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Title: Rectal Shaving Using Plasma Energy in Deep Infiltrating Endometriosis of the Rectum: Four Years of Experience

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1 **Rectal shaving using plasma energy in deep infiltrating endometriosis of the rectum:**
2 **four years of experience**

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19 Endometriosis Surgeons ROUENDOMETRIOSE, France.

20

21 **Précis:**

22 Rectal shaving using plasma energy in deep infiltrating endometriosis of the rectum allows
23 for a low rate of post-operative complications with good functional digestive outcomes.

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25

26 **Abstract**

27 **Study Objective:** To evaluate postoperative complications, digestive function and fertility
28 outcomes in patients managed by rectal shaving using plasma energy in deep infiltrating
29 endometriosis of the rectum.

30 **Design:** A single center retrospective cohort study using data prospectively recorded,
31 including patients managed from December 2012 to December 2016.

32 **Design classification:** Canadian Task Force classification II-2.

33 **Settings:** Department of Gynecology and Obstetrics of Rouen University Hospital (France).

34 **Patients:** One hundred and ten patients.

35 **Interventions:** Laparoscopic rectal shaving using plasma energy.

36 **Measurements and Main Results:** Clinical history, baseline symptoms, preoperative
37 assessment, intraoperative findings and postoperative outcomes were prospectively recorded.
38 Follow-up evaluations were performed at one and three years. Mean age of patients was $37 \pm$
39 6.4 years. Most patients had rectal nodules infiltrating either the mid or upper rectum and
40 measuring less than 3 cm in length. No intraoperative complications were recorded. One
41 patient with multiple previous surgical procedures presented a postoperative recto-vaginal
42 fistula (0.9%). Another patient presented a postoperative recto-uterine fistula treated
43 exclusively by antibiotics. Two patients (1.8%) had bladder atony requiring ≥ 3 weeks of
44 daily self-catheterization. The number of patients with Clavien-Dindo I, II, IIIa, IIIb and IVa
45 complications was 4 (3.6%), 12 (10.9%), 1 (0.9%), 5 (4.5%) and 1 (0.9%) respectively.
46 Conversely, 103 patients (93.6%) were free of severe complication. Significant improvement
47 in constipation and gastrointestinal quality of life was recorded 1 and 3 years postoperatively.
48 Thirty-two patients attempted pregnancy after surgery (29.1%), 17 of whom became pregnant
49 (53.1%).

50 **Conclusions:** Rectal shaving using plasma energy allows for a low rate of post-operative
51 complications with good digestive function and fertility outcomes and seems suitable in
52 selected women with symptomatic rectal endometriosis.

53 **Keywords:** Shaving; rectal endometriosis; plasma energy; ablation.

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55 Introduction

56 Deep infiltrating endometriosis of the rectum (DIER) is responsible for various
57 symptoms, such as catamenial diarrhea, constipation, rectorrhage, bloating and defecation
58 pain. Severe complications include progressive lumen obstruction that can lead to colorectal
59 sub-occlusion or occlusion. In the review of Mueleman *et al.*, more than 70% of patients
60 presenting DIER were managed by colorectal resection (1), which can negatively impact
61 postoperative rectal function. However, in a more recent survey enrolling patients managed
62 for colorectal endometriosis in France in 2015, almost half (48.1%) were treated by rectal
63 shaving (2). This conservative procedure, also known as partial full thickness excision,
64 involves the removal of the endometriosis nodule from the rectal wall without opening the
65 lumen (3). As this technique respects the rectal wall, it results in a lower rate of post-operative
66 complications as digestive fistulae (2). Since 2013, we have introduced a variant of rectal
67 shaving using plasma energy (4), which is comparable to that reported by Donnez *et al.*
68 employing the CO₂ laser (5). To assess our preliminary results we performed this
69 retrospective cohort study using prospectively recorded data in patients managed during 48
70 consecutive months in our department for deep endometriosis infiltrating the rectum.

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78 **Materials and methods**

79 **Patients**

80 We included consecutive patients managed by plasma energy rectal shaving for DIER
81 in the Department of Gynecology and Obstetrics of Rouen University Hospital (France) from
82 December 2012 to December 2016. Inclusion criteria were DIER revealed by clinical
83 examination, magnetic resonance imaging (MRI) and/or endorectal ultrasound and computed
84 tomography-based virtual colonoscopy, and confirmed intraoperatively. Rectal infiltration
85 was up to 15 cm above the anus and involved at least the muscular layer. Patients requiring
86 associated segmental resection procedures on sigmoid colon, small bowel or cecum were
87 excluded. We excluded the patients managed by rectal shaving with monopolar scissors using
88 a laparoscopic approach robotic assistance in 2013 and 2014 (6). We also excluded some
89 patients managed by rectal shaving using other energies mainly because PlasmaJet generator
90 was being used in another operative room or the devices were not promptly available during
91 the surgery. All the patients were placed on continuous hormonal therapy (contraceptive pills,
92 progestin or GnRH analogs) before the surgery, and surgical treatment was only proposed in
93 those women with incomplete relief of symptoms.

