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MRI of intestinal endometriosis

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Endometriosis is a common gynecological condition of unknown etiology, which mainly affects women of reproductive age. The commonest site of gastrointestinal endometriosis is the rectosigmoid colon. Involvement of the sigmoid, cecum, appendix, and small bowel are less common, but one third of rectosigmoid endometriosis is associated with right-sided extra-pelvic bowel endometriosis. Intestinal endometriosis represents one of the most severe forms of deep endometriosis (DE).

Magnetic resonance imaging (MRI) is recommended as a second-line technique in the preoperative workup of DE, especially for gastrointestinal endometriosis. An optimal MRI protocol is required for a complete mapping of endometriotic lesions. MRI could be used as a triage test in the diagnosis of rectosigmoid colon endometriosis. Magnetic resonance enterography should be additionally performed requiring a specific additional MRI protocol for the evaluation of multicentric intestinal endometriotic lesions.

Except other imaging techniques, the aim of this chapter is to expose indications for MRI, technical requirements, patient preparation, MRI protocols, and criteria for the diagnosis of intestinal endometriosis.

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Introduction

Endometriosis is defined by the presence of endometrium-like tissue outside the uterus, involving structures and organs located mainly in the pelvic cavity, and less commonly the abdominal cavity or distant sites [1]. The true prevalence of endometriosis is uncertain with estimates varying widely among population samples and diagnostic approaches [2].

Intestinal endometriosis is responsible for chronic pelvic pain and various gastrointestinal symptoms. It represents one of the most severe forms of endometriosis, being present in 5–12% of cases, reaching more than 30% in several expert centers [3–5]. Intestinal endometriosis can be evaluated by different imaging techniques, including transvaginal sonography (TVS), rectal endoscopic sonography, magnetic resonance imaging (MRI), and helicoidal computed tomography (CT) scanner. Among these techniques, MRI is recommended as a second-line technique in the preoperative workup of deep endometriosis (DE) [6]. An optimal MRI protocol is required to perform a complete mapping of endometriotic lesions, especially intestinal endometriosis [6]. Magnetic resonance enterography (MRE) could be additionally performed requiring a specific additional MRI protocol for the evaluation of multifocal and multicentric intestinal endometriotic lesions [7]. MRI and MRE provide important data for gynecologic surgeons to plan a better and safer surgery, and especially know if additional support of digestive and urologic surgeons would be needed. Then, the patients can be informed on surgical risks to obtain a share making decision.

The aim of this chapter is to expose indications for MRI, technical requirements, patient preparation, MRI protocols, and criteria for the diagnosis of the different locations of intestinal endometriosis.

Diagnostic performance of MRI for intestinal endometriosis

In line with recent European Society of Urogenital Radiology (ESUR) recommendations, MRI is recommended as a second-line technique in the preoperative workup of DE [6]. A recent Cochrane analysis also suggested that MRI could be used as a triage test in the diagnosis of rectosigmoid colon endometriosis [8]. In this setting, MRI could be used as a first-line investigation in women having a high clinical suspicion of intestinal endometriosis.

An optimal pelvic MRI protocol is required to perform a complete mapping of endometriotic lesions, especially intestinal endometriosis. Rectosigmoid colon is the most common intestinal location, but extra-pelvic bowel endometriosis can be associated, mainly in the right iliac fossa. In this setting, MRE can be additionally performed using a specific MRI protocol [7].

The sensitivity and specificity reported in MRI for **rectosigmoid endometriosis** are 63–98% and 89–100%, respectively [4,9–11]. These large variations in sensitivity could be related to MRI protocol used. Studies not using anti-peristaltic drugs, administration and intestinal preparation have significantly lower sensitivities [9,11,12]. Another limitation is represented by the difficult differentiation between early intestinal endometriosis and simple adhesion with adjacent structures (e.g. uterus). In a recent Cochrane analysis, a total of six studies (seven data sets, 612 participants) assessed the accuracy of MRI for detecting rectosigmoid endometriosis with a sensitivity of 0.92 (95% CI 0.86–0.99) and specificity of 0.96 (95% CI 0.93–0.98). The highest diagnostic estimates of all MRI methods included 3.0 T MRI (one study, 41 participants; sensitivity: 1.00, 95% CI 0.75–1.00; specificity: 0.96, 95% CI 0.82–1.00) [13].

Other intestinal lesions, including sigmoid, cecum, appendix, ileo-cecal junction and small bowel, can be detected using multiplanar two-dimensional (2D-T2WI) or three-dimensional T2-weighted image (3D-T2WI) sequences of the pelvis MRI. These locations are isolated or associated with different other posterior sub-peritoneal locations. The interest of MRE in the evaluation of extra-pelvic digestive locations was recently highlighted [7]. Rousset et al. suggested that 3.0 T MRE was accurate in the preoperative diagnosis and mapping of bowel DE lesions located above the rectosigmoid junction with a sensitivity of 93–96% and a specificity of 100% [7]. Another study suggested that 3.0 T MRE and 1.5 T MRE had similar low performance for diagnosing multifocal and multicentric bowel endometriosis (sensitivity: 57%, specificity: 89%) [14]. Indeed, MRE is not appropriate to assess rectosigmoid endometriosis, but useful to assess extra-pelvic intestinal locations (sigmoid, ceco-appendicular region, and small bowel). However, its relevance is mainly related to the quality of the MR examination,

requiring a specific protocol. In this setting, without free-residue diet prior to the MRE, feces stasis in the cecum can create false-positive lesion due to the lack of contrast between the cecum content and its wall. More, subtle lesions of the small bowel in case of suboptimal distension of its lumen could be misdiagnosed. Finally, spasms of the bowel could be misinterpreted as intestinal wall thickening.

