitute for the fibroid devitalizing effects of natural childbirth.

The Ambiguous Role of Hormonal Contraception

Widespread use of hormonal contraception dates from the 1960s in Western countries. Despite the complexity of the literature on contraception and fibroids, most studies report reduced fibroid prevalence in women with a history of oral contraceptives,[6] levonorgestrel intrauterine systems (LNG-IUS),[27] levonorgestrel implants[28] or depo-medroxy-progesterone acetate (DMPA).[29-32] A systematic review reported that prior use of oral contraceptives was a protective factor for uterine fibroid risk.[6] In general, oral contraceptive use reduced fibroid risk with prolonged utilization by approximately 30% after 5 to 10 years. Use of oral contraceptives at young ages was reported to be associated with an elevated risk in at least one study.[6] Presently, even when oral contraceptives are packaged with 4–7 days of placebo pills per month, some women and caregivers recommend taking the active pills without interruption, thus avoiding regular monthly withdrawal bleeding. In addition, some oral contraceptive products are now available that are designed for uninterrupted, year-long daily dosing; various other contraceptive regimens and devices have long been available that lead to continuously suppressed menstruation.

LNG-IUS produce an extended state of amenorrhea or oligomenorrhea and may limit the development of new fibroids. In a multicenter, prospective 7-year randomized controlled trial in USA and Canada, the LNG-IUS reduced the incidence of bleeding and, in the long-term, of myoma and myoma-related surgery in comparison with the copper-T intrauterine device. Among TCu380 users, incidence of fibroids increased significantly with time, notably so after 5 years of use (P<0.001), and with age at admission (P<0.05). No myoma

or enlarged uterus required surgery in LNG-IUS group. Five women in TCu380 had myomectomy and 1 woman had hysterectomy.[27] Similar effect has been reported in chimpanzees in captivity. Compared to females with non-hormonal or no contraception, those with levonorgestrel implants had significantly reduced fibroid risk, both in parous (P<0.03) and nulliparous (P<0.04) animals.[28]

Four studies have reported a significant reduction in fibroid risk with long-term treatment with DMPA.[29-32] Current use of DMPA was associated with approximately 50% reduction in risk. Harmon and Baird[31] reported that participants exposed to DMPA within the previous 2 years experienced reduced leiomyoma development during the subsequent observation interval compared with never users, including lower leiomyoma incidence (5.2% vs. 10.7%), adjusted hazard ratio: 0.6 [95% confidence interval (CI): 0.4–1.0], 42.0% lower leiomyoma growth (95% CI: 251.4 to 230.7) and 60% greater leiomyoma loss (adjusted risk ratio 1.6, 95% CI: 1.1–2.2). Excess leiomyoma loss was also seen for those who used DMPA 2-4 years before the visit compared with never users, 2.1-fold increase (95% CI: 1.4–3.1).[32]

However, the apparent protective effect of progestin-based contraception against incident fibroids remains puzzling given the essential role of endogenous progesterone for fibroid initiation and development.[2] Given the rapid evolution of fibroid therapeutics, including the use of specific progesterone receptors modulators and gonadotropin releasing hormone agonists and antagonists, all of which have been effective in short-term treatment of symptomatic fibroids, we found no evidence that any of these agents prevents formation or decreases the incidence of fibroids. Further research may shed light on the impact of these therapeutic molecules on fibroid development.[33]

Conclusion

To walk and run on the ground, the human pelvic skeleton became narrow and convoluted. At the same time, fetal brains and heads became larger. To push a large-headed baby through a convoluted pelvis, myometrium enlarged. The enlargement carried with it a silent, hidden, high risk of fibroids. The risk remained latent for millennia, due to high parity and few lifetime menstrual cycles. Modern family planning has resulted in smaller families and has unmasked the latent, increased fibroid risk of the neomoymetrium (Figure 2). Given modern demographic realities, fibroid prophylaxis (methods to decrease the number of menstrual

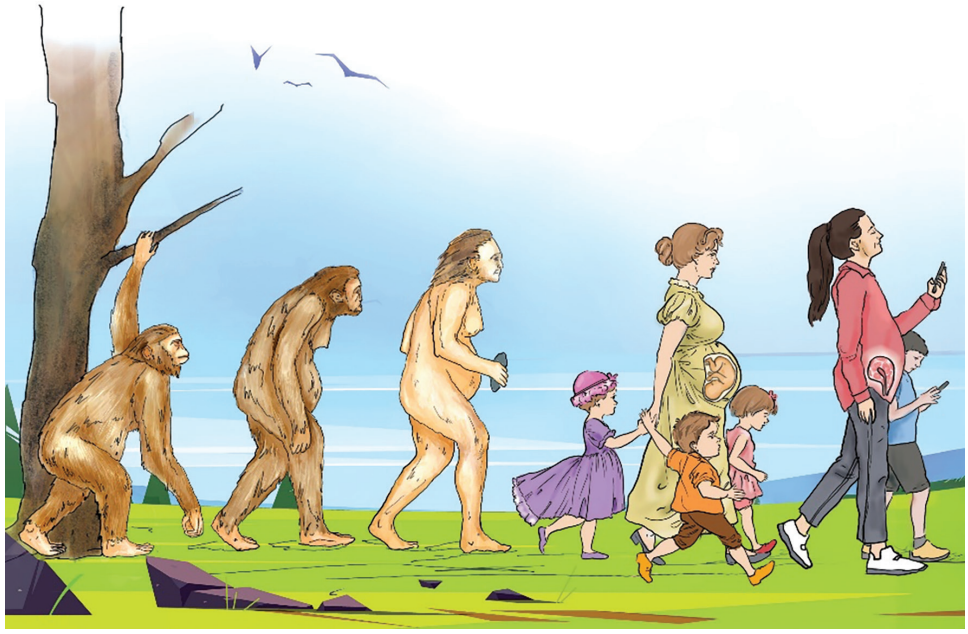

Figure 2. The ascent of modern woman. Family size has declined substantially in recent decades, as birth control has allowed women to delay or opt out of pregnancy. As a result of increased average age at first pregnancy and wider spacing between pregnancies, it is now common for women to experience a nearly uninterrupted series of menstrual cycles from menarche to menopause—an atypical pattern for women in prehistory and even in recent history. Among the possible physiological consequences of this change is an increase in the frequency of uterine fibroids. We propose that a high risk of fibroids was always present for humans, although in latent form, and that this risk has been unmasked as women experience more menstrual cycles and fewer pregnancies. Original art courtesy of Ms. Deepti Saxena (Kasaza Art and Design, Toronto, Ontario, Canada). Image size: 1063 × 709 px (72 dpi).

cycles and methods to emulate the biology of childbirth) may become priorities in women's healthcare.

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ORIGINAL ARTICLE

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A prospective trial comparing the effect of preoperative information given verbally with the use of an explanatory animated video before outpatient hysteroscopy on patients' anxiety and pain

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ABSTRACT

Background: Hysteroscopy without anaesthesia is a routine gynaecological procedure but is commonly associated with patient anxiety and pain.

Objectives: To compare preoperative information provision using usual verbal interaction with the use of an animated video on patients' anxiety and pain associated with outpatient hysteroscopy.

Methods: Patients were allocated to receive verbal explanations immediately prior to the outpatient hysteroscopy or via an informative short, animated video.

Main Outcome Measures: Proportion of patients with moderate-high preoperativee anxiety levels as assessed by the State-Trait Anxiety Inventory questionnaire. Secondary outcomes included maximal intraoperative pain levels recorded on a 10 cm visual analogue scale (VAS) completed directly after the procedure.

Results: One hundred patients undergoing 78 diagnostic hysteroscopies and 22 operative hysteroscopies were included in the study, with 50 patients allocated to each intervention group. Preoperative moderate or high anxiety levels were reported by 28 participants who also had higher VAS pain scores (3.6±3.2 cm vs. 2.0±2.5 cm in the lower anxiety group, *P*=0.02). The rates of preoperative moderate/high anxiety levels were significantly higher in the standard verbal education group compared with the animated video group [19 (38.0%) vs. 9 (18.0%), respectively, *P*=0.04], although their VAS pain scores were not significantly different. The logistic regression analysis confirmed that a low level of anxiety was associated with education by an animated video (odds ratio: 2.9, 95% confidence interval: 1.1-7.6).

Conclusions: Preoperative education by an animated video prior to hysteroscopy is associated with lower rates of moderate/high anxiety levels compared to the standard verbal education preparation.

What is New? Animated videos are an effective and easy-to-implement tool that may reduce anxiety before office hysteroscopy.

Keywords: Hysteroscopy, anxiety, State-Trait Anxiety Inventory (STAI)

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Introduction

Diagnostic and operative hysteroscopy without anaesthesia (level 1 analgesia according to the international consensus classification) are common gynaecologic procedure indicated for various gynaecologic problems, including abnormal uterine bleeding, infertility, habitual abortions, retained intrauterine device, and investigation of endometrial ultrasound findings.[1] Although hysteroscopy without anaesthesia is usually well tolerated and associated with high patient satisfaction, this awake procedure could cause considerable preoperative anxiety in up to 80% of patients.[2] Subsequently, high anxiety levels may adversely impact pain perception, procedural success rates, and overall satisfaction.[3] Non-pharmacologic interventions, such as preoperative patient education, may reportedly alleviate excessive anxiety.[3] Several strategies for patient education may be offered, including verbal explanation, use of pictorial charts, and the use of animated videos.[4,5] Animated videos have emerged as a powerful tool for patient education, particularly for medical procedures which can be visually depicted. This strategy may reduce anxiety by providing clear representations of the procedure in a way that is easy to understand and remember.[5] However, the most effective preoperative educational approach for reducing patient anxiety is undetermined.[3]

In the current study, we aimed to compare the standard preoperative verbal education with the education delivered via an animated video prior to diagnostic or operative hysteroscopy in the office setting. We specifically measured and compared preoperative anxiety levels and maximal intraoperative visual analogue scales (VAS) for pain.

Methods

This prospective non-blinded study included patients referred for diagnostic and/or operative hysteroscopy without anaesthesia (level 1) in an outpatient hysteroscopy clinic of Shamir Medical Centre, department of obstetrics and gynaecology.[1] Upon arrival at the hysteroscopy clinic, all patients aged 18 years or older who had not previously undergone the procedure were invited to participate in the study by the senior gynaecologist performing the hysteroscopy. The participants' demographic characteristics, gynaecological and obstetrical history, history of depression and/or anxiety, clinical presentation and hysteroscopic findings, and procedure time were prospectively recorded.

Patients were assigned to either the control group (verbal explanation) or the study group (animated video) by arbitrarily designating specific clinic days for each group (i.e., one type of preoperative education was delivered to all patients participating in the study on a given date). There was no stratification for patient characteristics or hysteroscopy indications.

The patients in the control group received the standard preoperative verbal education from the attending gynaecologist who performed the hysteroscopy. The patients in the study group viewed a 4-minute animated video developed by the study investigators (Supplementary Video), which provided step-by-step information on the hysteroscopy process and recovery. The animated video also explained the indications for hysteroscopy, exam room setup, and the roles of the medical and nursing staff present during the procedure.

Immediately following the preoperative education by either the verbal explanation or the educational video, preoperative anxiety was measured using a validated questionnaire: the State-Trait Anxiety Inventory (STAI) (licensed for use in this study by Mind Garden, Inc.).[6] The STAI questionnaire is a validated psychological assessment tool designed to assess two types of anxiety: "state anxiety", which reflects a temporary condition or emotional state in response to specific situations, and "trait anxiety", which indicates a more general and long-standing tendency to experience anxiety across various circumstances. The questionnaire includes 20 questions, each assigned a score from 1 to 4. According to the recommended classifications of anxiety levels, a total score of less than 30 is considered indicative of low anxiety, scores between 30 and 45 represent moderate anxiety, and scores of 46 or higher denote high anxiety.[6]

The hysteroscopy procedure was then performed by means of the vaginoscopy approach. The diagnostic hysteroscopies were performed with the use of a diagnostic sheath fitted on a 2.9 mm 30° rigid hysteroscope (Karl Storz, Tuttlingen, Germany). The operative procedures included visually directed endometrial biopsy, removal of endometrial polyps, removal of retained products of conception, adhesiolysis, and removal of an intrauterine device. A 5 mm 30° rigid Bettochi hysteroscope equipped with a working channel and miniaturised non-electrical hysteroscopic instruments, including a grasper and scissors (Karl Storz, Tuttlingen, Germany), was utilised for the operative procedures. Normal saline 0.9% delivered by a manual pressure pump was used as the distention

medium. All procedures were performed without any anaesthesia or analgesia (level 1), by three experienced minimally invasive gynaecology surgeons.

Directly after completion of the hysteroscopy, all patients were asked to record the maximal intraoperative pain by means of a 10 cm VAS anchored at 0 (designated as "no pain") and 10 (designated as the "worst pain imaginable").

The study's primary outcome was the proportion of patients reporting preoperative moderate or high anxiety levels (as assessed by the STAI score) in the study group vs. the control group. The secondary outcome was the mean maximal intraoperative VAS pain level scores in each group.

The study was approved by the Shamir Medical Centre Institutional Review Board (0011-23-ASF) on January 30th, 2023, and registered in the Clinicaltrials.gov registry (NCT06625567). All participants signed an informed consent upon enrolment, as well as the standard written informed consent for undergoing the hysteroscopy.

Sample Size and Statistical Analysis

The sample size was calculated to detect a 30% difference in the rates of moderate/high anxiety between groups, using a 80% power and 5% significance. This calculation yielded a minimum cohort of 90 patients, which was inflated to 100 to allow for loss to follow-up. All statistical analyses were performed using the SPSS software (Version 29, IBM Corp). The Student t-test, analysis of variance, Fisher's exact test, and chi-square test were employed as appropriate. A binary logistic regression model was used to predict whether participants had low anxiety or moderate/high anxiety, considering factors such as group allocation (control or study), the type of hysteroscopy performed, and other demographic and gynaecologic variables. The results are shown as odds ratios (ORs) with 95% confidence intervals (CIs). A two-sided *P* value of <0.05 was considered statistically significant.

Results

The study included 100 women, 50 in the study group (standard verbal education) and 50 in the control group (education by animated video). Comparisons of demographic and gynaecologic characteristics between groups are shown in Table 1. Groups were comparable apart from the clinical indications for hysteroscopy (Table 1). The flow chart of the study is shown in Figure 1.

A diagnostic hysteroscopy was performed in 76 cases and an operative hysteroscopy in the remaining 24 cases. The operative procedures included visually

Table 1. Comparison of the demographic, gynaecologic, and clinical characteristics between the study group (educational video) and the control group (standard education).

Characteristic	Control group (n=50)	Study group (n=50)
Age (years)	41.5±12.6	38.4±11.3
Body mass index (kg/m^2)	26.2±5.2	25.8±5.6
History of anxiety/depression	8 (16.0)	3 (6.0)
Parity	2 (0-5)	2 (0-4)
Nulliparity	11 (22.0)	8 (16.0)
History of caesarean section	14 (28.0)	12 (24.0)
Menopausal status		
Premenopausal	41 (82.0)	46 (92.0)
Postmenopausal	9 (18.0)	4 (8.0)
Indication for hysteroscopy referral		
Abnormal uterine bleeding	11 (22.0)	25 (50.0)
Suspected uterine polyp	15 (30.0)	14 (28.0)
Infertility workup	9 (18.0)	7 (14.0)
Suspected retained products of conception	11 (22.0)	0 (0)
Other*	4 (8.0)	4 (8.0)

*Including intrauterine device removal and assessment of caesarean section defect. Data are presented as mean ± standard deviation, median (range) or number (%).

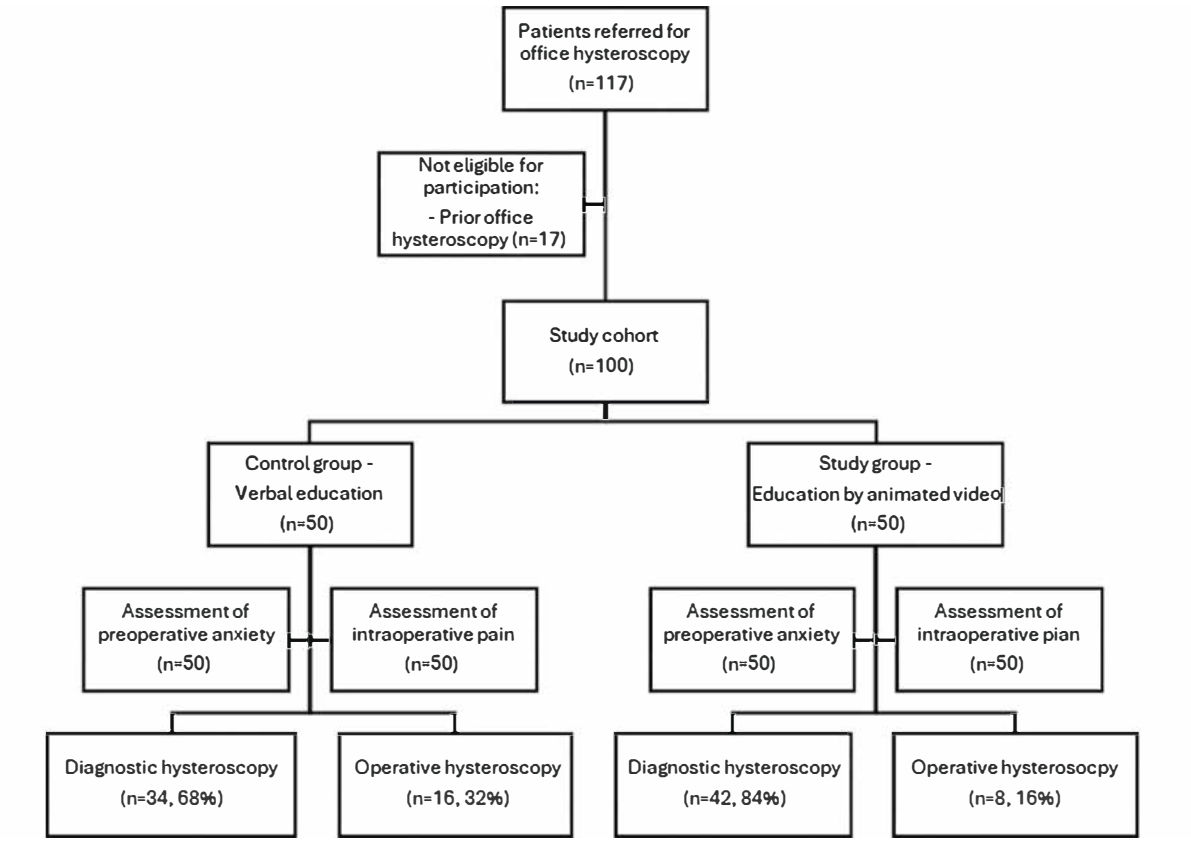

Figure 1. Flow chart of the study.

