



HAL
open science

Comparison of robotic versus conventional laparoscopy for the treatment of colorectal endometriosis: Pilot study of an expert center

Marjolaine Le Gac, Clément Ferrier, Cyril Touboul, Clémentine Owen, Alexandra Arfi, Anne-Sophie Boudy, Aude Jayot, Sofiane Bendifallah, Emile Darai

► To cite this version:

Marjolaine Le Gac, Clément Ferrier, Cyril Touboul, Clémentine Owen, Alexandra Arfi, et al.. Comparison of robotic versus conventional laparoscopy for the treatment of colorectal endometriosis: Pilot study of an expert center. *Journal of Gynecology Obstetrics and Human Reproduction*, 2020, 49, pp.101885 -. 10.1016/j.jogoh.2020.101885 . hal-03492925

HAL Id: hal-03492925

<https://hal.science/hal-03492925v1>

Submitted on 21 Nov 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

1 **Comparison of Robotic versus conventional laparoscopy for the treatment of colorectal**
2 **endometriosis: pilot study of an expert center**

3

4 Marjolaine Le Gac¹, Clément Ferrier¹, Cyril Touboul^{1,2,3}, Clémentine Owen¹, Alexandra
5 Arfi¹, Anne-Sophie Boudy¹, Aude Jayot¹, Sofiane Bendifallah^{1,2,3}, Emile Daraï^{1,2,3}.

6

7 1. Department of Gynecology-Obstetrics and Medicine of Reproduction, Hôpital Tenon,
8 Sorbonne University, Assistance Publique des Hôpitaux de Paris.

9 2. Groupe de Recherche Clinique in endometriosis (GRC-6 Sorbonne University), Centre
10 Expert En Endometriose (C3E).

11 3. UMRS-938 Sorbonne University

12

13

14

15

16 Corresponding Author

17 Professor Emile Daraï,

18 Department of Gynecology-Obstetrics, Hôpital Tenon, Sorbonne University, Assistance
19 Publique des Hôpitaux de Paris

20 4 rue de La Chine 75020 Paris France

21 e-mail : emile.darai@aphp.fr

22 Abstract:

23 Introduction: Surgical management of deep endometriosis with colorectal involvement
24 remains an option after failure of medical treatments. Conventional laparoscopy is currently
25 considered the standard approach for surgical treatment. Recently, assisted-robotic
26 laparoscopy emerged as an alternative to conventional laparoscopy but with low evidence.

27 Methods: From March 2019 to September 2019, we conducted a prospective cohort study of
28 48 patients undergoing a surgical treatment for colorectal endometriosis (rectal shaving,
29 discoid excision or segmental resection). The interventions were either performed by robotic
30 or conventional laparoscopy. Patients' characteristics, operative and post-operative data were
31 compared between the robotic and the conventional laparoscopic group.

32 Results: 48 patients were included, 25 in the conventional laparoscopy group and 23 in the
33 robotic group. Patients' characteristics and operative findings were similar between the two
34 groups, except for a trend in a higher incidence of associated surgical urinary or digestive
35 procedures in the robotic group ($p=0.06$). The mean total surgical room occupancy time and
36 operating time were longer in the in the robotic group (281 ± 97 min vs 208 ± 85 min;
37 $p=0.008$) and (221 ± 94 min vs 163 ± 83 min ($p=0.03$), respectively. The mean intra operative
38 blood loss, the incidence of intra operative, post-operative complication (according to
39 Clavien-Dindo classification) rates and voiding dysfunction were similar in the two groups.
40 The rate of grade III complication was higher in the robotic group (13% vs 0%) without
41 reaching a significance ($p=0.17$). The mean hospital stay was 8 ± 4.4 days in the robotic
42 group and 6.5 ± 2.6 days in the conventional laparoscopy group ($p=0.18$).

43 Conclusion: Despite our initial experience in robotic surgery, our results support that robotic
44 surgery is an adequate alternative to conventional laparoscopy for endometriosis colorectal
45 resection.

46

47 Keywords: Endometriosis; Colorectal endometriosis; Laparoscopy; Robotic surgical
48 procedures.

49

50

51

52 INTRODUCTION

53 Endometriosis is a chronic disease, characterised by the presence of glands and
54 endometrial stroma outside the uterus, affecting up to 10% of women ^{1 2 3}. Deep
55 endometriosis (DE) is defined by the infiltration of anatomical structures and organs beneath
56 the peritoneal surface by endometriotic tissue. DE with colorectal involvement is considered
57 one of the most severe and complex form with an impact on the quality of life and fertility ^{4 5}.

