



Comprehensive Review of Endometriosis Based on Imaging Findings: What Radiologists Need to Know

영상 소견에 기반한 자궁내막증에 대한 전반적 고찰

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Endometriosis is a complex and challenging medical condition characterized by endometrial-like tissue outside the uterine cavity. MRI plays a crucial role in characterizing lesions and assessing disease. Radiologists must be familiar with the diverse entities and imaging findings associated with endometriosis, considering its locations and atypical manifestations, to accurately diagnose endometriosis and formulate effective treatment plans.

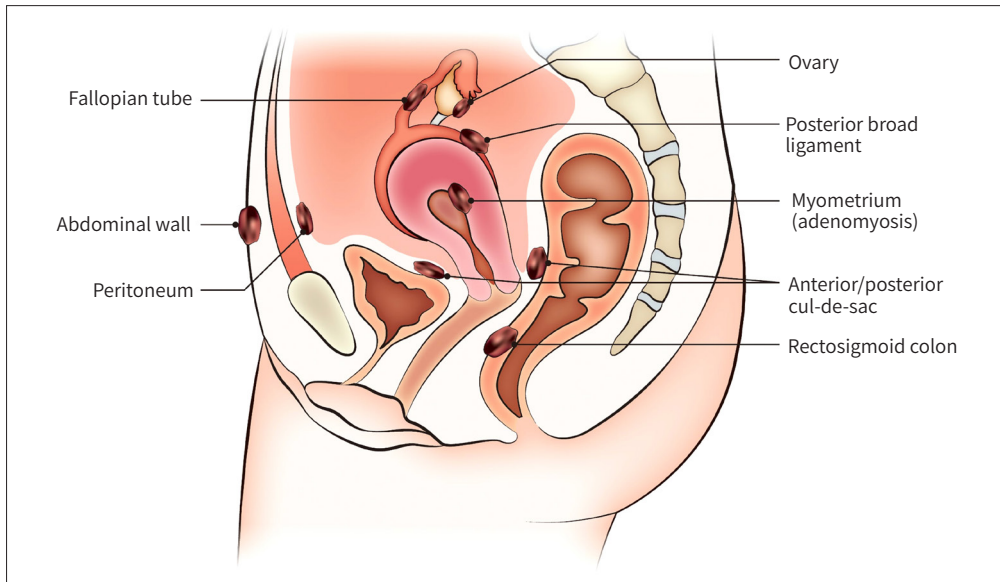
Index terms Endometriosis; Endometrioma; Deep Infiltrating Endometriosis;
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INTRODUCTION

The classic definition of endometriosis is the presence of functional endometrial glands and stroma outside the uterine cavity and myometrium. It is a significant gynecological condition that predominantly affects women during their reproductive years, with a mean age of 25–29 years (1). Ectopic tissue is hormonally active and may undergo bleeding, inflammation, and adhesion, leading to symptoms such as pelvic pain, dysmenorrhea, and infertility. Although the ovaries are the most commonly affected sites, endometriotic implants can appear anywhere in the pelvis and beyond. The reported ultrasound-based prevalence of deep infiltrating endometriosis (DIE) and/or ovarian endometrioma is approximately 20.0%, and 56.0% to 70.5%

Fig. 1. Common location of endometriosis.

This illustration depicts the common sites of endometriosis involvement, including the ovary, fallopian tubes, anterior and posterior cul-de-sac, posterior broad ligament, sigmoid colon, and abdominal wall (image courtesy of the INDIE VISUAL Lab).



of ovarian endometriomas are accompanied by DIE (2, 3). The most common locations of DIE is the rectocervical area (47.7%), uterosacral ligament (27.6%), bowel (11.5%), adnexa (9.2%), vagina (1.4%), rectovaginal septum (0.9%), abdomen (0.9%), and bladder/utero-vesical fold (0.9%) (Fig. 1) (3). Variability in implant sites makes diagnosing endometriosis challenging (4). In this pictorial essay, we aim to enhance radiologists' understanding of the disease process by presenting the pathogenesis and various imaging spectra of endometriosis tailored to its entities and anatomical locations. Additionally, we discuss several unusual manifestations of endometriosis that radiologists should consider when including endometriosis as a differential diagnosis.

PATHOGENESIS

The underlying causes and mechanisms of endometriosis are complex and involve multiple factors. The three theories explaining endometriosis are the metastatic theory, metaplastic theory, and induction theory, with the metastatic theory being the most widely accepted. According to this theory, endometriomas arise from metastatic implantation of endometrial tissue. It is proposed that viable endometrial tissue may reflux through the fallopian tube during retrograde menstruation and then deposit on the peritoneal surface or pelvic organs (1, 5). The metaplastic theory suggests that peritoneal cells may differentiate into functional endometrial cells, supported by the common embryonic origin of endometrial and peritoneal cells from the coelomic epithelium. Solid evidence for this theory includes cases of endometriosis in women without functional ectopic endometrium, including those with Turner syndrome, gonadal dysgenesis, and uterine agenesis, and even in men, substantiating the metaplastic theory (1, 6).

