Deep retroperitoneal pelvic endometriosis is defined as subperitoneal infiltration of endometrial implants in the uterosacral ligaments, rectum, rectovaginal septum, vagina, or bladder. It is responsible for severe pelvic pain. Accurate preoperative assessment of disease extension is required for planning complete surgical excision, but such assessment is difficult with physical examination. Various sonographic approaches (transvaginal, transrectal, endoscopic transrectal) have been used for this purpose but do not allow panoramic evaluation. Furthermore, exploratory laparoscopy has limitations in demonstrating deep endometriotic lesions hidden by adhesions or located in the subperitoneal space. Despite some limitations, magnetic resonance (MR) imaging is able to directly demonstrate deep pelvic endometriosis. The MR imaging features depend on the type of lesions: infiltrating small implants, solid deep lesions mainly located in the posterior cul-de-sac and involving the uterosacral ligaments and torus uterinus, or visceral endometriosis involving the bladder and rectal wall. Solid deep lesions have low to intermediate signal intensity with punctate regions of high signal intensity on T1-weighted images, show uniform low signal intensity on T2-weighted images, and can demonstrate enhancement on contrast-enhanced images. MR imaging is a useful adjunct to physical examination and transvaginal or transrectal sonography in evaluation of patients with deep infiltrating endometriosis.

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Introduction
The definition of deep endometriosis includes rectovaginal lesions as well as infiltrative forms that involve vital structures such as the bowel, ureters, and bladder. According to the definition of this entity by Koninckx et al (1), deeply infiltrating endometriosis is defined as an endometriotic lesion penetrating into the retroperitoneal space or the wall of the pelvic organs to a depth of at least 5 mm. Peritoneal, ovarian, and deep endometriosis may be diverse manifestations of a disease with a single origin (2). Drugs induce temporary quiescence of active deep lesions and may be useful in selected cases. However, in most cases of severely infiltrating disease, surgery is the final solution (2).

The preoperative work-up is crucial in order to establish the precise distribution of the deeply infiltrating endometriotic lesions, which is the only means of ensuring complete surgical removal. The success of treatment depends on radical surgical removal. The location and extent of the lesions govern the modalities for the operation, and these are difficult to establish based only on physical examination results. Various sono
graphic approaches (transvaginal, transrectal, endoscopic transrectal) do not ensure panoramic evaluation of this entity. Furthermore, exploratory laparoscopy presents limitations in detecting deep locations of endometriosis hidden by adhesions or located in the subperitoneal space. Despite some limitations, magnetic resonance (MR) imaging is able to directly depict deep endometriosis.

In this article, we provide an overview of the pathologic features, classic locations, clinical features, and classification of deep pelvic endometriosis. Furthermore, we analyze the capability and potential of MR imaging in diagnosis and staging of deep pelvic endometriosis with laparoscopic correlation. Finally, we discuss the treatment of this entity.

Definition
Endometriosis is classically defined as the presence of endometrial glands and stroma outside the uterine cavity and musculature. It is unclear whether both glands and stroma are required for the pathologic definition of the disease (3). The ectopic endometrium responds to hormonal stimulation with various degrees of cyclic hemorrhage, which result in suggestive symptoms and appearances.

The definition of deep endometriosis is based on anatomic assumptions that may prove erroneous. In fact, the term “deep endometriosis” should be reserved for lesions in the retroperitoneal tissue. For practical purposes, several reports include in the so-called deep endometriosis the infiltrative forms that involve vital structures such as the bowel, ureters, and bladder, as well as forms such as many rectovaginal lesions. For the term “deep” to apply, there should be ectopic endometrial tissue penetrating the peritoneum more than 5 mm in depth (2,4).

Pathologic Features
Peritoneal implants of endometriosis are classically described as bluish gray “powder burns” at visual inspection. The color is attributed to menstrual blood that becomes encapsulated by fibrotic tissue and then hemolyzed (5). Ectopic endometrium may also appear as nonpigmented clear vesicles, white plaques, and reddish petechiae or flamelike areas. These implants range from several millimeters to 2 cm in diameter and may be superficial or invasive.

