Pelvic Endometriosis: 
MR Imaging Spectrum 
with Laparoscopic 
Correlation and Diagnostic Pitfalls1

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Endometriosis is a common multifocal disease involving a number of anatomic sites in the pelvis. Although laparoscopy is the standard of reference for diagnosis, magnetic resonance (MR) imaging is a noninvasive method for evaluating areas inaccessible to laparoscopy. A large endometrioma (≥1 cm in diameter) appears as a homogeneously hyperintense mass on T1-weighted MR images and as a low-signal-intensity mass with areas of high signal intensity on T2-weighted images. A small endometrioma may be indicated when a pelvic mass less than 1 cm in diameter is hyperintense on T1-weighted images irrespective of its appearance on T2-weighted images. Endometriosis may also manifest as multiple, homogeneously hyperintense cysts on T1-weighted images. Involvement of the alimentary tract or bladder can appear as areas of high signal intensity. Although MR imaging is limited in its ability to depict small endometrial implants and adhesions, the advantages of MR imaging over laparoscopy include the ability to characterize endometriotic lesions and to evaluate extraperitoneal sites of involvement, contents of a pelvic mass, or lesions hidden by dense adhesions. The roles of the two modalities are therefore complementary. Knowledge of the variety of MR imaging appearances of endometriosis and organ involvement within the pelvis is important for guiding a subsequent laparoscopic examination.

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INTRODUCTION

Endometriosis is defined as the presence of endometrial epithelium and stroma in an ectopic site outside the uterine cavity and musculature (1). It is a disease found almost exclusively in women of reproductive age (1). Approximately 25% of infertile women between the ages of 20 and 55 years have endometriosis as determined with laparoscopy, and 30%-40% of women with endometriosis suffer from infertility (2,3). The estimated prevalence of endometriosis in the general population of women is 10% (1).

The most common symptoms of endometriosis are dysmenorrhea, dyspareunia, pelvic pain, and infertility, although only 39% of affected women present with all four major symptoms (4). Pathologic diagnosis requires microscopic demonstration of endometrial tissue, preferably both glands and stroma (5). However, this latter requirement remains unclear (1). The sites at which endometriosis is most commonly found, in descending order of frequency, include the ovaries, uterine ligaments, Douglas cul-de-sac, uterine serosal surface, fallopian tubes, rectosigmoid, and urinary bladder (6), although implants have been found in such distant locations as the pleural surface (7). The cause of the disease is controversial. Theories include peritoneal seeding by way of retrograde transport of endometrial cells and metaplastic transformation of peritoneal epithelium into functional endometrium (8). A third theory—the induction theory—combines elements from the first two theories and proposes that the shed endometrium releases unknown substances that induce undifferentiated mesenchyma to form endometriotic tissue (1).

The standard of reference for the diagnosis and staging of endometriosis is laparoscopy; however, this is an invasive procedure and the need for a noninvasive imaging modality is apparent. Among the various cross-sectional imaging modalities, magnetic resonance (MR) imaging is the most promising for the evaluation of patients with suspected primary or recurrent endometriosis. In this article, we briefly discuss the various procedures used to diagnose endometriosis and then describe the MR imaging examination of the condition. The spectrum of pelvic endometriosis as depicted with MR imaging and accompanying pathologic correlations from laparoscopic studies are presented. In addition, diagnostic pitfalls are discussed to facilitate the interpretation of pelvic MR images.

DIAGNOSIS

Laparoscopy

Laparoscopy is the standard of reference for the diagnosis of endometriosis (1). The diagnosis is made by noting the presence of either typical lesions consisting of blue-brown or black nodules or stains on peritoneal surfaces of the ovaries, fallopian tubes, uterus, uterosacral ligaments, and bowel. These lesions are the result of tissue bleeding and retention of blood pigments.

Although considered the standard of reference, laparoscopy has several diagnostic pitfalls (9). Frequently, there are atypical lesions that lack the typical brown or black appearance but show histologic evidence of endometrial glands and stroma. These lesions require biopsy for confirmation. In fact, in one large series of 137 patients, only 35% of lesions had the typical black appearance and 40% lacked the appearance that would indicate the retention of blood pigments (10). Finally, the presence of endometriosis, which is obscured by overlying dense adhesions, will be missed at laparoscopy if careful dissection is not performed.

Serum Markers

Elevated levels of carcinoembryonic antigen 125 (11) in the peripheral blood have been detected in women with endometriosis. However, the carcinoembryonic antigen 125 level has low sensitivity and specificity as a screening test; therefore, its usefulness for therapeutic monitoring is doubtful. Alternative serum markers such as placental protein 14 (11) and antibodies to endometrial tissue (12) are being investigated.