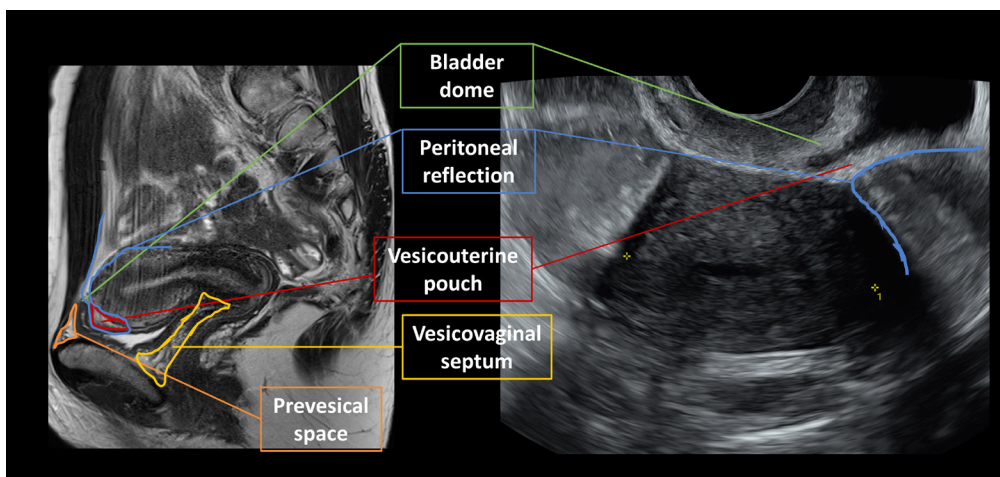
In contrast, the induction theory posits that substances released by the shed endometrium induce undifferentiated mesenchyme formation in endometriotic tissue (1). Endocrinological, immunological, pro-inflammatory, and pro-angiogenic processes affect the development of endometriosis. As the endometrial tissue responds to estrogen, the hormonal status can affect endometriosis, including proliferation or regression, hemorrhage or inflammation, and tumorigenesis (7, 8). In addition, endometrial tissue triggers localized immune and inflammatory responses and promotes the production of cytokines, chemokines, and prostaglandins. The inflammatory response involves monocytes, macrophages, neutrophils, T-cells, and eosinophils, resulting in the enhanced activation of pro-inflammatory cytokines, growth factors, pro-angiogenic factors, and adhesion molecules (9). The intricate endocrine and pro-inflammatory microenvironment within and around endometriotic lesions promote their proliferation, vascularization, and nociception, contributing to the clinical manifestations of endometriosis.

DIAGNOSIS AND EVALUATION

The gold standard for diagnosing pelvic endometriosis is laparoscopic biopsy with histological confirmation (1). Radiologists frequently evaluate endometriosis in patients with pelvic pain or infertility. Ultrasonography remains the primary imaging technique for the initial assessment, helping differentiate endometriomas from other ovarian cysts (4). MRI is considered the most effective imaging technique for mapping endometriosis, providing a more reliable depiction of DIE than that achieved with physical examination or transvaginal ultrasonography (TVUSG). MRI also enables a comprehensive assessment by pinpointing the exact locations of endometriosis, characterizing the features associated with ovarian endometriotic cysts, and determining the extent of pelvic endometriosis (10).

Fig. 2. Normal anatomy of the anterior compartment.

On pelvic MR, a sagittal T2-weighted image of the anterior pelvic compartment shows the bladder, prevesical space, vesicouterine pouch, and vesicovaginal septum. Transvaginal ultrasonography displays the anterior pelvic compartment, which includes the anterior peritoneal reflection that outlines the space between the bladder dome and the uterus.



NORMAL ANATOMY OF FEMALE PELVIS

A detailed understanding of normal female pelvic anatomy is essential to accurately comprehend the typical locations of endometriosis. This includes classifying these regions into anterior, middle, and posterior compartments based on their functional and clinical significance.

The anterior pelvic compartment extends from the anterior uterine serosa to the anterior pelvic wall and comprises the urinary bladder and urethra. It is situated anterior to the uterus-vagina complex, with the pubic symphysis delineating the ventral border of this compartment (5, 11). These structures are delineated by fat planes, notably the vesicovaginal septum and prevesical space. The base of the urinary bladder is located in the extraperitoneal space beneath the peritoneal reflection and the dome of the urinary bladder is encapsulated by the peritoneal reflection (Fig. 2). When the probe is placed in the anterior vaginal fornix, sagittal gray-scale TVUSG reveals the anterior pelvic compartment, including the bladder dome, peritoneal reflection, and vesicouterine pouch (Fig. 2).

The middle compartment houses the female genital organs, including the cervix, vagina, uterus, and ovaries (Fig. 3). The broad ligaments are peritoneal folds positioned between the uterus and the lateral pelvic wall. The mesovarium is a double fold of peritoneum that suspends the ovaries in the ovarian fossa (5).

The most prevalent site for endometriosis, the posterior compartment, stretches from the posterior uterine serosa to the presacral space, exclusively housing the rectum (5, 11). The rectovaginal septum, a thin membranous structure composed of fat, is located between the posterior vaginal wall and the anterior rectal wall, extending from the deepest portion of the rectouterine pouch (pouch of Douglas) (Fig. 4). The hypointense uterosacral ligament originates

Fig. 3. Normal anatomy of the middle compartment.

Transvaginal ultrasonography and sagittal T2-weighted MR images include the cervix, vagina, uterus, and ovaries.

