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CLINICAL ARTICLE

Anatomical-based classification of dorsolateral parametrectomy for deep endometriosis. Correlation with surgical complications and functional outcomes: A single- center prospective study

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Abstract

Objective: To evaluate complication rate and functional outcomes of nerve-sparing parametrectomy for deep endometriosis in relation to the extension of the surgical procedure, based on recognizable anatomical landmarks.

Methods: This was a prospective single-center study including all patients undergoing parametrectomy for deep endometriosis from September 2020 to June 2023 at our tertiary center. Dorsolateral parametrectomies were divided into parametrectomies medial to the presacral fascia and cranial to the medial rectal artery (superficial parametrectomy), and parametrectomies in which one of the two landmarks was overcome during the surgical procedure, leading to the excision of tissue lateral to the presacral fascia (deep parametrectomy type 1, or DP1) or caudal to the medial rectal artery (DP2). Finally, we used the hypogastric fascia as landmark to define type 3 deep parametrectomy (DP3), when the procedure was deeply lateral to the fascia.

Results: Bladder voiding deficit occurred in 9.7% of cases, with higher rates in DP2 (20.8%) and DP3 (30%) groups. Regarding postoperative gastrointestinal function, our data showed a significant improvement over time in all groups, with the exception of DP2; instead an improvement in postoperative bladder function was only shown in DP3. Parametrectomy was not associated with a simultaneous improvement in sexual function expressed with the female sexual function index, in any of the four groups.

Conclusion: Our classification constitutes a concrete approach for comparing, in a standardized way, the complications and functional outcomes of parametrectomy, which, even if carried out by expert surgeons, demonstrates a non-negligible rate of bladder voiding deficit.

KEYWORDS
bladder voiding deficit, functional outcomes, hypogastric nerve, inferior hypogastric plexus, neurolysis, parametrectomy, parametrial endometriosis, sexual disfunction

1 | INTRODUCTION

Deep endometriosis (DE), defined by endometrial glands and stroma, or the consequent fibrosis, infiltrating the peritoneum by at least 5 mm, is the most severe form of endometriosis.[1] A common site is the dorsolateral parametrium, causing disabling pain, reduction in quality of life, dysfunction of the pelvic organs or somatic innervation when the disease becomes deeper more laterally and deeper in the pelvis.[2–5]

Lateral and dorsal parametria may be defined as areas of connective tissue extending from the uterus to the pelvic wall and enveloping vascular and autonomic nerve structures, but the clear definitions and anatomical limits of these structures are not agreed upon uniformly by all authors.[3–9]

Parametrectomy for DE carries risks of major complications, including postoperative pelvic dysfunction due to accidental injury of the ortho- and parasympathetic innervation of the pelvis or due to their intentional removal consequent to their involvement in parametrial disease.[3–5,10] Over the years, various nerve-sparing surgery techniques, borrowed from gynecologic oncology, have been applied to DE,[10,11] but results are conflicting and often incomparable due to unclear definitions of parametrectomy and its anatomical limits.[5] This difficulty in defining the extent of a parametrectomy for DE and the absence of a replicable classification, contribute to creating a "gray zone" regarding the real incidence of functional complications following the procedure, which can be different based on the extent of surgical resection.

The aim of the present study was to assess complication rates and functional outcomes of nerve-sparing parametrectomy for DE, depending on the lateral and caudal extension of the surgical procedure, based on recognizable anatomical landmarks.

2 | MATERIALS AND METHODS

2.1 | Study design

Monocentric prospective observational study adhering to "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) guidelines.[12] The study was conducted at the tertiary academic center for Endometriosis of Fondazione Policlinico Universitario A. Gemelli, IRCCS, in Rome. Patients undergoing surgery for parametrial DE were consecutively enrolled between September 2020 and June 2023. Eligible criteria included suspected parametrial deep endometriosis based on clinical, ultrasound or at magnetic resonance evaluation, and scheduled for surgery. Exclusion criteria were: age < 18 years, no sexual activity, prior bowel or bladder resection, ureteral reimplantation and previous pelvic radiotherapy.

2.2 | Ethics statement

This study received approval from Ethical Committee of the "Fondazione Policlinico Gemelli" (protocol no. 0037847/20), and was carried out according to the Helsinki declaration. During preoperative evaluation, patients were asked to sign in advance a consent to the subsequent use of their anonymized data.

2.3 | Variables and procedures

Patients experiencing pelvic pain refractory to medical therapy were considered for surgery. Typically, before opting for surgery, patients attempt at least one progestin, such as dienogest, norethisterone acetate, or desogestrel. Before surgery, each patient underwent a rectovaginal examination and a dedicated transvaginal and transabdominal ultrasound or magnetic resonance imaging (MRI). If there was ureteral dilation, a uro-computed tomography (CT) or uro-MRI and angioscintigraphy were required.

In cases of suspected symptoms due to compression of the sacral plexus or somatic nerves, a neuropelveological evaluation was conducted following ISON recommendations.[13] Electromyography and/or urodynamic testing were also performed if deemed necessary. Additionally, a pain symptom severity interview was conducted, using visual analog scale (VAS) scores ranging from 0 to 10, about dysmenorrhea, dyspareunia, chronic pelvic pain, dysuria and dyschezia.

We prospectively collected the following in a data collection system: clinical data (i.e., age, body mass index, current hormonal therapy, and previous surgery); clinical variables (pain symptoms, urinary, gastrointestinal and sexual function both before and after intervention); surgical findings (operating time, estimated blood loss, intraoperative complications, any other procedure in addition to parametrectomy and the extent of parametrectomy in the lateral and caudal directions); perioperative data (days of hospitalization, need for self-catheterization, and postoperative complications). The severity of the disease was intraoperatively classified using the revised American-Fertility-Society (r-ASRM) score[14] and the #ENZIAN classification.[15]

Postoperative complications within 30 days after surgery were categorized using the Clavien-Dindo classification.[16] Six months after surgery, patients underwent rectovaginal evaluation, transvaginal and transabdominal ultrasonography. Interviews regarding pain symptoms and questionnaires were also reassessed. Pain symptom severity (dysmenorrhea, dysuria, dyschezia, and dyspareunia) was evaluated using visual analog scale (VAS) scores ranging from 0 to 10, representing absence to severe pain. Functional outcomes were evaluated using validated questionnaires.