At microscopic examination, all lesions of both typical and deep endometriosis contain endometrial glands and stroma and may be accompanied by adjacent fibrosis and hemorrhage.

On the contrary, the histologic findings of infiltrative lesions of deep pelvic endometriosis are mainly characterized by fibromuscular hyperplasia that surrounds foci of endometriosis, and the foci sometimes contain small cavities. The endometrial glands and stroma infiltrate the adjacent fibromuscular tissue and elicit smooth muscle proliferation and fibrous reaction, resulting in solid nodule formation (1,2).

In visceral solid endometriosis, the implants adhere to the serosal surface of the bowel and may invade the muscular layers, eliciting marked smooth muscle proliferation. Stricture formation and obstruction may result.

Locations
The most common locations of endometriosis are the ovaries and the pelvic peritoneum, followed in order of decreasing frequency by deep lesions of the pelvic subperitoneal space, the intestinal system, and the urinary system. Results of pelvic mapping with laparoscopy or laparotomy indicate
that the cul-de-sac and uterosacral ligaments are the most common pelvic sites of involvement by endometriosis (4,6). Results of another study indicate that the frequency of endometriosis in the posterior cul-de-sac is up to 56% (7) (Fig 1).

Deep nodular (solid) endometriosis is typically found in the rectovaginal septum and in other fibromuscular pelvic structures such as the uterine ligaments (69.2%), the vagina (14.5%), and the muscular wall of pelvic organs. In detail, solid endometriosis can involve the alimentary tract (9.9%). Bladder involvement has been described, and similarly the ureter may be involved (6.4%). The rectosigmoid is the most common segment of bowel involved (5,7).

Pelvic pain is a frequent complaint among patients with endometriosis. Such pain generally manifests as secondary dysmenorrhea, worsening primary dysmenorrhea, dyspareunia, or even non-cyclic lower abdominal pain and backaches. The pain may be site specific when endometriosis is found in unusual locations outside the pelvis.

Although peritoneal endometriosis can be asymptomatic, deep pelvic endometriosis is a cause of pelvic pain, dysmenorrhea, dyspareunia, dyschezia, and urinary symptoms and is associated with infertility. Urinary tract disease may manifest as hydronephrosis caused by ureteral obstruction or as a submucosal lesion within the bladder or ureter. Dyschezia may manifest as rectal involvement by the disease; dyspareunia is often due to endometrial lesions in the cul-de-sac and vagina, while localized tenderness along the uterosacral ligaments and cul-de-sac is often related to endometrial lesions in these sites.

Localized tenderness of the cul-de-sac and uterosacral ligaments is frequently found in women with minimal or mild endometriosis. Thickened, nodular uterosacral ligaments or rectovaginal masses may be palpable. Retroverted
fixation of the uterus may be noted with obliteration of the posterior cul-de-sac (9).

**Classification**

It is essential to take the location of the deeply infiltrating endometriotic lesions into account because where pelvic pain is concerned, the success of the surgical operation depends on how radical the surgical removal is (10). With implants in this location, the deep endometriotic lesions are separated according to anatomic distribution, based on their location in the anterior cul-de-sac, posterior cul-de-sac, or pelvic sidewall (2).

Anterior cul-de-sac lesions include endometriosis of the bladder detrusor. At surgery, the uterus is anteflexed and the anterior cul-de-sac is obliterated due to extensive adhesions between the peritoneum of the bladder fold and the uterine wall and fundus. The detrusor nodule is almost always palpated medially in the posterior wall or dome of the bladder, adherent to the anterior uterine wall, well above the isthmus, trigone, and vesicovaginal septum (2). Endometriosis of the vesicovaginal septum is anatomically more caudal (2).