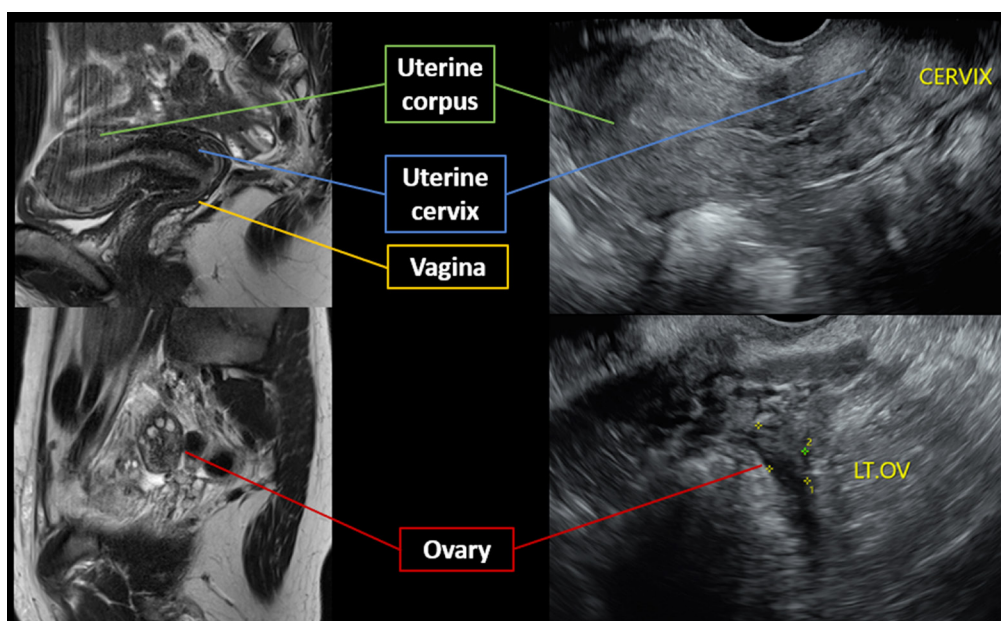
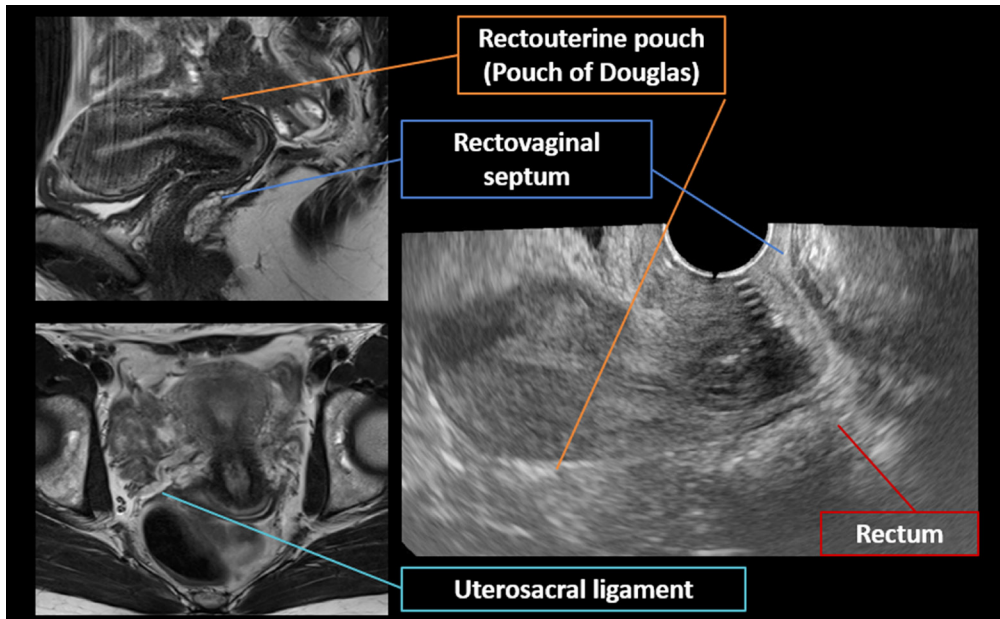


Fig. 4. Normal anatomy of the posterior compartment.

Sagittal and axial T2-weighted images detail the rectouterine pouch (pouch of Douglas), rectovaginal septum, and uterosacral ligaments. Transvaginal ultrasonography captures the structures comprising the rectovaginal septum and rectum, outlined by the peritoneal reflection.



from the lateral margin of the uterine cervix, encircles the rectum, and inserts dorsolaterally on the sacrum (Fig. 4). Additionally, the sagittal gray-scale TVUSG image demonstrates that the rectosigmoid colon is defined by a peritoneal reflection in the rectovaginal area, which encompasses the rectovaginal septum and the posterior lip of the uterine cervix (Fig. 4).

ENTITIES OF ENDOMETRIOSIS

Endometriosis is classified into three types based on the location of occurrence: endometrioma, DIE, and superficial peritoneal endometriosis. Endometrial tissue migration involving the uterine myometrium is referred to as external adenomyosis or endometriosis externa, which shows a relatively intact junctional zone due to the outside-in process of ectopic endometrial tissue invasion into the myometrium (1). Adenomyosis (internal adenomyosis or endometriosis interna) can be classified differently from endometriosis, which represents the benign invasion of the endometrial glands and stroma within the deep myometrium, accompanied by hypertrophy and hyperplasia of smooth muscle cells, resulting in widening of the junctional zone (1, 12, 13).

ENDOMETRIOMA

Endometriomas, or endometriotic cysts, are characterized by ectopic endometrial tissue implants in the ovary that enlarge and undergo repeated hemorrhaging due to hormonal stimulation. They typically occur within the natural menstrual cycle, and the tissue naturally sheds following the withdrawal of progesterone. This process results in cystic lesions filled

with dark and degenerated blood, commonly called “chocolate cysts” (1, 14).