94 Clinical history, baseline symptoms, preoperative assessment, intraoperative findings
95 and postoperative outcomes were prospectively recorded in the CIRENDO database (the
96 North-West Inter Regional Female Cohort for Patients with Endometriosis, NCT 02294825).
97 CIRENDO is a prospective cohort financed by the G4 Group (the University Hospitals of
98 Rouen, Lille, Amiens, and Caen, France), receiving funds from ROUENDOMETRIOSE
99 association, and coordinated by one of the authors (H.R.). Patients filled self-questionnaires
100 before surgery and follow-up evaluations were performed by a clinical research technician at
101 one and three years after surgery. The surgeon filled in a specific questionnaire on

102 intraoperative findings and gave an exhaustive description of surgical procedures. Prospective
103 data recording and analysis were approved by the French authorities CNIL (Commission
104 Nationale de l'Informatique et des Libertés, the French data protection commission) and
105 CCTIRS (Comité Consultatif pour le Traitement de l'Information en matière de Recherche
106 dans le domaine de la Santé, the advisory committee on information technology in healthcare
107 research).

108 **Technique**

109 Patients are proposed rectal shaving, rather than disc excision or colorectal resection,
110 based on their age and parity, symptoms and nodule localization. The fact that shaving might
111 be less complete than disc excision or colorectal resection for the removal of microscopic
112 endometriosis foci is also taken into account(7). In older patients and in those with no
113 pregnancy intention, rectal shaving is performed systematically as the risk of recurrence is
114 expected to be very low. Rectal shaving is also preferred in some women whose digestive
115 symptoms are completely relieved preoperatively by therapeutic amenorrhea, independently
116 of nodule features. In patients with low and mid rectal nodules, in whom low colorectal
117 resection could lead to unfavorable postoperative functional outcomes, rectal shaving is
118 considered when rectal wall involvement is superficial (8). The size of rectal nodule and the
119 infiltration depth were not major criteria in our choice, as we have experience in saving rectal
120 nodules as large as 4 cm, this relieving rectal stenosis and rendering the mobility of the
121 rectum. In patients with multiple colorectal nodules, we would have suggested shaving on the
122 rectum along with segmental resection or disc excision of the sigmoid colon, however those
123 patients were excluded from this case-series.

124 The procedure of rectal shaving using PlasmaJet® device (Plasma Surgical, Inc.,
125 Roswell, GA, USA) was introduced in 2012 and was based on the specific properties of this
126 energy: absence of lateral thermal spread around the plasma jet ensuring safe dissection close

127 to the rectal wall, precise ablative properties allowing in situ ablation of rectal endometriosis
128 implants, and kinetic energy enhancing the dissection of sub-peritoneal spaces (4).

129 For the purposes of this present study, pre-operative assessment including clinical
130 examination, MRI, endorectal ultrasound and/or computed tomography-based virtual
131 colonoscopy, was performed exclusively by experienced operators (9). Rectal shaving was
132 performed by a senior gynecologic surgeon with experience in deep endometriosis surgery.
133 Briefly, plasma energy was used to dissect pelvic adhesions, open rectovaginal space, resect
134 the nodule along with infiltrations of uterosacral ligaments and vagina, when required, and to
135 shave the rectal wall down to the deep muscular layer as previously described in two video
136 articles (4) (10).

137 The procedure starts by opening deep sub-peritoneal spaces close to the lateral faces of
138 the rectum. This step is made possible by the absence of lateral thermal diffusion induced by
139 plasma energy and is enhanced by the kinetic energy of the plasma beam that opens the sub-
140 peritoneal spaces up to the healthy rectovaginal space located below the nodule. Then, rectal
141 shaving is performed exclusively using the PlasmaJet®. The plasma beam is oriented
142 tangentially to the surface of the rectum, in cutting mode set at 40-50 Ultra, to paint the rectal
143 surface in a frontal plane. Dissection is made into the thickness of the rectal wall and the
144 nodule is dissected away from the rectal wall, which is progressively mobilized upward. This
145 step is performed under direct visual control, as the tip of the handpiece does not hide the
146 target tissue unlike thermofusion or ultrasonic probes.