Knowles-Eccersley-Scott Symptom (KESS) questionnaire assessed bowel function (0 to 39 points) and a cutoff criterion of ≥10 points in the total KESS score indicate constipation.[17] Gastro-Intestinal Quality of Life Index (GIQLI) questionnaire measured health-related quality of life (QoL) for patients with gastrointestinal disease (0 to 144 points), where higher score indicate a better QoL.[18] Bristol female lower urinary tract symptoms (BFLUTS) questionnaire evaluated urinary function (total scores 0 to 45), with higher scores indicating decreased bladder function.[19] Female sexual function index (FSFI) questionnaire, in a validated Italian translation, assessed sexual function with 19 questions.[20] A total score <26.5 indicated female sexual dysfunction. Urinary retention was defined as a post-voiding residual volume ≤100 mL, and if present for three consecutive measurements, self-catheterization was recommended.

2.4 | Endpoints and outcome assessments

The primary endpoint was to assess surgical outcomes, including intraoperative, perioperative, and postoperative complications, in women undergoing nerve-sparing parametrectomy based on the lateral and caudal extension of the procedure. Secondary endpoints included evaluating functional outcomes concerning pelvic organs (bowel, urinary, and sexual function) using validated questionnaires. Pain symptoms were also assessed at baseline and 6-month follow-up to identify potential improvements post-intervention. Additionally, correlation between surgical and functional outcomes at follow-up was examined using KESS, GIQLI, FSFI, and BFLUTS questionnaires, in conjunction with surgical, anthropometric, and intraoperative findings.

2.5 | Surgical procedure and anatomical landmarks for parametrectomy

This section provides a summary of key anatomical landmarks utilized in our study (Figure 1).

Our anatomical approach aligns with the nomenclature established by Ercoli et al.[6] and subsequent anatomical dissections on cadavers, as detailed in our recent publications.[8,21] The term dorsolateral parametrium prevails in the surgical language[5,8,10,12] and therefore we used it to simplify the concept of paracervix, lateral parametrium, and posterior or dorsal parametrium.[8,21] For this study we identified two anatomical structures serving as landmarks for preserving the inferior hypogastric plexus: the presacral fascia, that surrounds the hypogastric nerve, and the middle rectal artery (MRA) (Figures 2 and 3), usually contained in the lateral ligament of the rectum (LLR).[3,5,6,9,11] Dorsolateral parametrectomies were divided into parametrectomies medial to the presacral fascia and cranial to the MRA (superficial parametrectomy or SP) and parametrectomies in which one of the two landmarks was overcome during the surgical procedure, leading to the excision of tissue lateral to the presacral fascia (deep parametrectomy type 1 or DP1) or caudal to the MRA

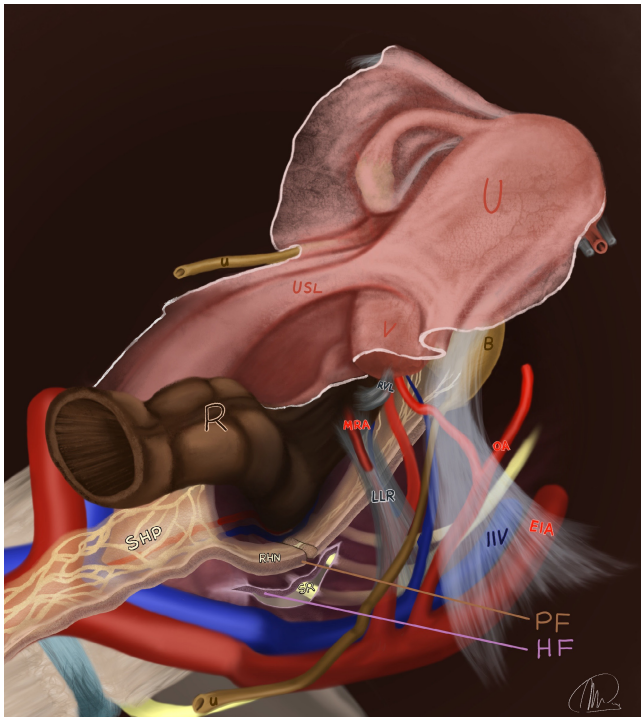

FIGURE 1 Summary view of the anatomical landmark used in our classification of deep endometriosis (DE) parametrictomies. The drawing shows the hypogastric nerve wrapped by the presacral fascia; caudally and laterally the sacral roots covered by the hypogastric fascia and more ventrally the medial rectal artery passing through the lateral ligament of the rectum. B, bladder; EIA, external iliac artery; HF, hypogastric fascia; IIV, internal iliac vein; LLR, lateral ligament of the rectum; MRA, middle rectal artery; PF, presacral fascia; R, rectum; RHN, right hypogastric nerve; RVL, recto-vaginal ligaments; SHP, superior hypogastric plexus; SR, sacral routes; u, ureter; U, uterus; UA, umbilical artery; USL, uterosacral ligaments; V, vagina.

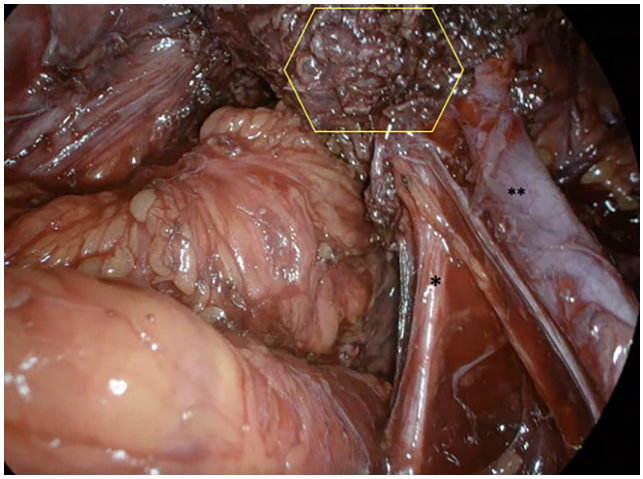

FIGURE 2 Right hypogastric nerve and presacral fascia involved in the parametrial endometriotic nodule (in the yellow hexagon). *Right hypogastric nerve covered by presacral fascia. **Right ureter.