To date, no current consensus exists on the selection of patients who could benefit from complementary MRE. In our experience, MRE should be suggested when the preoperative workup (TVS and MRI) displays the presence of large rectosigmoid endometriosis. In this setting, the risk of multifocal or multicentric endometriotic lesions is more frequent in this sub-population of patients. Sometimes, pelvic MRI may present limits for the detection of extra-pelvic intestinal endometriosis and MRE needs to be reported and reviewed by an expert radiologist. Indeed, limitations of the accuracy of these image-quality-related investigations should be kept in mind. Finally, it is important to note that some patients report a significant discomfort associated with MRE.

MRI protocols

Usual pelvic MRI protocol for the diagnosis of intestinal endometriosis

Contraindications are rarely present in women with clinical suspicion of endometriosis. Claustrophobia may represent a limitation and could be overcome by prone setting, without or with additional medical treatment [15].

Technical requirements

Most published studies use a **1.5T magnet**, but few publications using 3.0 T suggested promising results [7,13,16–19]. At 3.0 T, improved signal-to-noise ratio (SNR) results in the acquisition of high-spatial resolution images and accurate detection of all lesions of DE [7,13,16]. An increased heterogeneity of the image is sometimes noted at 3.0 T in comparison with 1.5 T. This can have a negative effect on the fat-saturation techniques routinely performed in the evaluation of endometriosis [16,20]. However, the routine application of Dixon technique overcomes this limitation with a stronger fat-suppressed MR images [20]. Actually, 1.5 T and 3.0 T devices seem valuable, but studies comparing both systems are lacking for the evaluation of intestinal endometriosis.

Pelvic-**phased array coils** are always recommended in the evaluation of intestinal endometriosis. In line with different publications, pelvic-phased array coils provide a higher SNR than body coils [21,22]. Endocavitary coil could be added in conjunction with pelvic-phased array, but drawbacks in terms of cost and acceptability limit its potential use [23–25].

No recommendation can be proposed for the **best timing of MRI** in relation to the menstrual cycle in the evaluation of DE, especially for intestinal endometriosis. Hence, discrepant results regarding timing of MRI evaluation are reported. First, the presence of pelvic free fluid effusion (e.g. menstruation, post-ovulatory phase) was suggested as a helpful tool for MRI interpretation [4,26]. The presence of suspended or lateralized fluid collection is particularly useful to look for partial or complete obliteration of Douglas pouch between the rectosigmoid colon and the uterus. Second, the potential presence of spontaneous T1W high signal intensity of blood prior to day 8 of the menstrual cycle conducted by Fiaschetti et al. to examine patients between days 8 and 12 of the menstrual cycle [27]. Finally, Botterill et al. showed no significant difference in disease extent evaluation between menstruating and non-menstruating scans [28].

There is no consensus regarding **patient preparation before MRI**. Hence, the majority of studies did not mention this pre-imaging preparation. When fasting prior to the MRI study was mentioned, the length of fast was variable at 3, 4, or 6 h [4,9,16,27,29–31]. However, fasting is highly recommended in the evaluation of intestinal endometriosis.

The use of **bowel preparation** prior to pelvic MRI was not usually mentioned in most studies. When authors used bowel preparation, the type of preparation varied. In this setting, bowel enema with either rectal suppository pills (e.g. bisacodyl) or water was most commonly used [30,32]. In our experience, **bowel preparation should be advocated as “best practice” for the detection of pelvic bowel endometriosis.**

A **partially full-filled bladder** is recommended in the evaluation of DE. No study has been published in the medical literature about the significance of bladder distension for detection of anterior DE. When bladder distension is discussed, authors described a moderately filled or full bladder to correct the angle of uterine anteversion and, thereby, improve visualization of the anterior compartment. Also, a full bladder displaces the bowel superiorly and then reduces artefact caused by bowel motion [10,16,30,33–37]. However, excessive bladder distension is not recommended because the detrusor contractions may cause artefact which could compromise the identification of small parietal nodules [33,35,37]. To achieve the appropriate distension, authors mainly ask their patients not to empty their bladder for 1 h prior to the examination [16,30].

Supine position is recommended in the evaluation of pelvic endometriosis. A recent systematic review specifically looked at possible ways to reduce anxiety, distress, and the need for sedation in adults undergoing MRI exams and this confirmed evidence for the benefit of prone scanning in reducing claustrophobia [15].