58 The rectum and the rectosigmoid junction are the most common locations representing
59 over 80% of all bowel endometriosis ^{6 7}. Surgical management of DE with colorectal
60 involvement remains an option after failure of medical treatments ⁸⁻¹⁰. Colorectal resection for
61 endometriosis has demonstrated its efficacy on gynecological, digestive and urinary
62 symptoms, fertility, as well as on quality of life ^{8 9}. However, colorectal resection expose
63 patients to the risk of severe complications such as rectovaginal fistula, anastomotic
64 dehiscence, pelvic abscess and voiding dysfunction imposing a share making decision with
65 the patients according to their priorities ¹²⁻¹⁸.

66 Conventional laparoscopy is currently considered the standard for endometriosis
67 colorectal resection thanks to its advantages on intra and postoperative complications, hospital
68 stay and short recovery compared to open surgery ^{11,19-21}. Recently, assisted-robotic
69 laparoscopy emerged as an alternative to conventional laparoscopy although its superiority
70 remains questionable in gynecological surgery ¹⁰⁻¹¹. In the specific setting of colorectal
71 endometriosis, few small studies and case reports have been published to compare assisted-
72 robotic to conventional laparoscopy ^{12 13}.

73 Therefore, the aims of the present pilot study from an expert center in endometriosis
74 were to evaluate and to compare safety, intra and postoperative complications and short

75 postoperative outcomes of robotic to conventional laparoscopy for endometriosis colorectal
76 resection on a series of 48 patients operated on the short period of 6 months.

77

78

79 MATERIEL AND METHODS

80

81 From March 2019 to September 2019, we conducted a prospective cohort study of
82 patients undergoing a colorectal resection for endometriosis at Tenon University Hospital,
83 Expert Centre in Endometriosis (CE), Groupe de Recherche Clinique in endometriosis
84 Sorbonne University (GRC-6 SU), Paris, France.

85 Patients

86 The inclusion criteria were patients over 18 years-old, after failure of medical
87 treatment or with infertility; with a preoperative diagnosis of DE with colorectal involvement
88 confirmed by transvaginal ultrasonography, magnetic resonance imaging (MRI), and rectal
89 echo endoscopy (REE) using previously published criteria ¹⁴⁻¹⁵, schedule for colorectal
90 resection. Patients with DE without proved colorectal endometriosis or requiring an Assisted
91 Reproductive Technique (ART) and refusing bowel surgery were excluded of the study.
92 Patients with prior colorectal surgery were also excluded.

93

94 Surgical Procedure

95 In February 2019, the hospital was equipped with the da Vinci Surgical System Si
96 (Intuitive Surgery). The two surgeons began to perform colorectal procedures in March 2019,
97 after being trained specifically in robotic surgery, between September 2018 and February
98 2019. The surgeons specific-procedure (conventional laparoscopy for rectal endometriosis)
99 volume per year is 40-50 cases.

100 During the study period, the interventions were either performed by robotic or
101 conventional laparoscopy depending on availability of robotic room without criterion to select

102 patients according to the extent of the lesions neither prior surgery for endometriosis as the
103 surgery was planned one year ago.

104 The surgery was performed under general anesthesia. An indwelling urinary catheter was
105 placed and an intrauterine manipulator. For robotic surgery, an umbilical incision was done
106 to create a pneumoperitoneum using a Veress needle. Then an 8 mm umbilical trocar was
107 placed for endoscope. On the same horizontal line, a 12 mm trocar was placed at the right side
108 for harmonic scapel or automatic stapler and an additional 8 mm trocar on right flank for
109 grasping forceps. On the left side an 8 mm trocar was placed for bipolar forceps and an
110 additional classic 5 mm trocar for suction/irrigator device. For conventional laparoscopy,
111 surgery was performed as previously described ¹⁶.

112 All the robotic and conventional laparoscopic colorectal resections were performed by
113 surgeons (ED, SB) with an experience of at least 150 laparoscopic colorectal resections. All
114 the robotic and conventional laparoscopic colorectal resections were performed with the
115 objective of complete resection, as previously described ¹⁶⁻¹⁷. Procedures included adnexal
116 surgery (ovarian cystectomy or salpingo-oophorectomy), uterosacral ligament, torus
117 uterinum, parametrium, partial colectomy, hysterectomy, ureterolysis; and ureteral
118 reimplantation when required. The first step of the surgery consisted in exploring the
119 abdomen, mobilizing the colorectum to evaluate the size and extension of the bowel
120 endometriosis, identifying critical structures, and determining whether it was multicentric or
121 multifocal. For segmental resection, the ureter was identified crossing the pelvic brim and
122 mobilization was continued inferiorly to open the pararectal space. The mesocolon was then
123 opened and dissection extended down to the pararectal space. The space posterior to the
124 rectosigmoid mesocolon was opened. During this dissection the anterior branches of the
125 hypogastric plexus were identified, allowing a nerve-sparing surgery.