(deep parametrectomy type 2 or DP2). Finally, we used the hypogastric fascia as the last landmark to define type 3 deep parametrectomy (DP3), when the procedure was deeper, lateral to the fascia.

All patients were operated on by surgical teams with extensive experience in laparoscopic surgical excision of DE, with dissection always performed by the same surgeon (MMI). In all cases the same surgical approach for dorsolateral parametrectomies using a nerve-sparing approach was conducted as previously published.[5,22] In particular, posterior parametrectomy was performed using interfascial dissection between parietal and visceral pelvic fasciae, as described in a previous cadaveric and in vivo study,[5,11] as follows:

1. Opening of the posterior parietal peritoneum at the sacral promontory level, medial to the infundibulopelvic ligament of the ovary or, in cases of modified radical hysterectomy, coagulation and transection of both round ligaments[22]; identification of the obliterated umbilical artery, uterine vessels and ureter; partial or complete development of the medial and lateral pararectal space, taking care to identify and preserve the presacral fascia enveloping hypogastric nerves, following the cleavage plane between it and the rectal wall enveloped by the *fascia propria recti*. When needed, a peritoneal incision at the rectouterine pouch facilitated development of the rectovaginal space and identification of the dorsolateral parametrium and MRA (Figure 3), while conserving nerve structures within the LLR and the presacral fascia. If grossly affected by the disease, LLR and/or rectovaginal ligaments and/or uterosacral ligaments were resected, sacrificing MRA. After development of lateral pararectal spaces, the uterine artery was isolated from its origin to the ureteral tunnel, and uncrossing between the ureter and uterine artery was performed. When possible, the uterine artery was spared, but in cases of extensive infiltration of the ureter and lateral parametrium the vessel was usually sacrificed. If the presacral fascia covering the hypogastric nerves was infiltrated, and the disease extended laterally and deeply, before proceeding with the parametrectomy, the internal iliac artery and vein were isolated and preserved, whenever possible. In cases of suspected compression or infiltration of the sacral plexus, alongside the medial approach described, the iliolumbar space between the iliopsoas muscle and the external iliac vessels was developed and the somatic nerve structures were systematically visualized and spared. The obturator nerve (Figure 4), lumbosacral plexus, L5, S1, ischial nerve and, if necessary, S2–S3 were identified, and then neurolysis and parametrectomy were performed.
2. In cases of rectosigmoid endometriosis, a shaving technique was attempted first. If a residual nodule remained, segmental resection or discoid resection was performed, depending on nodule characteristics, distance from the anus and the circumferential involvement of bowel lesions.[23–25]
3. In the case of further ureteral involvement due to disease, ureterolysis was performed first and, if this failed to solve ureteral infiltration, ureteroneocistostomy was performed, as previously published by our group.[26,27]

All of the women had a histologically confirmed diagnosis of endometriosis.

2.6 | Statistical analysis

Taking into account the information from studies we conducted previously, we assumed a proportion of post voiding deficit of 23%

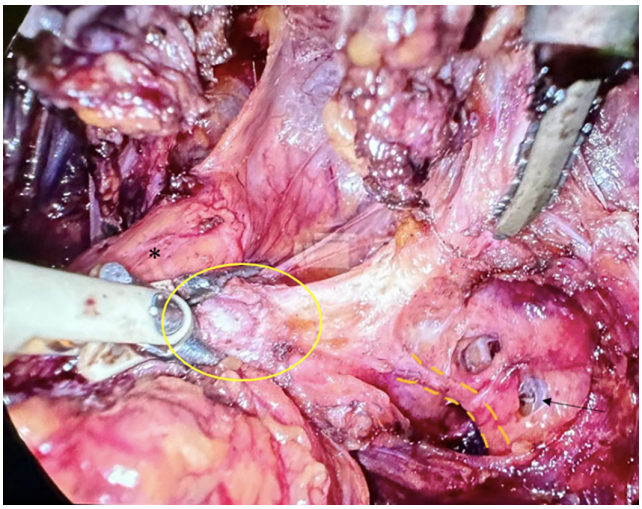

FIGURE 3 Right lateral ligament of the rectum (LLR) with endometriotic nodule (in the yellow circle). Through the partially dissected LLR you can see the middle rectal artery (indicated by the yellow dotted lines) and caudally and laterally to it, part of the branch of the inferior hypogastric plexus directed to the rectum (indicated by the arrow). *Rectal wall.

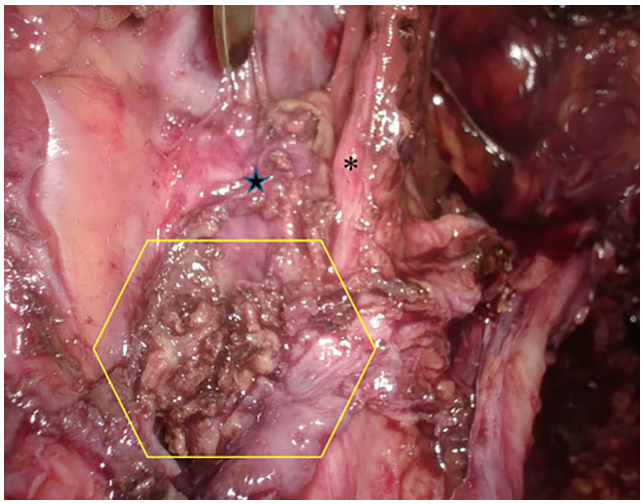

FIGURE 4 Left pelvic side wall endometriosis nodule (in the yellow hexagon), involving the left obturator nerve and the internal obturator muscle. *Left obturator nerve. ★, Internal obturator muscle.

for the deep parametrectomy (DP1, DP2, DP3) and 8.3% for the superficial parametrectomy (SP), with a confidence level of 95% and a power of 80% the minimum sample size needed is 92 per group. The total sample required is 184 to which we added an additional patient corresponding to the inclusion and exclusion criteria.