Abdominal strapping is recommended in the evaluation of pelvic endometriosis. Few papers recommend the use of a broad abdominal belt in MRI examinations for the evaluation of endometriosis [26,38,39]. The purpose is to reduce artefact caused by respiratory movement and it has been recommended to apply and to fasten the belt at the end of expiration [40,41].

Anti-peristaltic agent is recommended in the evaluation of intestinal endometriosis. The use of an anti-peristaltic agent (e.g. glucagon, butyl-scopolamine), unless contraindicated (e.g. pregnancy, allergies or pheochromocytoma), is the most efficient tool to limit bowel motion artefact [42]. Recently, Gutzeit et al. suggested that intravenous spasmolysis was more reliable than intramuscular administration and glucagon better than butyl-scopolamine [42].

Rectal opacification has been suggested as an “option” in the evaluation of rectosigmoid endometriosis. Routinely, two different types of contrast media can be used (sonographic gel or water) [10,13,43,44]. In the literature, no consensus exists on the value of rectal opacification in the diagnosis of rectosigmoid endometriosis. Some publications claim that rectal opacification provides a better evaluation of the Douglas pouch and rectosigmoid colon endometriosis [27,34,44,45]. In contrast, other studies argue that this technique is useless in the evaluation of the posterior compartment, especially for intestinal endometriosis [13,43,46]. Hence, different arguments against systematic rectal opacification could be underlined, including time, patient discomfort, movement artefact, and rectosigmoid colon spasm [46].

Vaginal opacification with sonographic gel is considered an “option” in the evaluation of DE. Different studies provided discordant results on the value of vaginal opacification with gel in the diagnosis of posterior DE [10,27,43,44,47]. Chassang et al. reported an improvement in sensitivity between pre- and post-contrast MRI in the diagnosis of DE, however, this improvement was only significant for junior radiologists [10]. Fiaschetti et al. reported a better evaluation for the detection of vaginal and uterosacral endometriosis, but not for Douglas pouch or recto-vaginal septum locations [27]. Kikuchi et al. reported a significant improvement in the diagnosis of pouch of Douglas obliteration in the presence of vaginal opacification [44]. Finally, two studies did not find any significant difference in the diagnosis of vaginal or rectal endometriosis with and without vaginal opacification, whatever the level of expertise of readers [43,47].

MRI sequences and criteria

There is significant variability in the literature regarding the MRI protocols used to assess endometriosis [4,10,13,16,25,27,31,35,48–51].

2D-T2W MRI sequences (sagittal, axial, coronal, and oblique) are recommended in the evaluation of pelvic endometriosis [6]. The addition of 3D-T2W MRI sequence is suggested as an “option” [6]. Hence, T2W MRI sequences without fat-suppression technique are the best sequences to detect intestinal endometriosis [4]. Most MRI studies are performed using at least two orthogonal 2D-T2W planes [4,10,13,16,25,27,31,35,48–51]. Further studies are required to clarify the field-of-view used for the axial acquisition and which additional 2D-T2W MR plane should be used. Axial 2D-T2W MRI from renal hila to pubic bone, allowing a systematic visualization of kidneys and potential analysis of the bowel (i.e. cecum, small bowel, appendix) should be recommended [4]. The use of thin section-oblique 2D-T2W imaging improves the success of conventional MRI (sagittal and axial) for the assessment of

uterosacral and parametrial endometriosis [52,53]. In addition, several authors have recently reported the potential value of 3D-T2W imaging in the evaluation of intestinal endometriosis [16,48]. In our experience, coronal 2D-T2W MRI sequence could be useful in the evaluation of sigmoid endometriosis.

Data are missing for the evaluation of DE using **T1W MRI** without and with fat suppression. However, these sequences are recommended in the evaluation of pelvic endometriosis. The “Dixon technique” should be now used in replacement to standard T1W sequence. 2D or 3D Dixon technique provides four simultaneous different T1W contrast during the same acquisition and a stronger fat suppression in the female pelvis [54].

Few data are available regarding the value of **intravenous injection of gadolinium chelate** in the evaluation of intestinal endometriosis and no recommendation can be achieved. Scardapane et al. underlined that the combination of magnetic resonance colonography (MR-colonography) and 3D-T1W MRI allows easier recognition of colorectal endometriosis and higher inter-observer agreement [5]. Bazot et al. suggested the absence of benefit of intravenous gadolinium for the diagnosis of rectosigmoid and vaginal endometriosis, whatever the level of reader expertise [43].

When a bowel endometriosis cannot be definitively affirmed, balanced gradient echo MRI sequences (e.g. “Fiesta, Trufisp, Balanced-FFE” sequences) after intestinal opacification with warm water (MR-colonography) may help to affirm rectosigmoid wall involvement. Some authors propose the use of endocavitary coil or T1 sequences with gadolinium injection to optimize diagnostic accuracy [23,25]. In daily practice, the discomfort caused by the endocavitary coil in the context of symptomatic endometriosis makes its use highly questionable.