147 Although the rectum is generally completely freed, in patients with large rectal nodules
148 the shaved area of the anterior rectal wall may still be infiltrated by implants of deep
149 endometriosis, as it may have appeared hollow, rigid and thickened under palpation with a
150 laparoscopic probe. In these patients, shaving can be carried out using the ablative property of
151 the PlasmaJet® to treat fibrotic lesions *in situ*. Ablation is performed by painting the

152 infiltrated rectal surface slowly with the plasma beam held at a distance of 5 mm, and is based
153 on the property of the PlasmaJet® which induces only shallow necrosis of approximately 0.2-
154 0.5 mm in depth. The goal of rectal ablation is to relieve stenosis in patients with large
155 nodules. In rare cases, when the rectal lumen is opened or when rectal mucosa is widely
156 visible, the surgeon resected the shaved area using a transanal stapler rather than covering it
157 by muscular stitches. For the purposes of the present study, these procedures were recorded as
158 disc excision and as a result they were not included. Discontinuous stoma has never been
159 performed, except in one woman with postoperative rectovaginal fistula in whom stoma was
160 carried out during a secondary emergency procedure. Postoperative treatment by continuous
161 contraceptive pill intake until menopause was systematically recommended for women who
162 were not intending to conceive in order to reduce the overall risk of pelvic endometriosis
163 recurrences.

164 **Statistical analysis**

165 Statistical analysis was performed using Stata 9.0 software (Stat Corporation,
166 Lakeway Drive, TX, USA). Qualitative variables were reported as number (percentage) and
167 continuous variables as mean (SD) or median (range). Comparison of continuous variables
168 was carried out using the Wilcoxon test, and that of qualitative variables using the Fischer
169 exact test.

170 **Results**

171 One hundred and ten patients were included between December 2012 and December
172 2016. All patients were managed laparoscopically by rectal shaving using plasma energy.
173 They were 37 (± 6.4) years old, 32 of them (29.1%) had preoperative pregnancy intention and
174 44 (40.0%) had previous documented infertility (Table 1). Fifty-six (50.9%) and 15 (13.6%)

175 patients respectively had undergone previous gynecologic laparoscopy and previous open
176 surgery.

177 Intraoperatively, exclusive laparoscopic route was used in 100 (90.9%) patients (Table 2)
178 and a combined vaginal-laparoscopic procedure was performed in 9 patients due to large
179 vaginal infiltration by the nodule (11). Most patients had rectal nodules infiltrating either the
180 mid or upper rectum and measuring less than 3 cm in length. No intraoperative complications
181 were recorded.

182 One postoperative recto-vaginal fistula was recorded in our series (0.9%). The patient
183 was 36-years-old, nulliparous and had no pregnancy intention. She was followed for Steinert
184 disease and had previously undergone 2 laparoscopies for deep and ovarian endometriosis.
185 The procedure, which was not considered as technically difficult, included superficial rectal
186 shaving along with extensive adhesiolysis. Twenty-one days after the procedure, she was re-
187 hospitalized with fever due to a pelvic abscess and a fistula on the upper rectum. We
188 performed an emergency colostomy, and the patient was then transferred to the intensive care
189 unit due to sepsis. Due to the lack of spontaneous closure of the fistula, we performed
190 colorectal resection, which was complicated by stenosis of the anastomosis requiring 3
191 endoscopic dilation procedures. A 38-year-old patient was managed for frozen pelvis using
192 rectal shaving, and was re-hospitalized at day 9 after surgery due to fever. Computed
193 tomography revealed recto-uterine fistula without pelvic abscess. Evolution was favorable
194 with antibiotic treatment (cefalosporins and metronidazol). Further follow-up computed
195 tomography revealed spontaneous healing of the fistula.

196 Two patients (1.8%) had bladder atony requiring ≥ 3 weeks of daily catheterization.
197 The number of patients with Clavien-Dindo I, II, IIIa, IIIb and IVa complications was
198 respectively 4 (3.6%), 12 (10.9%), 1 (0.9%), 5 (4.5%) and 1 (0.9%) (any one patient could be
199 recorded as having more than one complication). Most Clavien-Dindo 3b complications were

200 pelvic hematomas with presumption of infection, which were managed by a second
201 laparoscopy. Conversely, 103 patients (93.6%) were free of severe complication (Table 3).

202 Three patients underwent second surgery during follow-up. One 40-year-old patient
203 with very low ovarian reserve required rectal shaving and endometrioma drainage after which
204 she attempted spontaneous conception for 6 to 9 months (she declined ART management); as
205 no pregnancy occurred, she underwent colorectal resection one year after due to incomplete
206 relief of digestive complaints. Two other patients with a large adenomyotic uterus underwent
207 second surgery for total hysterectomy due to residual pelvic pain and deep dyspareunia, with
208 no argument for rectal recurrence.

209 The assessment of digestive function is presented in Table 4, with comparison
210 between baseline, 1-year and 3-year postoperative values of gastrointestinal scores.
211 Significant improvement in constipation and gastrointestinal quality of life was recorded
212 postoperatively. Thirty-two patients (29.1%) had postoperative pregnancy intention and 17
213 (53.1%) became pregnant after surgery (Table 5). The delay between surgery and pregnancy
214 was 11.4 ± 7.4 months.