Table 2. Comparison of hysteroscopic characteristics between the study group (educational video) and the control group (standard education).

Characteristic	Control group (n=50)	Study group (n=50)
Successful completion of the hysteroscopy procedure	48 (96.0)	50 (100.0)
Hysteroscopic diagnosis of cervical stenosis	6 (12.0)	6 (12.0)
Hysteroscopy operative time (seconds)	52.5±35.3	60.6±25.7
Type of hysteroscopy procedure		
Diagnostic	34 (68.0)	42 (84.0)
Operative	16 (32.0)	8 (16.0)

Data are presented as mean ± standard deviation or number (%).

directed endometrial biopsy in 8 cases, removal of retained intrauterine device in 7 cases, removal of retained products of conception in 6 cases, uterine adhesiolysis in 2 cases, and resection of endometrial polyp in one case. Hysteroscopy was successfully completed in 98 cases. Two patients were diagnosed as having complete cervical stenosis and failed to complete the hysteroscopy. Comparisons of the hysteroscopic characteristics between the two groups are given in Table 2. There were no significant group differences in operative time, rates of diagnostic versus operative procedures, or rates of failed hysteroscopy due to cervical stenosis (Table 2).

The STAI questionnaire revealed low levels of preoperative anxiety in 72 cases, moderate levels in 25 cases, and high levels in 3 cases. Nulliparous women exhibited higher incidences of moderate to high anxiety than parous patients; however, there were no statistically significant differences observed among other demographic, gynaecologic, or hysteroscopic characteristics (Tables 3 and 4). The mean maximal

intraoperative pain scores as measured by VAS and the proportion of women who reported a VAS ≥5 cm were significantly higher among women with moderate/high preoperative anxiety (Table 4).

On comparisons of anxiety and pain scores between the study and control group, the rates of moderate/high anxiety were significantly lower in the study group compared with the control group (9/50 vs. 19/50), respectively, *P*=0.04), while the mean anxiety scores were not significantly different (22.2±9.9 vs. 25.9±10.4, respectively, *P*=0.07). The mean maximal intraoperative pain scores were similar between groups (VAS of 2.3±2.5 cm vs. 2.6±3.0 cm, respectively, *P*=0.6).

A logistic regression analysis was performed to assess the association between the study group allocation and moderate/high vs. low levels of anxiety. Education by the animated video was significantly associated with low anxiety levels (OR: 2.93, 95% CI: 1.12-7.66), while none of the other demographic, gynaecologic, and hysteroscopic parameters was independently associated with low versus moderate/high anxiety levels (data not shown).

Table 3. Comparison of demographic and clinical characteristics between patients with low versus moderate/high preoperative anxiety scores.

Characteristic	Low anxiety* (n=72)	Moderate/high anxiety* (n=28)	*P* value
Age (years)	39.6±11.6	42.1±12.9	0.3
Body mass index (kg/m^2)	26.7±5.4	24.4±5.2	0.06
History of anxiety/depression	7 (9.7)	4 (14.3)	0.5
Parity	2 (0-5)	2 (0-4)	0.8
Nulliparity	10 (13.9)	9 (32.1)	0.04
History of caesarean section	20 (27.8)	6 (21.4)	0.6
Premenopausal	64 (88.9)	23 (82.1)	0.5
Indication for hysteroscopy referral			
Abnormal uterine bleeding	25 (34.7)	11 (39.3)	0.5
Suspected uterine polyp	22 (30.6)	7 (25.0)	
Infertility workup	12 (16.7)	4 (14.3)	
Suspected retained products of conception	9 (12.5)	2 (7.1)	
Other**	4 (5.6)	4 (14.3)	

*Assessment of preoperative anxiety was conducted using the State-Trait Anxiety Inventory (STAI) questionnaire, with participants categorised as having low anxiety (score <30), moderate anxiety (scores between 30 and 45), or high anxiety (scores of 46 or above).
**Including: Intrauterine device removal and assessment of caesarean section defect.
Data are presented as mean ± standard deviation, median (range) or number (%).

Table 4. Comparison of hysteroscopic characteristics between patients with low versus moderate/high preoperative anxiety scores.

Characteristic	Low anxiety** (n=72)	Moderate/high anxiety** (n=28)	*P* value
Hysteroscopy successfully completed	71 (98.6)	27 (96.4)	0.4
Hysteroscopic diagnosis of cervical stenosis	7 (9.7)	5 (17.9)	0.2
Hysteroscopy operative time (seconds)	56.7±32.2	56.3±28.2	0.9
Hysteroscopy procedure			
Diagnostic hysteroscopy	56 (77.8)	20 (71.4)	0.6
Operative hysteroscopy	16 (22.2)	8 (28.6)	
VAS* pain score (cm)	2.0±2.5	3.6±3.2	**0.02**
VAS** ≥5 cm	10 (13.9)	9 (32.1)	**0.04**

*VAS: Visual analogue scale, recorded on a 10 cm line anchored at 0 (designated as "no pain") and 10 (designated as the "worst pain imaginable").
**Assessment was conducted using the State-Trait Anxiety Inventory (STAI) questionnaire, with participants categorized as having low anxiety (score <30), moderate anxiety (scores between 30 and 45), or high anxiety (scores of 46 or above).
Data are presented as mean ± standard deviation or number (%).

Discussion

Main Findings

Office hysteroscopy is a common procedure indicated for a wide range of gynaecologic problems, but could be associated with significant anxiety, which may adversely affect patients' satisfaction and pain.[2] Non-pharmacologic interventions designed to decrease patients' anxiety (such as detailed preoperative education, use of virtual reality headset, listening to music, and "vocal local") may offer significant benefits with low potential side effects.[3] In the current study, we have found that preoperative education using an animated video successfully reduced rates of moderate/high anxiety when compared to the standard preoperative communication. However, the mean anxiety score and the mean intraoperative pain score did not differ between the study and control groups.

Strengths and Limitations

Our study has several limitations. First, it was conducted in a single centre, and all procedures were performed by experienced surgeons, which may limit the generalisability of our findings. Assignment to the study and control groups was determined arbitrarily based on the day of the procedure, without randomisation or stratification for patients' characteristics and types of hysteroscopy, which may have led to selection bias. Although the assessment of the study outcomes was self-reported by the participants, the non-blinded study design may have also introduced investigator bias. The results may have been influenced by differences in the indications for hysteroscopy between groups, although the hysteroscopic procedures performed—diagnostic versus operative—were comparable. Lastly, while rates of moderate/high anxiety were lower in the animated video group, there were no statistical differences in the mean anxiety score or in the mean intraoperative pain, possibly due to insufficient power.

Strengths and Limitations Compared to Other Studies

Several studies have investigated the effectiveness of non-pharmacologic approaches in reducing anxiety before office hysteroscopy.[7-11] Among those, decreasing waiting time, listening to music during the procedure, continuous interaction and support, and the use of a virtual reality headset during hysteroscopy have been shown to be effective. Akca et al.[5] investigated the effectiveness of preoperative education using an animated video to reduce anxiety and pain during office hysteroscopy, compared with providing written information. Like our results, they observed decreased anxiety levels but found no impact on pain.

Several patient characteristics have also been investigated in association with anxiety levels prior to hysteroscopy, including age, menopausal status, parity, previous caesarean section, history of depression or anxiety, and the type of hysteroscopic procedure (diagnostic vs. operative). Similar to previous studies, we did not find any significant association between these parameters and moderate/high levels of anxiety.[5,7]

Importantly, increased anxiety has been associated with higher pain levels due to the physiological interconnection between anxiety and pain perception.[3,12] Similar to previous studies, we found higher mean VAS pain scores and higher rates of VAS >5 among patients with moderate/high levels of anxiety compared to those with low levels of anxiety.[8,9,12] These findings highlight the importance of reducing anxiety prior to the performance of office hysteroscopy in the effort to concomitantly address patients' pain perception.

Clinical and Policy Implications

Preoperative education is key to reducing patients' anxiety before office hysteroscopy. Among the available strategies for patient education, the use of an animated video is a simple and effective tool which may be superior to standard verbal education. It is recommended that all clinics offering office hysteroscopy adopt protocols aimed at addressing patient anxiety.

Unanswered Questions and Future Research

As office-based hysteroscopy procedures–particularly those with an operative component–become increasingly prevalent, addressing preoperative patient anxiety is of growing importance. The optimal strategy for managing this anxiety has not yet been established, and further studies are necessary to determine the most effective approach.

Conclusion

Animated preoperative videos before office hysteroscopy without anesthesia can lower moderate/high anxiety rates compared to standard verbal education, and may help reduce anxiety commonly experienced during office procedures.

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Informed consent: All participants signed an informed consent upon enrolment, as well as the standard written informed consent for undergoing the hysteroscopy.

Data sharing: Data will be available upon request.

Transparency: We affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Supplementary Video: https://precare.ca/healthcare-guides diagnostic-hysteroscopy/

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ORIGINAL ARTICLE

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Surgical outcomes according to the degree of parametrial dissection with hysterectomy for deep endometriosis

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ABSTRACT

Background: There is no standardisation of the degree of parametrial dissection and excision with hysterectomy in the presence of deep endometriosis (DE).

Objectives: To apply an anatomical classification of dorso-lateral parametrectomy to hysterectomy for DE and correlate with postoperative complications and functional outcomes.

Methods: Women with histologically confirmed DE who underwent hysterectomy with varying degrees of parametrectomy were retrospectively identified. Dorso-lateral parametrectomy was classified as follows: superficial (medial to presacral fascia), deep type 1 (beyond the presacral fascia), type 2 (caudal to medial rectal artery), and type 3 (laterally and deeply the hypogastric fascia). Statistical analysis was performed to correlate the degree of parametrial dissection with operative complications and functional outcomes at 6 months.

Main Outcome Measures: Incidence of intra- and postoperative complications; changes in gastrointestinal, urinary, and sexual function; pain improvement.

Results: Eighty-nine patients underwent parametrectomy with hysterectomy: superficial extended hysterectomy (EH) with superficial parametrectomy (EHSP, n=52), deep EH with deep parametrectomy type 1 (EHDP1, n=19), deep type 2 (EHDP2, n=12), and deep type 3 (EHDP3, n=6). Eight patients (8.9%) had intraoperative complication of which 5/52 (9.6%) underwent EHSP, 1/19 (5.3%) EHDP1, 2/12 (16.7%) EHDP2. Bladder voiding dysfunction occurred in 11 patients (12.3%) with higher incidences of 6/19 (31.6%) undergoing EHDP1 and 1/6 (16.7%) EHDP3 (P=0.016). Pain outcomes significantly improved across all groups (P<0.001).

Conclusions: This classification of parametrectomy at the time of hysterectomy for DE offers a framework for assessing surgical complexity and outcomes. While substantial pain relief is observed, bladder dysfunction remains a significant concern, especially when parametrectomy extends beyond the presacral fascia.

What is New? This classification for modified radical hysterectomy provides a method to standardise the description of parametrectomy for DE, facilitating more precise correlations between the extent of disease in the parametria and functional outcomes.

Keywords: Bladder, fascia, hysterectomy, intraoperative complication, pelvic pain, postoperative complications

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Introduction

Parametrial deep endometriosis (DE) is recognised as one of the most complex forms of this disease. It is frequently associated with severe pelvic pain, dysfunction of adjacent pelvic organs, and technically demanding surgical procedures that carry a substantial risk of neurofunctional complications.[1-5] In particular, parametrectomy is known to entail a broad range of postoperative risks, including bladder voiding dysfunction, reported in 6.5–32% of cases,[1-7] and overall complication rates of approximately 2–26%,[1-8] even in high-volume, specialised referral centres. Despite its clinical relevance, parametrial DE remains a highly debated topic in the literature. This is largely due to the absence of a shared definition of the parametrium itself,[1,2,7-12] along with the use of inconsistent terminology, heterogeneity in reporting outcomes, and the lack of a classification system specifically dedicated to DE. While numerous studies have explored surgical complications and recurrence rates after hysterectomy for endometriosis,[13-15] only a few have addressed how the extent of parametrial resection influences functional outcomes or postoperative morbidity.[7,8]

Unlike early-stage cervical cancer, in which the width of parametrectomy is determined by tumour size and oncological risk factors, the extent of resection in cases of DE is determined by the need for complete removal of infiltrative lesions. Although nerve-sparing strategies adapted from oncologic gynaecology are often employed,[10,16] their application for DE can be challenging and imprecise due to the marked tissue distortion and fibrotic remodelling that characterise this condition.

To address these limitations and to enable meaningful comparison between studies, our group has recently introduced an anatomical classification of dorsolateral parametrectomy for DE.[7] The present study applies this classification to extended hysterectomy (EH) for parametrial DE, with the aim of exploring the association between the extent of parametrial dissection, postoperative complications, and functional outcomes.

Methods

Study Design

In this retrospective observational analysis, 89 consecutive cases of women treated with EH for histologically verified DE were included. We enrolled all patients who underwent surgery during the study period and who met the inclusion criteria, without subjectively excluding any case. Surgeries were performed at the University Hospital 'Policlinico Universitario IRCCS "A. Gemelli"' in Rome between March 2019 and June 2023, and at the Mater Olbia Hospital, Olbia (Sardinia region) between March 2023 and March 2024.

Women were considered eligible if they were over 18 years old, sexually active, and suffering from pelvic pain refractory to medical therapy. All candidates had undergone clinical evaluation supported by transvaginal and transabdominal ultrasound and/or pelvic magnetic resonance imaging (MRI) showing suspected parametrial involvement, and they were all scheduled for hysterectomy. Final histopathological confirmation of parametrial DE was required for inclusion. Exclusion criteria included being aged under 18 years, absence of sexual activity, and any history of bowel or bladder resection, ureteral reimplantation, or prior pelvic radiotherapy.

The research protocol received approval from the Institutional Review Boards of both participating institutions Policlinico Universitario IRCCS A. Gemelli (protocol number: 0007739/25, date: 24.03.2025) and Mater Olbia Hospital (protocol number: MOH 0001921, date: 29.11.2024). All procedures complied with the Declaration of Helsinki. Prior to surgery, all patients signed written informed consent forms that allowed the use of their anonymised clinical data for research purposes.

Preoperative Evaluation

Prior to surgery, all patients underwent a standardised diagnostic assessment, which included rectovaginal examination along with targeted transvaginal and transabdominal ultrasound and/or pelvic MRI. In cases of ureteral dilatation, further imaging such as uro-computed tomography, uro-MRI, and renal angioscintigraphy was conducted to allow a more precise evaluation of the urinary tract. If patients reported symptoms suggesting possible compression or infiltration of the sacral plexus or other somatic nerves, they were referred for neuropelveological assessment in accordance with the recommendations of the International Society of Neuropelveology.[17] Electromyography and/or urodynamic studies were added when clinically indicated. Pelvic pain symptoms including dysmenorrhea, dyspareunia, chronic pelvic pain, dysuria, and dyschezia were consistently assessed using a visual analogue scale (VAS) ranging from 0 (no pain) to 10 (the most severe pain imaginable).

Data Collection and Classification Systems

All clinical, surgical, and functional data were prospectively entered into a dedicated database. Collected variables included: demographic data [age, body mass index (BMI) ongoing hormonal therapy, and surgical history]; pre- and postoperative clinical data (pain scores, urinary, gastrointestinal, and sexual function); surgical variables (operative time, blood loss, intraoperative complications, additional procedures, and the lateral/caudal extent of parametrectomy); and perioperative outcomes (hospital stay, postoperative complications, and the need for self-catheterisation). The extent of the disease was assessed intraoperatively using both the revised American Society for Reproductive Medicine (r-ASRM) classification[18] and the Enzian system.[19] Postoperative complications within 30 days of the procedure were classified based on the Clavien–Dindo grading system.[20] At six months post-surgery, patients underwent clinical follow-up, which included a rectovaginal examination and repeat transvaginal and transabdominal ultrasonography. Pain symptoms were reassessed using the same VAS scale. To evaluate functional outcomes, patients completed a number of validated questionnaires. Specifically, bowel function was assessed using the Knowles-Eccersley-Scott symptom (KESS) questionnaire[21] (0–39 points, with scores of 10 or higher indicating constipation); gastrointestinal quality of life was measured using the gastro-intestinal quality of life index (GIQLI)[22] (0–144, where higher scores reflect better quality of life); urinary symptoms were evaluated via the Bristol female lower urinary tract symptoms total score (BFLUTS) questionnaire[23] (0–45, with higher scores corresponding to more severe symptoms); and sexual function was assessed through the female sexual function index (FSFI),[24] a 19-item questionnaire, where total scores below 26.5 suggest dysfunction. Urinary retention was identified when post-void residual volume remained ≤100 mL on three successive measurements, prompting the initiation of intermittent self-catheterisation.