MRE for the diagnosis of extra-pelvic intestinal endometriosis

MRE was recently proposed as a complementary technique to assess deep endometriotic lesions located in the bowel above the rectosigmoid junction [7]. Two studies using 3.0 and 1.5 T devices suggested the relevance of MRE to diagnose small bowel, cecum, and appendix involvement by DE [7,14]. Different specific requirements are needed for MRE. First, a fecal-free feature of the cecum due to 3-day residue-free diet is recommended. Second, the patient fast at least 6 h and ingest a 5% mannitol solution (1000–1500 mL) over a 45–60-min period before the MR examination allowing distension of the small bowel. Third, a balanced fast field-echo MR sequence assesses small bowel and cecum distension. If there is adequate distension, axial and coronal MRI sequences covering the entire abdominopelvic cavity are performed using rapid T2 single-shot fast spin-echo sequence (SSFSE) and 3D-T1W Dixon before and after gadolinium administration. Finally, to reduce peristaltic movement artifacts, patient receive two intravenous 1-mg doses of glucagon. One dose is administered before the start of MRE, and the second dose is given prior to injection of the gadolinium-contrast material. Small bowel endometriosis appears on T2W as a low signal nodule of the muscularis layer in contrast to the high signal intensity of endoluminal fluid.

MRI criteria of intestinal endometriosis

The diagnosis of intestinal endometriosis using MRI is based on the association of morphological and signal intensity abnormalities [4]. MRI allows an appropriate analysis of bowel endometriosis due to its high-contrast resolution and its multiplanar analysis. Previous intestinal preparation by rectal enema is an essential way to optimize the visualization of the digestive wall and to increase the quality of MRI interpretation [12]. Intestinal endometriosis presents as a low signal T2 intensity and isosignal T1 intensity thickened wall corresponding to fibrosis and muscularis hypertrophy, with or without cystic or hemorrhagic foci visible in T2WI or T1WI(4). This thickening may be minimal in linear appearance in early forms or in mass in advanced digestive endometriosis.

Detection of endometriosis

Endometriosis of the rectosigmoid colon is the most frequent digestive tract location, involving mainly the rectosigmoid junction (60%). The presence of a low signal T2W mass of the anterior rectal wall responsible for the disappearance of the fatty space between the uterus and the rectosigmoid

strongly suggests the diagnosis [4]. The angles of connection with the intestinal wall on sagittal views are variable depending on the degree of retraction of the intestinal segment. A definitive diagnosis of intestinal endometriosis is made in presence of a thickening of bowel wall (muscularis > 3 mm). On axial sequences, a triangular appearance with a posterior base facing the digestive wall and an anterior apex converging towards the uterus is highly suggestive [4]. When the bowel preparation is optimal owing to good quality images, it is sometimes possible to differentiate muscularis from submucosa. Endometriosis of the rectosigmoid junction is usually associated with obliteration of the Douglas pouch, sometimes underlined by a hanging pelvic fluid effusion [4].

Bowel segment involvement varies according to the deep endometriotic location:

- Retrocervical and/or vaginal endometriosis usually extent to the anterolateral wall of the mid to upper rectum with a risk of recto-vaginal fistula after surgery,
- Torus uterinum and utero-sacral ligament endometriosis usually involve the anterior aspect of the upper rectum to rectosigmoid junction,
- Uterine corporeal and fundus endometriosis usually extent to the lower aspect of the sigmoid,
- Anterior and upper pelvis endometriosis usually involve the more proximal sigmoid segment facing the pelvic peritoneum of the left lateral pelvic wall [4],
- Right-sided anterior and upper pelvis endometriosis can also extent to the appendix, the ileo-cecal junction and/or the pelvic small bowel.

Intestinal endometriosis involving the **upper rectum** is visualized in front of the anterolateral rectal wall and is nearly almost associated with vaginal endometriosis. In this setting, some authors recommend to perform T2W MRI sequence after vaginal opacification with ultrasound gel. This additional technique could be particularly useful in the absence of visualization of vaginal spots in high