126 Depending on the evaluation of the size and extension of the bowel endometriosis, three
127 types of colorectal resection could be performed: rectal shaving, discoid excision or
128 segmental resection. Rectal shaving was performed for lesions with superficial serosal rectal
129 infiltration. A discoid excision was performed for lesions infiltrating the rectal muscularis less
130 or equal to 3 cm in length and involving less than 90° of the bowel circumference. Performed
131 either by standard laparoscopy or robotic surgery, the steps of a discoid excision procedure
132 were identical. Segmental resection was performed for colorectal endometriosis over 3 cm or
133 involving more than 90° of the bowel circumference or for multifocal lesions ¹⁸. Segmental
134 resections require a laparotomy step. The bowel is extracted through a supra-pubic mini-
135 laparotomy incision, and resected. Then, a purse is created for the anvil and the colon is
136 reintroduced inside the peritoneal cavity before closing the supra-pubic incision. Rectal
137 anastomosis was performed by introducing an automatic stapler in the rectum. Except for the
138 skin incisions, trocars localization and the docking procedure in the robotic group, the
139 surgical steps were identical either performed by robotic or conventional laparoscopy.

140 Indication of laparotomic conversion were technical difficulties or major
141 intraoperative complication. The creation of ileostomy was performed for patients requiring
142 partial colectomy when interposition of prevesical peritoneal was not feasible ¹⁹⁻²⁰.
143 Colorectal endometriosis was histologically confirmed in all the patients.

144 **Statistical analysis**

145 The following patient characteristics were recorded: age, body mass index (BMI),
146 parity, previous surgery, details of surgical procedure performed and preoperative symptoms.
147 The American Society for Reproductive Medicine score and Enzian score were systematically
148 calculated ²¹.

149 Postoperative complications were classified according to the Dindo-Clavien classification
150 system as minor (grade I-II) or major (grade IIIA and IIIB-IV), and compared between the
151 two surgical groups. Voiding dysfunction was defined by the need of intermittent bladder
152 self-catheterization when postvoid residual urine volume was greater than 100 millilitres.
153 Persistent voiding dysfunction is defined by urinary dysfunction lasting more than 1 month.
154 The population was divided into two groups according to the surgical route i.e. robotic or
155 conventional laparoscopy group.

156 Univariate analysis was performed using the Student's t test for normally distributed data
157 and Chi Square test for categorical data were used the Wilcoxon test for continuous variables
158 and the Fisher exact test for categorical variables. All reported p values were 2-sided.
159 Significant difference was denoted when $p < 0.05$. All statistical analysis was performed using
160 commercially available software (Stata/IC 14.0).

161

162

163

164

165

166

167

168

169

170 RESULTS

171 Epidemiologic characteristics of the study population

172 During the study period, 48 patients were included, 25 in the conventional laparoscopy
173 group and 23 in the robotic group.

174 No difference was found in epidemiologic characteristics between the groups Table 1.
175 The mean age was 36 ± 7 years in the robotic group and 37 ± 8 years in the conventional
176 laparoscopy group ($p=0.60$). No difference in the rate of prior surgery was found between the
177 groups (65% vs 52%, $p=0.35$). No difference in the rate of prior surgery for endometriosis
178 was found between the groups (43% vs 28%, $p=0.26$).

179 The mean ASRM score was 98 ± 49 in the robotic group and 86 (± 49) in the
180 conventional laparoscopy group, respectively ($p=0.39$). The mean Enzian score was 0.9 in the
181 robotic group and 0.8 in the conventional laparoscopy group for the A classification, 2.1 and
182 1.9 for the B classification, and 1.5 and 1.4 respectively for the C classification.