Posterior cul-de-sac lesions include retroperitoneal lesions and dependent intraperitoneal locations that may result in infiltrating lesions. The inflammation triggered by bleeding intraperitoneal endometriotic papules in the most dependent portion of the pouch of Douglas may result in adhesions between the adjacent peritoneal surfaces of the anterior rectal wall and posterior vaginal fornix, with subsequent infiltration of the muscular layers of both organs. This means that what is called rectovaginal septum endometriosis may instead be massive disease of the deepest portion of the pouch of Douglas, which has been buried and excluded from the remaining pelvis by adhesions (2). It has been suggested that retroperitoneal endometriotic lesions originate from metaplasia of müllerian remnants located in the rectovaginal septum. Furthermore, these retroperitoneal lesions are subclassified into groups by analyzing their locations, as precisely defined with transrectal ultrasonography and MR imaging: rectovaginal septum lesions (type I), posterior wall forniceal lesions (type II), and hourglass-shaped lesions (type III) (Fig 2) (11).

Rectovaginal septum lesions account for 10% of cases and are usually found to be small. They are situated within the rectovaginal septum be-
between the posterior wall of the vaginal mucosa and the anterior wall of the rectal muscularis. The lesion is not linked or attached to the cervix and is situated under the peritoneal fold of the cul-de-sac of Douglas (11). Posterior fornix foci and deep pelvic endometriosis are often small, and there is no extension to the rectovaginal septum or rectal wall (11). Finally, hourglass-shaped lesions, found in 25% of cases, occur when posterior foci extend cranially to the anterior rectal wall. These lesions are usually larger lesions, more than 3 cm, with a greater risk of extension to the rectal wall. These lesions always occur under the peritoneal fold of the rectouterine pouch of Douglas. Infiltration of the rectal muscularis is systematically observed in this subtype (11).

Pelvic sidewall deep endometriotic lesions include the ureteral locations. The prevalence of ureteral endometriosis ranges from 0.01% to 1% of all women with the disease (12). Endometriosis of the ureter usually arises by extension from pelvic foci and ovarian endometriosis. Endometriosis of the ureter may not necessarily be secondary to endometriotic cysts, but more generally may be due to ectopic implantation of endometrial cells along the lateral gonadal surface and ovarian fossa (11,13).

Diagnosis

Diagnosis and evaluation of extension of deep peritoneal endometriosis is difficult with physical examination and explorative laparoscopy and requires palpation and opening of the subperitoneal space in order to confirm and to evaluate the extent of the lesions (14,15). Physical examination and laparoscopic exploration may not allow diagnosis or prediction of the extension of deep pelvic endometriosis, especially in pelvic subperitoneal sites (16).

Transvaginal sonography is recommended for diagnosis of endometriomas (17,18) and endometriosis of the bladder (19), but its value for assessment of superficial peritoneal lesions, ovarian foci, and deep pelvic endometriosis is uncertain. Rectal endoscopic sonography with high-frequency probes has been recommended for detection of endometriosis in rectal, rectovaginal, uterosacral, or rectosigmoid locations (20,21), even though high-frequency sonography shows poor penetration. The main advantage with rectal endoscopic sonography is that it provides a reliable means of investigation to diagnose any infiltration of the bowel wall (22–24). Preliminary results show that rectal endoscopic sonography appears to perform better than MR imaging for diagnosis of bowel wall infiltration.

MR imaging is now commonly used for diagnosis of endometriomas (25,26) and provides a tremendous advantage over other methods of investigation, owing to the possibility of making a complete survey of the anterior and posterior compartments of the pelvis at one time (27). However, its value for diagnosis of endometriosis in the bladder, in superficial peritoneal lesions, and in ovarian foci is controversial (23,25–27); some authors underline the limitations of MR imaging in depicting small endometrial lesions in these sites, even though a recent study demonstrated good sensitivity for detection of small peritoneal implants (28,29). Furthermore, Bazot et al (30) recently demonstrated the high accuracy of pelvic MR imaging in evaluation of deep pelvic endometriosis.

MR Imaging Protocol

In our experience, MR imaging studies were performed with a 1.5-T superconducting magnet (Magnetom Avanto; Siemens, Erlangen, Germany) and a surface phased-array coil. Patient preparation required a moderately filled bladder in order to correct the angle of uterine anteversion, leading to better evaluation of the pelvic structures. Furthermore, a half-filled bladder displaces the bowel superiorly, contributing to reduce artifacts from bowel motion, in association with injection of intramuscular hypotonic drugs such as glucagons (1 mg). Excessive bladder distention sometimes represents a source of additional artifacts due to detrusor contractions.