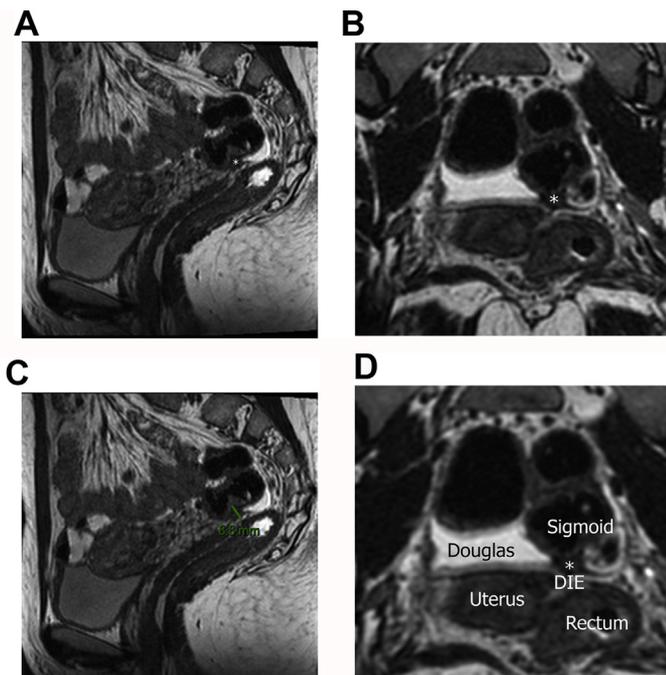


Fig. 1. A 36-year-old patient with chronic pelvic pain, dysmenorrhea, painful defecation during menstruation, constipation, and diarrhea. Sagittal and coronal pelvis MRI 3D-T2W images show a discrete thickening of the torus uterinum and USL in low signal intensity on T2 intensity with a left-sided spiculated nodule (*) tethering the adjacent sigmoid. At surgery, resection of torus uterinum and USL with adhesiolysis with minimal shaving of the sigmoid serosal.

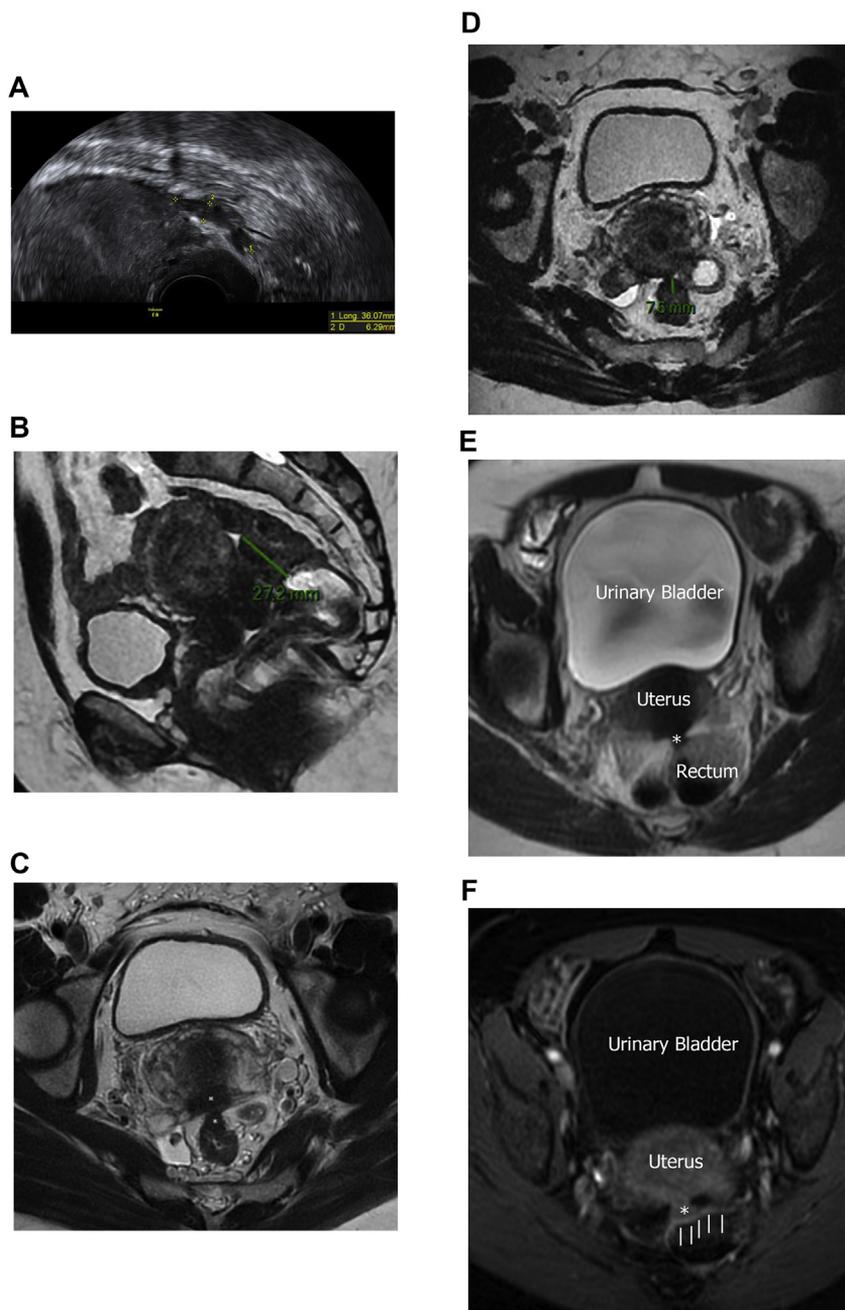


Fig. 2. A 36-year-old patient with chronic pelvic pain as dysmenorrhea and deep dyspareunia. (a) The first-line TVS estimated posterior DE of the compartment with a 36 mm length involvement of the anterior rectal wall. (b, c) Sagittal and axial pelvis MRI 3D-T2W images confirmed DE (*) of torus uterini and USL with a 7.6 mm depth and a 27 mm length involvement of the upper rectal wall at 12 cm from the anal verge. (e, f) On the axial T2WI and T1WI of MRE, the rectal wall appears thinly enhanced (IIII) with a feature suggestive of a normal wall. At surgery, discoid resection of upper rectum performed. At histopathological examination, exophytic endometriosis of torus, and USL without intestinal endometriosis.

signal on T1W MRI. Axial oblique thin slices on the cervix in 2D-T2WI or 3D-T2WI are recommended to assess lateral extension of the disease [6].