Typical USG findings include a unilocular cyst with homogeneous low-level echoes or ground-glass echogenicity. The cystic lesion generally exhibits a smooth wall without septations or solid components (Fig. 5A) (4). Endometriomas might also present a multilocular appearance with septations that resemble cystic neoplasms. However, typical endometriomas should appear as cystic lesions with three or fewer locules, no internal vascularity, smooth inner walls, or septations according to the Ovarian-Adnexal Reporting and Data System (O-RADS) US risk stratification version 2022 and classified as O-RADS 2 (almost certainly benign, <1% likelihood of malignancy) (Fig. 5B) (15). Additionally, hyperechoic peripheral echogenic mural foci, corresponding to cholesterol deposits within the cyst wall from a prior hemorrhage, are frequently observed and are regarded as features that enhance the specificity of endometrioma diagnosis (15, 16). For a typical endometrioma less than 10 cm in size, initial follow-up at 12 weeks is recommended for premenopausal women if not surgically removed (15).

On MRI, three essential imaging indicators for diagnosing ovarian endometriotic cysts are identified: T1-high signal multiplicity, T2 shading, and the T2 dark spot sign (Fig. 6). Multiple hyperintense cysts on T1-weighted images, known as multiplicity, are a hallmark of recurrent bleeding and the formation of new blood locules. In addition to endometrioma, other primary conditions that should be considered in the differential diagnosis of adnexal lesions displaying high signal intensity on T1-weighted images include hemorrhagic functional ovarian cysts. In addition, fat-containing masses such as mature cystic teratomas and mucin-containing mucinous cystic neoplasms can show high signal intensity on T1-weighted images (17). Endometriomas typically show higher T1 and lower T2 signal intensities than hemorrhagic cysts. On fat-saturated T1-weighted images, endometriomas maintain hyperintensity, which helps differentiate them from fat-containing masses such as mature cystic teratomas, confirming that T1 shortening is not due to fat (18, 19). T2-shading is characterized by a reduction in signal intensity on T2-weighted images, ranging from subtle layered signal loss to complete intense signal loss. This pattern suggested chronic recurrent bleeding with elevated iron and

Fig. 5. Typical US findings of endometrioma.

A. Transvaginal ultrasonography illustrates a 4.1 cm-sized unilocular cyst with an internal ground-glass appearance and homogeneous low-level echoes in the left ovary, indicative of a typical endometrioma.

B. Transvaginal ultrasonography shows a roughly 3.5 cm, thin-septated cyst (arrow) with homogeneous echogenicity in the left ovary. This is also consistent with typical endometrioma, as defined in the O-RADS criteria for a cystic lesion with homogeneous low-level echogenicity, a smooth inner wall, and septation in three or fewer locules.

O-RADS = Ovarian-Adnexal Reporting and Data System

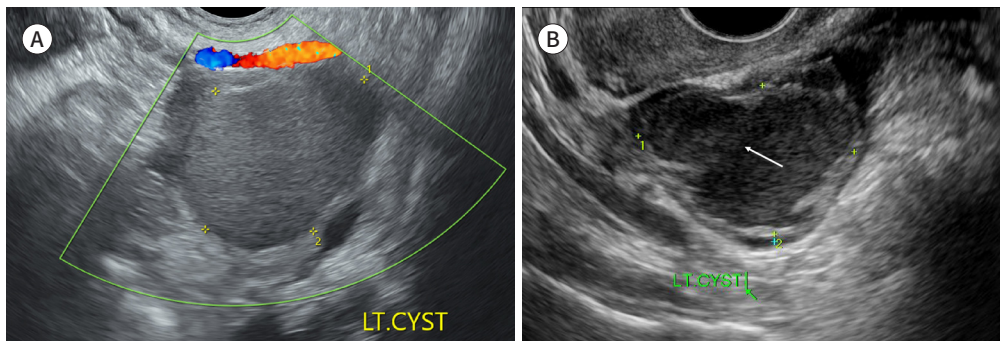
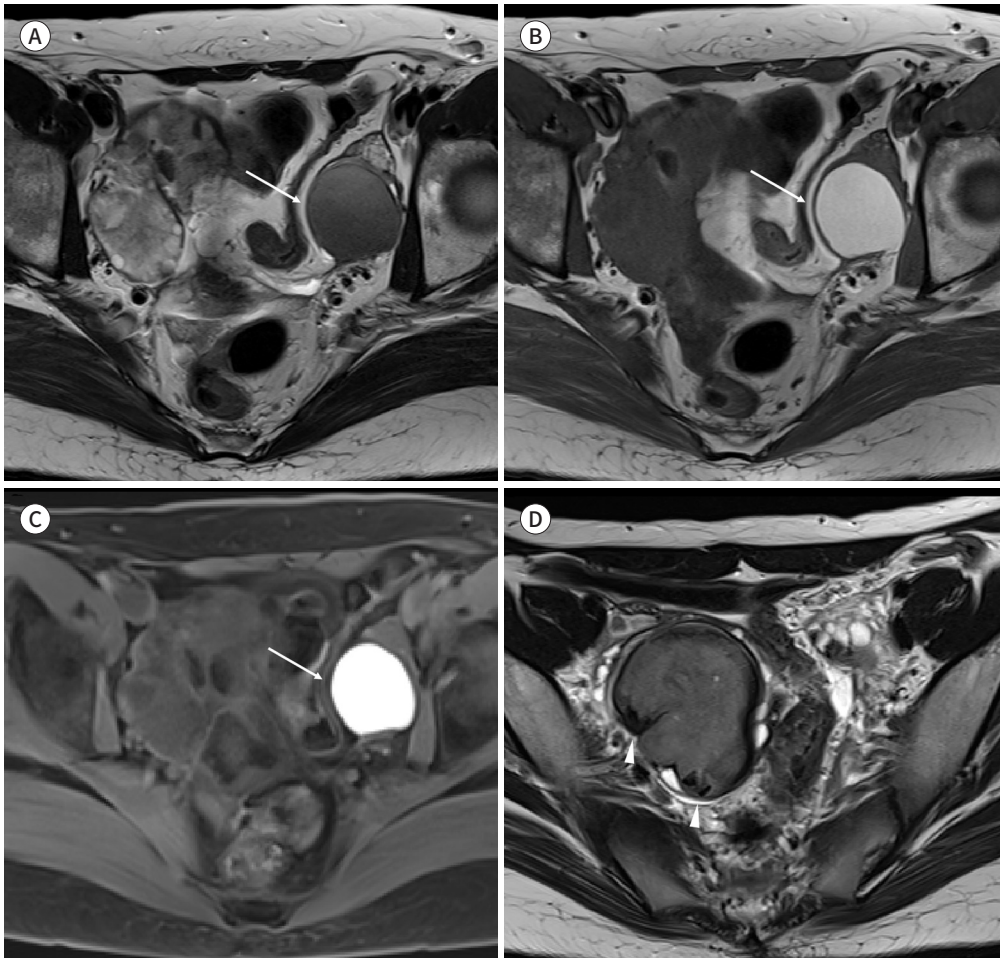