The sample was described in its clinical and demographic characteristics using descriptive statistical techniques. Qualitative data sets were expressed as absolute and relative percentage frequencies, whereas quantitative variables were expressed as the mean and deviations (SD) or median and interquartile ranges (IQR), as appropriate. To verify the Gaussian distribution of quantitative variables, the Shapiro–Wilk test was applied. Differences in the quantitative variables between groups were tested by ANOVA or Kruskal Wallis test as appropriate. Pre-post differences in the questionnaires on quality of life were analyzed using the student's *t*-test or the Wilcoxon rank-sum test for paired data, as appropriate. Differences in the questionnaires on quality of life between groups were tested using the analysis of variance (ANOVA) or Friedman test, as appropriate. Finally, two ANOVAs for repeated measures were applied to compare the pre-6-month follow-up differences between the parametrectomy groups in terms of their mean scores on the questionnaires. Statistical significance was set at *P* values less than 0.05. All analyses were conducted using R software version 4.2.0 (CRAN, R Core 2022).

3 | RESULTS

Clinical and demographic characteristics of the study groups are described in Table 1. The sample included 185 women, with a mean age of 38.2 ± 6.1 years, and a median body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters) of 24.1 kg/m^2. Age and the mean BMI were similar for the groups. No significant difference was revealed between the proportion of patients with previous surgery for endometriosis. Differences between groups were statistically significant for a distribution of r-ASRM stages among the four groups.

3.1 | Intervention and complication rate

Intraoperative variables are summarized in Table 2. The rate of intraoperative complications was low, with only six cases reported (3.2%). These included three vascular lesions of the external iliac vessels, managed with laparoscopic sutures, one spontaneous pneumothorax, and iatrogenic lesions of the bladder and ileum, each identified during surgery and solved through suturing. Urinary tract infections and bladder voiding deficit were statistically different between groups ($P = 0.01$ and $P = 0.001$, respectively). Bladder voiding deficit was observed in 18 cases (9.7%), with a higher percentage in DP2 (20.8%) and DP3 (30%) groups, and urinary tract infections appeared in 14 women (7.6%), with 11.8% in DP1 and 20.8% in DP2. Days of autocatheterization were longer in DP2, with a mean of 5.41 days ±13.72. Only three (1.6%) patients needed self-catheterization until the 6-month follow-up visit: one (0.09%) in the SP group, one (4.2%) in DP2 and one (10%) in DP3; with a statistically significant difference between the four groups ($P = 0.095$). They had previous surgery for DE (patient in SP group: resection of nodule in the rectovaginal space; DP2 group: monolateral ureterolysis and partial resection of uterosacral ligament nodule; DP3 group: partial resection of nodules of both uterosacral ligaments).

A median of 4 days of hospitalization were required overall. Hospital stays were similar in both groups, but mean blood loss (345 ± 328.7) and the mean operative time (396.4 ± 163.2) were longer in the DP3 group. Statistically significant differences emerged regarding operative time and blood loss.

Endometriosis was further mapped using the #Enzian classification, as shown in Table 3. Ovarian and ureteral involvement with signs of obstruction differed statistically between groups.

TABLE 1 General characteristics of the study sample groups at baseline ($N = 185$).

Variables	Overall ($n = 185$)	SP ($n = 117$)	DP1 ($n = 34$)	DP2 ($n = 24$)	DP3 ($n = 10$)	*P* value
Age (years)	38.2 (6.1)	38.5 (7.5)	37 (6.8)	37.6 (6.9)	40 (7.29)	0.863
BMI (kg/m^2)	24.1 (3.8)	23.9 (3.8)	24.3 (4.0)	23.9 (3.9)	24.98 (1.76)	0.501
Previous surgery for endometriosis	72 (38.9)	45 (38.5)	10 (13.9)	12 (50.0)	5 (50.0)	0.382
Hydronephrosis	6 (3.2)	—	2 (5.9)	1 (4.2)	3 (30)	**<0.0001**
r-ASRM						
II	8 (4.3)	7 (6.0)	1 (2.9)	—	—	**<0.0001**
III	89 (48.1)	70 (59.8)	10 (29.4)	8 (33.3)	1 (10)	
IV	88 (47.6)	40 (34.1)	23 (67.6)	16 (66.7)	9 (90)	

Note: Values are presented as median (range) or mean (standard deviation) and as a number (percentage). Statistically significant values in bold were entered.

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); DP1, deep parametrectomy type 1; DP2, deep parametrectomy type 2; DP3, deep parametrectomy type 3; r-ASRM, revised American Society for Reproductive Medicine; SP, superficial parametrectomy.

TABLE 2 Intra- and postoperative complication rates.[a]