Endometriosis of the **sigmoid** colon often presents as a circumscribed mass, sometimes retracted on itself due to the greater sigmoid mobility. Depending on the length and the mobility of the sigmoid colon, the lesion may appear attached with adhesions to the uterus, adnexa and lateral pelvic wall, or sometimes free of adhesions in the pelvic cavity in the mobile segments. Visualization of some proximal sigmoid involvement may be difficult on strict sagittal and axial sequences. In this context, a native 2D-T2W (SSFSE, Haste) or reconstructed (3D-T2W) coronal incidence may be useful [12].

Endometriosis of the **cecum** usually appears like the rectosigmoid endometriosis with an adhesive feature corresponding to initial serosal and finally muscularis involvement. To our experience, the cecum is mostly involved when its topography is low in the abdominopelvic cavity, indeed, endometriosis would most likely extent to a fixed and pelvic-descended cecum than to a mobile and sub-hepatic-ascended cecum.

Appendicular endometriosis displays various appearances depending on the stage of the disease, involving the body (50%) or the tip (50%) of the appendix. At MRI, a slight thickening containing few irregular parietal nodules with low signal intensity on T2W can be visible at early stage [55]. Later on, an appendicular mass can occur with a fibrotic low signal intensity on T2W containing high signal intensity on T2W or T1W with homogeneous enhancement after intravenous injection of contrast media.

Endometriosis of the **small bowel** appears as a circumscribed nodular thickening of the muscularis in low signal on T2W MR images enhancing homogeneously after intravenous injection of contrast media. Small bowel involvement is frequently multifocal and is difficult to detect, that is why we recommend to perform axial and coronal sequences in T2W covering all the abdominopelvic cavity in addition to the specific pelvic MRI sequences. And in our experience, this is common to see extra-pelvic small bowel endometriosis as a plaque-like lesion in the muscularis of a mobile ileal loop without any serosal adhesion or tethering. If MRE is performed in addition, the radiologist needs to know that the position of the lesion in the abdominopelvic cavity would change.

Description and surgical implications of bowel endometriosis

Pelvic MRI is essential for the management of women clinically suspected of endometriosis, especially to determine the comprehensive mapping of the lesions. From the patient's point of view, this is crucial because imaging quality allows an accurate and personalized information and thus an adequate share making decision. For the gynecologist, more precisely the surgeon, different important elements should be assessed, including specific intestinal location, number of lesions, size, wall extension, degree of stenosis, distance to anal margin, and associated deep endometriotic lesions.

Involvement of rectum and sigmoid muscularis and the distance between the inferior margin of the lowest bowel lesion and the anal verge should be evaluated as this is expected to have a real impact on the surgery. In this setting, it is important to recall the definition of the different portions of the rectum; the lower rectum extends from 0 to 5 cm from the anal verge, the mid rectum from 5 to 10 cm, and the upper rectum from 10 to 15 cm. Indeed, it is well known that the involvement of the lower part of the rectum is associated with a higher risk of anastomotic leakage with an increased risk of pelvic abscess and of recto-vaginal fistula especially when colectomy is required justifying for most surgeons a systematic defunctioning stoma. Moreover, the resection of the low rectum is associated with more postoperative *de novo* digestive symptoms [56].

The evaluation of the length and the circumference of bowel involvement by endometriosis is also crucial. Indeed, even there is no clear consensus on the respective indication for various surgical techniques for colorectal resection for endometriosis, it appears that rectal shaving imposing the excision of the serosa and partially the muscularis without opening the bowel lumen is mainly restricted to lesion ≤ 3 cm although some authors use this technique for longer lesions (Fig. 1) [56]. A recent meta-analysis underlined that the risk of histologically proven recurrence of intestinal endometriosis was higher for rectal shaving compared with discoid excision or segmental resection [57].

Discoid excision is also mainly restricted to lesion ≤ 3 cm but imposing the opening and excision of the mucosa. In addition to the length of intestinal lesion, the bowel circumference involved by endometriosis is also important. Indeed, due to the limit of endoscopic staplers used for the discoid excision, the lesions should fulfill both a length lesion ≤ 3 cm and a circumference under 90° , although some authors have been reported double discoid excision for larger lesion [58,59]. For lesion of less or equal of 3 cm, using a propensity score, discoid excision appears an adequate option associated with less complications especially the rate of voiding dysfunction compared with segmental resection (Fig. 2) [58].

For colorectal endometriosis not fulfilling criteria for discoid resection, a segmental resection is required (Fig. 3). However, it is important to underline that these various techniques can be associated for multifocal colorectal endometriosis depending on the distance between the lesions. Therefore, it appears important for the surgeon to have preoperatively not only the number of multifocal lesions, but also when possible the distance between the different intestinal lesions.