Surgical Procedure and Anatomical Landmarks for Extended Hysterectomy

This study applied a standardised surgical approach for dorsolateral parametrectomy performed during EH, building on the anatomical classification recently described by our group.[7] This classification distinguishes four types of parametrial dissection based on three key anatomical landmarks used to preserve the inferior hypogastric plexus: the presacral fascia, which envelops the hypogastric nerves (HN) (Figure 1), the middle rectal artery (MRA), typically contained in the lateral ligament of the rectum (LLR) (Figure 2), and the hypogastric fascia (Figure 3).

Using this system, procedures were categorised as:

- EH with superficial parametrectomy (EHSP): limited medially to the presacral fascia and cranially to the MRA;
- EH with deep parametrectomy type 1 (EHDP1): extending laterally beyond the presacral fascia;
- EH with deep parametrectomy type 2 (EHDP2): reaching caudally beyond the MRA;
- EH with deep parametrectomy type 3 (EHDP3): progressing laterally to the hypogastric fascia.

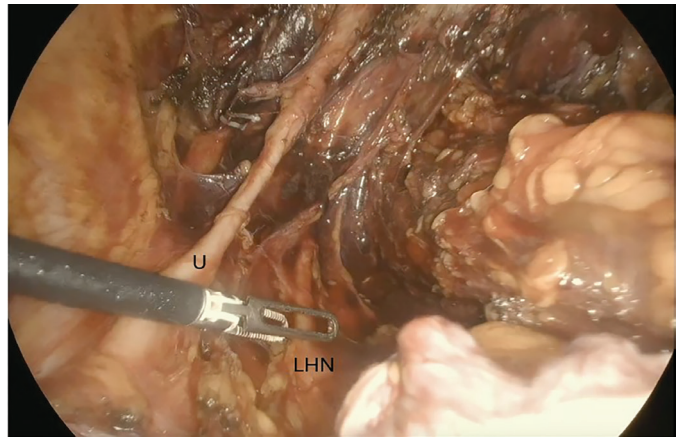

Figure 1. Left Medial pararectal space with hipogastric nerve covered by presacral fascia.

U: Left ureter, LHN: Left hypogastric nerve covered by presacral fascia.

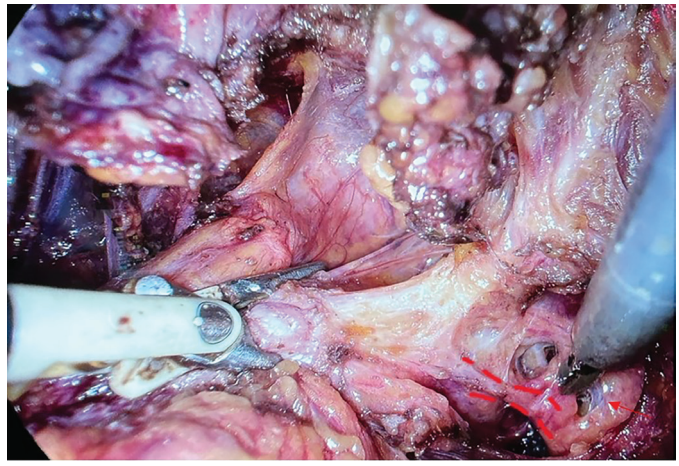

Figure 2. Through the partially dissected lateral ligament of the rectum, the middle rectal artery can be seen (indicated by the red dotted lines), and caudally and laterally to it, part of the branch of the inferior hypogastric plexus directed to the rectum (indicated by the arrow).

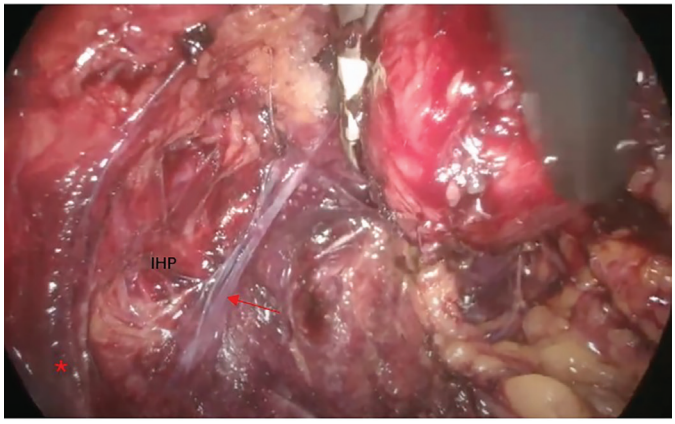

Figure 3. A red arrow indicates the left hypogastric fascia dissected during a dorsal-lateral parametrectomy.

*Left hypogastric nerve, IHP: Inferior hypogastric plexus.

All operations were conducted by surgeon MMI, who has a high level of proficiency in the surgical management of DE. The nerve-sparing method, previously documented, foresees interfascial dissection between the parietal and visceral pelvic fasciae, performed via a combined latero-medial and medio-lateral approach.[4,7] The only parameter used to decide the depth of parametrectomy was the macroscopic visualisation of soft tissue free of macroscopic disease. Among the patients who underwent surgery, none of them had considered "non-radical" surgery to minimise the risk of complications, and thus no selection biases were evident.

In cases of recto-sigmoid endometriosis, an initial conservative shaving technique was employed. When residual nodules remained, either segmental or discoid bowel resection was performed based on lesion characteristics, proximity to the anal verge, and the degree of circumferential involvement.[25] When the disease involved the ureter, ureterolysis was attempted first. If this was insufficient to release the ureter, ureteroneocystostomy was carried out.[5] All patients included received a histological confirmation of endometriosis.

Study Endpoints

The main objective of this study was to assess surgical outcomes including intraoperative, perioperative, and postoperative complications in women undergoing nerve-sparing dorsolateral parametrectomy, categorised according to the lateral and caudal depth of resection. Secondary outcomes included an assessment of postoperative changes in pelvic organ function (bowel, urinary, and sexual domains) using validated questionnaires (KESS, GIQLI, FSFI, BFLUTS), an evaluation of changes in pain symptoms from baseline to 6 month follow-up, and an exploration of potential correlations between the extent of parametrial dissection and postoperative functional outcomes, in combination with clinical, anthropometric, and intraoperative data.

Statistical Analysis

Given the retrospective observational design, no formal sample size calculation was performed. A total of 89 patients who met the inclusion criteria and underwent surgery during the study period were enrolled. Descriptive statistics summarised cohort characteristics. Categorical variables were reported as absolute numbers and percentages, while continuous variables were expressed as means with standard deviations or medians with interquartile ranges, depending on data distribution. The Shapiro–Wilk test assessed the normality of continuous variables.

Comparisons of quantitative variables across EH groups (EHSP, EHDP1, EHDP2, and EHDP3) were made using analysis of variance -one way or the Kruskal-Wallis test, as appropriate for non-normally distributed data. Differences in qualitative variables across HS groups were assessed using the chi-squared test or Fisher's exact test, as appropriate. Changes in quality-of-life and functional scores between baseline and follow-up were analysed using paired Student's t-tests or Wilcoxon signed-rank tests, as appropriate. A *P* value less than 0.05 was considered statistically significant. All statistical analyses were conducted using R software, version 4.2.0 (CRAN®, R Core 2022).

Results

The clinical and demographic characteristics of the study population are summarised in Table 1. The study included 89 women, whose mean age was 43.48±5.10 years and whose mean BMI was 24.78±3.33 kg/m². Both age and BMI (calculated as weight in kilograms over height in meters squared) showed no significant differences between groups. More than 60% of the cohort (n=54) had previously undergone surgery for endometriosis, and specifically 55.8% were in the SP group, 63.1% were in EHDP1, 83.3% were in EHDP2, and 50% were in EHDP3. Prior surgery occurred most frequently in EHDP2 (83.3%, n=10), although this difference did not achieve statistical significance (*P*=0.3). The only preoperative variable that differed significantly between groups was hydronephrosis, which was more common in EHDP3.

In accordance with the revised ASRM classification,[26] all patients were categorised as either stage III (40.4%) or stage IV (59.6%).

Intraoperative and Postoperative Complications

Intra- and postoperative surgical variables are summarised in Table 2 and Supplementary Figure 1. Overall, 8 patients (8.9%) experienced intraoperative complications: 5 (9.6%) with EHSP, 1 (5.3%) with EHDP1, and 2 (8.3%) with EHDP2. These events included six bladder injuries and two rectosigmoid injuries, all of which were detected intraoperatively and successfully repaired by primary suturing. There were no occurrences of rectovaginal, vesicovaginal, ureteral, or bladder fistulas, nor cases of ureteral stenosis, uroperitoneum, hemoperitoneum, subcutaneous hematoma, or pelvic abscess. Significant differences were observed among groups for postoperative bladder voiding dysfunction (*P*=0.001). Bladder voiding dysfunction occurred in 11 women (12.3%), most frequently with EHDP1 (31.6%, 6 patients). At the 6-month follow-up, only two women (2.24%) needed self-catheterisation: one who had EHDP1 (5.26%) and one who had EHDP2 (8.3%). The mean duration of self-catheterisation was longest for EHDP2 (6.7 days).

Table 1. General characteristics of the study sample groups at baseline (n=89).

Variables	Overall (n=89)	EHSP (n=52)	EHDP1 (n=19)	EHDP2 (n=12)	EHDP3 (n=6)
Age (years)	43.48 (5.10)	44.15 (4.9)	42.57 (5.82)	42.3 (4.5)	42.8 (5.4)
BMI, kg/m^2	24.78 (3.33)	24.46 (3.8)	25.07 (2.86)	25.1 (2.63)	25.8 (1.9)
Previous surgery for endometriosis	54 (60.8)	29 (55.8)	12 (63.1)	10 (83.3)	3 (50.0)
Hydronephrosis	8 (8.9)	1 (1.9)	3 (15.8)	0	4 (66.7)
r-ASRM					
III	36 (40.4)	28 (77.8)	5 (13.9)	3 (8.3)	0
IV	53 (59.6)	24(46.1)	14 (73.6)	9 (75)	6 (100)

EHSP: Extended hysterectomy with superficial parametrectomy, EHDP1: Extended hysterectomy with deep parametrectomy type 1, EHDP2: Extended hysterectomy with deep parametrectomy type 2, EHDP3: Extended hysterectomy with deep parametrectomy type 3, BMI: Body mass index, r-ASRM: Revised American Society for Reproductive Medicine.

Table 2. Comparison in term of intra- and post-operative complications between the study groups.

Complications	Overall (n =89)	EHSP (n=52)	EHDP1 (n=19)	EHDP2 (n=12)	EHDP3 (n=6)	*P* values
Intraoperative complications	8 (8.99)	5 (9.6)	1 (5.3)	2 (8.3)	0	0.031*
Transfusion	3 (3.37)	3 (5.8)	0	0	0	-
Bladder voiding deficit	11 (12.36)	2 (3.8)	6 (31.6)	2 (16.7)	1 (16.7)	0.016*
Intestinal anastomosis leakage	1 (1.10)	0	1 (5.3)	0	0	-
EBL	221.4 (168.7)	201.5 (193.3)	266.8 (152.5)	217.5 (80.0)	258.3 (91.7)	0.024*
ORT	262.6 (97.91)	229.7 (67.03)	280.5 (118.5)	319.8 (97.03)	377.2 (124.3)	0.013*
Day of hospitalisation	4.96 (1.97)	4.36 (1.6)	5.78 (2.25)	5.3 (1.8)	6.8 (2.7)	0.076*
Clavien-Dindo maximum grade						
0	63 (70.8)	43 (82.7)	9 (47.4)	8 (66.7)	3 (50)	
1	9 (10.1)	2(3.8)	5 (26.3)	2 (16.7)	0	0.047*
2	16 (18.0)	7 (13.5)	4 (21.1)	2 (16.7)	3 (50)	
3	1 (1.1)	0	1 (5.3)	0	0	
Definitive auto catheterisation	2 (2.24)	0	1 (5.26)	1 (8.3)	0	

Descriptive statistics are expressed as a median and interquartile range for quantitative variables, and as absolute and relative percentage frequencies for qualitative variables. Statistically significant values were marked with an *.
EHSP: Extended hysterectomy with superficial parametrectomy, EHDP1: Extended hysterectomy with deep parametrectomy type 1, EHDP2: Extended hysterectomy with deep parametrectomy type 2, EHDP3: Extended hysterectomy with deep parametrectomy type 3, EBL: Estimated blood loss, ORT: Operative time in minutes.

Median hospital stay was 4.96 days overall, ranging from 4.36 days with EHSP to 6.8 days with EHDP3 (not statistically significant). Mean estimated blood loss was 221.4±168.7 mL and was similar across groups, while mean operative time (377.2±124.3 min) was longest with EHDP3. There was only one Clavien–Dindo grade III complication, namely an intestinal anastomotic leak with EHDP1, which was managed conservatively.

Additional Surgical Procedures

Disease mapping in accordance with the #Enzian classification is reported in Supplementary Table 1, which also shows a significantly different distribution of ovarian and ureteric involvement, with obstruction among groups. Ureterolysis was required in 79 women (88.8%), which included all patients who had EHDP1-3 and 80.8% (n=42) of those who had EHSP (Table 3). Rectal shaving was performed in 11 cases (12.4%) and segmental bowel resection in 26 (29.2%). Shaving was mainly performed with EHSP (8/52; 15.4%) and EHDP2 (2/12; 16.7%), while segmental resection was more frequent with EHDP1 (7/19; 36.8%), EHDP2 (6/12; 50%), and EHDP3 (3/6; 50%). Partial vaginal resection was done in 20 patients (22.5%), including 6 in EHDP1 (31.6%). No laparotomic conversions occurred. Neurolysis of the hypogastric, obturator, sacral plexus or sciatic nerves was carried out in 10 patients (11.2%), mainly those who had EHDP2 (60%). Unilateral nerve ablation of the HN or inferior hypogastric plexus was required in 8 cases (9%), predominantly on the left side with EHDP1 and on the right with EHDP3.

Functional Outcomes

A significant reduction in VAS scores for pain was observed between baseline and 6-month follow-up across all groups, especially for dyspareunia and dyschezia ($P<0.0001$; Table 4; Supplementary Figure 2). In terms of functional outcomes, KESS scores improved significantly with EHDP1, EHDP2, and EHDP3. GIQLI scores improved in the same three groups. BFLUTS scores improved significantly only with EHSP and EHDP3. FSFI scores showed no significant changes with EHDP1 and EHDP2, whereas EHDP3 showed significant improvement across all questionnaires.

Table 3. Intraoperative variables.

Surgery	**Overall (n=89)**	**EHSP (n=52)**	**EHDP1 (n=19)**	**EHDP2 (n=12)**	**EHDP3 (n=6)**	***P* values**
Bowel surgery	42 (47.2)	21 (40.4)	9 (47.4)	9 (75)	3 (50)	0.194
Shaving	11 (12.4)	8 (15.4)	1 (5.3)	2 (16.7)	0	0.498
Discoid resection	6 (6.7)	4 (7.7)	1 (5.3)	1 (8.3)	0	0.891
Segmental resection	26 (29.2)	10 (19.2)	7 (36.8)	6 (50)	3 (50)	0.078*
Distance from the anal verge, cm	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-5.0)	2.00 (0-5)	2.6 (0-5)	0.056
Ileostomy	14 (15.7)	2 (3.8)	4 (21.1)	5 (41.7)	3 (50)	0.001*
Ureterolysis	79 (88.8)	42 (80.8)	19 (100)	12 (100)	6 (100)	0.045*
Neurolysis						
Right	3 (3.4)	0	3 (15.8)	0	0	-
Bilateral	3 (3.4)	1 (1.9)	1 (5.3)	1 (8.3)	0	
Left	4 (4.5)	0	2 (10.5)	1 (8.3)	1 (16.7)	
Ablation						
Right	4 (4.5)	0	3 (15.8)	0	1 (16.7)	-
Left	4 (4.5)	0	1 (5.3)	0	3 (50)	
Other data						
Urethral resection/reimplantation	7 (7.9)	1(1.9)	2 (10.5)	0	4 (66.7)	0.001*
Partial resection of the bladder	4 (4.5)	1 (1.9	2 (10.5)	1 (8.3)	0	0.375
Partial vaginal resection	20 (22.5)	9 (17.3)	6 (31.6)	3 (25.0)	2 (33.3)	0.541
Conversion to laparotomy	0	0	0	0	0	-
Anterior parametrectomy	3 (3.4)	0	1 (5.3)	1 (.3)	1 (16.7)	-

Statistically significant values were marked with an *.
EHSP: Extended hysterectomy with superficial parametrectomy, EHDP1: Extended hysterectomy with deep parametrectomy type 1, EHDP2: Extended hysterectomy with deep parametrectomy type 2, EHDP3: Extended hysterectomy with deep parametrectomy type 3.

Table 4. Pain VAS scale and questionnaire evaluations before intervention and at 6-month follow-up (n=89).