215 Discussion

216 We report a large series of consecutive patients managed by rectal shaving using plasma
217 energy. Our results show a low rate of postoperative complications with an improvement
218 in digestive function and satisfactory fertility outcomes. In our opinion, rectal shaving is
219 mainly suitable in patients with a lower risk of postoperative recurrence. We recommend
220 rectal shaving in older women, who no longer intend to get pregnant, or in women presenting
221 small/mid rectal nodules infiltrating the muscular layer only and free of advanced stenosis of
222 rectal lumen, which can be completely removed without opening the bowel.

223 The main advantage of rectal shaving is the treatment of rectal infiltration without
224 opening the rectal wall and suturing it. Avoiding rectal opening reasonably decreases the risk
225 of postoperative complications related to sutures of the mid and lower rectum, such as
226 rectovaginal fistulae or rectal suture leakage (2). Recent data suggest that in women with
227 DIER, pursuing a policy that promotes rectum conservation would lead to an improvement in
228 postoperative digestive functional outcomes (7) (9). This is probably be related to several
229 factors such as absence of rectal denervation, conservation of rectal volume and reduced risk
230 of postoperative stenosis at the level of colorectal anastomosis. These arguments, associated
231 with a lower rate of immediate complications, have led us to recommend rectal shaving as the
232 first line procedure in the management of DIER, whenever it is technically feasible.

233 The strengths of our study are the prospective recording of patients' data by a clinical
234 researcher dedicated to the follow-up of the cohort, which may explain the low rate of patients
235 lost to follow-up. In addition, the same surgical technique was used in all patients.
236 Furthermore, the assessment of pre and postoperative digestive function was based on widely
237 used standardized gastrointestinal questionnaires.

238 Our study also presents several weaknesses. One of them is the absence of a control
239 group, which would allow for comparison with other techniques. Our study only included
240 patients managed by rectal shaving using plasma energy, so direct comparison of our results
241 with those observed in our other series of patients managed by colorectal resection would be
242 inappropriate, because this latter group includes both women with large nodules of the upper
243 rectum and circumferential endometriosis of the mid and lower rectum. Consequently,
244 baseline characteristics and nodule features are different and prevent direct comparison
245 between surgical procedures.

246 In our series, rectal shaving was associated to resections of uterine torus, vagina,
247 uterosacral ligaments, or bladder. Thus, it is impossible to state that rectal shaving precisely

248 relieved pelvic pain symptoms. To accurately characterize the outcomes directly related to
249 rectal shaving, we used standardized gastrointestinal questionnaires to assess the
250 improvement of digestive complaints.

251 PlasmaJet is a surgical device employing plasma energy. It provides an energy jet that
252 dissipates rapidly upon contact with tissues and is responsible for limited additional thermal
253 spread, ensuring safe dissection close to the rectal wall. The depth of necrosis averages 0.5
254 mm (12). This property makes it suitable for rectal shaving where the aim is to remove the
255 nodule without opening the rectal lumen. No electricity is delivered to the patient's tissue,
256 which prevents the risk of secondary burns. In addition, the kinetic energy of the plasma jet
257 enhances the dissection of deep subperitoneal spaces. When the jet is applied tangentially
258 onto the rectal wall, it can be used as a virtual blade thanks to the absence of lateral thermal
259 spread. However, plasma energy is a new device, which requires continuous thorough
260 evaluation utilizing standardized steps, through: first, technical reports concerning the use of
261 the device in specific procedures; second, case-series of patients managed using the device
262 which focus on overall outcomes, benefits and complications ; third, two arm studies, where
263 the device is compared to other techniques routinely used in our daily practice; fourth,
264 randomized trial where sample size is estimated on the basis of precedent comparative
265 studies. To date, only the first 2 steps have been utilized with regard to use of plasma energy
266 in rectal shaving, thus it is too early to bravely state any superiority of our technique over other
267 procedures.

268 Although microscopically incomplete in most cases, rectal shaving is sufficient to
269 achieve considerable improvement in digestive symptoms in most patients. In addition, as
270 there is a low risk of unfavorable postoperative functional outcomes, such as low anterior
271 rectal resection syndrome, patients managed by rectal shaving are less likely to have
272 postoperative impairment of digestive function. For these reasons, rectal shaving is suitable in

273 patients whose nodule features and localization are associated with a high risk of unfavorable
274 postoperative functional outcomes, or in those with significant improvement in rectal function
275 under therapeutic amenorrhea (in these latter cases, surgery may still be required due to
276 associated complaints such as deep dyspareunia or pelvic pain).