On the basis of the characteristics of our system, the standard imaging protocol included a T2-weighted fast spin-echo sequence (5000/118, flip angle = 150°, matrix = 230 × 256, field of view = 230 × 230 mm, 20 sections, section thickness = 4 mm, intersection gap = 20%, one signal acquired) and a T1-weighted fast spin-echo sequence (865/11, flip angle = 150°, matrix = 224 × 320, field of view = 230 × 230 mm, 20 sections, section thickness = 4 mm, intersection gap = 20%, one signal acquired), both performed...
in the axial plane. These sequences were performed to ensure complete anatomic evaluation of pelvic organs and detection and preliminary characterization of endometriotic lesions, which appear hyperintense on T1-weighted images and mildly hypointense or hyperintense on T2-weighted images. On the available 1.5-T systems, relaxation times for T2-weighted images vary from 3200 to 5000 msec, with an optimal echo time around 90 msec for a repetition time of 4000 msec to produce optimal contrast of the junctional zone for diagnosing associated adenomyosis.

Because spectrally selective fat saturation allows differentiation between hemorrhagic or fatty content of cystic lesions (endometriomas or dermoid cysts, respectively), increased detection of small implants, and better definition of their conspicuity, a T1-weighted fast spin-echo fat saturation sequence was performed in the axial plane (852/12, flip angle = 90°, matrix = 192 × 256, field of view = 230 × 230 mm, 20 sections, section thickness = 4 mm, intersection gap = 20%, one signal acquired). A T1-weighted fast spin-echo sequence in the sagittal plane (865/11, flip angle = 150°, matrix = 256 × 192, field of view = 230 × 230 mm, 20 sections, section thickness = 4 mm, direction of the section slice = sagittal, section thickness = 3 mm, number of sections = 20) was performed to evaluate associated adenomyosis.

Figure 3. Hemorrhagic endometrial implants of the rectovaginal septum in a 26-year-old woman with dyspareunia and dysmenorrhea who presented with a palpable nodule in the posterior vaginal fornix. (a) Axial T1-weighted fast spin-echo fat-suppressed image (852/12) shows multiple round, hyperintense hemorrhagic foci (arrow) in the retrocervical space and pouch of Douglas. (b) Sagittal T1-weighted fast spin-echo fat-suppressed image (852/12) shows an endometrial implant in the posterior fornix (arrow), a finding consistent with the palpable nodule. (c) Photograph obtained during laparoscopy (same orientation as in a) shows adhesions (asterisk) and multiple red endometrial implants (arrow) on the surface of the uterus and rectum and in the pouch of Douglas. (d) Photograph obtained after initial lysis of the adhesions (near the tip of the laparoscope) shows that the forniceal implant remains hidden.
MR Imaging Features

MR imaging characteristics of deep pelvic endometriosis depend on the type of lesions: infiltrating small implants, solid deep lesions mainly located in the posterior cul-de-sac involving the uterosacral ligaments and torus uterinus, and visceral endometriosis involving the bladder and rectal wall. When the lesion is an implant with deep infiltration, MR imaging may demonstrate only a punctate focus of high signal intensity, which represents a small area of hemorrhage. This correlates with burn implants at laparoscopy (Figs 3, 4). Whenever the implants are white or red, the MR imaging results may be completely negative.

Solid deep lesions demonstrate low to intermediate signal intensity with punctate regions of high signal intensity on T1-weighted images, uniform low signal intensity on T2-weighted images, and enhancement, corresponding to the abundant fibrous tissue seen in these lesions at histologic examination (5). The punctate foci of high signal intensity represent regions of hemorrhage surrounded by solid fibrotic tissue (Fig 5). These solid masses of endometriosis may simulate metastatic peritoneal implants from intraperitoneal malignancies such as ovarian carcinoma. These disease processes can be differentiated by the low

Figure 4. Endometrial implant of the uterovesical septum in a 36-year-old woman with dysmenorrhea and dysuria. (a) Sagittal T1-weighted fast spin-echo fat-suppressed image (852/12) shows a hyperintense hemorrhagic nodule (arrow) in the uterovesical septum. (b) Photograph obtained during laparoscopy (cranial view) shows the region of the uterovesical cul-de-sac after raising of the uterus. The endometriotic nodule (arrow) is attached to the posterior surface of the bladder.