Complications	Overall ($n=185$)	SP ($n=117$)	DP1 ($n=34$)	DP2 ($n=24$)	DP3 ($n=10$)	*P* value
Intraoperative complications	6 (3.2)	3 (2.6)	2 (5.9)	1 (4.2)	0	0.879
Transfusion	6 (3.2)	5 (4.3)	1 (2.9)	0	0	0.882
Fever	17 (9.1)	7 (5.9)	5 (14.7)	3 (12.5)	2 (20.0)	0.221
Subcutaneous hematoma	1 (0.54)	1 (0.09)	0	0	0	
Pelvic abscess	6 (3.2)	3 (2.6)	1 (2.9)	1 (4.2)	1 (10.0)	0.385
Uroperitoneum	–	–	–	–	–	
Hemoperitoneum	1 (0.54)	0	1 (2.9)	0	0	
Urinary tract infections	14 (7.6)	4 (3.4)	4 (11.8)	5 (20.8)	1 (10.0)	**0.012**
Bladder voiding deficit	18 (9.7)	4 (3.4.)	6 (17.6)	5 (20.8)	3 (30.0)	**0.001**
Definitive autocatheterization	3 (1.6)	1 (0.09)	0	1 (4.2)	1 (10)	0.095
Intestinal anastomosis leakage	1 (0.5)	0	1 (2.9)	0	0	–
Anastomosis stenosis	–	–	–	–	–	–
Rectovaginal fistula	–	–	–	–	–	–
Vesicovaginal fistula	–	–	–	–	–	–
Ureteral fistula	–	–	–	–	–	–
Ureteral stenosis	–	–	–	–	–	–
Vesical fistula	–	–	–	–	–	–
EBL	209.5 (200.1)	168.6 (164.6)	294.7 (243.8)	231.7 (169.1)	345 (328.7)	**0.001**
Operative time (minutes)	262.2 (112.1)	231.2 (87.71)	299.8 (106.1)	304.1 (136.3)	396.4 (163.2)	**<0.0001**
Days of hospitalization	4.0 (3.0–6.0)	4.08 (1.95)	6.0 (4.0–7.0)	5.0 (3.7–7.0)	4 (2–10)	0.078
Clavien Dindo maximum grade	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.0 (0.0–1.0)	0.0 (0.0–1.0)	**0.011**
Days of autocatheterization	1.79 (7.36)	0.965 (6.03)	1.47 (4.23)	5.41 (13.72)	3.9 (6.40)	**0.012**
Time from surgery to stool passage	3.0 (3.0–4.0)	3.0 (3.0–4.0)	3.0 (3.0–4.0)	4.0 (3.0–4.0)	4.0 (3.2–4.8)	**<0.0001**

Note: Statistically significant values in bold were entered.

Abbreviations: DP1, deep parametrectomy type 1; DP2, deep parametrectomy type 2; DP3, deep parametrectomy type 3; EBL, estimated blood loss; SP, superficial parametrectomy.

[a]Descriptive statistics are expressed as a median and interquartile range for quantitative variables, and as absolute and relative percentage frequencies for qualitative variables.

Ureterolysis was performed in 144 women (77.8%) and differences between groups were seen (Table 4). Shaving and segmental resection was performed respectively in 33 (17.8%) and 51 (27.6%) cases. In particular, shaving was performed in the SP (25 women, 21.4%) and DP2 (6 women, 25%) groups, while there was segmental resection in the DP1 (15 women, 44.1%), DP2 (9 women, 37.5%) and DP3 (4 women, 40.0%) groups. Partial vaginal resection was performed in 31 patients (16.8%), of which 11 (32.4%) in the DP1 groups. No laparotomic conversions were observed. Neurolysis (hypogastric nerve, obturator nerve, sacral plexus or sciatic nerve) was performed in nine patients (4.9%), distributed between DP1 and DP3, with a significant difference between the four groups. Nerve ablation of the hypogastric nerve or inferior hypogastric plexus was necessary in 11 patients (5.9%), and this was only unilateral, predominantly left-sided, in four patients (11.8%) in the DP1 group, one patient (4.2%) in the DP2 group, and two patients (20%) in the DP3 group. Among the patients who underwent neurolysis of somatic nerves in the DP3 group, only one (10%) reported, during the follow up, a sensory and motor deficit of adduction.

3.2 | Functional outcomes

A statistically significant difference ($P<0.0001$) in VAS scores between baseline and 6-month follow-up (6FU) was measured in each of the four groups.

Regarding questionnaire scores, a statistically significant difference between baseline and 6 month follow up (6FU) for KESS emerged in the SP, DP1, DP3 groups (see Tables 5 and 6). Notably, in group DP2, no difference between scores was significant, contrasting with group DP3, where the differences between baseline and 6FU

TABLE 3 Enzian classification system ($N = 185$)[a].

Enzian classification system	Overall ($n = 185$)	SP ($n = 117$)	DP1 ($n = 34$)	DP2 ($n = 24$)	DP3 ($n = 10$)	*P* value
Peritoneum						
Absent	5 (2.7)	5 (4.3)	0	0	0	0.730
P1	179 (96.8)	111 (62.0)	34 (19)	24 (13.4)	10 (100)	
P2	1 (0.05)	1 (10.0)	0	0	0	
P3	—	—	—	—	—	
Ovaries						
Absent	54 (29.2)	30 (25.6)	8 (23.5)	13 (54.2)	3 (30)	**0.029**
O1	11 (5.9)	3 (2.6)	4 (11.8)	1 (4.2)	3 (30)	
O2	109 (58.9)	75 (64.1)	21 (61.8)	10 (41.7)	2 (20)	
O3	11 (5.9)	9 (7.7)	0	0	1 (10)	
Tubes						
Absent						
T1	10 (5.4)	9 (7.7)	1 (2.9)	0	0	0.126
T2	126 (68.1)	77 (65.8)	22 (64.7	21 (87.5)	6 (60)	
T3	49 (26.5)	31 (26.5)	11 (32.4)	3 (12.5)	4 (40)	
Compartments						
A (rectovaginal septum and vagina)						
Absent	148 (80.0)	102 (87.2)	21 (61.8)	18 (75.0)	7 (60)	0.135
A1	10 (5.4)	4 (3.4)	4 (11.8)	1 (4.2)	1 (10)	
A2	25 (13.5)	10 (8.5)	8 (23.5)	5 (20.8)	2 (20)	
A3	2 (1.1)	1 (0.09)	1 (2.9)	0	0	
B (uterosacral/cardinal ligaments, parametrium, pelvic sidewalls)						
Absent	0	0	0	0	0	0.900
B1	1 (0.05)	0	0	0	0	
B2	184 (99.5)	116 (99.1)	34 (100)	24 (100)	10 (100)	
B3	0	0	0	0	0	
C (rectum)						
Absent	91 (49.2)	63 (53.8)	14 (41.2)	8 (33.3)	6 (60)	0.090
C1	13 (7.2)	9 (7.6)	1 (2.9)	3 (12.5)	0	
C2	56 (30.2)	36 (30.8)	10 (29.4)	8 (33.3)	1 (10)	
C3	27 (14.6)	10 (8.5)	9 (26.5)	5 (20.8)	3 (30)	
Fa (adenomyosis)	183 (98.9)	116 (99.1)	34 (100)	24 (100)	9 (90)	0.444
Fb (urinary bladder involvement)	3 (16)	1 (0.09)	1 (2.9)	1 (4.2)	0	
Fi (other intestinal locations)	96 (51.9)	54 (46.2)	21 (61.8)	17 (70.8)	4 (40)	0.075
Fu (ureteric involvement with signs of obstruction)	8 (4.3)	0	2 (5.9)	1 (4.2)	5 (50)	**<0.001**
Fn (hypogastric nerve)	11 (5.9)	0	7 (20.5)	1 (4.16)	3 (30)	**0.010**

Note: Statistically significant values in bold were entered.