Measurements of intestinal wall thickening, circumference involvement, and distance from the anal verge must be provided in the MRI report as well as the concomitant involvement of vagina by

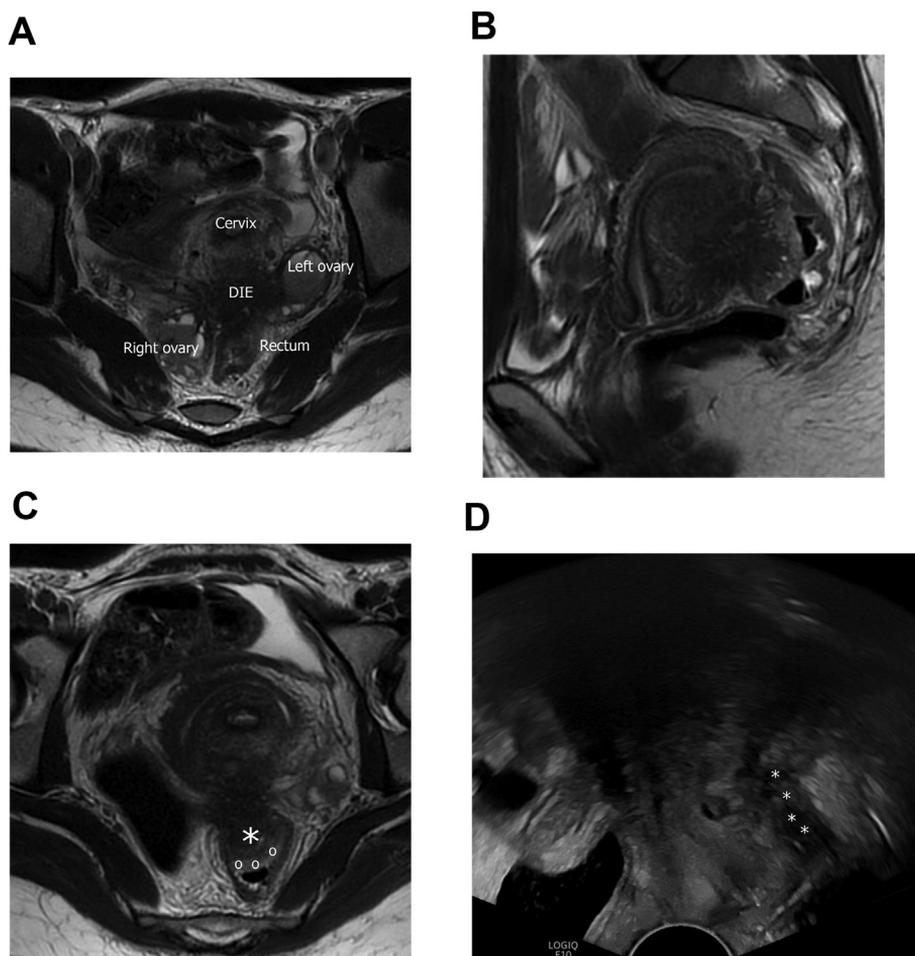


Fig. 3. A 27-year-old patient with chronic pelvic pain. (a, c) Axial and (b) sagittal pelvis MRI 3D-T2W images show a DE (*) of the lower posterior compartment with a 50 mm length fan-shaped lesion of the mild and upper rectum at 9 cm from the anal verge on 20 mm depth and 90° of circumference. Note the presence of sub-mucosal edema (o) in keeping with its involvement characteristic of the mushroom cap sign (3b). At surgery, segmental resection performed.