Cross-sectional Imaging Diagnosis

Computed Tomography and Ultrasonography.—Thus far, neither computed tomography (CT) nor ultrasonography (US) has been helpful in the diagnosis or management of endometrio-
sis. The low soft-tissue contrast resolution of CT and US is the major limiting factor in the detection of small implants and subsequent diagnosis and staging of the disease (13,14). Use of US has focused on differentiating endometriomas from other adnexal masses without taking into consideration the more common diffuse form of the disease. Friedman et al (8) found no significant role for US in the evaluation of 85 patients for endometriosis. Furthermore, there is no echo pattern specific for the diagnosis of endometriosis (15).

**MR Imaging.**—Several capabilities of MR imaging—lack of ionizing radiation, multiplanar imaging, and sensitivity in the detection of blood products—have prompted investigators to evaluate the efficacy of MR imaging in patients with endometriosis. In the detection of ovarian endometrial cysts, MR imaging has demonstrated a sensitivity and specificity of 90% and 98%, respectively (16). However, in earlier studies conducted by different investigators who correlated MR imaging findings with laparoscopic findings, MR imaging demonstrated an overall sensitivity and specificity of 71% and 82% (17) and 64% and 60% (18), respectively. These studies, in which conventional spin-echo sequences without fat suppression or contrast material enhancement were used, reflected the limitation of MR imaging in the detection of endometrial implants (17,18) and adhesions (18). However, even fat-saturated MR imaging, both with (6) and without contrast enhancement (19), shares the limitations of conventional MR imaging in the detection of endometrial implants. Thus, MR imaging cannot replace laparoscopy in the diagnosis and staging of endometriosis. On the other hand, direct inspection of extraperitoneal sites of involvement, the contents of a pelvic mass, or lesions hidden by dense adhesions is not possible with laparoscopy. In such cases, MR imaging can provide this additional information and so contribute to the diagnosis (16). Furthermore, MR imaging can be used as a noninvasive method for evaluating treatment response in cases in which the diagnosis has been established (17).

### MR Imaging Examination

- **Technique**

  In the series of patients that forms the basis for this review of MR imaging of endometriosis with laparoscopic correlation, MR imaging was performed on a 1.5-T SP 4000 Magnetom imager (Siemens Medical Systems, Iselin, NJ) (n = 13) and a 1.5-T Signa imager (GE Medical Systems, Milwaukee, Wis) (n = 6). Because a phased-array body coil was not available at the time of our series, imaging was performed with a quadrature body coil. All patients were given an intramuscular injection of 1 mg of glucagon to decrease bowel peristalsis before imaging was performed. The pulse sequences used were similar for both systems and included axial conventional T1-weighted (repetition time msec/echo time msec = 500–700/15–18), sagittal and axial conventional T2-weighted (1,500–2,000/70–90), and sagittal and axial turbo (fast) spin-echo (3,000–4,500/90–140; echo train length, seven or eight) sequences. Other parameters were as follows: 192 × 256 (T1- and conventional T2-weighted sequences) and 192 × 512 to 320 × 512 (turbo spin-echo sequences) matrix; 350–380-mm three-fourths rectangular field of view; 5-mm section thickness with a 1-mm gap between sections; and two or three acquisitions. In addition, conventional T1-weighted MR imaging with fat suppression was performed both before and after the administration of gadopentetate dimeglumine (0.1 mmol/kg).

- **MR Imaging Appearance**

  Only pigmented lesions can be detected with non-contrast-enhanced MR imaging because of the presence of hemorrhage (20). MR imaging criteria for the diagnosis of both large and small endometriomas have been described in the literature (16,19,21). A large endometrioma (≥1 cm in diameter) appears as a homogeneously hyperintense mass on T1-weighted MR images; on T2-weighted MR images, it appears as a low-signal-intensity mass with areas of high signal intensity. Alternatively, endometriosis may
**Figure 1.** Small ovarian endometrial implant. (a) Transaxial turbo T2-weighted MR image (5,000/140) shows high-signal-intensity fluid in the cul-de-sac (straight arrow). Two high-signal-intensity foci (follicles) are noted involving the right ovary (arrowheads). Curved arrow indicates a focus of low signal intensity caused by hemorrhage. Incidentally noted is a small submucosal leiomyoma (L). (b) Transaxial T1-weighted fat-saturated MR image (630/15) shows a 4-mm focus of high signal intensity (open arrow) caused by hemorrhage, corresponding to the focus of low signal intensity seen in a. Note the high-signal-intensity mucoproteinaceous fluid in the bowel (curved arrows), which should not be mistaken for hemorrhage. (c) Photograph taken during laparoscopy demonstrates two brown-pigmented lesions on the ovarian surface (arrows). At biopsy, only the superior lesion proved to be an endometrial implant; the inferior lesion proved to be a corpus albicans cyst.