277 As expected, the recurrence rate may be higher after rectal shaving than after disc
278 excision or colorectal resection (1) (13) (7) (14). Recurrence could be explained by the
279 probability of leaving behind microscopic foci of endometriosis that may develop after
280 surgery (15) (16). However, residual foci of endometriosis may also be found on the bowel
281 after disc excision and colorectal resection (17) (18) (19). To reduce the risk of recurrence, we
282 routinely recommend continuous amenorrhea after surgery using either progestin or
283 contraceptive pills (20). Furthermore, in our series rectal shaving was mainly performed in
284 women without pregnancy intention, in whom the risk of recurrence was expected to be low.
285 This choice explains why patients included in this series were older than those managed by
286 disc excision (21) or segmental colorectal resection, and were more likely to undergo
287 hysterectomy for adenomyosis. However, recurrence does not systematically require second
288 surgery and second surgery does not systematically employ colorectal resection. On the basis
289 of our own experience, we previously estimated that we would have needed to perform 12
290 colorectal resections instead of rectal shaving to avoid recurrence in only 1 patient (13).
291 Furthermore, we would have had to carry out 25 colorectal resections to avoid the 1 colorectal
292 resection which was necessary due to recurrence after rectal shaving. When the risk of
293 immediate postoperative complications and functional outcomes are considered together, the
294 price to pay to avoid recurrence might be too high.

295 Our rectal fistula rate is comparable to the 1.3% reported by the FRIENDS study (2).
296 Although the rate of fistulae may appear low, it must be emphasized that this complication
297 occurring after shaving might be more severe for the following reasons: i) rectal fistula after

298 shaving is unexpected, as the surgeon believes that the deep muscular layer has been
299 maintained and the risk of fistula has been avoided, ii) delayed fistula may occur several days
300 or weeks later, due to necrosis induced by thermal spread, when the patient has already
301 recovered, and iii) surgeons never perform discontinuous stoma to protect the rectal shaved
302 area, thus rectal fistula may be complicated by peritonitis and sepsis (2). For these reasons, we
303 recommend removing the shaved area by disc excision instead of rectal shaving alone in
304 circumstances where nodule excision widely exposes rectal mucosa.

305 The pregnancy rate observed in our present series was inferior to that reported in our
306 previous studies (22) (23) (13) (24). Several factors may explain this difference: women
307 undergoing shaving are usually older, and several of them had attempted spontaneous
308 conception for several months despite low ovarian reserve.

309 It is our policy to recommend postoperative medical treatment after the surgery, in order
310 to reduce the risk of recurrences, unless the patient desires pregnancy. To date, strong
311 evidence exists about the reduction of pain and endometriotic lesion recurrences in women
312 with postoperative amenorrhea (20,25). On the other hand, all the patients benefited from
313 medical therapy in continuous intake (contraceptive pills, progestin or GnRH analogs) before
314 the surgery, and surgical treatment was only proposed in those women with incomplete relief
315 of presenting symptoms. Thus, it is most likely that any noted difference between baseline
316 and postoperative symptoms would be due to the surgical management..

317 Numerous authors compared the outcomes of patients managed by either shaving or
318 colorectal resection. The French coloRectal Infiltrating ENDometriosis Study group recently
319 reported a survey enrolling 1,135 patients managed for colorectal endometriosis in France in
320 2015 (2), and observed that the risk of rectovaginal fistula was significantly lower in patients
321 managed by shaving (1.3, 3.6 and 3.9% after shaving, disc excision and
322 segmental resection respectively). Similar findings were reported by Mohr et al, who recorded

323 lower rates of postoperative complications in patients managed by shaving compared to those
324 managed by disc excision or colorectal resection (26). Kondo et al recorded lower
325 complications rate in 183 patients managed by shaving (6.7%) when compared to 25 patients
326 undergoing colorectal resection (24%) (27). Afors et al reported a series of 92 women
327 managed by shaving, disc excision or segmental resection for bowel endometriosis and
328 observed higher rates of symptom recurrence and reintervention in the shaving group (28).
329 Although the length of the follow up in their series was comparable to ours, their rate of
330 reinterventions for DIER recurrences after shaving was high (27.6%). This large difference in
331 deep endometriosis recurrences rate is astonishing and can be explained by various factors: i)
332 the use of term “shaving” could be applied to different surgical procedures; ii) the selection of
333 patient undergoing shaving could be different between the two centers; iii) the lack of
334 postoperative medical treatment could lead to deep endometriosis recurrences in patients who
335 could have benefited from induced amenorrhea. Furthermore, we recently published a study
336 comparing women managed by either shaving or colorectal resection, with postoperative
337 follow up of 5 to 10 years, that was obviously longer than that of patients of Afors et al (7).
338 Despite this excess of the lapse of time at risk of recurrences, only 8% of patients received a
339 new surgery for bowel recurrences after shaving, among which half received another shaving
340 and only half ultimately had a colorectal resection. However, when compared to women
341 managed by colorectal resection, those treated by shaving had better values of gastro-
342 intestinal quality of life questionnaires and were more likely to recommend the surgery to a
343 friend suffering from the same disease. On the basis of these data, we estimate that, in order to
344 prevent a recurrence risk of 8% at 75 months after conservative surgery, 12 patients should
345 receive colorectal resection instead of the shaving. Furthermore, to prevent the risk of
346 recurrences requiring a colorectal resection in one patient, 25 patients should undergo
347 colorectal resection instead of shaving (7). However, the major weakness of comparative

348 studies mentioned above is of concern about the enrollment of women with overall less severe
349 disease in patients managed by shaving, which may potentially jeopardize outcomes
350 assessment. A more definitive answer should be provided by the ENDORE randomized trial
351 comparing colorectal resection to conservative surgery in DIER, which final report will soon
352 be available within the next few months.