Abbreviations: DP1, deep parametrectomy type 1; DP2, deep parametrectomy type 2; DP3, deep parametrectomy type 3; SP, superficial parametrectomy.

[a]Descriptive statistics are expressed as absolute and relative percentage frequencies.

for each questionnaire were statistically significant. For the GIQLI questionnaire, differences were significant in groups DP1 and DP3. BFLUTS total scores differed only within group DP3. FSFI total scores differed between baseline and 6FU in group SP and group DP3.

Table 7 shows the *P* values obtained by applying two-way ANOVA for the four functional variables. Regarding KESS, we observed a statistically significant difference for time and paramentrectomy factors; specifically, KESS changed significantly between pre- and post-treatment and also varied among the four groups ($P < 0.0001$). While the interaction term was not statistically significant, for FSFI and GIQLI, we found results at the borderline of significance for time and parametrectomy factors, respectively.

TABLE 4 Intervention data of the study population ($N = 185$)[a].

Surgery	Overall ($n = 185$)	SP ($n = 117$)	DP1 ($n = 34$)	DP2 ($n = 24$)	DP3 ($n = 10$)	*P* value
Intestinal tract 11						
Rectum	73 (39.5)	39 (33.3)	19 (55.9)	11 (45.8)	4 (40)	0.087
Sigmoid	13 (7.0)	7 (6.0)	4 (11.7)	2 (8.3)	—	
Ileum	—	—	—	—	—	
Ileocecal	1 (0.05)	1 (0.9)	—	—	—	
Rectum + sigmoid	7 (3.8)	3 (2.6)	—	2 (8.3)	2 (20)	
Rectum + ileum	1 (0.05)	—	1 (2.9)	—	—	
Rectum + ileocecal	1 (0.05)	1 (0.9)	—	—	—	
Distance from the anal verge, cm	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.0 (0.0–4.8)	0.0 (0.0–4.3)	0.0 (0.0–4.0)	0.313
Ileostomy	18 (9.7)	3 (2.6)	5 (14.7)	6 (25.0)	4 (40.0)	**<0.0001**
USO	24 (13.0)	14 (12.0)	5 (14.7)	2 (8.3)	3 (30.0)	0.339
BSO	23 (12.4)	15 (12.8)	4 (11.8)	2 (8.3)	2 (20.0)	0.807
Ureterolysis	144 (77.8)	83 (70.9)	30 (88.2)	22 (91.7)	9 (90.0)	**0.031**
Neurolysis						
Right	6 (3.24)	0	5 (14.7)	0	1 (10)	**<0.0001**
Bilateral	2 (1.08)	0	1 (2.9)	0	1 (10)	
Left	1 (0.54)	0	0	0	1 (10)	
Nerve ablation						
Right	4 (2.2)	0	3 (8.8)	0	1 (10)	**<0.0001**
Left	7 (3.8)	0	4 (11.8)	1 (4.2)	2 (20)	
Shaving	33 (17.8)	25 (21.4)	2 (5.9)	6 (25.0)	0	**0.042**
Segmental resection	51 (27.6)	23 (19.7)	15 (44.1)	9 (37.5)	4 (40.0)	**0.016**
Discoid resection	13 (7.1)	7 (6.0)	4 (11.8)	2 (8.3)	0	0.552
Other data						
Ureteral resection/ reimplantation	8 (4.3)	0	2 (5.9)	2 (8.3)	4 (40)	**<0.0001**
Endometrioma resection						
Monolateral	44 (23.8)	30 (25.6)	9 (26.5)	3 (12.5)	2 (20.0)	0.583
Bilateral	41 (22.2)	30 (25.6)	6 (17.6)	4 (16.7)	1 (10.0)	0.475
Partial bladder resection	3 (1.6)	1 (0.9)	1 (0.9)	1 (0.9)	0	0.584
Partial vaginal resection	31 (16.8)	12 (10.3)	11 (32.4)	6 (25.0)	2 (20)	**0.013**
Conversion to laparotomy	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total hysterectomy	70 (37.8)	40 (34.2)	15 (44.1)	10 (41.7)	5 (50)	0.570
Anterior parametrectomy	5 (2.7)	1 (0.9)	2 (5.9)	1 (4.2)	1 (10)	0.168

Note: Statistically significant values in bold were entered.

Abbreviations: BSO, bilateral salpingo-oophorectomy; DP1, deep parametrectomy type 1; DP2, deep parametrectomy type 2; DP3, deep parametrectomy type 3; SP, superficial parametrectomy; USO, unilateralsalpingo-oophorectomy.

[a]Descriptive statistics are expressed as the mean and standard deviation or median and interquartile ranges for quantitative variables, and as absolute and relative percentage frequencies for qualitative variables.