manifest as multiple, homogeneously hyperintense cysts on T1-weighted MR images regardless of its signal intensity on T2-weighted images. A small endometrioma may be indicated when a pelvic mass less than 1 cm in diameter is hyperintense on T1-weighted images irrespective of its appearance on T2-weighted images (6). The majority of endometriomas re-
Figure 2. Small ovarian endometrial implant. (a) T1-weighted fat-saturated MR image (695/15) reveals a high-signal-intensity lesion on the left ovary (curved arrow), caused by acute hemorrhage. This lesion had low signal intensity on a T2-weighted MR image (not shown). Note also the high-signal-intensity mucoproteinaceous fluid within bowel loops (straight arrows). (b) Photograph taken during laparoscopy shows a nodular black-pigmented lesion on the surface of the ovary (arrow), corresponding to the lesion seen on MR images.

main bright on MR images obtained after intravenous administration of gadopentetate dimeglumine. Furthermore, contrast enhancement of peritoneal surfaces subjacent to endometrial implants is frequently seen (6).

**SPECTRUM OF DISEASE**

Endometriosis is usually a multifocal disease. The first grossly recognizable lesions are blisterlike blebs 2-3 mm in diameter on the surfaces of target organs. Over time, these blebs assume the characteristic "powder burn" appearance produced by a collection of hemorrhagic spots and bluish-red nodules or patches.

The lesions may become cystic, but the cysts do not enlarge except in the ovary. As the disease progresses, the endometriotic sites may become fibrotic, distorting the affected organ and forming adhesions with the surrounding structures (22).

The ovaries may be affected in two ways. Small implants of endometrial tissue (Figs 1-3) may cause paraovarian scarring and adhesions (23), or they may evolve into endometriomas or
Figure 3. Ovarian and paraovarian endometriosis. (a) Transaxial T1-weighted fat-saturated MR image (630/15) shows increased signal intensity centrally (solid straight arrows), indicating acute hemorrhage. Note the focus of high signal intensity situated between the uterus (U) and the left ovary (curved arrow) indicating a site of paraovarian hemorrhage. High signal intensity in the rectal and perirectal region (open arrows) represents susceptibility artifact between air and fat, which is accentuated due to peristalsis. (b) Transaxial postcontrast fat-saturated MR image demonstrates intraovarian endometriomas (straight arrows). In addition, there is enhancement of the tissue planes between the uterus (U) and the left ovary (curved arrows). These findings indicate surrounding inflammatory reaction with adhesion formation. (c) Photograph taken during laparoscopy performed after extensive dissection shows dark red pigments (black arrows) in the left ovary (white arrow), indicating ovarian disease. F = fallopian tube, i = tip of laparoscope, U = uterus. (d) Photograph taken after probing near the tip of the laparoscope during the same examination shows adhesions within the left adnexa (solid arrows). White raised lesions (open arrows) are the result of endometriosis.
chocolate cysts (Figs 4, 5). Endometriomas are moderately thin-walled cysts containing dark, semisolid, sticky material that represents hemorrhage within the lumen of the cyst. Although the chocolate cyst is highly suggestive of endometriosis, hemorrhage within a corpus luteum cyst, a follicular cyst, or even a neoplastic cyst can have a similar appearance (22).

When the uterine ligaments are involved, especially the uterosacral ligaments, thickening of these structures occurs due to endometriotic nodule formation, which renders the ligaments...
Figure 6. Bilateral uterosacral ligament endometriosis. (a) Transaxial contrast-enhanced T1-weighted fat-saturated MR image (720/20) shows a retroverted uterus (U) with bilaterally enhancing uterosacral ligaments (arrows). The uterosacral ligaments do not normally enhance on contrast-enhanced MR images. Their enhancement on this image suggests the presence of endometriosis. (b) Photograph taken during laparoscopy demonstrates a red-pigmented lesion along the right uterosacral ligament (arrow). (c) Photograph taken during the same examination shows several small, brown-pigmented lesions along the course of the left uterosacral ligament (arrows).

palpable at physical examination. Involvement of peritoneal reflections over the uterosacral ligaments (Fig 6), within the cul-de-sac (Figs 7, 8), and over the uterus (Fig 9) usually manifests on contrast-enhanced fat-saturated MR images as diffuse peritoneal enhancement secondary to the inflammatory reaction incited by microscopic endometrial implants. Occasionally, larger hemorrhagic foci and even solid implants are detected.
Figure 7. Posterior cul-de-sac endometriosis. (a) Sagittal proton-density-weighted conventional spin-echo MR image (2,000/30) shows several foci of high signal intensity (arrow, arrowheads) in the posterior cul-de-sac between the uterus (U) and the rectosigmoid colon (C). L = leiomyoma. (b) On a sagittal T2-weighted conventional spin-echo MR image (2,000/80), these lesions appear hyperintense (arrow, arrowheads). At laparoscopy, endometriosis was identified after careful dissection. L = leiomyoma.