Fig. 6. Typical MR findings of endometrioma.

A-C. On pelvic MRI, axial T2-weighted images (**A**) and T1-weighted images (**B**) demonstrate a unilocular cystic lesion displaying T1 high signal intensity and T2 shading with bright signal intensity on a fat-suppressed T1-weighted image (**C**), representing typical manifestations of an endometrioma (arrows, **A-C**).

D. T2-weighted image shows hypointense foci within the T2 low-signal intensity cyst, indicative of the T2 dark spot sign (arrowheads).

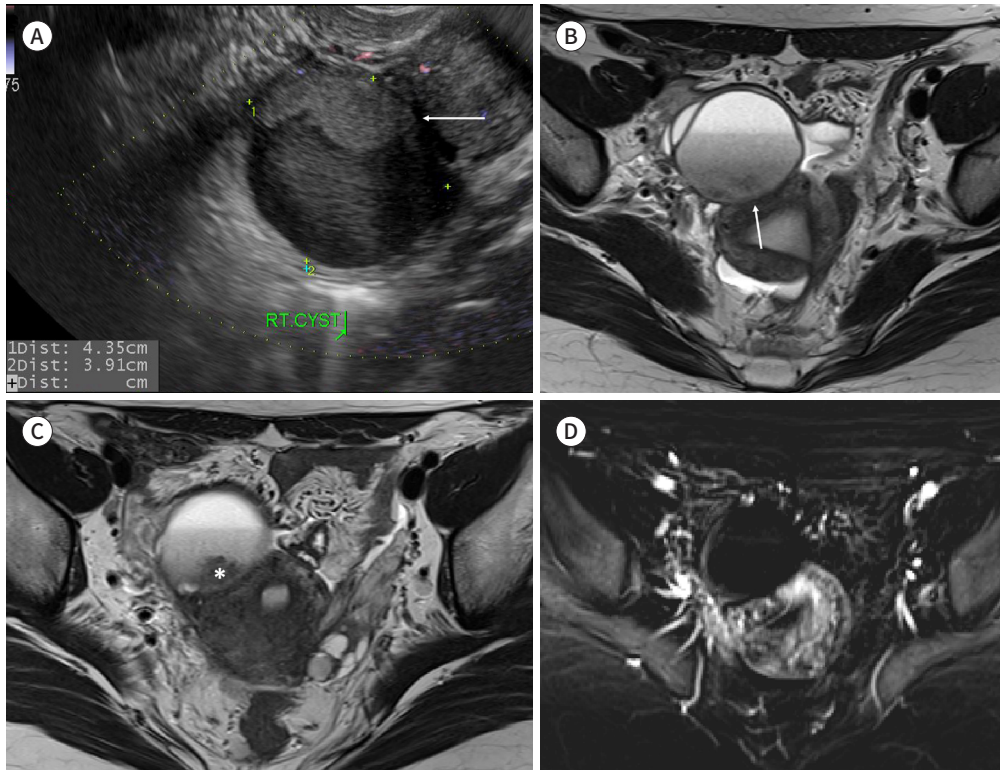


protein concentrations within the cyst (20). T2 dark spots, seen as distinct, well-defined, markedly hypointense foci within the cyst on T2-weighted images, are specific for chronic hemorrhage with high concentrations of protein and hemosiderin and serve as a key finding for differentiating endometriomas from hemorrhagic cysts. However, as T2 dark spots may also appear with calcification, careful interpretation is necessary (14, 19).