183 Surgical findings and intra-operative complications.

184 Characteristics of the surgical procedures are presented in the Table 2. There was no
185 difference between the groups regarding the type of rectal procedure. In the robotic group, 8
186 patients (35%) underwent a shaving, 6 patients (26%) a discoid excision, and 8 patients (35%)
187 a segmental resection. In the conventional laparoscopy group, 10 patients (40%) underwent a
188 shaving, 4 (16%) a discoid resection and 11 patients (44%) a segmental resection. In the
189 robotic group 6 (26%) underwent a hysterectomy and 11 (44%) in the conventional
190 laparoscopy group. A trend for a higher incidence of associated procedures was noted in the

191 robotic group ($p=0.06$) (i.e. 2 (9%) partial bladder resection, 1 (4%) ureteral resection and 2
192 ileo caecal resection (9%).

193 Anastomotic leakage diagnosed by leak test was observed in two patients (9%) in the
194 robotic group requiring an immediate second rectal resection and anastomosis (none in the
195 conventional laparoscopy group). Intraoperative complications occurred in two cases in the
196 robotic group consisting in one vaginal opening and one incomplete resection by discoid
197 excision requiring a segmental resection and one bladder injury in the conventional
198 laparoscopy group ($p=0.5$).

199 An ileostomy was performed in three cases (13%) in the robotic group for colectomy
200 in two cases and rectal and ileocecal resection in one case. Ileostomy was required in six
201 cases (24%) in the conventional laparoscopy group for low rectal anastomosis in two cases,
202 colectomy in two cases, excision of the Douglas pouch peritoneum and double resection in
203 one case each. No difference in ileostomy was noted between the groups.

204 The mean total surgical room occupancy time were 281 ± 97 min in the robotic group
205 and 208 ± 85 min in the conventional laparoscopy group ($p=0.008$). For the robotic group,
206 mean docking time was 18 min. The mean total operating time were 221 ± 94 min in the
207 robotic group and 163 ± 83 min in the laparoscopic group ($p=0.03$). The mean intra operative
208 blood loss was 130 ± 86 ml and 108 ± 99 ml in the robotic and in the conventional
209 laparoscopy group, respectively ($p=0.43$). None of the patients required transfusion during or
210 after the surgery. No conversion to laparotomy was needed. In the robotic group, no
211 conversion to conventional laparoscopy was needed.

212 Postoperative complications

213 The mean hospital stay was 8 ± 4.4 days in the robotic group and 6.5 ± 2.6 days in the
214 conventional laparoscopy group ($p=0.18$). Postoperative complications occurred in 6 cases in
215 the robotic group, with three major complications requiring a radiological or surgical
216 treatment (grade III complication according to Clavien-Dindo classification): one recto-
217 vaginal fistulae treated by ileostomy with spontaneous healing, one deep pelvic abscess and
218 one parietal evisceration. No major complications occurred in the conventional laparoscopy
219 group. Immediate postoperative voiding dysfunction was noticed in one case in the robotic
220 group and four cases in the conventional laparoscopy group ($p=0.22$). Voiding dysfunction
221 requiring a bladder self-catheterization more than 1 month after surgery was noticed in one
222 case in each group. The proximal and distal margins of the resection were confirmed to be in
223 sano in 14/15 patients (93%) in the robotic group and in 12/15 (80%) in the conventional
224 laparoscopy group ($p=0.27$).

225

226

227

228 DISCUSSION

229 The results of the current pilot study support that robotic surgery is a reliable
230 alternative to conventional laparoscopy for the surgical treatment of colorectal endometriosis.
231 Although no difference in intra and postoperative complications were noted between the
232 groups, operating time was higher in the robotic group.

233 To our knowledges, no data comparing robotic to conventional laparoscopy for the
234 surgical treatment of deep endometriosis with colorectal involvement are available. In the
235 present pilot study, most patients underwent a conservative surgery consisting in a rectal
236 shaving or discoid resection (58%) while a radical surgery consisting in a segmental resection
237 was required in 42% of cases without difference between the groups. Although the current
238 study is not randomized, it is important to note that no selection for robotic or conventional
239 laparoscopy was done on preoperative characteristics as the route was based on the assess to
240 the robotic room. Indeed, for the department of gynecology, robotic room was reserved once a
241 week and twice a week every other week for the patients who were previously scheduled for
242 colorectal surgery at one year. Finally, none of the patients refused a robotic approach.

243 Only few previous studies with small sample sizes, long periods of inclusion and high
244 heterogeneity in endometriosis are available ^{3 22 23 24 25}. In a cohort of patients with severe
245 endometriosis, Nezhat et al. observed longer operating time for robotic compared to
246 conventional laparoscopy (251 min vs 173 min; p=0.0005) but without difference in intra and
247 postoperative complications and in hospital stay ²⁶. In our study, patients in the robotic and in
248 the conventional laparoscopy groups had similar epidemiological characteristics (age, BMI,
249 prior surgery for endometriosis) and similar extent in endometriosis as proved by the values
250 of ASRM and ENZIAN scores. However, a trend for a higher rate of associated surgical

251 procedures was noted in the robotic group ($p=0.06$) including ileocecal resection, partial
252 bladder resection or ureteral resection.