353 In conclusion, our study suggests that rectal shaving allowed for a low rate of post-
354 operative complications with good functional digestive outcomes and seems suitable in
355 women with symptomatic rectal endometriosis and a presumed low risk of postoperative
356 recurrence.

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369 Surgeons ROUENDOMETRIOSE, France.

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References

- 374 1. Meuleman C, Tomassetti C, D'Hoore A, Van Cleynenbreugel B, Penninckx F,
375 Vergote I, et al. Surgical treatment of deeply infiltrating endometriosis with colorectal
376 involvement. *Hum Reprod Update*. 2011 Jun;17(3):311–26.
- 377 2. Roman H. A national snapshot of the surgical management of deep infiltrating
378 endometriosis of the rectum and colon in France in 2015: A multicenter series of 1135 cases.
379 *J Gynecol Obstet Hum Reprod* [Internet]. [cited 2017 Feb 28]; Available from:
380 <http://www.sciencedirect.com/science/article/pii/S246878471730020X>
- 381 3. Daraï E, Cohen J, Ballester M. Colorectal endometriosis and fertility. *Eur J Obstet*
382 *Gynecol Reprod Biol*. 2016 Jun 9;
- 383 4. Roman H. Rectal shaving using PlasmaJet in deep endometriosis of the rectum. *Fertil*
384 *Steril*. 2013 Nov;100(5):e33.
- 385 5. Donnez J, Nisolle M, Casanas-Roux F, Bassil S, Anaf V. Rectovaginal septum,
386 endometriosis or adenomyosis: laparoscopic management in a series of 231 patients. *Hum*
387 *Reprod Oxf Engl*. 1995 Mar;10(3):630–5.
- 388 6. Abo C, Roman H, Bridoux V, Huet E, Tuech J-J, Resch B, et al. Management of deep
389 infiltrating endometriosis by laparoscopic route with robotic assistance: 3-year experience. *J*
390 *Gynecol Obstet Biol Reprod (Paris)*. 2016 Mar 14;
- 391 7. Roman H, Milles M, Vassilieff M, Resch B, Tuech J-J, Huet E, et al. Long-term
392 functional outcomes following colorectal resection versus shaving for rectal endometriosis.
393 *Am J Obstet Gynecol*. 2016 Jul 5;
- 394 8. Roman H, Abo C, Huet E, Tuech J-J. Deep shaving and transanal disc excision in
395 large endometriosis of mid and lower rectum: the Rouen technique. *Surg Endosc*. 2016
396 Jun;30(6):2626–7.
- 397 9. Roman H, Vassilieff M, Tuech JJ, Huet E, Savoye G, Marpeau L, et al. Postoperative
398 digestive function after radical versus conservative surgical philosophy for deep
399 endometriosis infiltrating the rectum. *Fertil Steril*. 2013 May;99(6):1695–704.
- 400 10. Roman H, Tuech J-J, Arambage K. Deep rectal shaving followed by transanal disc
401 excision in large deep endometriosis of the lower rectum. *J Minim Invasive Gynecol*. 2014
402 Oct;21(5):730–1.
- 403 11. Roman H, Darwish B, Schmied R, Remorgida V, Tuech J-J. Combined vaginal-
404 laparoscopic-transanal approach for reducing bladder dysfunction after conservative surgery
405 in large deep rectovaginal endometriosis. *J Gynecol Obstet Biol Reprod (Paris)*. 2016
406 Jun;45(6):546–8.
- 407 12. Roman H, Auber M, Mokdad C, Martin C, Diguët A, Marpeau L, et al. Ovarian
408 endometrioma ablation using plasma energy versus cystectomy: a step toward better
409 preservation of the ovarian parenchyma in women wishing to conceive. *Fertil Steril*. 2011
410 Dec;96(6):1396–400.
- 411 13. Roman H, Moatassim-Drissa S, Marty N, Milles M, Vallée A, Desnyder E, et al.
412 Rectal shaving for deep endometriosis infiltrating the rectum: a 5-year continuous
413 retrospective series. *Fertil Steril*. 2016 Aug 23;
- 414 14. Donnez J, Squifflet J. Complications, pregnancy and recurrence in a prospective series
415 of 500 patients operated on by the shaving technique for deep rectovaginal endometriotic
416 nodules. *Hum Reprod Oxf Engl*. 2010 Aug;25(8):1949–58.
- 417 15. Roman H, Opris I, Resch B, Tuech JJ, Sabourin J-C, Marpeau L. Histopathologic
418 features of endometriotic rectal nodules and the implications for management by rectal nodule
419 excision. *Fertil Steril*. 2009 Oct;92(4):1250–2.
- 420 16. Donnez O, Orellana R, Van Kerk O, Dehoux J-P, Donnez J, Dolmans M-M. Invasion
421 process of induced deep nodular endometriosis in an experimental baboon model: similarities