Endometriomas can also exhibit irregular inner walls, and their size can exceed 10 cm. A retracted blood clot may manifest as a solid component resembling a papillary projection mimicking the mural nodule of a malignant neoplasm. However, the absence of vascularity in the papillary projections can be a distinguishing feature (Fig. 7) (21). Consultation with a US specialist or MRI is warranted if there is an increase in size, changes in morphology, or the development of a vascular component (15). According to O-RADS US risk stratification, these 'atypical' endometriomas or typical endometriomas larger than 10 cm are classified as O-RADS 3 (low risk, 1%–<10% likelihood of malignancy). Patients in this category can be man-

Fig. 7. Atypical US imaging findings of endometrioma.

A-D. Transvaginal ultrasonography (**A**) shows a 4.3 cm-sized unilocular cyst with homogeneous echogenicity in the right ovary featuring a small echogenic component without internal vascularity (arrow, **A**). On pelvic MR, the T2-weighted image (**C**) reveals a T2 high-signal intensity mass in the right ovary with T2 shading (arrow, **B**) and internal dark signal intensity components (asterisk, **C**), which show no enhancement on contrast-enhanced imaging (**D**). These findings suggest an atypical endometrioma.



aged by gynecologists without the need for gynecologic oncologists. Atypical features include a larger cyst size and the absence of T2 shading (Fig. 8). According to Kobayashi et al. (22), ovarian endometriomas measuring 9 cm or greater in diameter were identified as independent predictive factors for ovarian cancer development. T2 shading alone has a specificity of only 45% for identifying endometriomas due to overlap with hemorrhagic cysts and malignant lesions (14). Additionally, loss of T2 shading is associated with endometriosis-associated ovarian cancer (EAOC) (10).

DEEP INFILTRATING ENDOMETRIOSIS

DIE is characterized by the penetration of endometrial tissue through the peritoneum to a depth >5 mm. This results in the infiltration of the adjacent tissue by the endometrial glands and stroma, which drives the proliferation of smooth muscles and a fibrous reaction. These changes lead to the development of solid nodules, thickening of fibromuscular tissue, and distortion of anatomical structures. Given the microscopic characteristics of fibrotic tissue, MR reveals low-signal-intensity nodular lesions or soft-tissue thickening on T1- and T2-weighted images. In contrast, high-signal-intensity lesions on T1-weighted images indicate hemorrhag-

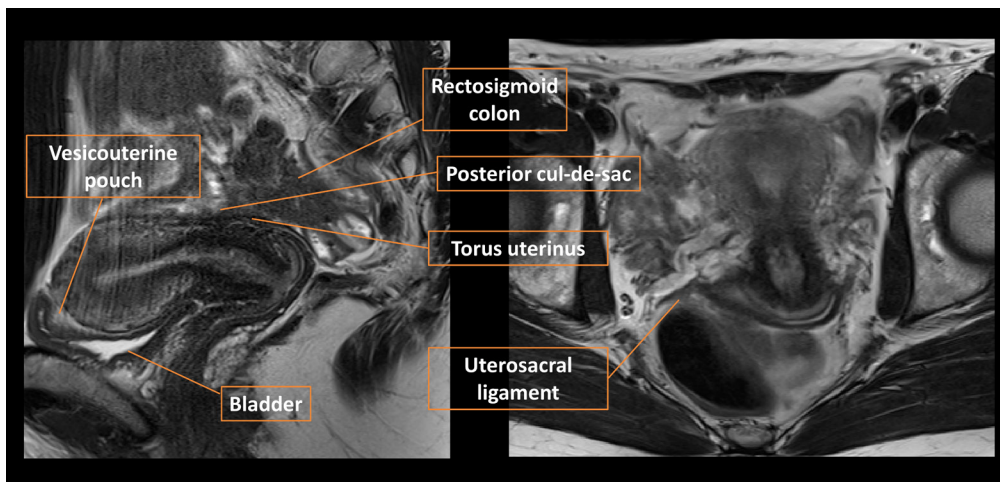
Fig. 8. Atypical MR findings of endometrioma.

A-C. On pelvic MRI, axial T2-weighted image (**A**) and T1-weighted image (**B**) display a mass over 7 cm in the left ovary showing T2 low signal intensity with shading and T1 high signal intensity, containing internal tubular structures or debris (arrows, **A, B**). A non-enhancing solid component is observed on the subtraction contrast-enhanced fat-suppressed T1-weighted image (**C**), suggesting intraluminal retracted blood clots. The cystic mass was diagnosed as an endometrioma after a left ovarian cystectomy.



Fig. 9. Common location of deep infiltrating endometriosis.

Pelvic MR imaging illustrates common sites of deep infiltrating endometriosis, including the posterior cul-de-sac, torus uterinus, uterosacral ligament, rectosigmoid colon, vesicouterine pouch, and bladder.