253 As previous studies, we observed a higher operative time in the robotic group (281
254 min versus 208 min; $p=0.008$). Even when excluding the docking time (18 minutes on
255 average), the robotic route was longer with a mean difference in operating time of 40 minutes.
256 Our results are in agreement with those of a Cochrane review showing that robotic
257 gynecologic procedures (hysterectomy and sacrocolpopexy) were 40 minutes longer than
258 conventional laparoscopy but including the docking time^{12 27}. Therefore, a better criterion is
259 probably the total surgical room occupancy time that was also higher for the robotic group
260 (281 min vs 163 min, $p=0.03$). However, in the current study, the difference in both operating
261 and surgical room occupancy time could be also explained by different parameters. First, a
262 trend for a higher rate of associated surgery in the robotic group. Second, the initial
263 experience of the two operators in robotic surgery. Indeed, using the CUSUM methods on
264 operating time, a previous study on robotic rectal resection for cancer showed that the phase
265 3, representing the mastery phase, was achieved after 25 cases²⁸.

266 Except operating time, the crucial criterion to compare robotic and conventional
267 laparoscopy is the incidence of complications. Using the Clavien-Dindo classification, the
268 intra and postoperative complication rates were similar between the groups. However, a
269 higher rate of grade III complication was found in the robotic group although not reaching
270 significance (13% versus 0%). As for operating time, this could be explained by both the rate
271 of associated procedures and the limited experience of surgeons in robotic with subsequent
272 trend for a slight increase in hospital stay (8.0 versus 6.5 days) and in rehospitalization (9%
273 versus 0%). Moreover, our complications rate is in agreement with those of a recent meta-
274 analysis on laparoscopic colorectal resection for endometriosis involving 38 series with 3079
275 patients²⁹. Finally, our rate of voiding dysfunction, that is one of the most frequent

276 postoperative complication not taken into account by the Clavien-Dindo classification, was
277 particularly low in the robotic group (4%) compared to previous studies affecting up to 20%
278 of the patients underlying the feasibility of robotic nerve sparing surgery ^{16 30 31}.

279 Many advantages of the robotic techniques were already underlined: greater view with the
280 three-dimensional visual system, motion range allowed by the articulated instruments,
281 filtration of any natural tremor of the surgeon ^{32 33}. Then, we won't attribute the higher
282 proportion of associated procedure in the robotic group to the better 3D visualisation.

283 Moreover, robotic procedure confers ergonomic advantages and the ability to sit. Robotic
284 procedures appear to be associated with less fatigue for surgeons. However, advantages on
285 intra- and postoperative complications, quality of life, patient's satisfaction on incisions and
286 medico-economic have to be evaluated. In our population, all the associated procedures were
287 planned before the surgery.

288 Some limits of the current pilot study deserve to be underlined. First, our data
289 corresponded to the initial experience in robotic of two experienced surgeons in laparoscopic
290 colorectal resection for endometriosis that might be a source of bias especially concerning
291 operating time and complication rate. Second, the number of patients included in the two
292 groups was relatively low but on a short period reflecting the recruitment of an expert centre
293 operating on severe forms as proved by the high rate of associated procedures to colorectal
294 endometriosis. Graham et al reported their experience on robotic colorectal resection for
295 endometriosis on 15 patients operated on a period of three year with an incidence of severe
296 complications in one-third of the population ³⁴. Similarly, on a series of 10 cases of robotic
297 colorectal resection for endometriosis on a period of two years, Morelli et al reported similar
298 complication rate³. However, a recent study by Bendifallah and al underlined that the risk of
299 complications after colorectal resection for endometriosis by conventional laparoscopy was

300 higher for center with an hospital volume of less than 20 cases per year and for surgeons with
301 less than 8 procedures per year ³⁵. Third, despite the small sample size, the advantage of the
302 current study is offering data for power calculation for further trials. Finally, due to the short
303 follow-up, it was not possible to evaluate according to the groups changes in symptoms,
304 quality of life, sexual function and fertility outcomes.