	Overall (n=89)		***P* value**	**EHSP (n=52)**		***P* value**	**EHDP1 (n=19)**		***P* value**	**EHDP2 (n=12)**		***P* value**	**EHDP3 (n=6)**		***P* value**
	Baseline	**FU-6**		**Baseline**	**FU-6**		**Baseline**	**FU-6**		**Baseline**	**FU-6**		**Baseline**	**FU-6**	
VAS															
Dysuria	**0 (0–2)**	**0 (0–0)**	**0.0001***	**0 (0–0.5)**	**0 (0–0)**	0.0001*	0 (0–3)	0 (0–0)	0.148	0 (0–3)	0 (0–0)	0.083	0 (0–4.5)	0 (0–0)	0.064
Dysmenorrhea	8 (7–10)	-	-	8 (6.7–9.2)	-	-	7 (6–8.5)	-	-	10 (9–10.5)	-	-	8 (7.5–9)	-	-
Dyspareunia	**8 (6–9)**	**0 (0–2)**	**0.0001***	**8 (4.5–8.3)**	**0 (0–0.2)**	**0.0001***	**8 (7–9)**	**0 (0–0.3)**	**0.0001***	**8 (6.5–9)**	**2 (0–3.3)**	**0.0001***	**6 (1.3–7.8)**	**0 (0–2)**	**0.0001***
Dyschezia	**0 (3–7)**	**0 (0–0)**	**0.0001***	**2 (0–7)**	**0 (0–0)**	**0.0001***	**3 (0–8.5)**	**0 (0–2)**	**0.0001***	**6 (0–8)**	**0 (0–0)**	**0.0001***	**4 (0–7)**	**0 (0–0)**	**0.0001***
Questionnaires															
KESS	**16.35 (6.61)**	**13.13 (7.21)**	0.0001*	15.65 (6.18)	14.25 (7.7)	**0.027***	**17.21 (6.6)**	**12.26 (5.8)**	**0.0001***	**19.5 (6.5)**	**12.7 (6.7)**	**0.0001***	**13.5 (9.1)**	**7 (4.5)**	**0.0001***
GIQLI	83.1 (25.2)	87.6 (27.8)	0.057	87.19 (22.0)	88.05 (26.91)	0.420	**77.21 (28.89)**	**88.8 (28.1)**	**0.0001***	**89 (21.2)**	**93.3 (24.4)**	**0.0001***	**54.6 (29.8)**	**69.5 (39.7)**	**0.0001***
FSFI tot	19.5 (7.4)	17.5 (9.9)	0.079	20.30 (6.3)	18.58 (9.6)	0.084	18.5 (6.3)	16.1 (7.3)	0.094	16.84 (11.7)	18.2 (13.0)	0.075	**21.8 (9.7)**	**11.01 (12.2)**	**0.0001***
BFLUTS tot	14.8 (10.2)	13.3 (10.04)	0.097	**15.23 (10.44)**	**12.92 (9.74)**	**0.0001***	17.9 (10.9)	17.2 (10.6)	0.704	**10.9 (8.3)**	**13.1 (10.4)**	**0.0001***	**12.4 (8.2)**	**9.5 (5.7)**	**0.0001***

Statistically significant values were marked with an *.

BFLUTS tot: Bristol female lower urinary tract symptoms total score, EHSP: Extended hysterectomy with superficial parametrectomy, EHDP1: Extended hysterectomy with deep parametrectomy type 1, EHDP2: Extended hysterectomy with deep parametrectomy type 2, EHDP3: Extended hysterectomy with deep parametrectomy type 3, FSFI tot: Female sexual function index total score, GIQLI: Gastro-intestinal quality of life index, KESS: Knowles-Eccersley-Scott symptom; VAS: Visual analog scale, FU-6: Follow-up 6 months.

Discussion

Main Findings

This study provides preliminary evidence that the proposed classification of dorsolateral parametrectomy can be a useful framework to link the extent of parametrial resection to both postoperative complications and functional outcomes in patients undergoing EH for DE. In particular, our data show that EHDP1 procedures involving more extensive dorsolateral dissections were associated with a significantly higher incidence of postoperative bladder dysfunction (31.6%) compared to EHSP (3.8%) and EHDP2 (16.7%). This finding aligns with the work of Ianieri et al.,[7] who demonstrated that parametrial dissection beyond the presacral fascia and the MRA carries an increased risk of neurovegetative injury.

Consistent with our earlier findings,[4,7] we observed that EH for DE was associated with improvements in dyspareunia, but not necessarily with better sexual function as measured by FSFI scores. No significant differences emerged among the groups, which could be due to partial damage to autonomic fibres that regulate vaginal blood flow and lubrication.

Regarding bowel function, KESS scores significantly improved with EHDP1 and EHDP3, while no change was seen with EHDP2. This difference may relate to the variable degree of preservation of the rectal autonomic innervation, which passes through the LLR, in one of the three branches of the inferior hypogastric plexus, and which reaches the rectum. This data should also prompt reflection on the real impact that intestinal surgery for DE can have on organ dysfunction. Indeed, patients undergoing a caudal parametrectomy

that overcomes the MRA have potential dysfunction, but not patients undergoing intestinal surgery per se. [27]

Strengths and Limitations

To our knowledge, this is the first study to evaluate gastrointestinal, urinary and sexual outcomes using validated questionnaires in patients undergoing EH for DE, stratified according to the extent of parametrial dissection. This classification makes it possible to have a clearer attribution of complications regarding parametrectomy and supports the need for a standardised system. We have recently proposed an anatomical landmark-based system for parametrial dissection, which we hope will enable more consistent comparison across studies.[7]

This study has some limitations. The number of EHDP3 cases was small, and the follow-up period was too short to evaluate long-term pain recurrence or functional deterioration. In fact, the limited number of cases of EHDP3 did not allow us to describe the real incidence of complications in this group, particularly intraoperative ones, which would probably have been higher, especially in terms of potential vascular lesions. The retrospective nature of our study is usually connected to biases relating to incomplete or imperfect data collection, but our data comes from a prospective collection of questionnaires that are routinely collected during hospital admission and visits. Nonetheless, there is potential bias related to this being the surgical experience of a single surgeon, which can make the reproducibility of the classification unverified and, above all, dependent on a high level of knowledge of anatomy and endometriosis surgery, limiting its use to a small number of more experienced surgeons. Moreover, although validated questionnaires were used, they carry an inherent risk of subjective bias.

Strengths and Limitations Compared to Other Studies

The lack of sexual function improvement, measured by FSFI scores, is probably due to the intraoperative damage of nerve fibres and is consistent with previous data reported by our group.[4,7] This element should be addressed during the preoperative counselling of patients, to help avoid false expectations. Moreover, this finding may lead surgeons to understand that, even though they can use a "nerve-sparing" approach, sometimes they cannot really ensure complete preservation of all the ortho- and para-sympathetic nerve fibres. Furthermore, we must not forget that endometriosis can be associated with disorders of the contractility of the pelvic floor muscles.[28]

In our previous series,[4] post-voiding dysfunction occurred in approximately 13% of patients undergoing EH, and Darlet et al.[6] reported a comparable rate (13.5%) of self-catheterisation in 52 similar cases. However, neither study stratified outcomes according to the lateral–caudal extent of parametrectomy, limiting interpretation of the findings.

More broadly, the literature on EH for DE is highly heterogeneous, largely because the extent of parametrial dissection is rarely defined in precise anatomical terms.[5,6,15] Most studies describe the surgical technique[15,29-31] without specifying which portions of the parametrium were excised, likely explaining the wide variability reported for postoperative urinary retention (3.4–32%).[3,7]

Our data suggest that parametrectomy does not consistently improve urinary function, and discrepancies in the literature[31,32] may reflect not only patient selection bias but also the lack of assessment of how dissection depth relative to key anatomical landmarks influences the risk of pelvic autonomic nerve injury. Overall, published data on the functional impact of parametrial resection remain inconsistent, as many studies fail to provide a clear definition of parametrectomy.[5,6,15,31-33] Even for procedures widely adopted since their first description in 2008,[11] substantial variation has been documented among surgeons regarding the actual extent of dissection performed.[11,34]

Unlike the Querleu–Morrow classification,[10] originally developed for oncological surgery, our system is intended to reflect the anatomical features of parametrial DE, where radical excision must be balanced with preservation of pelvic autonomic nerves. As recently emphasised by our group,[7] this highlights the need for a classification tailored to the specific topography and neurovascular anatomy of endometriosis.

Clinical and Policy Implications

From a clinical perspective, these findings could guide intraoperative decisions regarding the extension of dissection beyond defined anatomical landmarks, balancing radical excision with functional preservation. Preoperative counselling is essential to align expectations regarding pain relief and postoperative functional recovery, in particular regarding potential post-operative bladder dysfunctions and the lack of improvement in sexual dysfunction.

Given the complexity of these surgical procedures, and especially the wide heterogeneity of symptoms and post-operative complications, referral to specialised centres with multidisciplinary expertise should be mandatory in cases of parametrial DE. Standardisation of terminology and classification would further improve comparability between centres and facilitate the development of consensus recommendations for radical surgery in DE.

Unanswered Questions and Future Research

The element that is probably most lacking in this study is the absence of a recurrence rate over a longer follow-up, which would have provided further information and evidence regarding the choice of whether to pursue radical surgery in the subgroup of patients with parametrial endometriosis. Obviously, the evaluation of functional outcomes, over a follow-up period of years after surgery for parametrial DE, deserves a separate study, especially to understand whether compensatory mechanisms can be established over time to convey potential ortho- and parasympathetic nerve lesions. That, however, goes beyond the scope of this study.

Conclusion

In conclusion, our classification for EH constitutes a significant advance in standardising the description of parametrectomy for DE, facilitating more precise correlations between disease extension in the parametria and functional outcomes. Nonetheless, it should be emphasised that the retrospective nature of this study and the heterogeneous size of the four groups do not make definitive conclusions possible. Prospective and especially multicentre validation will be needed to demonstrate the reproducibility of our proposed classification.

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Informed consent: Prior to surgery, all patients signed written informed consent forms that allowed the use of their anonymised clinical data for research purposes.

Data sharing: The dataset used and analysed in the current study is not publicly available but can be made available by the corresponding author upon reasonable request.

Transparency: The authors affirm that the manuscript is an honest, accurate, and transparent account of the studies assessed. There are no important aspects of the studies omitted.

Supplementary Figures: https://d2v96fxpocvxx.cloudfront.net/37eae217-e8b5-4f55-976f-35df98003e83/content-images/e0b07c94-1449-45ae-accb-acbf0e565472.pdf

Supplementary Table: https://d2v96fxpocvxx.cloudfront.net/37eae217-e8b5-4f55-976f-35df98003e83/content-images/2de32bf9-4064-42f9-836d-68bf93c7ab62.pdf

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SHORT COMMUNICATION

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Intra-ureteric indocyanine green for ureteric visualisation in complex benign gynaecological surgery: a prospective series of 50 cases

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ABSTRACT

Ureteric injury is a serious complication of gynaecological surgery, particularly in cases involving deep endometriosis. This prospective cohort study assessed the feasibility and safety of intra-ureteric indocyanine green (ICG) for real-time ureteric visualisation in complex endometriosis surgery at a tertiary referral unit. Fifty consecutive patients undergoing laparoscopic procedures received cystoscopy-guided bilateral intra-ureteric ICG. Mean additional operative time was 160 seconds. Bilateral ureteric fluorescence was achieved in all cases and persisted throughout surgery. Guidewires and intra-operative stents were required in 2% and 4% of cases, respectively. No ICG-related adverse events or ureteric injuries occurred, demonstrating a rapid, safe and reproducible technique.

Keywords: Cystoscopy, endometriosis, gynaecological surgery, indocyanine green, laparoscopic, ureter

Introduction

Ureteric injury is a serious complication of benign gynaecological surgery, with an incidence of 0.5%-2%[1] in laparoscopic procedures, of which 70% of injuries are detected post-operatively.[2] In a large United Kingdom series of 14,692 laparoscopic hysterectomies, overall ureteric injury rate was reported at 0.6%, increasing to 2.2% among patients with endometriosis.[1] In selected high-risk subgroups such as patients with deep infiltrating endometriosis (DIE) and hydronephrosis, rates as high as 21% have been described. These figures highlight the difficulty of ureteric identification in complex pelvic surgery where anatomy is distorted, and the importance of adjunctive visualisation techniques. Conventional preventive strategies include meticulous ureterolysis and prophylactic ureteric stenting, though evidence for routine stenting is weak.[3]

Indocyanine green (ICG) has been safely used across multiple surgical specialties for several decades with excellent safety and predictable pharmacokinetics.[4] Within gynaecology, ICG with near-infrared (NIR) imaging has applications in both oncological and non-oncological surgery–from sentinel lymph-node mapping to assessment of tissue perfusion, tubal patency, bladder and ureteric identification, and evaluation of ovarian and bowel vascularity.[5] Reported adverse effects from ICG are rare (0.05%–0.07%),[6] and when administered into the ureter, remains intraluminal with negligible systemic absorption and minimal renal or ureteric toxicity. Furthermore, the dose used in this study (25 mg in 10 mL) is well below thresholds associated with systemic exposure.[6] Intra-ureteric administration avoids the intravascular route altogether, further reducing the potential for allergic or haemodynamic effects, while providing

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prolonged and stable visualisation throughout surgery. In theory, improved visualisation of the ureter through the retroperitoneum using ICG should mitigate the risk of inadvertent ureteric injury and potentially lessen the need for routine pelvic sidewall opening and ureterolysis. This may subsequently reduce fibrosis, chronic pelvic pain and the complexity of repeat surgery when required.

ICG's use for ureteric delineation was first described in 2013 by Lee et al.,[7] who demonstrated real-time intra-operative visualisation during robotic ureteroureterostomy. Subsequently, small series have reported successful, safe and sustained ureteric mapping with ICG fluorescence,[8-11] highlighting its potential to enhance safety. Building on these developments, we report a single-surgeon prospective series of 50 complex benign gynaecological procedures in which intra-ureteric ICG with NIR-imaging was employed for real-time ureteric identification. The objectives were to assess the feasibility and safety of this technique in routine tertiary practice and explore its potential to reduce reliance on prophylactic ureteric stenting while enhancing safety in minimally invasive gynaecological surgery.

Methods

Study Design

A prospective analysis of 50 consecutive patients undergoing complex benign gynaecological surgery between February 2024 and June 2025 was performed. Data on intra-operative #Enzian classification, success of NIR-fluorescence and operative outcomes were collected at a single-surgeon unit within a tertiary referral centre specialising in endometriosis and complex non-oncological gynaecological surgery. All patients with DIE were followed up post-operatively as routine practice at six months.

Inclusion and Exclusion Criteria

Eligible patients were adults (≥18 years) undergoing complex benign gynaecological surgery in which difficult ureteric visualisation was anticipated-such as procedures for DIE, dense adhesions, large fibroids or significant adenomyosis-and where ureteric stenting, ureterolysis or enhanced identification would typically be considered. All patients provided written consent for cystoscopy and intra-ureteric ICG. Patients with known allergy to ICG or iodide, significant renal impairment or ureteric obstruction precluding catheterisation, active urinary tract infection, pregnancy, or prior urological ureteric reconstruction were excluded. Cases were also excluded if intra-operative judgement deemed ureteric catheterisation unsafe or unnecessary (i.e., in the case of a simple hysterectomy). As ureteric ICG was introduced as a standard component of complex gynaecological surgery at this centre, there was no requirement for a full ethical approval according to local institutional policy and the United Kingdom Health Research Authority guidance.

Surgical Methods

Cystoscopy with ICG was performed prior to commencement of all surgical procedures. A 22 or 25 French (Fr) 30-degree rigid cystoscope was used to place a 6 Fr open-tip ureteric catheter 1-2 cm into each ureteric orifice. ICG was prepared as 25 mg of dye diluted in 10 ml of sterile water, with 5 mL instilled into each ureter. The time taken to perform cystoscopy and ICG injection was recorded. Use of guidewires, adequacy of ureteric visualisation under fluorescence, and any intraoperative or postoperative complications were also documented.

Results

Fifty patients were included. Indications predominantly included deep endometriosis, laparoscopic hysterectomy with or without endometriosis surgery, and other complex benign procedures (Table 1). All cases of DIE were classified according to #Enzian classification. Deep endometriosis was predominantly multicompartmental, with compartment B (uterosacral ligaments and pelvic sidewall) involved in 92.6% of cases, most commonly as moderate to severe disease (B2–B3). Compartment A (rectovaginal septum/retrocervical region) and tubo-ovarian adhesions (T category) were each present in 85.2% of patients, again largely reflecting A2–A3 and T2–T3 disease. Rectosigmoid involvement (compartment C) was identified in 74.1% of cases, with a substantial proportion demonstrating lesions ≥1 cm (C2–C3). Peritoneal disease was present in 77.8% of patients, while ovarian involvement was noted in 63.0%. Extra-genital disease (F category) occurred in over half of cases (55.6%), most frequently adenomyosis and ureteric involvement,

Table 1. Indications and index procedures.

Indication/procedure	**n (%)**
Deep endometriosis surgery	30 (60)
Laparoscopic hysterectomy	10 (20)
Hysterectomy with endometriosis surgery	7 (14)
Other complex benign procedures	3 (6)

with bladder and non-rectal bowel disease observed less commonly.

The mean additional time required for cystoscopy and ICG administration was 160 seconds (standard deviation: 23.6; range: 120-210 s). A guidewire was required in 1/50 (2%). Bilateral ureteric fluorescence was achieved in 50/50 (100%) and this persisted throughout each procedure. Intra-operative stenting was performed in 2/50 (4%). No intra-operative or post-operative complications occurred, and no iatrogenic ureteric injuries were observed. All patient with DIE were followed up six months post-operatively with no reported ICG or procedure-related complications. Examples of the ureteric fluorescence achieved from intra-ureteric ICG are shown in Figure 1.