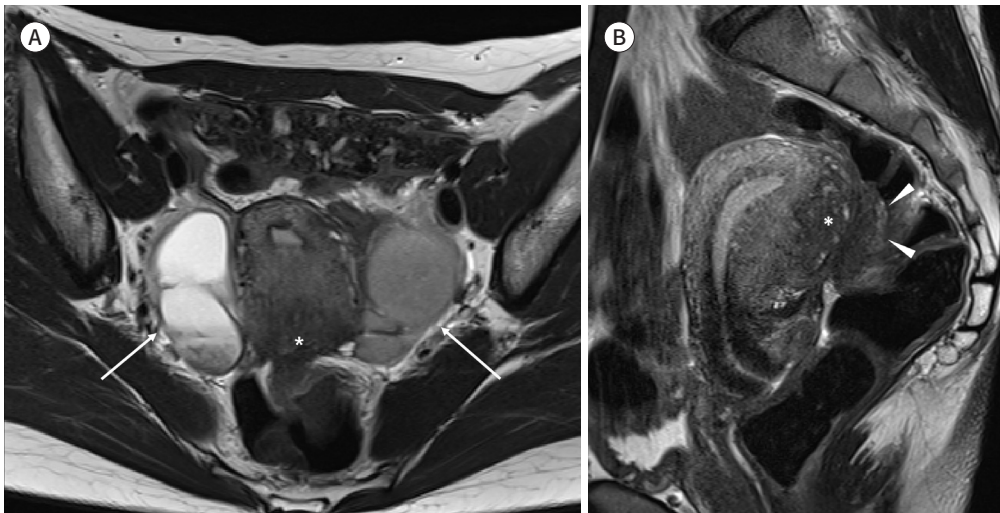
ic foci (19). DIE appears as a multifocal disease, simultaneously affecting various pelvic sites such as the posterior cul-de-sac, uterosacral ligaments, rectovaginal septum, and rectosigmoid colon. Less commonly affected sites include the pelvic nerve, bladder, ureter, appendix, and cecum (Fig. 9) (23). We present diverse imaging findings correlating with the typical locations where DIE manifests.

DEEP INFILTRATING ENDOMETRIOSIS: POSTERIOR COMPARTMENT

The posterior compartment of the pelvis is the most commonly involved site in DIE, encompassing the posterior cul-de-sac, rectovaginal septum, uterosacral ligaments, and rectum (23). On MR, this region is characterized by ill-defined hypointense lesions on T2-weighted images featuring internal T2 high-signal intensity endometriotic foci. The obliteration of the posterior cul-de-sac occurs when the retrouterine lesions affect the outer wall of the rectum (Fig. 10A). In rectal endometriosis, the notable “mushroom cap” sign appears on sagittal or axial T2-

Fig. 10. Common location of deep infiltrating endometriosis.

A, B. On pelvic MR of an asymptomatic 30-year-old female patient, axial (**A**) and sagittal T2-weighted images (**B**) reveal loss of the fat plane between the posterior myometrium, rectum, and both adnexa, featuring a T2 dark signal intensity lesion indicative of deep infiltrating endometriosis. Note focal involvement of the myometrium in the posterior body (asterisks, **A, B**). A focal T2 low signal intensity nodular lesion on the anterior wall of the rectum, covered by a high signal intensity rim (arrowheads, **B**), displays the “mushroom cap sign,” which represents endometriosis involvement of the outer wall of the rectum with a normal mucosal layer. Note a cystic lesion with a fluid-fluid level in the right adnexa and a T2-hypointense cystic lesion in the left adnexa, both showing adhesion to the uterus and suggestive of endometriomas (arrows, **A**).



weighted MR images, displaying focal thickening of the rectal wall akin to the cap of a mushroom (Fig. 10B) (19). This sign reflects T2 hypointensity due to hypertrophy of the muscularis propria, likely caused by the invasion of endometrial tissue. A T2 hyperintense ‘cap’ corresponds to edema within the submucosal or mucosal layer of the bowel resulting from chronic inflammation and endometrial involvement (24). The term “kissing ovaries” describes the medial displacement and positioning of the bilateral ovaries in the posterior cul-de-sac or cornua of the uterus due to adhesions from endometriosis (25). The congregation of the bilateral ovaries and rectum at the torus uterinus suggests significant adhesions among these structures (Fig. 11).

The retrocervical space is the intraperitoneal space located between the cervix and midrectum. The extraperitoneal rectovaginal space, separating the vagina from the lower rectum, includes the posterior vaginal fornix and rectovaginal septum. DIE in these areas leads to fat obliteration of the posterior cul-de-sac and fibrous thickening of the torus uterinus and uterosacral ligaments (Fig. 12) (19, 25).

DEEP INFILTRATING ENDOMETRIOSIS: URETER

Urinary tract involvement occurs in 1.0% to 6.4% of patients with endometriosis (19). Ureteral endometriosis is observed more frequently on the left side, attributed to the obstructed peritoneal flow of ectopic endometrial tissue by the sigmoid colon, with the distal ureter being the predominantly affected site (26, 27). Ureteral endometriosis can be broadly classified into extrinsic and intrinsic categories. Extrinsic ureteral endometriosis involves periureteral infiltration, which can occur through the local extension of adjacent pelvic structures. Ureter-

Fig. 11. Common location of deep infiltrating endometriosis.

A. Pelvic MR imaging of a 42-year-old female patient with dysmenorrhea and obliteration of the fat plane at the level of the torus uterinus. Axial T2-weighted image showing an indistinct T2 hypointense lesion with internal T2 high-signal intensity foci in the posterior wall of the uterine myometrium (asterisk) with adhesions to the rectum, posterior pelvic peritoneum, and both adnexa (arrow); findings suggestive of deep infiltrating endometriosis.