305 Despite the limits of the present pilot study, our results support that robotic surgery is
306 an adequate alternative to conventional laparoscopy for endometriosis colorectal resection.
307 Further studies are required to explore the non-inferiority of robotic surgery regarding
308 postoperative complications. Moreover, potential benefit for the patient should be
309 investigated.

310

311

C	Robotic group (n=23)	Conventional Laparoscopy group (n=25)	p-value
Age, years mean (± SD)	36 ± 7	37 ± 8	0.60
BMI,kg/m2 mean (± SD)	25 ± 3	25 ± 4	0.91
Prior abdominal surgery, n (%)	15 (65%)	13 (52%)	0.35
Prior surgery for endometriosis, n (%)	10 (43%)	7 (28%)	0.26
Pregnancy before surgery, n (%)	9 (39%)	11 (44%)	0.73
Live birth before surgery, n (%)	6 (26%)	9 (36%)	0.46
Infertility, n (%)	9 (39%)	9 (36%)	0.82
-MRI	23 (100%)	25 (100%)	1
-Rectal endoscopic sonography	13 (57%)	9 (38%)	0.19
-Entero MRI	10 (43%)	8 (32%)	0.41
-Cystoscopy	3 (13%)	1 (4%)	0.26
MRI ENZIAN classification			
A, mean	0.9	0.8	0.92
B, mean	2.1	1.9	0.51
C, mean	1.5	1.4	0.75
Indication for surgery, n (%)			0.77
-Pain	14 (61%)	15 (60%)	
-Infertility	2 (9%)	1 (4%)	
-Pain and infertility	7 (30%)	9 (36%)	

312

313 Table 1: Epidemiologic and imaging characteristics of the study population

314

315

316

	Robotic group (n=23)	Conventional Laparoscopic group (n=25)	p-value
ASRM score	98 (\pm 49)	86 (\pm 49)	0.39
Rectal procedure			0.69
-Shaving	8 (35%)	10 (40%)	
-discoid resection	6 (26%)	4 (16%)	
-Segmental resection	9 (39%)	11 (44%)	
Size of digestive resections cm			
-Discoid resection	4 (\pm 1)	4.8 (\pm 1.3)	0.69
-Segmental resections	12 (\pm 4,1)	11 (\pm 4,7)	0.60
Free-margins digestive resections	14/15 (93%)	12/15 (80%)	0.27
Sigmoid resection	3 (13%)	3 (12%)	0.91
Ureterolysis	23 (100%)	25 (100%)	1
Torus resection	21 (91%)	25 (100%)	0.74
Uterosacral ligament resection (uni or bilateral)	21 (91%)	25 (100%)	0.74
Hysterectomy	6 (26%)	11 (44%)	0.20
Parametrium resection (uni or bilateral)	11 (48%)	15 (60%)	0.40
Salpingectomy (unilateral or bilateral)	4 (17%)	3 (12%)	0.57
Urinary and/or digestive associated procedures	5 (22%)	1 (4%)	0.06
- Cecal resection	1 (4%)	1 (4%)	0.95
- Ileocecal resection	2 (9%)	0	0.13
- Partial bladder resection	2 (9%)	0	0.13
- Ureteral resection	1 (4%)	0	0.29
Partial colectomy	6 (26%)	4 (16%)	0.39
Endometrioma fenestration	9 (39%)	13 (52%)	0.42
Protective ileostomy	3 (13%)	6 (24%)	0.30

318

319 Table 2: Surgical characteristics according to robotic and conventional laparoscopy groups

320

321

322

323

324

325 Table 3: Intra operative and postoperative complications and voiding dysfunction according

326 to robotic and conventional laparoscopy groups.

327

	Robotic group (n=23)	Conventional laparoscopic group (n=25)	p-value
Operative outcomes			
-Total surgical room occupancy time (min)	281 ± 97	208 ± 85	0.008
-Total operating time (min)	221 ± 94	163 ± 83	
-Conversion for laparotomy	0	0	0.03
-Unsatisfying leak test requiring a second resection-anastomosis.	2 (9%)	1 (4%)	1
-Blood loss (ml)			0.50
-Transfusion	130 ± 86	108 ± 99	0.43
-Blood loss (ml)	0	0	1
-Transfusion			
Post-operative outcomes			
-Hospital stay (day)	8.0 ± 4.4	6.5 ± 2.6	0.18
-Post-operative complication	6 (27%)	4 (15%)	0.31
Grade of complications (Clavien-Dindo classification)			0.43
I	1 (4%)	1 (4%)	
II	2 (9%)	3 (12%)	
IIIa	1 (4%)	0	
IIIb	2 (9%)	0	
IV	0	0	
-Rehospitalization	2 (9%)	0	0.13
-Voiding dysfunction requiring bladder self-catheterization	1 (4%)	4 (16%)	0.22
<1 month	0	3 (12%)	
>1 month	1 (4%)	1 (4%)	

328

329 BIBLIOGRAPHY

330

331 1. Kennedy, S. *et al.* ESHRE guideline for the diagnosis and treatment of endometriosis.
332 *Hum. Reprod. Oxf. Engl.* **20**, 2698–2704 (2005).