4 | DISCUSSION

Nerve-sparing surgical techniques for DE treatment originated from gynecologic oncology principles[7,28] and have been refined over the past 15 years by various authors,[11] underscoring the importance of understanding pelvic somatosensory innervation in depth. However, no one has ever truly established a definition and the anatomical limits of the procedure, unlike such achievements in the field of oncology.[7] This is probably due to the complex nature of DE, which distorts surgical planes and makes it challenging to recognize anatomical structures in detail. Consequently, discussions persist regarding the feasibility of nerve-sparing surgery for DE.[29]

This lack of a single definition for parametrectomy in DE is also reflected in the results published over the years by various authors. Ballester et al.[30] studied the impact of extraserosal pelvic fascia

resection on postoperative outcomes in patients with colorectal endometriosis. With nerve-sparing surgery, 36% of these patients required self-catheterization during the immediate postoperative course and 12.5% needed bladder catheterization after 3-month follow-up. In a study that can be considered a milestone in nerve-sparing surgery for DE, Negrar's group reported an incidence of self-catheterization during the first 30 days after surgery in 32.8% of patients undergoing parametrectomy and segmental intestinal resection.[10] In a 2018 study on patients undergoing surgery for parametrial endometriosis, Mabrouk et al.[3] reported the need for self-catheterization in 6.5% of patients at discharge and in 3.9% at the 1-month follow-up evaluation. However, in a recent 2022 study, Benoit et al. compared patients undergoing parametrectomy for DE versus patients who did not require the procedure, and reported a use of self-catheterization in 17.5% and 8.98%, respectively.[31] In previous publications, our group reported the use of postoperative self-catheterizations in 8.7% of patients undergoing dorsolateral parametrectomy for DE,[5] which increased to 13% in the case of patients undergoing modified radical hysterectomy[22] and to 22.2% in cases of patients undergoing parametrectomy during ureteroneocystostomies for ureteral stenosis.[26] This different incidence for the most frequent complication after surgery for parametrial endometriosis, rather than being influenced by the nerve-sparing surgical technique, could therefore reflect a different extension of the limits of parametrectomy, which in our study we have linked to different anatomical landmarks.

In our study, extension of the parametrectomy laterally to the presacral fascia, particularly involving the hypogastric fascia, was linked to a higher incidence of bladder voiding deficit. However, we

TABLE 5 Pain VAS scale and questionnaire overall evaluations before intervention and at 6-month follow-up ($N = 185$).

	Baseline	FU	*P* value
VAS			
Dysuria	0 (0–0)	0 (0–0)	<0.0001
Dysmenorrhea	8 (6–9)	0 (0–0)	<0.0001
Dyspareunia	7 (5–8)	0 (0–0)	<0.0001
Dyschezia	0 (0–7)	0 (0–0)	<0.0001
CPP	8 (6–9)	0 (0–2)	<0.0001
Questionnaires			
KESS	15.8 (7.1)	12.8 (6.5)	<0.0001
GIQLI	81.7 (26.4)	85.6 (29.4)	0.041
FSFI tot	19.7 (8.63)	17.9 (10.6)	0.015
BFLUTS tot	12.3 (9.9)	11.6 (10.4)	0.294

Abbreviations: BFLUTS, Bristol female lower urinary tract symptoms total score; CPP, chronic pelvic pain; FSFI tot, female sexual function index total score; GIQLI, Gastro-Intestinal Quality of Life Index; KESS, Knowles-Eccersley-Scott Symptom; VAS, visual analog scale.

TABLE 6 Pain VAS scale and questionnaire evaluations before intervention and at 6-month follow-up ($N = 185$).

	SP ($n = 117$)		DP1 ($n = 34$)		DP2 ($n = 24$)		DP3 ($n = 10$)	
	Baseline	FU-6	Baseline	FU-6	Baseline	FU-6	Baseline	FU-6
VAS								
Dysuria	0 (0–0)	0 (0–0)	0 (0–3)	0 (0–0)	0 (0–4.5)	0 (0–0)	0 (0–4.5)	0 (0–0)
Dysmenorrhea	8 (6–9)	0 (0–0)	8 (6–9)	0 (0–0)	9 (7.5–10)	0 (0–0)	8 (7.5–9)	0 (0–0)
Dyspareunia	7 (5–8)	0 (0–0)	7 (4.5–8)	0 (0–1.3)	7 (4.5–8.5)	0 (0–1.3)	6 (1.3–7.8)	0 (0–2)
Dyschezia	0 (0–7)	0 (0–0)	0 (1–8)	0 (0–0)	1.5 (0–7)	0 (0–0)	4 (0–7)	0 (0–0)
Questionnaires								
KESS	15.2 (6.7)	12.0 (6.4)	16.3 (7.9)	12.9 (6.01)	18.0 (7.1)	15.1 (7.4)	15.1 (8.6)	8.2 (4.13)
GIQLI	82.3 (25.8)	85.5 (30.9)	80.12 (30.3)	88.8 (26.0)	85.09 (19.2)	90.8 (19.6)	71.5 (33.8)	63.9 (33.9)
FSFI tot	20.1 (8.3)	18.2 (10.6)	17.7 (7.9)	16.0 (9.2)	20.31 (10.1)	20.2 (11.0)	20.3 (10.7)	8.75 (13.7)
BFLUTS tot	11.8 (10.2)	10.9 (10.5)	15.03 (10.2)	13.3 (10.6)	10.7 (8.03)	12.6 (9.2)	12.4 (8.2)	5.0 (12.5)

Abbreviations: BFLUTS, Bristol female lower urinary tract symptoms total score; CPP, chronic pelvic pain; DP1, deep parametrectomy type 1; DP2, deep parametrectomy type 2; DP3, deep parametrectomy type 3; FSFI tot, Female Sexual Function Index total score; GIQLI, Gastro-Intestinal Quality of Life Index; KESS, Knowles-Eccersley-Scott Symptom; SP, superficial parametrectomy; VAS, visual analog scale.

TABLE 7 Two-way ANOVA results.

	FSI	KESS	BFLUTS	GIQLI
Time	0.075	**<0.0001**	0.502	0.171
Parametrectomies	0.214	**0.015**	0.245	0.052
Time*parametrectomies	0.747	0.693	0.815	0.694

Note: Statistically significant values in bold were entered.

Abbreviations: ANOVA, analysis of variance; BFLUTS, Bristol female lower urinary tract symptoms; FSFI tot, Female Sexual Function Index; GIQLI, Gastro-Intestinal Quality of Life Index; KESS, Knowles-Eccersley-Scott Symptom.

did not observe significant differences in postoperative complication rates among the four parametrectomy groups.