Discussion

Main Findings

In this prospective series of 50 consecutive high-risk benign gynaecological cases, intra-ureteric ICG achieved 100% bilateral ureteric fluorescence, required an average of 160 seconds to set up, and was not associated with any complications or ureteric injuries up to 6 months post-operatively. Ureteric catheters were placed 1–2 cm into the ureter to minimise instrumentation, reduce the risk of ureteric trauma, and allow controlled instillation under direct cystoscopic vision. Deeper catheter placement may be considered in selected cases, especially if ICG back flow spillage into the bladder occurs, however was not routinely required. Intra-operative ureteric stenting was required in two cases with pre-existing hydronephrosis in whom extensive dissection was necessary to mobilise the ureters: a multidisciplinary decision in conjunction with urology colleagues. Guidewire use was reserved for when there was difficulty angulating the ureteric catheters directly into the ureteric orifices, encountered in only one case in this cohort. These findings demonstrate the feasibility and safety profile of intra-ureteric ICG and suggest that it enables dynamic, continuous real-time visualisation of the ureteric course.

Strengths and Limitations

Strengths of this series include prospective data capture, uniform surgical technique, and a deliberately high-risk population managed in a tertiary referral centre, highlighting the feasibility to integrate intra-ureteric ICG as a surgical adjunct in benign gynaecology. A limitation of this study is potential selection bias, as all procedures were performed by a single surgeon in a high-volume tertiary endometriosis centre with expertise exceeding that of many general gynaecology settings. Consequently, while cystoscopy and intra-ureteric ICG instillation were rapid, procedural setup and dye preparation may add incremental time depending on local logistics. The findings may therefore be less generalisable to lower-volume units or centres without NIR imaging, and the technique has an associated learning curve requiring familiarity with fluorescence optimisation and workflow integration. Nevertheless, intra-ureteric ICG is a straightforward, transferable technique that can be adopted in most gynaecological settings using existing equipment, with structured training supporting uptake in lower-volume centres.

Intra-ureteric ICG involves additional costs for dye, cystoscopy, and ureteric catheters, but these may compare favourably with prophylactic ureteric stenting

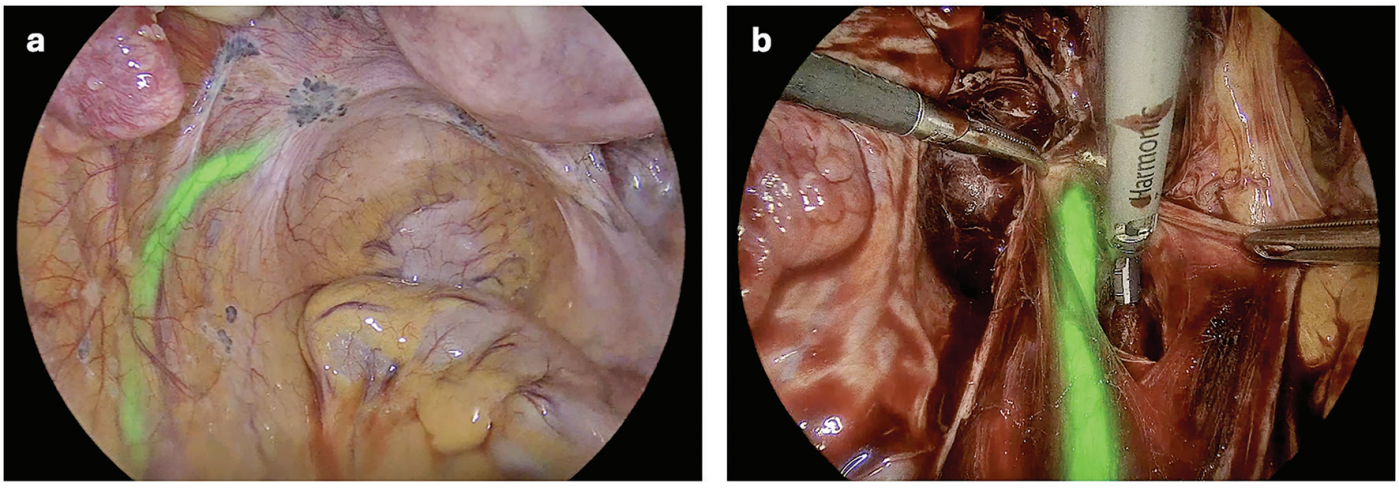

Figure 1. Laparoscopic view of intra-ureteric indocyanine green and near-infrared fluorescence during (**a**) laparoscopic excision of endometriosis involving the ureter (**b**) ureterolysis in a frozen pelvis secondary to endometriosis.

when stent-related morbidity and postoperative resource use are considered. Formal cost-effectiveness analyses are warranted.

Upcoming multicentre randomised trials–such as the ongoing ICE trial comparing ICG with conventional stenting–will be key to defining indications, optimising dosing protocols, quantifying cost-effectiveness, and evaluating broader applicability and reproducibility in routine practice.[12]

Strengths and Limitations in Relation to Other Studies

ICG fluorescence imaging is now well established across multiple surgical specialties–including colorectal, urological and gynaecological oncology–for real-time assessment of tissue perfusion and anatomical mapping. These established applications provide a strong foundation for its wider use in benign gynaecology.

The ureter is particularly vulnerable to iatrogenic injury during pelvic surgery, especially with dense adhesions and DIE, where fibrosis and scarring distort the ureteric course. Conventional preventive strategies, such as prophylactic ureteric stenting, may aid identification but offer limited protection. A systematic review of 10 studies involving 8,661 patients found no significant reduction in ureteric injury with prophylactic stenting (relative risk: 0.9; 95% confidence interval: 0.49–1.65).[3] Moreover, stenting is associated with additional morbidity, including urinary tract infection (≈1.5%), acute renal impairment (≈0.6%), ureterovaginal fistula (≈0.3%), haematuria, bladder irritability, and, more rarely, stent migration, obstruction, or perforation.[13-15] Placement also requires urological input, fluoroscopy, and radiography, increasing both cost and radiation exposure. These drawbacks underscore the need for safer and reliable methods of intra-operative ureteric visualisation. NIR imaging of instilled ureteric ICG offers such alternative –providing real-time, dynamic, and radiation-free delineation.

Our prospective series of 50 complex benign gynaecological cases adds to this growing evidence base. Bilateral fluorescence was achieved and maintained in every case, with a short setup time and no adverse events or ureteric injuries, confirming the safety, simplicity and reproducibility of the technique.

Future Directions

Although the results of this study are encouraging, further research is required to quantify the true impact of intra-ureteric ICG on ureteric injury rates, operative efficiency and overall cost-effectiveness compared with conventional techniques such as prophylactic stenting. Multicentre randomised trials will be key to defining optimal dosing, timing of administration and clinical indications. Future work should also evaluate surgeon learning curves, integration into training curricula, and wider implementation across differing institutional settings to assess generalisability and sustainability of this technique within everyday benign gynaecological practice.

Conclusion

This prospective series supports emerging evidence that intra-ureteric ICG with NIR fluorescence may be safely and feasibly integrated as an adjunct in complex benign gynaecological surgery. By enabling continuous dynamic mapping of the ureteric course, this technique may reduce reliance on prophylactic ureteric stenting, limit the extent of pelvic side-wall dissection, and support safer surgery in anatomically challenging cases. Intra-ureteric ICG should be regarded as a complement to, rather than a replacement for, surgical expertise and anatomical knowledge, offering a practical, reproducible, and safe method to potentially enhance ureteric safety in minimally invasive gynaecological surgery. Further controlled studies are warranted to confirm its clinical and cost-effectiveness in order to incorporate the technique into clinical guidance and policies.

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Informed consent: Written informed consent for intraoperative ICG used and anonymised data collection was obtained from all patients.

Data sharing: All the papers cited within the article are available online via their respective publishers.

Transparency: The authors affirm that the manuscript is an honest, accurate, and transparent account of the studies assessed. There are no important aspects of the studies omitted.

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SYSTEMATIC REVIEW

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Incisional hernia after specimen extraction in minimally invasive gynaecologic surgery: a systematic review

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ABSTRACT

Background: The location and size of abdominal incisions to enable tissue extraction might increase the risk of incisional hernia (IH).

Objectives: To determine the reported incidence of IH after specimen extraction in gynaecological minimally invasive surgery.

Methods: On January 9th 2025 we performed a systematic literature review of PubMed, Embase, and Clarivate Analytics/ Web of Science Core Collection from inception to 25 May 2023. Minimally invasive surgery, IH, specimen extraction, morcellation and gynaecology were used as search terms. All cohort studies and randomised controlled trials reporting IHs after minimally invasive gynaecological surgery with either morcellation or abdominal specimen extraction through an enlarged trocar site or mini-laparotomy were included.

Main Outcomes Measures: The primary outcome was the incidence of IH. Secondary outcomes included incision length and location, time to diagnosis and risk factors for developing IH.

Results: Thirty one studies were identified, of which three retrospective cohort studies met the inclusion criteria. The reported incidence of IH was between 0.02% and 8.3%, with a time to diagnosis spanning two days to two and a half years. Data were lacking or insufficient on the size and location of the incision and on the technique used for specimen extraction.

Conclusions: There is a lack of evidence on the risk of developing IH in minimally invasive gynaecological surgery. Given the increasing use of minimally invasive surgical techniques, there is a pressing need for high-quality research on the prevalence and risk factors of IH, as well as on interventions aimed at mitigating this risk.

What is New? This review reveals a lack of high-quality evidence and consistent reporting on factors influencing IH after specimen extraction in minimally invasive gynaecological surgery.

Keywords: Minimally invasive surgery, morcellation, incisional hernia

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#Equal contribution and therefore qualify for joint first authorship

Introduction

Incisional hernias (IHs) are one of the most common complications after abdominal wall incisions. IH is defined as any abdominal wall gap with or without a bulge in the area of a postoperative scar, perceptible or palpable by clinical examination or imaging.[1] A meta-analysis of Bosanquet et al.,[2] including over 14,000 patients between 1980 and 2011, reported the incidence of IH to be 12.8% two years after midline laparotomy. Kossler et al.[3] performed a systematic review (SR) and meta-analyses including 24 trials and showed a significantly reduced incidence after laparoscopy (4.3%) compared to open abdominal surgery (10.1%). However, when a tissue extraction site was used, the incidence was comparable (5.5 vs. 7.8%)[3] IH can cause pain, small bowel obstructions, strangulation and incarceration.[4] The consensus European Hernia Society (EHS) and the American Hernia Society (AHS) guidelines recently recommended avoiding a midline incision for tissue extraction sites to reduce the risk of IH.[5]

In minimally invasive gynaecologic surgery (MIGS), specimen extraction can be performed through an incision in the abdominal wall or through a vaginal incision. Morcellation is a technique used to divide large masses of tissue that allows removal through a small incision and is an integral part of making MIGS possible.[6,7] A vaginal incision such as a colpotomy theoretically leads to a 0% chance of IH. Still, it can result in other complications such as vaginal cuff dehiscence, bladder injury, conversion to an abdominal incision for extraction and vaginal wall laceration.[8] When using an abdominal wall incision for specimen extraction, the options are either in-bag power morcellation, involving a trocar incision of 15 mm,[9] or cold knife morcellation, performed with a mini-laparotomy of 20-60 mm by either enlarging the incision of a trocar site or by creating a separate abdominal incision.[10]

Gynaecology is not represented in either of the Hernia Societies, nor in the presented guideline by the EHS and AHS. There are no guidelines or recommendations from the most common gynaecologic authorities on the incision other than "to perform a small incision" on the abdominal wall.[11,12] As specimen extraction is a common procedure in MIGS it may contribute to the overall incidence of IH. Specific characteristics of gynaecologic procedures involve the extraction of large specimens, including large uteri or fibroids, and often require morcellation techniques. This may result in longer or differently located incisions compared to other minimally invasive surgeries,[13] and may create a different force on the abdominal wall, which may all contribute to an additional risk for developing IH. Understanding the risk of IH in gynaecologic surgeries is important to continue MIGS procedures when specimen extraction is needed. There is a need for a targeted review to supplement the existing guidelines of the EHS and AHS. This study aims to determine the reported incidence and location of IH after specimen extraction in MIGS in the current literature, in addition to the current IH literature of other surgical specialties.

Methods

We systematically reviewed the literature on the incidence of IH in MIGS, an area in which focused data remains limited. In contrast, over the past six years, several SRs have addressed IH incidence in other surgical subspecialties, including urology, bariatric surgery, general surgery, and colorectal surgery.[14-17] Part of these studies have contributed to the development of international consensus guidelines of the EHS and AHS.[5] These previous studies have extensively covered the prevalence of IH within these other disciplines; therefore, our search strategy was deliberately tailored to gynaecology. Where relevant, the findings of this review will be compared with the data from SRs from other surgical specialties to identify broader trends and formulate recommendations for surgical practice.

Systematic Search

On January 9th 2025, we searched the electronic databases of PubMed, Embase, and Clarivate Analytics/Web of Science Core Collection from inception to January 9, 2025. We used all terms for minimally invasive surgery, IH, specimen extraction, morcellation, and gynaecology as search terms (Figure 1, Supplemental Figure 1a-c). No limitations on date or language were applied in the search. The protocol of this SR was prospectively registered in the PROSPERO registry under the identification number CRD42023486103.

Inclusion and Exclusion Criteria

Cohort studies and randomised controlled trials on MIGS, including abdominal specimen extraction reporting on IH, were included. Minimally invasive surgery was defined as either straight stick laparoscopy or robotic surgery. Studies that included patients who received chemotherapy or radiotherapy before surgery were excluded. Studies were excluded if they did not clearly state details on technical aspects of the incision of the

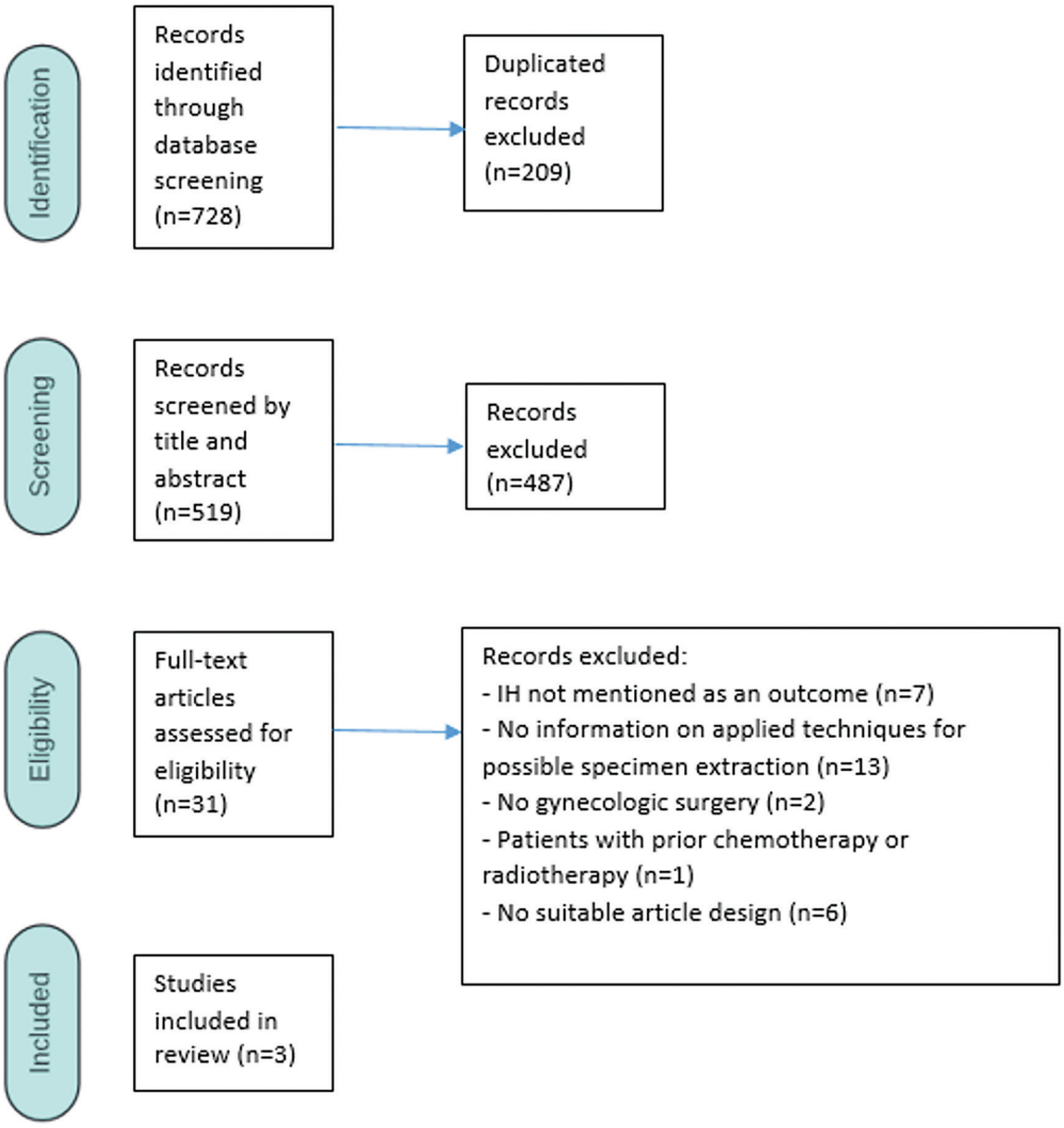

Figure 1. Prisma flowchart.