333 2. Ballweg, M. L. Impact of endometriosis on women’s health: comparative historical
334 data show that the earlier the onset, the more severe the disease. *Best Pract. Res. Clin. Obstet.*
335 *Gynaecol.* **18**, 201–218 (2004).

336 3. Morelli, L. *et al.* Robot-assisted surgery for the radical treatment of deep infiltrating
337 endometriosis with colorectal involvement: short- and mid-term surgical and functional
338 outcomes. *Int. J. Colorectal Dis.* **31**, 643–652 (2016).

339 4. Darai, E. *et al.* Fertility after laparoscopic colorectal resection for endometriosis:
340 preliminary results. *Fertil. Steril.* **84**, 945–950 (2005).

341 5. Chapron, C. *et al.* Anatomical distribution of deeply infiltrating endometriosis:
342 surgical implications and proposition for a classification. *Hum. Reprod.* **18**, 157–161 (2003).

343 6. Bailey, H. R., Ott, M. T. & Hartendorp, P. Aggressive surgical management for
344 advanced colorectal endometriosis. *Dis. Colon Rectum* **37**, 747–753 (1994).

345 7. Coronado, C., Franklin, R. R., Lotze, E. C., Bailey, H. R. & Valdés, C. T. Surgical
346 treatment of symptomatic colorectal endometriosis. *Fertil. Steril.* **53**, 411–416 (1990).

347 8. Darai, E. *et al.* Randomized trial of laparoscopically assisted versus open colorectal
348 resection for endometriosis: morbidity, symptoms, quality of life, and fertility. *Ann. Surg.*
349 **251**, 1018–1023 (2010).

350 9. Roman, H. *et al.* Baseline severe constipation negatively impacts functional outcomes

- 351 of surgery for deep endometriosis infiltrating the rectum: Results of the ENDORE
352 randomized trial. *J. Gynecol. Obstet. Hum. Reprod.* **48**, 625–629 (2019).
- 353 10. Nezhat, C., Saberi, N. S., Shahmohamady, B. & Nezhat, F. Robotic-assisted
354 laparoscopy in gynecological surgery. *JSLs* **10**, 317–320 (2006).
- 355 11. Gala, R. B. *et al.* Systematic review of robotic surgery in gynecology: robotic
356 techniques compared with laparoscopy and laparotomy. *J. Minim. Invasive Gynecol.* **21**, 353–
357 361 (2014).
- 358 12. Nezhat, C. *et al.* Robotic versus standard laparoscopy for the treatment of
359 endometriosis. *Fertil. Steril.* **94**, 2758–2760 (2010).
- 360 13. Chammas, M. F. *et al.* Asymptomatic rectal and bladder endometriosis: a case for
361 robotic-assisted surgery. *Can. J. Urol.* **15**, 4097–4100 (2008).
- 362 14. Bazot, M. *et al.* Deep pelvic endometriosis: MR imaging for diagnosis and prediction
363 of extension of disease. *Radiology* **232**, 379–389 (2004).
- 364 15. Bazot, M. *et al.* Diagnostic accuracy of physical examination, transvaginal
365 sonography, rectal endoscopic sonography, and magnetic resonance imaging to diagnose deep
366 infiltrating endometriosis. *Fertil. Steril.* **92**, 1825–1833 (2009).
- 367 16. Darai, E. *et al.* Laparoscopic versus laparotomic radical en bloc hysterectomy and
368 colorectal resection for endometriosis. *Surg. Endosc.* **24**, 3060–3067 (2010).
- 369 17. Jayot, A., Nyangoh Timoh, K., Bendifallah, S., Ballester, M. & Darai, E. Comparison
370 of Laparoscopic Discoid Resection and Segmental Resection for Colorectal Endometriosis
371 Using a Propensity Score Matching Analysis. *J. Minim. Invasive Gynecol.* **25**, 440–446
372 (2018).
- 373 18. Jayot, A., Nyangoh Timoh, K., Bendifallah, S., Ballester, M. & Darai, E. Comparison