Figure 8. Posterior cul-de-sac endometrial implant mimicking a leiomyoma. (a) Sagittal T2-weighted conventional spin-echo MR image (1,500/90) shows a large fundal leiomyoma (L), as well as a focal low-signal-intensity mass (arrowheads) posterior to the cervix mimicking a subserosal leiomyoma. Low signal intensity suggested the presence of hemosiderin, which was confirmed at histologic analysis. (b) Sagittal T1-weighted postcontrast MR image shows slight peripheral enhancement of the mass (arrow), which protrudes within the posterior vaginal fornix. The mass was palpable, and the patient underwent biopsy before MR imaging was performed. The abnormality was diagnosed as an endometrial implant with chronic hemorrhage.
Figure 9. Uterine surface endometriosis. (a) Transaxial turbo T2-weighted MR image (4,800/91) shows nonspecific, somewhat heterogeneous high signal intensity along the right uterine surface (arrows). (b) Transaxial T1-weighted fat-saturated MR image (700/15) shows no evidence of hemorrhage. Note the high signal intensity in the external iliac veins caused by slow flow. (c) Contrast-enhanced fat-saturated MR image shows intense enhancement of the right postero-lateral uterine surface (arrows). Multiple lesions were found at laparoscopy.

Endometriosis of the fallopian tubes (Figs 10, 11) is usually a surface phenomenon, with the endometrial glands and stroma being situated in the subserosal layer (22). Figure 11 illustrates an additional feature of endometriosis: a predisposition to endometrial malignancies such as clear cell carcinoma, endometrioid carcinoma, and mixed müllerian carcinosarcoma (24).

Detection of parametrial disease with MR imaging is difficult due to the enhanced vascularity normally seen. However, parametrial disease should be suspected if there is asymmetric...
Figure 10. Endometrioma adherent to the right fallopian tube. (a) Transaxial conventional T2-weighted MR image (2,000/80) shows an area of hyperintensity representing an endometrioma (E). The fallopian tube is noted along its right lateral wall (arrow). (b) Transaxial T1-weighted postcontrast MR image shows the right fallopian tube (arrow) with a prominent and enhancing wall and containing low-signal-intensity fluid. The endometrioma (E) appears hyperintense as in a.

Figure 11. Hematosalpinx with clear cell carcinoma. Transaxial proton-density-weighted conventional spin-echo MR image (2,500/20) shows gross distention of the left fallopian tube (f) with focal nodularity (arrows). At surgery, hematosalpinx was confirmed as was clear cell carcinoma involving the fallopian tube wall. The hemorrhagic process of endometriosis is known to predispose to a variety of endometrial malignancies, including endometrioid carcinoma and mixed müllerian malignant tumor.
Figure 12. Right parametrial endometriosis. (a) Transaxial T1-weighted precontrast fat-saturated MR image (690/15) shows a focus of hemorrhage (arrow) located in the right periuterine-parametrial region. (b) Transaxial postcontrast fat-saturated MR image shows asymmetric intense enhancement of the right parametrial region (arrows). (c) Photograph taken during laparoscopy shows congestion of the right parametrium. A linear scar (straight arrows) is noted with microscopic implants (arrowheads) along its course. Curved arrow indicates the right ovary. The hemorrhage seen at MR imaging was not identified at laparoscopy.

signal intensity on T2-weighted or contrast-enhanced fat-saturated images (Fig 12).

Endometriosis of the alimentary tract usually affects the rectosigmoid colon (Fig 13). Radiographic findings may resemble those of colonic carcinoma (Fig 14) as endometriosis causes marked overgrowth of the external muscular coat, which is characteristic of bowel endometriosis (22). However, unlike colonic carcinoma, endometriosis does not cause mucosal ulceration, and the mucosa appears intact (25). The lesion may be constricting, or it can produce an eccentric intramural filling defect. Appendiceal and ileal involvement are also frequently manifested.