- 422 with collective cell migration? *Fertil Steril*. 2015 Aug;104(2):491–497.e2.
- 423 17. Ferrero S, Ragni N, Remorgida V. Post-operative digestive symptoms after colorectal
424 resection for endometriosis. *Hum Reprod Oxf Engl*. 2006 Jul;21(7):1941-1942; author reply
425 1942-1943.
- 426 18. Badescu A, Roman H, Aziz M, Puscasiu L, Molnar C, Huet E, et al. Mapping of
427 bowel occult microscopic endometriosis implants surrounding deep endometriosis nodules
428 infiltrating the bowel. *Fertil Steril*. 2016 Feb;105(2):430–434.e26.
- 429 19. Roman H, Hennesier C, Darwish B, Badescu A, Csanyi M, Aziz M, et al. Bowel
430 occult microscopic endometriosis in resection margins in deep colorectal endometriosis
431 specimens has no impact on short-term postoperative outcomes. *Fertil Steril*. 2016
432 Feb;105(2):423–429.e7.
- 433 20. Vercellini P, Crosignani P, Somigliana E, Viganò P, Frattaruolo MP, Fedele L.
434 ‘Waiting for Godot’: a commonsense approach to the medical treatment of endometriosis.
435 *Hum Reprod Oxf Engl*. 2011 Jan;26(1):3–13.
- 436 21. Roman H, Darwish B, Bridoux V, Chati R, Kermiche S, Coget J, et al. Functional
437 outcomes after disc excision in deep endometriosis of the rectum using transanal staplers:
438 a series of 111 consecutive patients. *Fertil Steril*. 2017 Jan 27;
- 439 22. Roman H, Quibel S, Auber M, Muszynski H, Huet E, Marpeau L, et al. Recurrences
440 and fertility after endometrioma ablation in women with and without colorectal
441 endometriosis: a prospective cohort study. *Hum Reprod Oxf Engl*. 2015 Mar;30(3):558–68.
- 442 23. Roman H, Abo C, Huet E, Bridoux V, Auber M, Oden S, et al. Full-Thickness Disc
443 Excision in Deep Endometriotic Nodules of the Rectum: A Prospective Cohort. *Dis Colon*
444 *Rectum*. 2015 Oct;58(10):957–66.
- 445 24. Mircea O, Puscasiu L, Resch B, Lucas J, Collinet P, von Theobald P, et al. Fertility
446 Outcomes After Ablation Using Plasma Energy Versus Cystectomy in Infertile Women With
447 Ovarian Endometrioma: A Multicentric Comparative Study. *J Minim Invasive Gynecol*. 2016
448 Dec;23(7):1138–45.
- 449 25. Seracchioli R, Mabrouk M, Frascà C, Manuzzi L, Montanari G, Keramyda A, et al.
450 Long-term cyclic and continuous oral contraceptive therapy and endometrioma recurrence: a
451 randomized controlled trial. *Fertil Steril*. 2010 Jan;93(1):52–6.
- 452 26. Mohr C, Nezhat FR, Nezhat CH, Seidman DS, Nezhat CR. Fertility considerations in
453 laparoscopic treatment of infiltrative bowel endometriosis. *JSLs*. 2005 Mar;9(1):16–24.
- 454 27. Kondo W, Bourdel N, Tamburro S, Cavoli D, Jardon K, Rabischong B, et al.
455 Complications after surgery for deeply infiltrating pelvic endometriosis. *BJOG Int J Obstet*
456 *Gynaecol*. 2011 Feb;118(3):292–8.
- 457 28. Afors K, Centini G, Fernandes R, Murtada R, Zupi E, Akladios C, et al. Segmental
458 and Discoid Resection are Preferential to Bowel Shaving for Medium-Term Symptomatic
459 Relief in Patients With Bowel Endometriosis. *J Minim Invasive Gynecol*. 2016
460 Dec;23(7):1123–9.
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463 Table 1. Preoperative data.