Teaching Point

Teaching Point
signal intensity on T2-weighted images of solid endometriosis, often in combination with the presence of endometrial cysts (4). Some masses of endometriosis, located in the uterosacral ligament, posterior vaginal fornix, or pouch of Douglas, may be composed of a large proportion of glandular material with little fibrotic reaction, resulting in high signal intensity on T2-weighted images. This solid glandular material will enhance with contrast material administration, thus distinguishing it from necrosis or intratumoral hemorrhage (5).

Often, signal intensity is not able to help in depicting deep endometriosis of the uterosacral ligaments, particularly when there is lack of punc-
tate foci of hemorrhage. In these cases, diagnosis is related to the presence of thickening of the ligaments, bilateral or asymmetric, larger than 9 mm, or nodularity inside the ligament (Fig 6) (4,30).

Bladder endometriosis can be demonstrated at MR imaging as morphologic abnormalities, including localized or diffuse bladder wall thickening and signal intensity abnormalities. The majority of patients have spots of high signal intensity in an abnormal thickening of the bladder wall (Fig 7) (4). MR images of the bladder may be abnormal even in patients with normal cystoscopic results or without urinary symptoms. In fact, as endometriosis seldom
Figure 7. Deep endometriosis of the bladder wall in a 30-year-old patient with dysuria and infertility. (a) Axial T2-weighted fast spin-echo image (5000/118) shows a solid, nodular hypointense mass in the posterior bladder wall. (b) Sagittal T1-weighted fast spin-echo image (865/11) shows multiple hemorrhagic foci in the lesion (arrow) and better demonstrates its craniocaudal extension along the bladder wall. (c) Photograph obtained during laparoscopy shows the vesicouterine cul-de-sac, with the bladder distended before the uterus by a Foley catheter. Linear tight adhesions (arrows) are evident between the bladder and uterus. (d) Photograph from the same examination shows the region depicted in c after lysis of the adhesions (white rectangles). (e) Close-up photograph of the region of the dashed white rectangle in d shows multiple small, black endometrial implants on the surface of the bladder in the zone of the lysed adhesion. (f) Close-up photograph of the region of the solid white rectangle in d shows the deep endometriotic nodule as tumescence of the bladder surface (arrow) under the lysed adhesion. On the basis of the MR imaging and laparoscopic findings, an open laparotomy was performed to excise the extended bladder lesion, which was confirmed to be a deep endometriotic lesion at pathologic analysis.
invades the mucosa, lesion identification remains difficult with cystoscopy (4). Deep rectal involvement is more difficult to depict with MR imaging, which has a sensitivity of 33%, particularly with conventional imaging, due to artifacts related to the rectal content. Better results are obtained with addition of phased-array coils, endovaginal coils, and rectal contrast enema (4). Thickening of the rectal wall in association with specific symptoms, with low signal intensity on T2-weighted images and sometimes the presence of punctate hyperintense foci of hemorrhage, may be helpful for diagnosis (Fig 8). Solid endometriosis can also develop in cesarean section scars involving the Pfannenstiel incision after cesarean section (5). MR imaging findings are characterized by hemorrhagic signal intensity on T1- and T2-weighted images, especially with fat-saturated sequences, in the context of the myometrium along the surgical scar.