- 374 of Laparoscopic Discoid Resection and Segmental Resection for Colorectal Endometriosis
375 Using a Propensity Score Matching Analysis. *J. Minim. Invasive Gynecol.* **25**, 440–446
376 (2018).
- 377 19. Vesale, E. *et al.* [Rectovaginal fistula prevention after enbloc colorectal resection and
378 hysterectomy for deep endometriosis]. *Gynecol. Obstet. Fertil. Senol.* **47**, 378–380 (2019).
- 379 20. [Omentoplasty is effective in lowering the complications of ano-rectal resections]. -
380 PubMed - NCBI. <https://www.ncbi.nlm.nih.gov/pubmed/15278031>.
- 381 21. Haas, D., Shebl, O., Shamiyeh, A. & Oppelt, P. The rASRM score and the Enzian
382 classification for endometriosis: their strengths and weaknesses. *Acta Obstet. Gynecol. Scand.*
383 **92**, 3–7 (2013).
- 384 22. Abo, C. *et al.* Postoperative complications after bowel endometriosis surgery by
385 shaving, disc excision, or segmental resection: a three-arm comparative analysis of 364
386 consecutive cases. *Fertil. Steril.* **109**, 172-178.e1 (2018).
- 387 23. Ercoli, A. *et al.* Robotic treatment of colorectal endometriosis: technique, feasibility
388 and short-term results. *Hum. Reprod. Oxf. Engl.* **27**, 722–726 (2012).
- 389 24. Neme, R. M. *et al.* Deep infiltrating colorectal endometriosis treated with robotic-
390 assisted rectosigmoidectomy. *JSLs* **17**, 227–234 (2013).
- 391 25. Diguisto, C. *et al.* [Robotic assisted laparoscopy: comparison of segmentary colorectal
392 resection and shaving for colorectal endometriosis]. *Gynecol. Obstet. Fertil.* **43**, 266–270
393 (2015).
- 394 26. Nezhat, C., Hajhosseini, B. & King, L. P. Robotic-assisted laparoscopic treatment of
395 bowel, bladder, and ureteral endometriosis. *JSLs* **15**, 387–392 (2011).
- 396 27. Nezhat, F. R. & Sirota, I. Perioperative Outcomes of Robotic Assisted Laparoscopic

- 397 Surgery Versus Conventional Laparoscopy Surgery for Advanced-Stage Endometriosis. *JSLs*
398 **18**, (2014).
- 399 28. Bokhari, M. B., Patel, C. B., Ramos-Valadez, D. I., Ragupathi, M. & Haas, E. M.
400 Learning curve for robotic-assisted laparoscopic colorectal surgery. *Surg. Endosc.* **25**, 855–
401 860 (2011).
- 402 29. Balla, A. *et al.* Outcomes after rectosigmoid resection for endometriosis: a systematic
403 literature review. *Int. J. Colorectal Dis.* **33**, 835–847 (2018).
- 404 30. Roman, H. *et al.* Conservative surgery versus colorectal resection in deep
405 endometriosis infiltrating the rectum: a randomized trial. *Hum. Reprod. Oxf. Engl.* **33**, 47–57
406 (2018).
- 407 31. Jayot, A. *et al.* Feasibility, Complications, and Recurrence after Discoid Resection for
408 Colorectal Endometriosis: A Series of 93 Cases. *J. Minim. Invasive Gynecol.* (2019)
409 doi:10.1016/j.jmig.2019.07.011.
- 410 32. Moon, A. S., Garofalo, J., Koirala, P., Vu, M.-L. T. & Chuang, L. Robotic Surgery in
411 Gynecology. *Surg. Clin. North Am.* **100**, 445–460 (2020).
- 412 33. Nezhat, C., Saberi, N. S., Shahmohamady, B. & Nezhat, F. Robotic-Assisted
413 Laparoscopy in Gynecological Surgery. *JSLs* **10**, 317–320 (2006).
- 414 34. Graham, A., Chen, S., Skancke, M., Moawad, G. & Obias, V. A review of deep
415 infiltrative colorectal endometriosis treated robotically at a single institution. *Int. J. Med.*
416 *Robot. Comput. Assist. Surg. MRCAS* **15**, e2001 (2019).
- 417 35. Bendifallah, S. *et al.* Impact of hospital and surgeon case volume on morbidity in
418 colorectal endometriosis management: a plea to define criteria for expert centers. *Surg.*
419 *Endosc.* **32**, 2003–2011 (2018).

420

421

422

423