IH: Incisional hernia.

specimen extraction site (such as length or location), the extraction technique used, or when IH was inadequately reported.

Study Selection

Two independent reviewers (JvK and RV) reviewed all studies. The search results were screened for titles and abstracts. Screening the remaining articles for full text determined which studies could be included. The references of the included studies were reviewed for other suitable studies. Disagreements were resolved between the independent reviewers. A third reviewer (RdL) was available when consensus could not be reached.

Data Extraction

Data from the selected studies were extracted by two independent reviewers (Jvk and RV) using a pre-determined form, which included year of publication, study design, number of participants, and duration of follow-up. Several baseline characteristics were extracted from the included studies. Patient characteristics included age and body mass index. Surgical characteristics included the type of operation, location of the specimen extraction, length of the extraction incision, fascial closure techniques and the method used to diagnose IH. The primary outcome of this study was the incidence of IH.

Secondary outcomes include incision length and location, time to diagnosis of IH and risk factors for developing IH. Due to the limited number of studies and heterogeneity in study design, sample size, and outcome reporting, statistical pooling was not considered appropriate. Consequently, results were synthesised descriptively.

Risk of Bias Assessment

Two independent reviewers (JvK and RV) assessed the quality of selected papers using the Cochrane Risk of Bias[18] for randomised controlled trials and The Newcastle-Ottawa Scale[19] for non-randomised studies. If a study received a score of ≥6, it was considered a high-quality publication with a low risk of bias.

Results

The final search resulted in 782 articles, of which 519 remained after duplication. After reviewing the title and abstract, 31 studies were selected. After full-text screening, three studies met our inclusion criteria (Figure 1). No randomised controlled trials were performed on this subject. The selected studies included three retrospective single-centre studies, which included 374, 300, and 55,244 patients (Table 1).

Outcomes

Griffith et al.[20] conducted a retrospective cohort study with a follow-up period from 1 month to 3 years. They reported 374 patients who underwent laparoscopic myomectomy (43%), or hysterectomy (57%) followed by a mini-laparotomy for specimen extraction. A mini-laparotomy was defined as an enlarged or a new incision of 3 to 6 cm at either the umbilical or suprapubic site. Specimen extraction was performed using a contained hand morcellation technique with a scalpel. In total, 289 women (77.3%) underwent an umbilical mini-laparotomy and 85 women (22.7%) underwent a suprapubic mini-laparotomy. Incision size was significantly smaller in the umbilical group (3.3±0.8 cm vs. 4.2±0.6 cm; $P<0.001$). All mini-laparotomies were closed using a running or interrupted closure technique with slowly absorbable polydioxanone (PDS II, Ethicon) or polyglactin (Vicryl, Ethicon). Time to diagnosis was reported at 4 to 14 months, and the diagnosis of IH was either patient-reported or clinically diagnosed. The overall incidence of IH was reported to be 2.7% (n=10). There was no significant difference in IH incidence between the umbilical group (n=9, 3.1%) and the suprapubic group (n=1, 1.2%) ($P=0.833$).

Table 1. Study characteristics and patient characteristics.

Study	Study design	Number of patients	Follow-up time	Age (years)	BMI (kg/m²)
Griffith et al.[20]	Retrospective cohort study	374	1-3 years	Umbilical: Mean 43.4 (±8.9) Suprapubic: Mean 43.7 (±7.0) (*P*=0.782)	Umbilical: Mean 27.9 (±7.3) Suprapubic: Mean 27.7 (±6.2) (*P*=0.828)
Ustunyurt et al.[21]	Retrospective study	300	1 year	IH group: Mean 42.12 (±10.2) No-IH group: Mean 40.64 (±11.1) (*P*=0.520)	IH group: Mean 28.44 (±4.26) No-IH group: Mean 27.05 (±) (*P*=0.520)
Zhu et al.[22]	Retrospective single-center study	55244	1-21 years	IH group: Mean 53.4 (±19) No-IH group: No information	IH group: Mean 25.1 (range 17.6-34) No-IH group: No information

BMI: Body mass index, IH: Incisional hernia.

Ustunyurt et al.[21] performed a retrospective study, reporting the incidence of IH in 300 patients who underwent laparoscopic surgery for benign gynaecologic indications. No information on specimen extraction techniques was reported. There was a minimum follow-up of one year, with no maximum follow-up mentioned. The incidence of IH was 8.3% (n=25). Twenty three patients had IH at the umbilical site and two at the extra-umbilical site. Diagnosis of IH was made by physical examination combined with ultrasound examination, and time to diagnosis was reported as 12-29 months. No significant difference was found based on whether the trocar incision was enlarged, nor was information given on which incisions were enlarged. Parity ≥3 (P=0.018) and not closing the fascia (P<0.001) were identified as risk factors for developing IH.

Zhu et al.[22] performed a retrospective single-center study to assess the incidence of IH following conventional or single-port laparoscopic surgery (SILS) for benign gynaecologic indications. The study included 55,244 patients with a 1 to 21-year follow-up period. Details on surgical characteristics such as the location of specimen extraction, length of the extraction incision, or fascia closure techniques was not reported. The time to diagnosis of IH varied from 2 to 730 days, with diagnosis methods including physical examination, CT-scan, or ultrasound. Of the 55,244 patients, 0.016% (n=9) developed IH. Among those who developed IH, 5 cases were associated with the right lateral port, 4 involving specimen extraction. 4 developed IH at the umbilical port, of which 2 were associated with specimen extraction using SILS. Despite reporting the incidence of IH across different incision locations, the sample size was too small to determine any significance. The reported lengths of incisions varied among IH cases, including 2 cases with 5 mm ports, 5 cases with 10 mm ports, 1 SILS with a 40 mm incision, and 1 SILS with a 25 mm incision (Tables 2 and 3). An overview of which key surgical variable was reported and which variable was missing per included study is reported in Table 4.

Risk of Bias Assessment

The quality of each study was scored. The studies of Griffith et al.[20] and Zhu et al.[22] were considered fair quality, corresponding with 3-5 points on the Newcastle-Ottawa Scale for cohort and case-control studies. Ustunyurt et al.[21] was considered high quality, corresponding with a score of 6 (Table 5).

Discussion

Main Findings

This review aimed to provide an overview of the available literature on the risk of IH after specimen extraction in MIGS. Two cohort studies of fair quality and one of high quality were included in this review and reported an incidence of IH between 0.016% and 8.3%, with a time to diagnosis spanning two days to 2.5 years. Ustunyurt et al.[21] had an average time of follow-up of 16 months post-surgery. Griffith et al.[20] had a follow-up up to 3 years. Zhu et al.[22] had a minimum of 1-year follow-up, but no further distribution of follow-up time is known. Only one of the included studies reported on the size and location of the incision used for specimen extraction; the same study that reported routine fascia closure. None of the studies specified the use of morcellation techniques for specimen extraction. Ustunyurt et al.[21] diagnosed IH consistently with ultrasound; the other studies used self-reported questionnaires or medical records.

Strengths and Limitations

This SR addresses a timely and clinically relevant topic in MIGS. It was conducted according to a predefined protocol and used standard methodological tools for literature search, study selection, data extraction, and quality assessment, ensuring transparency and methodological rigor. Despite an extensive search, only three studies were identified that specifically reported on IH following specimen extraction in gynaecologic surgery. All included studies were retrospective in nature and exhibited substantial heterogeneity in study design, sample size, follow-up duration, and outcome reporting, including poor reporting on key surgical variables. Due to heterogeneity no pooled analysis could be performed and results were presented descriptively and should be interpreted with caution.

Strengths and Limitations Compared to Other Studies

Given the limited number of gynaecologic studies identified in our review, findings from other surgical specialties may provide indirect contextual insight. Several SRs have evaluated the incidence of IH following minimally invasive surgery in colorectal, urologic, general, and bariatric procedures.[15-17,23] In colorectal surgery, den Hartog et al.[24] included 36 studies assessing IH after specimen extraction, predominantly following segmental colon and rectal resections. Their analysis demonstrated a significantly higher incidence of IH after

Table 2. Surgical characteristics.

Study	Operation type and techniques	Location specimen extraction	Length incision	Time to diagnosis	Fascia closure	Diagnosis IH
Griffith et al.[20]	Laparoscopic or robotic-assisted hysterectomy (n=213) or myomectomy (n=161) combined with a mini-laparotomy made at the umbilical or suprapubic site Using contained hand morcellation with a scalpel	Umbilical mini-laparotomy: n=289, 77.3% Suprapubic mini-laparotomy: n=85, 22.7%	Umbilical mini-laparotomy: Mean 3.3 cm (±0.8) Suprapubic mini-laparotomy: Mean 4.2 cm (±0.6) (*P*<0.001)	4-14 months	Slowly absorbable Polydioxanone or Vicryl suture using a running or interrupted closing technique (100%)	Reported by patient Clinical diagnosis (specific method is not mentioned)
Ustunyurt et al.[21]	Cystectomy (33%) Hysterectomy (25.3%) Tubal ligation (19.3%) Myomectomy (7.6%) Salpingectomy (6.3%) Salpingo-oophorectomy (4.6%) Other (3.7%) No information on morcellation techniques	Per patient, 3 trocars: Umbilical, n=1 Lateral (6-7 cm from midline and 4-5 cm above symphysis), n=2	Per patient, 3 trocars: Umbilical 10/12 mm, n=1 Lateral 5 mm, n=2	12-29 months	Techniques not mentioned IH group: 40% fascia closure No-IH group: 82.2% fascia closure	Physical examination AND ultrasound
Zhu et al.[22]	Hysterectomy (18.6%) Adnexectomy (57.5%) Myomectomy (19.6%) Other (4.3%)	No information	No information	2-730 days	Not mentioned	Physical examination OR CT OR ultrasound

IH: Incisional hernia, CT: Computed tomography.

midline extraction compared with Pfannenstiel extraction [odds ratio (OR): 9.7, 95% confidence interval (CI): 5.0–18.8; *P*<0.001). This finding suggests that extraction site location may be an important determinant of hernia risk, a factor that may also be relevant in gynaecologic surgery.

In urology, Calcerrada Alises et al.[15] reviewed 84 studies involving multiport laparoscopic procedures with specimen extraction of kidneys, ureters, and bladder, reporting an overall IH incidence of 1.9%. However, information regarding incision length and the use of morcellation was not provided. Similarly, Jensen et al.,[16] in a review of 56 studies on laparoscopic cholecystectomy, reported a low overall IH incidence of 0.2%, without detailed data on incision length, extraction site location, or morcellation techniques. In bariatric surgery, Karampinis et al.[17] included 68 studies—primarily sleeve gastrectomy and gastric bypass procedures—and reported an overall IH incidence of 3.22%. The largest incision reported was 15 mm, with no specification of extraction site location, and morcellation was not performed in any of the included studies.

Across these reviews, follow-up duration was inconsistently reported; only den Hartog et al.[24] specified a follow-up period of five years. Hernias were generally diagnosed through clinical examination and/or imaging [ultrasound or computed tomography (CT)], yet differences in detection rates by modality were not reported.

A related observation comes from SILS, which involves a larger (2-4 cm) umbilical incision without necessarily including specimen extraction. A recent SR including 2471 patients demonstrated higher odds of IH after SILS compared with conventional laparoscopy (OR: 2.37, 95% CI: 1.25–4.50, *P*=0.008).[14] Since enlarged umbilical incisions are also common for specimen extraction in

Table 3. Study outcomes.

Study	Incidence of IH	Location of IH	Length incision in IH group	Weight of extracted specimen	Enlarged incision (yes)	Risk factors
Griffith et al.[20]	10/374 patients (2.7%)	Umbilical: n=9 (90%) Suprapubic: n=1 (10%) (*P*=0.833)	Not mentioned	Umbilical: 472.6 gr (±357.1) Suprapubic: 683 gr (±475.7) (*P*<0.001)	Mini-laparotomy is defined as a new or enlarged incision to 3-to-6 centimeters long	Age, surgeon, mini-laparotomy size, specimen weight, operative time and BMI = all not significant
Ustunyurt et al.[21]	25/300 patients (8.3%)	Umbilical: n=23 Lateral: n=2 *P=not mentioned*	Not mentioned	Not mentioned	IH group: n=1 (4%) No IH group: n=37 (12.7%) (*P*=0.223) Size is not mentioned	Parity ≥3 (*P*=0.018) Not closing the fascia (*P*<0.001)
Zhu et al.[22]	9/55.244 patients (0.016%) Operation type has no significant effect on IH incidence (*P*=0.626)	Umbilical: n=4 (with specimen extraction: n=2) Lateral: n=5 (with specimen extraction: n=4) *P=not mentioned*	5 mm: n=2 10 mm: n=5 SILSs 40 mm: n=1 SILSs 25 mm: n=1	Not mentioned	Not mentioned	Age >60 years (*P*=0.008) SILS (*P*=0.003)

IH: Incisional hernia, SILS: Single-port laparoscopic surgery, BMI: Body mass index.

MIGS, the risk of IH may be comparable. While different surgical forces may explain SILS-related risk, specimen extraction in conventional laparoscopy–especially with cold knife morcellation–can similarly stress the fascia.

However, these data from colorectal, urologic, bariatric surgery and SILS represent indirect evidence. Differences in patient population, specimen characteristics, operative technique, and wound closure limit direct extrapolation to gynaecology. These findings should therefore be considered hypothesis-generating rather than practice-changing, reinforcing the need for gynaecology-specific prospective studies.

In MIGS, the umbilicus is often chosen for specimen extraction since the incision can be concealed and avoids an additional incision. If IH occurs, it often presents beyond routine gynaecologic follow-up and is managed by general surgeons, reducing specialty-specific awareness. Given that mean time-to-diagnosis has been reported at 11.1 months,[25] with only 31.5% occurring within six months and approximately 50% after one year,[26] short follow-up likely leads to under-ascertainment. Moreover, imaging modalities, particularly CT and ultrasonography, substantially increase the detection of IH compared with clinical examination alone.[27] Variable follow-up duration and inconsistent diagnostic reporting across studies therefore likely underestimate true IH incidence and limit cross-specialty comparability. Although direct comparison with other surgical fields and techniques is limited, there is some overlap, specifically with colorectal surgery that allows insight from a broader surgical field which highlight the potential relevance of extraction site characteristics and surgical technique in development of IH.

Clinical and Policy Implications

Even though the recent recommendation of EHS and AHS to avoid a midline incision for specimen extraction,

Table 4. Availability of key variables in included studies.

Study	Specimen size	Extraction site	Incision length	Fascial closure technique	Use of morcellation	Surgeon experience
Griffith et al.[20]	✓	✓	✓	✓	✗	✗
Ustunyurt et al.[21]	✗	✓	✓	✓	✗	✗
Zhu et al.[22]	✗	✗	✗	✗	✗	✗

Table 5. Newcastle-Ottawa Scale assessment.

Cohort studies									
	Selection					Comparability	Outcome		
Study, year (ref)	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study		Comparability of cohorts based on the design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow-up of cohorts	Total
Griffith et al.,[20] 2018	1	0	1	1		1	0	0	0	4
Ustunyurt et al.,[21] 2020	1	0	1	1		1	1	1	0	6
Zhu et al.,[22] 2019	0	0	0	1		0	1	1	0	3

and the presented increased risk of IH in colorectal surgery and SILS that endorses avoiding an umbilical incision for specimen extraction, there remains a notable lack of evidence specifically addressing the risk of IH in MIGS. Given the increasing use of minimally invasive surgical techniques, there is a pressing need for high-quality research on the prevalence and risk factors of IH, and to evaluate strategies for its prevention.

Unanswered Questions and Future Research

There is a need for more robust, standardised reporting within this field, including the size and location of the extraction incision and the technique of morcellation used. In addition, a long-term follow-up is needed to better understand the potential impact of specimen extraction in MIGS procedures on the risk of IH. For future research, we suggest an international prospective cohort study with a follow-up time of at least five years, using a standardized, accurate method such as ultrasound or CT for diagnosing IH. A prospective design allows for the collection of appropriate surgical details and close monitoring of the incidence and risk factors of IH.

Conclusion

Even though the recent recommendation of EHS and AHS to avoid a midline incision for specimen extraction, and the presented increased risk of IH in colorectal surgery and SILS that endorses avoiding an umbilical incision for specimen extraction, there remains a notable lack of evidence specifically addressing the risk of IH in MIGS. Given the increasing use of minimally invasive surgical techniques, there is a pressing need for high-quality research on the prevalence and risk factors of IH, as well as on interventions aimed at mitigating this risk.

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Supplementary Figure: https://d2v96fxpocvxx.cloudfront.net/37eae217-e8b5-4f55-976f-35df98003e83/content-images/d009762d-d577-4863-bbfc-cf1c500f6dc6.pdf

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Port placement and patient-specific docking strategies for robotic hysterectomy with the Hugo™ RAS system: an international Delphi consensus

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ABSTRACT

Background: Robotic-assisted hysterectomy is increasingly performed using modular platforms such as the Hugo™ robotic-assisted surgery (RAS) system, but optimal or personalised docking strategies remain undefined.

Objectives: To establish expert consensus on port placement and docking configurations for hysterectomy with the Hugo™ RAS system and to identify patient anthropometric factors requiring modification of standard setups.

Methods: A modified Delphi consensus was conducted involving two iterative rounds of anonymous, structured questionnaires distributed to an international panel of gynaecological robotic surgeons experienced with the Hugo™ RAS system. Survey items addressed preferred docking configurations, the influence of patient anthropometry on docking strategy, and specific technical adjustments in non-standard scenarios. Consensus was predefined as ≥66.7% agreement.