Figure 8. Rectal hemorrhagic endometrial implants and right-sided dermoid cyst in a 26-year-old woman with infertility and severe pelvic pain. The patient also had a left-sided endometriotic cyst (not shown). (a) Axial T1-weighted fast spin-echo image (865/11) shows a small hyperintense lesion (arrow) of the rectal wall, which represents an endometrial implant. A high-signal-intensity mass is seen in the right ovary. (b) Axial fat-suppressed T1-weighted fast spin-echo image (852/12) shows the rectal endometrial implant more clearly and also shows other small hyperintense foci in the same region (arrow). The signal intensity of the adnexal mass is markedly decreased, an appearance consistent with a dermoid cyst. (c) Photograph obtained during laparoscopy shows the pouch of Douglas, with the tip of the instrument moving apart the rectum. Multiple red endometrial implants are present, including one on the rectal wall (arrow). (d) Photograph from the same examination shows the dermoid cyst between the tips of the laparoscope, with a red endometrial implant on its surface.
Surgical Management

It is essential to take the anatomic distribution of deeply infiltrating endometriotic lesions into consideration for surgical management of patients with this problem. The importance of this point has prompted the gynecologists to propose a “surgical classification” for deeply infiltrating endometriosis, based on the location of the lesions (7). The advantage of this classification is that for each location corresponds a well-established surgical technique that has proved to be efficient (7).

When multifocal lesions are present, it is important to associate several surgical procedures.

For location of deep pelvic endometriosis in the anterior cul-de-sac, involving the bladder, the treatment of reference is partial cystectomy. This can perfectly well be achieved with laparoscopic surgery (33,34). However, in certain cases the operation should be performed with laparotomy, particularly when there is a need to reimplant the ureter or if an association with bowel involvement is present.

In cases of deep pelvic endometriosis located in the posterior cul-de-sac, various techniques have been proposed (Fig 9). For deeply infiltrating endometriosis of the uterosacral ligaments, surgical removal can take place with laparoscopic surgery (35). If the vagina is involved, the surgical technique is different and classically uses both the laparoscopic and the vaginal approaches. When the bowel wall is infiltrated (Fig 10), although in certain carefully selected cases surgery can be carried out with laparoscopy (36,37), the treatment of reference remains laparotomy (38,39). This is particularly true when resection and anastomosis are needed and because bowel lesions are multifocal in a considerable proportion of cases (7).

**Figure 9.** Deep fibrotic endometriosis of the pouch of Douglas in a 33-year-old woman with dyspareunia and a palpable nodule in the rectovaginal septum. (a) Axial T2-weighted fast spin-echo image (5000/118) shows a nodular region of hypointense tissue (arrow) between the anterior rectal wall and cervix, with some degree of surrounding soft-tissue distortion. (b) Axial fat-suppressed T1-weighted fast spin-echo image (852/12) shows that the nodule (arrow) is isointense relative to surrounding tissues with no hemorrhagic content, an appearance indicative of its fibrotic nature. (c) Photograph obtained during laparoscopy (same orientation as in a and b) shows the pouch of Douglas during the procedure of nodule excision, which was performed by using a finger placed through the vagina for guidance. The tip of the instrument (near the top of the image) is moving apart the posterior vaginal fornix. The fibrotic endometriotic lesion without hemorrhagic content (arrow) is seen in the rectovaginal septum.
Conclusions
MR imaging is a useful modality as an adjunct to physical examination and transvaginal and transrectal sonography in evaluation of patients with deep infiltrating endometriosis. MR imaging demonstrates high sensitivity, specificity, positive and negative predictive values, and accuracy in prediction of the locations and in evaluation of the extension of lesions in patients with this disease, as reported in the several articles published on this topic. All the information offered by MR imaging is useful in planning the best treatment, surgical or medical, for the disease. Therefore, in our opinion, MR imaging may be recommended in preoperative assessment of patients with deep pelvic endometriosis.

References


Deep Retroperitoneal Pelvic Endometriosis: MR Imaging Appearance with Laparoscopic Correlation

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On the contrary, the histologic findings of infiltrative lesions of deep pelvic endometriosis are mainly characterized by fibromuscular hyperplasia that surrounds foci of endometriosis, and the foci sometimes contain small cavities. The endometrial glands and stroma infiltrate the adjacent fibromuscular tissue and elicit smooth muscle proliferation and fibrous reaction, resulting in solid nodule formation (1,2).

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MR imaging characteristics of deep pelvic endometriosis depend on the type of lesions: infiltrating small implants, solid deep lesions mainly located in the posterior cul-de-sac involving the uterosacral ligaments and torus uterinus, and visceral endometriosis involving the bladder and rectal wall.

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