PREOPERATIVE DATA	N=110 Mean±SD	(%)
Age	37±6.4	
BMI	24.2±4.7	
Patients with documented preoperative infertility	44	(40.0)
Obstetrical antecedents		
Nulligesta	57	(51.8)
Nullipara	69	(62.7)
Antecedents of gynecological surgery		
Previous gynecological laparoscopy	56	(50.9)
Previous gynecological laparotomy	15	(13.6)
Dysmenorrhea	106	(96.4)
Intensity of dysmenorrhea (VAS scale)	8.3±1.5	
Deep dyspareunia	87	(79.1)
Intensity of dyspareunia (VAS scale)	5.7±2.4	
Non-cyclic abdominal pain	84	(76.4)
Intensity of dyspareunia (VAS scale)	6.6±2.3	
Cyclic symptoms associated with dysmenorrhea		
Diarrhea	50	(45.5)
Constipation	41	(37.3)
Rectorrhage	5	(4.5)
Bloating	64	(58.2)
Defecation pain	74	(67.3)
Urinary pain	25	(22.7)
Assessment of digestive function*		
Knowles-Eccersley-Scott-Symptom Questionnaire (KESS)	12±6.9	
Gastrointestinal Quality of Life Index (GIQLI)	87±20.7	
Wexner score	2±2.9	

464 VAS: 10 point-visual analog scale

465 *Normal values: KESS n.v. <7; GIQLI n.v. >100; Wexner score : 0-20, 0 = no anal
466 incontinence, 20 = maximum anal incontinence.

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470 Table 2. Intraoperative data.

INTRAOPERATIVE DATA	N= 110	(%)
	Mean±SD	
Operative time (min)	122+/-53	
Surgical approach		
Exclusive laparoscopic route	100	(90.9)
Combined vaginal-laparoscopic	9	(8.2)
Open surgery	0	(0.0)
Robotic assistance	1	(0.9)
AFS-R score	70+/-42	
Rectal nodule diameter		
<=10mm	29	(26.4)
10-29mm	60	(54.5)
>=30mm	21	(19.1)
Height of the nodule (cm above the anus)		
5-10cm	69	(62.7)
10-15cm	41	(37.3)
Douglas pouch complete obliteration	69	(62.7)
Associated endometriosis localizations		
Vagina	52	(47.3)
Bladder	4	(3.6)
Diaphragm	10	(9.1)
Small bowel	2	(1.8)
Appendix	8	(7.3)
Sigmoid colon	12	(10.9)
Surgical procedures on urinary tract		
Ureterolysis for ureter stenosis	5	(4.5)
Resection of the bladder	3	(2.7)
Uretero-cystostomy	1	(0.9)
Right ovarian adhesiolysis	73	(66.4)
Left ovarian adhesiolysis	81	(73.6)
Right endometrioma managed by plasma ablation	35	(31.8)
Left endometrioma managed by plasma ablation	34	(30.9)
Hysterectomy	36	(32.7)

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474 Table 3. Postoperative complications after rectal shaving using plasma energy

POSTOPERATIVE COMPLICATIONS	N=110	(%)
Rectovaginal fistulae, managed by colostoma	1	(0.9)
Rectouterine fistulae, managed by antibiotics only	1	(0.9)
Bladder atony requiring ≥ 3 weeks daily catheterization	2	(1.8)
Bladder suture leakage following bladder resection	1	(0.9)
Pelvic hematoma/abscess	5	(4.5)
Clavien Dindo classification		
1	4	(3.6)
2	12	(10.9)
3a	1	(0.9)
3b	5	(4.5)
4a	1*	(0.9)

475 *Patient with rectovaginal fistula, whose transfer to intensive care unit was required by
 476 concomitant Steinert disease.

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479 Table 4. Postoperative digestive functional outcomes.

Digestive function	Baseline (N=110)	1 year (N=65)	P ¹	3 years (N=20)	P ²
KESS	12+/-6.9	9+/-6.5	0.005	10+/-7.0	0.24
GIQLI	87+/-20.7	105+/-21.1	<0.001	105+/-24.8	<0.001
Wexner score	2+/-2.9	1+/-1.9	0.014	1+/-2.2	0.14
Lack of ability to defer defecation:			0.89		0.64
< 5 min	28 (25.5%)	15 (23.1%)		4 (20.0%)	
5 to 10 min	30 (27.3%)	19 (29.2%)		4 (20.0%)	
10 to 15 min	9 (8.2%)	4 (6.2%)		3 (15%)	
> 15 min	40 (36.4%)	27 (41.5%)		9 (45%)	

480 ¹Comparison between baseline and 1-year postoperative values; ²Comparison between baseline and 3-year postoperative values. KESS:
481 Knowles-Eccersley-Scott-Symptom Questionnaire, n.v. <7; GIQLI: Gastrointestinal Quality of Life Index, n.v. >100; Wexner score : range 0-20
482 (0 = no anal incontinence, 20 = maximum anal incontinence).
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485 Table 5. Fertility outcomes.

FERTILITY OUTCOMES	N=110	(%)
Pregnancy intention	32	29.1
Pregnant	17	53.1
Spontaneous	5	29.4
Assisted reproductive therapy	11	70.6
Insemination	3	25.0
In vitro fertilization	9	75.0

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492 Video. Rectal shaving using plasma energy in deep infiltrating endometriosis of the rectum.

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