Main Outcome Measures: Expert agreement on docking setups, port placement modifications, and anthropometric variables influencing technical adjustments.

Results: Seventeen experts completed round one and 16 completed round two. No single docking configuration reached consensus as universally optimal for standard hysterectomy. Ranking exercises identified the "standard" hysterectomy setup as the most preferred configuration, followed by the "alternate" and the "three-arm" setups. All experts agreed that patient anthropometry requires modification of port placement. Elevated body mass index (BMI), large uterine size and small pelvis were identified as key variables: increasing inter-port distance was recommended for BMI >30, cranial port displacement for large uteri, while no consensus emerged for patients with a small pelvis. A modified bridge configuration was proposed, and achieved strong expert agreement.

Conclusions: No single docking configuration is deemed to be universally optimal for Hugo™ RAS hysterectomy. Expert practice combines a limited number of preferred setups with patient-tailored adjustments.

What is New? This study provides the first Delphi-based expert consensus on Hugo™ RAS docking strategies, emphasizing patient-specific adjustments and flexible preoperative planning.

Keywords: Body mass index, Delphi consensus, robotic-assisted surgery, robotic hysterectomy

Introduction

Hysterectomy is one of the most frequently performed surgical procedures in women,[1] and over recent decades the proportion performed using minimally invasive approaches has steadily increased.[2] The introduction and diffusion of robotic platforms from 2005 onward further reshaped surgical practice patterns;[3,4] within three years of robotic platform adoption at institutions offering robotic hysterectomy, robotic procedures accounted for more than one-fifth of all hysterectomies performed.[5]

The rapid expansion of this market has stimulated several competitors to develop new robotic platforms, introducing technological innovations and distinct designs.[4,6] In 2022, the Hugo robotic-assisted surgery (RAS) system (Medtronic, Dublin, Ireland), was approved for clinical use and many different medical specialties adopted it in their practice.[7-11] Unlike boom-based platforms, the system is characterised by four independent robotic arm carts that can be positioned individually within the operating room. This modular architecture offers substantial flexibility and the potential to tailor docking strategies to specific pathologies, and patient characteristics, and is now used for a wide range of gynaecological procedures.[12] At the same time, it introduces additional complexity into preoperative planning, increasing the number of variables that must be considered to allow for optimal port placement.

Preclinical dry-lab and cadaveric studies have proposed several standardised port placement and docking configurations for gynaecological procedures, with the aim of standardising a number of robotic setups capable of reliably completing the planned operation.[13]

These studies have demonstrated technical feasibility and reproducibility under controlled conditions; however, they have generally not accounted for the wide anthropometric and anatomic variability encountered in routine clinical practice. Moreover, data describing how surgeons adapt these configurations in real-world settings are sparse, and no consensus currently exists regarding which setups are most commonly employed or how docking strategies should be modified in response to patient-specific factors.

In the absence of robust comparative clinical data, structured expert consensus represents a valuable method to synthesise collective experience and guide early adoption of emerging surgical technologies. The objective of the present study was therefore to establish expert consensus on port placement and docking configurations for hysterectomies performed with the

Hugo RAS system and to identify patient anthropometric variables that necessitate deviation from standard setups and to characterise the specific technical adjustments experts apply in these scenarios.

Methods

Study Design and Expert Panel Selection

This consensus statement was developed using a modified Delphi methodology organised by the European Society for Gynaecological Endoscopy (ESGE), Robotic Surgery Special Interest Group. The study was approved by the ESGE Academy Faculty before initiation and was reviewed after completion by the same Faculty. The Delphi approach was selected as an appropriate method to address areas of clinical uncertainty in which high-quality comparative data are lacking and expert experience plays a central role in informing best practice.[14-16] The study consisted of two iterative rounds of structured, anonymous questionnaires administered via email through a secure web-based platform (Jotform®, San Francisco, CA, USA).

Participants were selected based on predefined expertise criteria. Eligible experts were board-certified gynaecological surgeons with substantial experience in RAS and direct clinical familiarity with the Hugo RAS system. Additional inclusion criteria included a high annual robotic case volume and active involvement in robotic surgery programmes and education. Experts from multiple countries and practice settings were invited to ensure broad representation of clinical perspectives.

Delphi Rounds and Questionnaire Structure

Both Delphi rounds included Likert-scale and multiple-choice questions. An open-ended free-text field was included at the end of each section to allow participants to provide additional comments, propose alternative docking configurations, or identify relevant variables not captured by predefined response options.

The first round aimed to collect general information about the participants and their routine clinical practice and was divided into two sections. Section 1 focused on port, cart, and assistant placement for a standard hysterectomy, defined as a procedure in which the uterus, cervix, and, if indicated, adnexa are removed while preserving surrounding structures, performed on a patient with normal anatomy using a routine surgical approach without modifications. Questions 1-3 addressed general aspects of the procedure, including the preferred number of robotic arms, optimal assistant positioning, and cart placement within the operating room. Questions 4-9 focused on commonly used docking setups; schematic images of these configurations were provided to evaluate agreement with setups described in the literature and user manuals, to collect data on those most frequently used in clinical practice, and to identify any considered suboptimal (Figure 1).

Section 2 addressed non-standard hysterectomies, defined as procedures deviating from the standard due to atypical patient anthropometric characteristics or increased anatomical complexity that may interfere with the usual docking strategy, requiring modifications to optimise instrument positioning and facilitate access to the anatomy of interest. Questions 1-2 explored whether individual patient characteristics influence docking and cart placement in general, while questions 3-8 evaluated specific anthropometric variables, assessing whether they necessitate modifications to docking configuration and/or cart positioning. At the end of both sections, participants were given the opportunity to suggest additional setups or variables to be considered in the second round.

In the second round, the focus was (1) to evaluate the different port placement setups and anthropometric variables newly proposed by participants in the first round and (2) to further explore the variables that reached consensus in round 1, with the aim of understanding the technical adjustments and docking strategies applied in these situations to ensure an effective and safe surgical setup. Questions 1-4 focused on refining consensus regarding docking setups. The first question asked participants to subjectively rank the setups identified in the first round in order of preference on a five-point scale (1: most preferred; 5: least preferred), as none had reached the predefined consensus threshold. The subsequent three questions evaluated the docking setups newly proposed by participants. Questions 5-14 addressed the technical adjustments required for docking in the presence of anthropometric variables that had reached consensus in the previous round. For each variable, experts were allowed to select more than one adjustment and were also given the opportunity to describe any docking configurations routinely adopted in their clinical practice for these specific patient scenarios. Finally, Questions 15-18 evaluated the additional anthropometric variables proposed by participants during the first round, assessing their perceived relevance for modifying docking and setup strategies.

Two Delphi rounds were considered sufficient based on achievement of consensus in key domains and diminishing emergence of novel themes after the first iteration.

Data Analysis

Responses were summarised using descriptive statistics and reported as number and percentage of respondents[n (%) or n/N (%)]. Consensus was defined a priori as agreement by at least 66.7% of participants, corresponding to a score of 4 or 5 ("agree" or "strongly agree") on five-point Likert-scale items or concordant selection of the same option in multiple-choice questions. Although there is no standard threshold,[16] this one has been widely applied in prior Delphi-based consensus studies and was selected to balance stringency with feasibility in a specialised expert population.[15-17]

Free-text responses were reviewed qualitatively and used to inform questionnaire refinement and item generation for the second Delphi round.

Statistical analyses were performed using R software (version 4.3.1, R Foundation for Statistical Computing, Vienna, Austria).

Results

Expert Panel Characteristics

Of the 22 experts invited to participate, 17 agreed to take part in the first Delphi round, corresponding to a response rate of 77%. Participants represented seven countries and were predominantly male (12/17, 71%). The median age was 50 years [interquartile range (IQR) 43–55], with a median of 20 years (IQR 14–25) of overall clinical practice and 5 years (IQR 2–8.5) of robotic surgery experience.

Most participants reported a high robotic case volume, with 10 of 17 experts (59%) performing more than 50 robotic procedures annually. All panellists had direct clinical experience with the Hugo RAS platform. In addition, 13 participants (76%) routinely used the da Vinci system (Intuitive Surgical, Sunnyvale, USA), and 6 (35%) reported experience with the Versius platform (CMR Surgical, Cambridge, UK). The majority of experts (14/17, 82%) practiced in university or academic hospital settings. These results are summarised in Table 1.

Round 1 Results

The level of agreement among experts regarding docking configurations for standard hysterectomy is summarised

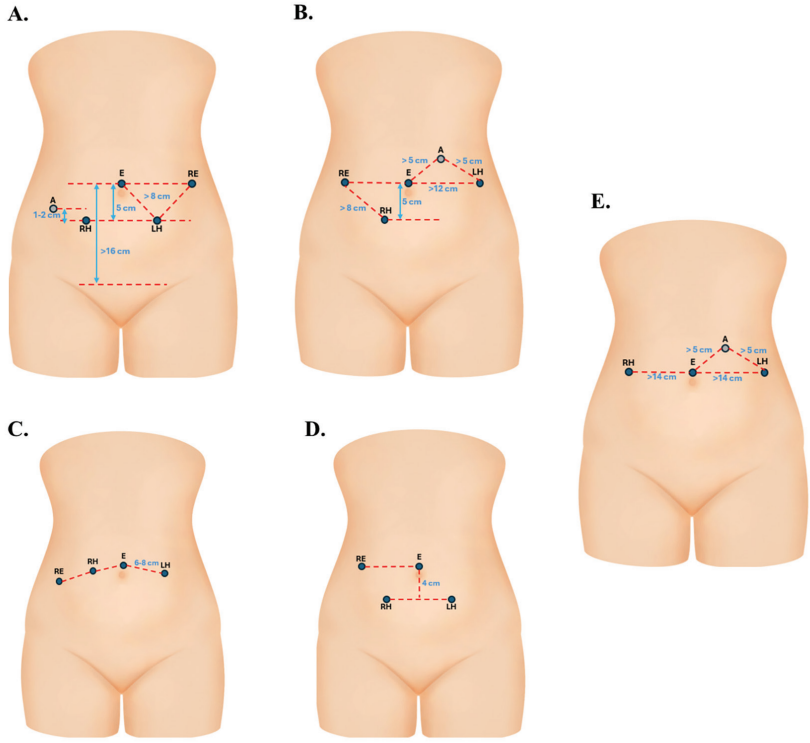

Figure 1. The 5 setups described in the user manual and in literature that were shown to the participants (A: "Standard" setup; B: "Alternate" setup; C: "Straight" setup; D: "Bridge" setup; E: "3-arm" setup).

E: Endoscope, RH: Surgeon right hand, LH; Surgeon left hand, RE: Reserve arm, A: Assistant.

in Table 2. No configuration reached the predefined consensus threshold.

The highest levels of agreement were observed for the assistant positioned at Palmer's point and the compact cart configuration, each endorsed by 11 of 17 experts (64.7%), followed by the straight hysterectomy setup, receiving agreement from 9 experts (52.9%).

All participants (17/17, 100%) agreed that patient anthropometric variables require modification of port placement strategies. In contrast, a smaller proportion of experts (12/17, 70.6%) indicated that cart placement also requires adjustment based on patient characteristics.

Among predefined anthropometric factors, body mass index (BMI) >30 (14/17, 82.4%), large uterus (16/17, 94.1%), and small pelvis (14/17, 82.4%) reached consensus as variables necessitating modification of standard port placement strategies. In contrast, xipho-pubic distance (7/17, 41.2%) and large pelvis (10/17, 58.8%) did not reach consensus.

During the first round, experts proposed three additional docking configurations for further evaluation: a modified hysterectomy alternate setup with the assistant positioned in the iliac fossa, a modified three-arm configuration, and a modified bridge setup (Figure 2). In addition, four anthropometric variables not included in the initial questionnaire were suggested for consideration in subsequent rounds: short umbilico–pubic distance, history of major abdominal surgery, abdominal hernia, and pelvic organ prolapse.

Table 1. Expert panel characteristics.

Country of residence	9: Italy 3: Denmark 1: Portugal 1: India 1: Spain 1 Australia 1: UK
Age	50 [43-55]
Years of experience as a gynaecological surgeon	20 [14-25]
Gender	12: male; 5: female
Years of experience in robotic surgery	5 [2–8.5]
Number of robotic procedures per year	7: <50; 6: 50 to 100; 4≥100
What robotic system have you used?	17: Hugo RAS; 13: DaVinci (Si, Xi, X, SP); 6: Versius; 1: other
In what type of hospital do you work?	12: university hospital; 2: both university and private; 1: community hospital; 1: private clinic; 1: other

RAS: Robotic-assisted surgery.

Table 2. Expert agreement on docking setups and anthropometric considerations during hysterectomy (Round 1).

Domain	Item	Agreement (n)	Agreement (%)
Docking setups	Assistant at Palmer's point	11/17	64.7%
	Compact cart configuration	11/17	64.7%
	Standard hysterectomy setup	4/17	23.5%
	Alternate hysterectomy setup	7/17	41.2%
	Three-arm hysterectomy setup	7/17	41.2%
	Bridge hysterectomy setup	6/17	35.3%
	Straight hysterectomy setup	9/17	52.9%
Anthropometric impact	Anthropometric variables require port placement modification	17/17	100%
	Anthropometric variables require cart placement modification	12/17	70%
Anthropometric variables	BMI	14/17	82.4%
	Large uterus	16/17	94.1%
	Small pelvis	14/17	82.4%
	Xifopubic distance	7/17	41.2%
	Large pelvis	10/17	58.8%

BMI: Body mass index.

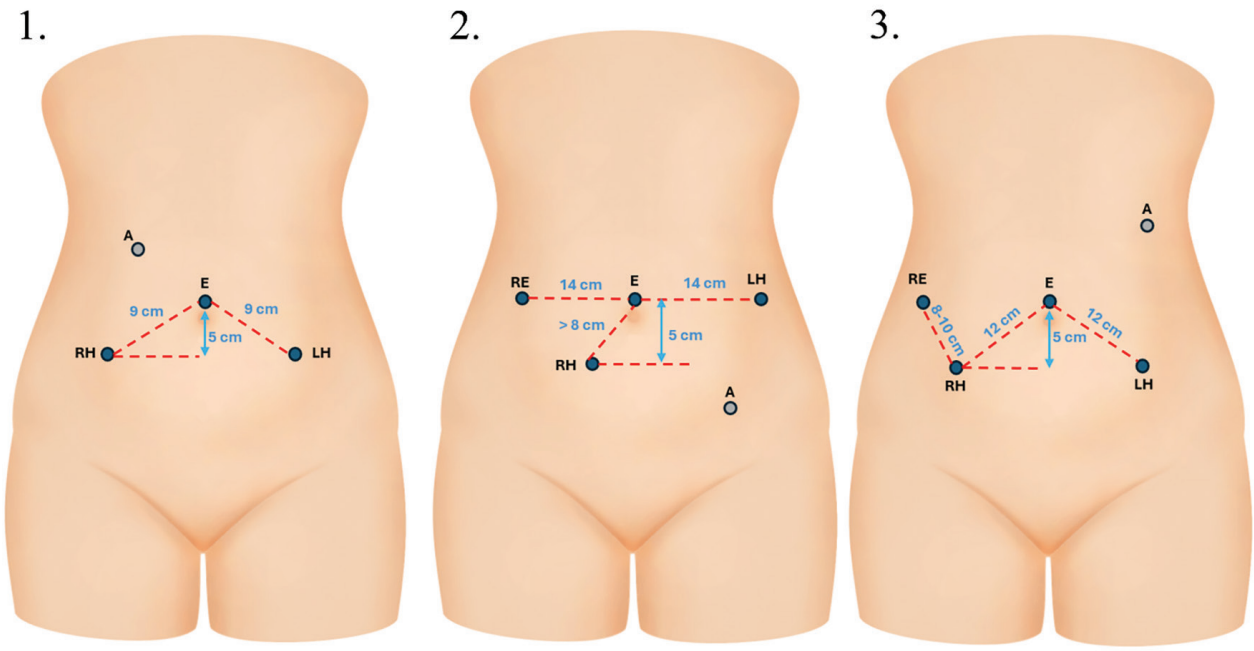

Figure 2. The 3 setups that were proposed in round 1 and then evaluated in round 2 by the participants (1: Modified 3-arm; 2: Alternate with assistant in iliac fossa; 3: Modified bridge).

E: Endoscope, RH: Surgeon right hand, LH; Surgeon left hand, RE: Reserve arm, A: Assistant.

Round 2 Results

Sixteen experts completed the second Delphi round.

Experts were asked to rank five hysterectomy docking configurations in order of preference on a five-point scale (1: most preferred; 5: least preferred). The standard hysterectomy setup was ranked as the most preferred configuration, with the lowest mean ranking score (2.25), indicating greater overall preference. This was followed by the alternate setup (2.62) and the three-arm configuration (2.87). The bridge (3.62) and straight (3.65) setups received the highest mean scores, reflecting lower relative preference (Table 3). Expert agreement regarding technical adjustments applied in the presence of anthropometric variables that reached consensus is summarised in Table 4. For practical applicability, a summary of expert-recommended docking adjustments according to anthropometric variables is provided in Table 5.

For patients with BMI >30, increasing the distance between ports was the only adjustment to reach the predefined consensus threshold (11/16, 68.7%). Other strategies, including the use of four robotic arms (4/16, 25%), three arms (2/16, 12.5%), cranial displacement of ports (3/16, 18.7%), or optical displacement (3/16, 18.7%), did not reach consensus.

In cases of large uterus, cranial displacement of ports reached consensus (11/16, 68.7%). Optical displacement was frequently selected (9/16, 56.2%) but did not meet the consensus threshold. The use of four robotic arms (7/16, 43.7%) and increased inter-port distance (3/16, 18.7%) also failed to reach consensus.