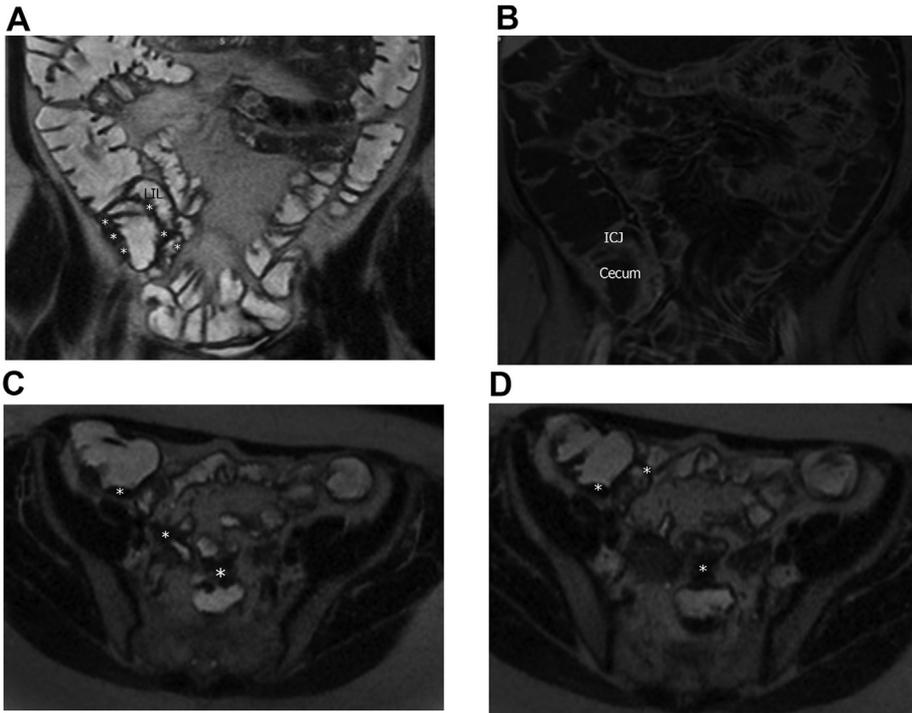


Fig. 4. A 40-year-old patient with known rectosigmoid endometriosis. The additional pre-operative MRE shows an irregular thick-walled cecum and last ileal loop (LIL) in low signal intensity in T2 (* 4a, c) with smooth enhancement after intravenous contrast media injection (4b). This feature is suggestive of endometriosis, the most important differential diagnosis being Crohn's disease. At surgery, segmental resection of rectosigmoid (4d) and of cecum, ileum, and appendix performed confirming multicentric intestinal endometriosis.

endometriosis [5]. 3D-T2W sequence is very useful owing to isotropic reformations, mainly for coronal oblique reformation according to the exact plane of the rectosigmoid bowel. These reconstructions allow accurate evaluation of unifocal or multifocal rectosigmoid colon involvement, measurement of each intestinal involvement (height, width, depth, circumference, and stenosis), and evaluation of the distance to the anal verge [12,60]. Using three 2D-T2W MRI sequences, Scardapane et al. suggested that the presence of an endometriotic rectal nodule >11 mm in short axis in pelvic MRI reliably predicts the need of a rectal resection [5]. In addition, these authors suggested that the presence of a stenosis >30% in additional MR-colonography also reliably predicts the need of a rectal resection [5].

The degree of extension of endometriosis in bowel wall, even using endocavitary catheters, is not satisfactorily evaluated with MRI [25]. The relevance of a high signal T2WI of the bowel wall involved by endometriosis is unclear. Some authors consider that this is indicative of muscularis damage, while others consider that this is an extension to the submucosa with associated submucosal edema [25,61]. The presence of a spiculated aspect of the intestinal involvement could be a relevant criterion suggesting submucosal involvement but this requires optimal digestive preparation [12]. Pelvic MRI allows detection of multifocal digestive tract involvement, but again this is significantly dependent on the quality of the digestive preparation used prior to the examination.

Involvement of small bowel muscularis and the distance between bowel lesion and the ileocecal junction should be evaluated as well as the presence of multiple small bowel lesions as this is expected to have an impact on the surgery. Indeed, the surgical treatment of the ceco-appendiceal and ileal endometriosis consists in segmental bowel resection by laparotomy, shaving and discoid resection are not possible (Fig. 4). Small bowel endometriosis is challenging to diagnose not only for

radiologists, but also for surgeons, because some of the lesions are not visible (when involving the muscularis without involving the serosa and subserosa) and then need a palpation detection by laparotomy. That is why measurement of each involvement in height, width, depth, circumference, and stenosis is not as essential as the number of lesions and the length of the overall small bowel involvement.

Summary

MRI is usually performed as an additional examination in complex cases of endometriosis or prior to surgery because of its high accuracy. MRI aims to determine location, size, and number of DE intestinal lesions as well as their stage of local infiltration. Radiologists and surgeons have to cooperate to perform the most relevant and specific investigations in order to plan the best surgical treatment. Surgery of rectosigmoid and sigmoid endometriosis could involve a shaving, a discoid or a segmental digestive resection. Surgery of the ileo-ceco-appendicular region consists in segmental bowel resection, shaving, and discoid resection are not usually performed. Moreover, the surgeon needs to be informed of a lower rectum and vaginal involvement as this is a risk of post-operative recto-vaginal fistula. The overall assessments of pelvic MRI and MRE should be performed using high-level standards

Practice points

1. Magnetic resonance imaging (MRI) should be considered as a second-line technique examination after transvaginal sonography in the evaluation of rectosigmoid colon endometriosis
2. MRI is recommended before surgery for optimal preoperative staging
3. Magnetic resonance enterography should be performed in addition to conventional MRI protocol to search additional ileo-cecal–appendicular endometriotic lesions

Research agenda

1. Diagnostic performance of magnetic resonance imaging (MRI) without and with bowel preparation to evaluate intestinal endometriosis
2. Diagnostic performance of MRI without and with vaginal and rectal opacification to evaluate intestinal endometriosis
3. Diagnostic performance of 3D-T2W in comparison with multiplanar 2D-T2W MRI sequences in the diagnosis of intestinal endometriosis

and the images should be reviewed or double read by expert radiologists.

Declaration of Competing Interest

There is no conflict of interest.

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