Figure 14. Rectal endometriosis. (a) Image from an air contrast barium enema study shows an apple core rectal lesion (arrow). (b) Coronal conventional T2-weighted MR image (2,000/80) also shows the apple core rectal lesion (arrows). The lesion is predominantly of low signal intensity and did not have high signal intensity on the precontrast T1-weighted MR image (not shown).
Figure 13. Small rectosigmoid lesion. (a) Sagittal turbo T2-weighted MR image (4,800/91) shows a small focus of high signal intensity (arrow) involving the anterior rectosigmoid wall. (b) Transaxial postcontrast fat-saturated MR image shows an irregular focus of enhancement (arrow). (c) Photograph taken during laparoscopy performed after extensive dissection shows a black-pigmented lesion involving the ventral rectosigmoid colonic wall (curved arrow) with puckering of the wall surface. Dense adhesions are also identified (straight arrow). C = colon, Ov = ovary, U = uterus.
Involvement of the urinary bladder is not common but may be indicated in patients who present with pelvic discomfort and urinary disturbances (Fig 15). Nearly two-thirds of patients with bladder disease have previously undergone abdominal or gynecologic operations. The lesions appear as small masses of round or lobulated hypertrophic tissue covered by normal mucosa. At cystography or US, they appear as filling defects. Most are found on the posterior wall near the dome or in the trigone area (26).

**PITFALLS**
False-positive diagnoses of endometriosis at MR imaging may result from the misinterpretation of normal anatomic structures or MR imaging-related phenomena. Because vascular peritoneal surfaces enhance after intravenous administration of gadopentetate dimeglumine, an enhancing inflammatory adhesion (Fig 16) or parametrium (Fig 17) may be misinterpreted as
Figure 16. Pericecal vascular adhesion with false-positive diagnosis of endometriosis. (a) Transaxial T1-weighted fat-saturated MR image (610/15) demonstrates the uterus (U) and the cecum (C) with a linear focus of high signal intensity in the right periuterine region (arrow). MR imaging findings were suggestive of a focus of hemorrhage and, therefore, of endometriosis. (b) Transaxial postcontrast fat-saturated MR image shows moderate enhancement (arrow) of the tissue planes between the uterus (U) and the cecum (C). (c) Photograph taken during laparoscopy demonstrates a pericecal adhesion (arrow) whose red color indicates that it is inflammatory. The presence of endometriosis, however, was not confirmed at laparoscopy. The cecum (C) is positioned to the left of and away from the right hemipelvis (R).
a focus of endometriosis. Uterosacral ligaments on which previous laser intervention was performed can be similarly misinterpreted (Fig 18).

Magnetic susceptibility artifacts can mimic disease and are most prominent on fat-saturated MR images at air-tissue interfaces (Fig 3) or near metallic foreign bodies (Fig 19). When ferromagnetic clips are present, conventional spin-echo fat-suppressed MR imaging techniques may fail. Care should also be taken when evaluating bowel loops as mucoproteinaceous fluid has high signal intensity on T1-weighted MR images and can mimic hemorrhage (Figs 1, 2, 19). Finally, flow-related phenomena in the pelvic venous system demonstrate high signal intensity on T1-weighted MR images, mimicking hemorrhagic foci, and may lead to a false-positive diagnosis of endometriosis (Fig 9).

■ CONCLUSIONS
We have presented the spectrum of pelvic endometriosis as seen at MR imaging. Laparoscopy remains the standard of reference because MR imaging has certain limitations in the diagnosis and staging of endometriosis, such as suboptimal depiction of small implants and adhesions. However, the role of MR imaging is to help visualize laparoscopic blind spots, such as beneath dense adhesions and at extraperitoneal sites such as the rectum, the vagina, or within the bladder wall. This use of MR imaging is especially helpful in patients with known endometriosis who present with recurrent pain. Also, MR imaging can be used to help characterize adnexal masses and to assess treatment response in cases in which the diagnosis has been established. In the future, the accuracy of MR imaging should improve with the routine use of phased-array coils and negative signal-reducing bowel contrast agents.

■ REFERENCES
Figure 19. False-positive diagnosis of incisional endometriosis. (a) Non-contrast-enhanced T1-weighted fatsaturated MR image (800/15) shows a ringlike area of high signal intensity (arrow). (b) Transaxial turbo T2-weighted MR image (4,480/91) shows a ringlike area of high signal intensity with low signal intensity centrally (arrow). The patient had presented with left lower quadrant pain and a history of endometriosis, which had been surgically treated. The diagnosis of incisional endometriosis was made with MR imaging; in retrospect, however, the area of high signal intensity represented magnetic susceptibility effects caused by fine metallic sutures in the abdominal wall.