For patients with a small pelvis, no technical adjustment achieved consensus. Moderate levels of agreement were observed for decreased distance between ports (8/16, 50%) and the use of a three-arm configuration (9/16, 56.2%), whereas other strategies were infrequently endorsed.

Agreement levels for additional anthropometric variables and docking configurations proposed during the first

Table 3. Ranking of hysterectomy docking setups based on expert preference.

Setup	Average position
Standard	**2.25**
Alternate	2.62
3 arms	2.87
Bridge	3.62
Straight	3.65

round are summarised in Table 6. Short umbilico–pubic distance reached consensus (12/16, 75%), as did history of major abdominal surgery (11/16, 68.7%). Abdominal hernia approached but did not reach the consensus threshold (10/16, 62.5%), whereas pelvic organ prolapse received low agreement (3/16, 18.7%).

The modified bridge setup achieved the highest level of agreement, with 15 of 16 experts (93.7%) supporting its consideration. The modified three-arm configuration reached consensus (11/16, 68.7%). In contrast, the alternate setup with the assistant positioned in the iliac fossa did not reach consensus (5/16, 31.2%).

Discussion

This Delphi study provides the first structured synthesis of expert opinion on docking configurations and port placement strategies for hysterectomy performed with the Hugo RAS system. In the context of limited platform-specific clinical literature, these findings offer clinical guidance that reflect real-world experience across

Table 4. Expert agreement on technical adjustments for key anthropometric variables during hysterectomy.

Anthropometric variable	Adjustment/Consideration	Agreement (n)	Agreement %
BMI >30	Increase distance between ports	11/16	68.7%
	Use of 4 arms	4/16	25%
	Use of 3 arms	2/16	12.5%
	Cranial displacement	3/16	18.75%
	Optical displacement	3/16	18.75%
Large uterus	Cranial displacement	11/16	68.7%
	Use of 4 arms	7/16	43.75%
	Use of 3 arms	1/16	6.25%
	Increase distance between ports	3/16	18.75%
	Optical displacement	9/16	56.25%
Small pelvis	Decreased distance	8/16	50%
	3-arm setup	9/16	56%
	Different assistant position	2/16	12.5%
	Optical entry point lower	1/16	6.25%

BMI: Body mass index.

Table 5. Summary of expert-recommended docking adjustments according to anthropometric variables in Hugo RAS hysterectomy.

Anthropometric variable	Preferred adjustment
BMI >30	Increase inter-port distance
Large uterus	Cranial displacement of ports
Small pelvis	Reduced spacing/3-arm (moderate agreement)

BMI: Body mass index.

Table 6. Expert agreement on additional anthropometric variables and on additional docking approaches.

	Panel proposal	Agreement (n)	% Agreement
Anthropometric variable	Short umbilico–pubic distance	12/16	75%
	History of major surgery	11/16	68.7%
	Abdominal hernia	10/16	62.5%
	Pelvic organ prolapse	3/16	18.7%
Docking setup	Modified 3-arm	11/16	68.7%
	Modified bridge	15/16	93.7%
	Alternate with assistant in iliac fossa	5/16	31.25%

different practice settings. The consensus indicates that expert-driven innovation contributes to the refinement of surgical techniques during the early phases of platform adoption and points to the limitations of relying solely on preclinical or standardised docking models. In addition, optimal use of the Hugo RAS system requires flexibility and case-specific adaptation, particularly with respect to patient anthropometry.

A key finding of this study is that no single docking setup reached consensus as universally optimal during the first Delphi round, confirming the heterogeneity of current clinical practice. This contrasts with the more standardised port placement paradigms established for earlier robotic platforms, where extensive clinical experience and a less flexible design have facilitated convergence toward a limited number of accepted configurations.[18,19]

The subsequent ranking exercise in round two revealed that, despite this variability, experts consistently favoured a standard hysterectomy setup, followed closely by an alternate and a three-arm configuration. Importantly, these results reflect relative preference rather than formal consensus and should therefore be interpreted as indicative of comparative inclination among experts rather than agreement on an optimal configuration. Notably, these three configurations share the fact that they are described in the system user manual, unlike other setups reported in the literature and their higher ranking may therefore reflect greater familiarity and visibility rather than superiority. As additional strategies are developed and standardised, strategies of disseminations should be adopted to help clinical adoption.

The strongest area of agreement among experts was the need to modify port placement in response to patient anthropometric characteristics.

For patients with elevated BMI, increasing the distance between ports was the only strategy to reach consensus. This observation is consistent with ergonomic and kinematic principles of robotic surgery. In patients with higher BMI, extensive modifications are usually not required; rather, taking advantage of the larger abdominal surface to increase the distance between ports is considered optimal, as it helps minimise robotic arm collisions even in the presence of increased abdominal wall thickness and limited intra-abdominal working space.[20,21]

Large uterine size is a recurrent challenge in minimally invasive surgery,[22,23] and despite new strategies are still emerging to solve this problem,[24] cranial displacement of the ports was the only adjustment reaching consensus. This modification consists in a translation of the ports while preserving the surgeon's preferred setup and for this reason is easy to implement, and it gives the advantage of having an appropriate working distance, enabling the robotic instruments to fully exit the trocars and achieve effective control without excessive proximity to the target anatomy.

For small pelvic anatomy, no single modification reached consensus. The moderate agreement observed for reduced port spacing and three-arm configurations suggests that surgeons may attempt to mitigate instrument crowding by simplifying the setup; however, the absence of consensus underscores a fundamental limitation of robotic surgery, namely the requirement for a minimum working space to ensure smooth and effective operative performance.

Another relevant contribution of this Delphi process was the identification and evaluation of docking configurations that are not prominently addressed in either the published literature or manufacturer guidance. The modified bridge configuration achieved a high level of agreement in the second round, reflecting strong expert support. Conceptually, this configuration may be interpreted as an intermediate solution between the three-arm and the standard four-arm setups, two configurations that were both highly ranked in the second round of this study. By combining elements of these approaches, the modified bridge setup appears to integrate their respective advantages: it allows both primary working arms to be positioned deeper within the pelvis, allowing for a better instrument reach, while maintaining a reserve arm on the dominant-hand side of the surgeon.

Although its geometric layout resembles a classical bridge configuration, a key difference is the incorporation of standardized spacing parameters between ports, potentially enhancing reproducibility across operators. Lastly, the relatively reduced distance between the right arm and the reserve arm may facilitate four-arm docking even in patients with smaller pelvic anatomy.

This finding illustrates how structured expert consensus can generate practical refinements that extend beyond preclinical testing, and how the progressive description and dissemination of new setups may contribute to further optimisation of surgical practice.[25-28]

From an educational perspective, the findings of this study support the incorporation of flexible docking strategies into robotic training curricula and simulation programmes.

Future research should focus on objective evaluation of docking configurations in relation to operative time, collision frequency and surgeon ergonomics to further validate the recommendations presented here.

Strengths and Limitations

A major strength of this study is the use of a structured, iterative modified Delphi methodology with predefined consensus thresholds. This approach is particularly well suited to the early evaluation of emerging surgical technologies, allowing for a systematic analysis of clinical experience. The inclusion of internationally recognised experts with direct clinical experience using the Hugo RAS system further enhances the relevance and credibility of the findings.

Several limitations should also be acknowledged. As with all Delphi-based studies, the findings reflect expert opinion rather than objective data and therefore should only be interpreted as guidance. However, in the context of a novel robotic platform with limited clinical literature, expert consensus represents an essential and widely accepted step in guiding safe adoption and informing subsequent hypothesis-driven research. Although the expert panel was international and highly experienced, the sample size was necessarily limited by the relatively small pool of surgeons with substantial hands-on experience with the platform.

Lastly, ongoing technological refinements to robotic platforms may change docking principles in the future, potentially impacting the longevity of specific recommendations. Still, the principles identified in this consensus, such as the need for flexible, patient-centred port placement strategies and adaptation to anthropometric variability, are likely to remain applicable even as hardware evolves.

Conclusion

This expert consensus demonstrates that no single docking configuration is universally optimal for hysterectomy performed with the Hugo RAS system. Rather, contemporary expert practice is defined by selective use of a limited number of preferred port placement setups, combined with deliberate modification in response to patient-specific anthropometric factors, such as elevated BMI, large uterine size, and small pelvis. These findings confirm the importance of flexibility and individualised preoperative planning when using a modular robotic platform.

Future research should focus on prospective clinical and simulation-based studies to validate and refine patient- and procedure-specific port placement strategies.

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Ethical approval: Given the design of the study (expert consensus), ethical approval was not required.

Informed consent: Given the design of the study, informed consent was not required.

Data sharing: The data that support the findings of this Delphi consensus are available upon reasonable request from the corresponding author.

Transparency: Hereby, I affirm (as corresponding author) that this manuscript is an honest, accurate, and transparent account of the study being reported. No important aspects of the study have been omitted. Discrepancies from the study as planned have been explained.

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VIDEO COMMENTARY

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Salvage pectopexy using detached lateral suspension mesh arms

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ABSTRACT

Background: Laparoscopic lateral suspension is an alternative to sacrocolpopexy when access to the sacral promontory is restricted or unsafe. However, prolapse recurrence may occur due to mesh arm detachment or progressive fascial attenuation. Pectineal fixation is an alternative approach that may provide a stronger, more stable anchoring vector and improved force distribution.

Objectives: To describe a minimally invasive salvage surgical strategy for managing recurrent anterior compartment prolapse in a patient with a history of laparoscopic lateral suspension and inaccessible sacral promontory.

Participant: A 73-year-old woman presented with symptomatic vaginal bulging fifteen years after undergoing laparoscopic lateral suspension with subtotal hysterectomy and bilateral adnexectomy following an aborted promontofixation. Examination revealed a grade 2–3 cystocele and a grade 2 hysterocele without mesh exposure. Laparoscopy confirmed bilateral detachment of the anterior mesh arms from the lateral abdominal wall.

Intervention: Laparoscopic anterior colporrhaphy was undertaken to reinforce the pubocervical fascia, with exposure supported by a device. The detached mesh arm was carefully trimmed and then secured using non-absorbable Ethibond® 1 sutures, with one fixation point anchored to the Cooper's ligament and the other to the mesh itself, in accordance with the principles of tension-free pectopexy bilaterally. Peritonisation was completed to fully cover the mesh.

Conclusions: Recurrent anterior prolapse after lateral suspension where the sacral promontory is inaccessible promontory can be managed by reusing the detached mesh arms and refixing to Cooper's ligament as a salvage strategy.

What is New? Reinforcing the native fascia and refixing the mesh to the pectineal ligament provides an anatomically sound solution while avoiding the risks of sacral promontory dissection.

Keywords: Fascia, laparoscopy, ligament, mesh, pelvic organ prolapse, surgery

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Data sharing: Data and related information are available from the corresponding author upon request.

Transparency: The authors affirm that the manuscript is an honest, accurate and transparent account of the studies assessed. No important aspects of the study have been ommited.

Video 1. Salvage pectopexy using detached lateral suspension mesh arms: https://youtu.be/Cm9UoED-Gc4

VIDEO COMMENTARY

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Hysteroscopic ablation of type 2 and type 3 fibroids using radiofrequency or microwave energy

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ABSTRACT

Background: Minimally invasive, uterus-sparing radiofrequency (RF) and microwave (MW) ablation have been introduced under ultrasound or laparoscopic guidance to treat uterine fibroids. These technologies enable targeted coagulative necrosis, potentially minimising surgical time and trauma while shortening recovery. They can also be used under hysteroscopic guidance, although feasibility data is lacking.

Objectives: To assess the feasibility and short-term outcomes of hysteroscopic RF and MW ablation for FIGO-type 2 and type 3 fibroids.

Participant: Four patients were included: two with FIGO-type 2 fibroids and two with FIGO-type 3 fibroids, all presenting with heavy menstrual bleeding (HMB) and no desire for pregnancy.

Intervention: Procedures were performed at a tertiary care university hospital under sedation. As no evidence-based guidelines define selection criteria between MW and RF, both modalities were employed in fibroids with similar presentation. Under direct hysteroscopic visualisation, the needles were inserted through the operative channel into the myoma, maintaining a 10-mm safety margin. Tissue necrosis was confirmed by hyperechogenicity of the treated area. Each procedure lasted approximately 4 minutes. All patients were discharged the same day without complications.

Conclusions: Hysteroscopic ablation was technically feasible and safe in this limited case series. The procedure induced necrosis, reduced fibroid vascularisation, and resolved HMB without complications, scarring, or adhesions. Future studies are needed to evaluate long-term outcomes and determine whether it may serve as a standalone option.

What is New? Hysteroscopic myolysis may expand the therapeutic armamentarium for selected patients seeking uterine preservation. By using the natural intracavitary pathway, the technique allows precise ablation while preserving uterine integrity and minimising procedural invasiveness.

Keywords: Heavy menstrual bleeding, hysteroscopy, microwave, myoma, radiofrequency ablation, uterine fibroids

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Ethical approval: The study was conducted in accordance with the principles of the Declaration of Helsinki. The internal committee of the Department of Maternal and Child Health, University Hospital of Naples "Federico II", Naples, Italy has reviewed the study and deemed this work exempt from IRB approval because this video will not involve any additional risk for partecipant than those ordinarily encountred in a normal scheduled surgery.

Informed consent: Written informed consent was obtained from all participants prior to inclusion in the study and for the use of anonymized clinical data and images for research and publication purposes.

Data sharing: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Transparency: The authors affirm that this manuscript is an honest, accurate, and transparent account of the study being reported, that no important aspects have been omitted, and that any discrepancies from the study as planned have been explained.

Video 1. Hysteroscopic ablation of type 2 and type 3 fibroids using radiofrequency or microwave energy: https://youtu.be/CYBjNez97Ls

VIDEO COMMENTARY

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V-NOSE en bloc laparoscopic hysterectomy with segmental bowel resection for deep infiltrating endometriosis (#ENZIAN C3)

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ABSTRACT

Background: Deep endometriosis (DE) with intestinal involvement occurs in up to 16% of patients with endometriosis, representing one of the most challenging manifestations of the disease.

Objectives: To describe a laparoscopic technique for the management of DE with bowel involvement through an en bloc resection that includes hysterectomy, appendectomy, and segmental bowel resection, using natural orifice specimen extraction (V-NOSE).

Participant: A 35-year-old woman presented with severe dysmenorrhea, deep dyspareunia, and intestinal symptoms. A pelvic magnetic resonance imaging revealed a 3.9 cm #ENZIAN C3 intestinal nodule.

Intervention: A laparoscopic approach was employed to perform an en bloc resection of the C3 rectal nodule, including segmental bowel resection and end-to-end anastomosis, with the V-NOSE technique. The patient provided informed consent for the publication of this video article and its online posting. The total time for the operation was 100 minutes, and the estimated blood loss was 30 mL. The complete excision was accomplished without intraoperative complications. The postoperative course was uneventful: the patient tolerated oral intake at 48 hours and was discharged 76 hours after surgery.

Conclusions: En bloc laparoscopic hysterectomy enables complete excision of DE with bowel involvement and could reduce operative time and complications, potentially contributing to favourable long-term outcomes.

What is New? The integration of a laparoscopic approach, anterior colpotomy with the uterus attached to the rectovaginal nodule, and V-NOSE specimen extraction could represent a safe and efficient strategy for complex cases of deep infiltrating endometriosis with intestinal involvement in carefully selected patients.

Keywords: Anastomosis, endometriosis, hysterectomy, intestines, laparoscopic, Natural Orifice Endoscopic Surgery

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Contributors: Surgical and Medical Practices: L.A.B.G., R.C.C., W.K., J.D.O., A.F.V.S., J.D.E.C., P.S.V.H., Concept: L.A.B.G., R.C.C., W.K., J.D.O., A.F.V.S., J.D.E.C., Design: L.A.B.G., R.C.C., Data Collection or Processing: L.A.B.G., R.C.C., W.K., J.D.O., J.D.E.C., Analysis or Interpretation: L.A.B.G., R.C.C., P.S.V.H., Literature Search: L.A.B.G., R.C.C., P.S.V.H., Writing: L.A.B.G.

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Ethical approval: Patient included in this video gave consent for the publication of this video article and its online posting, including social media, journal's website, scientific literature websites, and other applicable sites.

Informed consent: The patient featured in this video provided written informed consent for publication and online dissemination of the video material, including on digital platforms, social media, and scientific repositories.

Data sharing: The data supporting the findings of this study are not publicly available due to concerns regarding patient confidentiality and institutional restrictions. However, de-identified data may be made available from the corresponding author upon reasonable request, in accordance with ethical and legal standards.

Transparency: The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported. No important aspects of the study have been omitted, and any deviations from the original protocol have been clearly explained within the manuscript.

Video 1. V-NOSE en bloc laparoscopic hysterectomy with segmental bowel resection for deep infiltrating endometriosis (#ENZIAN C3): https://youtu.be/wi0RtayM5fk

ERRATUM

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On the first page of the manuscript, it has been noted that the name of one of the authors, O.D. Zouzoulas, should be corrected to D. Zouzoulas. Accordingly, the necessary correction has been indicated within the text in bold.

The uncorrected version is as follows:

O.D. Zouzoulas[1], D. Tsolakidis[1], I. Efstratiou[2], S. Pervana[2], E. Pazarli[2], G. Grimbizis[1]

The corrected version is as follows:

D. Zouzoulas[1], D. Tsolakidis[1], I. Efstratiou[2], S. Pervana[2], E. Pazarli[2], G. Grimbizis[1]