We did not demonstrate a clear improvement in post-operative bladder function, with the exception of the DP3 group, where the improvement was statistically significant at the 6-month postoperative follow-up. Our findings overlap with what has already been reported by Ballester et al.,[32] who also did not detect an impact for parametrial resection of the nerve-sparing approach on BFLUTS scores at 1-month follow-up. On the contrary, Laterza et al.[33] recently showed how, in a select population of patients with deep infiltrating endometriosis (not requiring bowel or ureteral resection), bladder function improved after surgery. However, in different study populations, the use of pre- and postoperative urodynamic tests and, above all, a different incidence of parametrectomies can explain these discrepancies. Our results are difficult to interpret because improvement in bladder function occurred mainly in the DP3 group, where the use of self-catheterization was more frequent. In all likelihood, the limited number of patients in this group may have influenced the questionnaire outcomes.

Our data showed a significant improvement over time in KESS in all parametrectomy groups, except for DP2, where the improvement was not statistically significant. Conversely, no significant improvement was observed in GIQLI scores after surgery. The available scientific literature is difficult to compare because, to the best of our knowledge, there are no studies focused on the role of parametrectomy when understood as a surgical procedure capable of improving functional gastrointestinal outcomes. However, even when analyzing the results of studies focused on functional outcomes after segmental intestinal resections for DE, there are conflicting results. Some did not observe relief from digestive complaints,[10,34] while others reported significant improvements.[21]

The rationale for a potential role of parametrectomy to influence functional outcomes assessed with validated questionnaires fundamentally lies in an anatomical structure that is part of the dorsolateral parametrium, that is, the LLR. Preservation of the branch of the inferior hypogastric plexus passing through this ligament, below the middle rectal artery, contributes to gastrointestinal motility and plays a fundamental role in the rectal innervation.[6–9]

Consistent with our previous findings,[21] parametrectomy for DE, despite a generic improvement in dyspareunia, does not lead to a concurrent improvement in sexual function, as measured by FSFI, across any of the four groups. This may depend on a direct or indirect damage to autonomic nerves responsible for decreasing blood flow and lubrication. Specifically, the parasympathetic and sympathetic fibers constitute the efferent arm of the spinal reflexes involved in the neuroregulation of female sexual response.[9,21] Moreover these findings do not appear to be influenced by a different distribution between the four groups of hysterectomies or vaginal resections. The groups subjected to SP and DP3, characterized by lower postoperative FSFI scores, exhibit a lower incidence of resected vaginal nodules.

During parametrectomy, neurolysis of parasympathetic or somatosensory nerves was required in 4.8% of patients, while approximately 6% necessitated selective neuroablation of the hypogastric nerve or components of the inferior hypogastric plexus. These results appear to be in contrast with previous findings by Chiantera et al.,[4] where 35.3% of patients with parametrial infiltration had simultaneous infiltration of the sacral plexus or sciatic nerve. This difference can probably be attributed to the natural selection of patients at a center focused on neuropelveology and in its retrospective design.

What is interesting in our study is that while 50% of DP3s required neurolysis (sacral plexus, obturator nerve, or sciatic nerve) or neuroablations (hypogastric nerve or the inferior hypogastric plexus), only 30% of these patients subsequently required self-catheterization, similar to that reported by Roman et al.[35] in 2021 (27%). Among these patients, only one needed neuromodulator implantation. One hypothesis to explain this aspect is that the damage induced by DE on the structure of the hypogastric nerve or the inferior hypogastric plexus, through ischemia, or secondary to iatrogenic surgical trauma, may have involved a "non-dominant" hemipelvis. Knecht et al.[36] demonstrated in 2000 that right-hemisphere language dominance increases linearly with the degree of left-handedness, suggesting the existence of a "dominant hemipelvis" from a neurofunctional standpoint. This hypothesis could explain why surgical lesions or compression due to conditions like DE may not consistently result in severe functional damage.

The classification system proposed in this study aims not to interfere a priori with management of the DE, but rather to provide a standardized description of parametrectomy for DE surgery. If widely adopted by authors and surgeons, this classification system could facilitate simpler and more accurate comparisons of results across various studies on the topic. Furthermore, a study focused on the outcomes of parametrectomy is undoubtedly helpful in counseling patients, who undergo these complex surgical procedures and can therefore choose with adequate awareness.

The limitations of our study concern the non-homogeneous distribution of patients between the various groups of parametrectomies and the tertiary level center, and this could lead to inaccurate estimate of the real incidence of surgical and dysfunctional complications in the groups of parametrectomy where the number of patients is lower. Furthermore, the lack of adequate follow-up to evaluate any changes in functional outcomes or relapse of pain after surgery. Nonetheless, having proposed for the first time a possible classification of parametrectomy for DE that is easily reproducible in expert hands, we believe it could have great value in the attempt to make the data of various authors more homogeneous and comparable, in particular for the important role parametrectomy plays in the surgical treatment of DE.

5 | CONCLUSIONS

Our findings demonstrate how the surgical extension of parametrectomy, despite the use of "nerve-sparing" techniques in expert hands, may produce a non-negligible rate of bladder voiding deficit.

Moreover, our results indicate that parametrectomy in and of itself is not associated with an improvement in sexual function, but only in dyspareunia.

AUTHOR CONTRIBUTIONS

Conceptualization: Manuel Maria Ianieri. Data curation: Maria Vittoria Alesi, Pierfrancesco Greco and Federica Campolo. Formal analysis: Antonella Calcagnì. Investigation: Manuel Maria Ianieri, Maria Vittoria Alesi, Pierfrancesco Greco and Federica Campolo. Methodology: Manuel Maria Ianieri. Supervision: Giovanni Scambia. Writing - original draft: Manuel Maria Ianieri. Writing - review and editing: Denis Querleu, Alfredo Ercoli and Vito Chiantera.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest and nothing to disclose.

DATA AVAILABILITY STATEMENT

Research data are not shared.

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