B. Axial T1-weighted image shows two hyperintense cystic lesions in both ovaries (arrows), suggesting endometriomas.

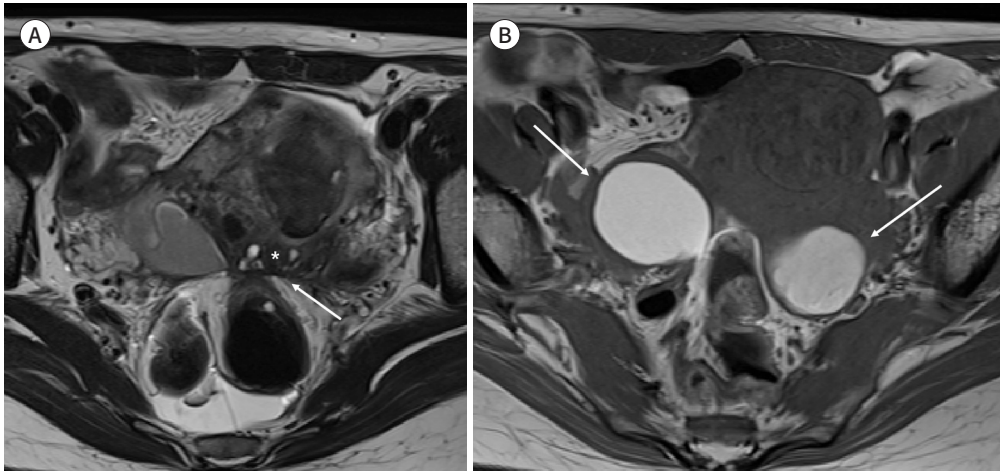
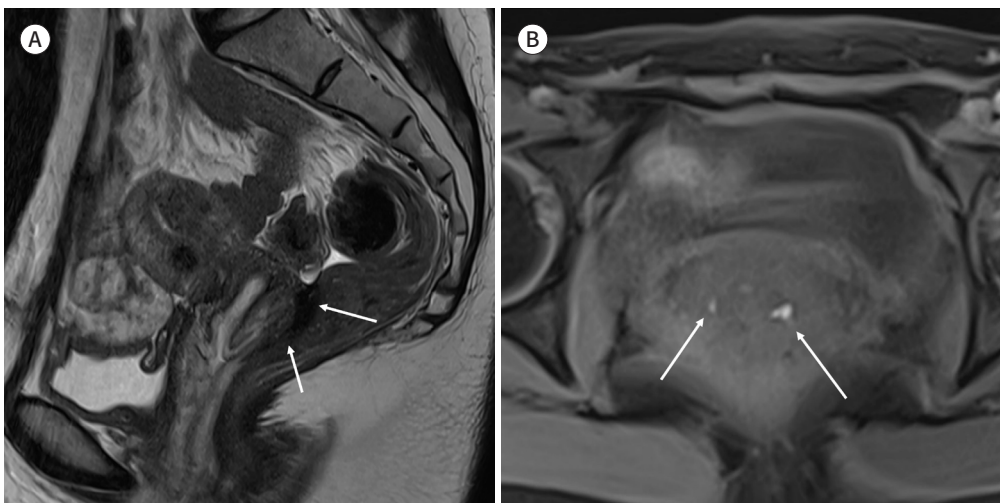


Fig. 12. Deep infiltrating endometriosis involving uterine cervix and vagina.

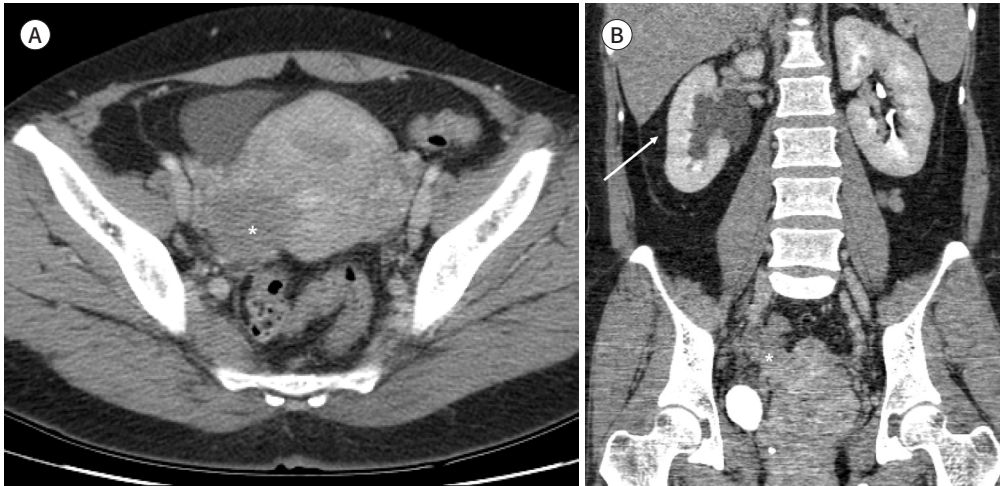
A, B. On pelvic MR of an asymptomatic 33-year-old female, axial and sagittal T2-weighted images depict an indistinct T2 dark signal intensity lesion involving the rectovaginal pouch and posterior wall of the cervix and vagina (arrows, **A**), with internal high signal intensity foci on a fat-suppressed T1-weighted image (arrows, **B**). These findings suggest adhesions to the rectum and obliteration of the posterior cul-de-sac, consistent with deep infiltrating endometriosis affecting the rectovaginal pouch and invading the posterior vaginal wall.



al infiltration should be suspected when the fat plane between the ureter and the endometrioma or DIE plaque is obscured (25). Fibrotic adhesions are identified as an indistinct soft tissue lesion surrounding the ureter on CT or a hypointense fibrotic implant on T2-weighted images (Fig. 13). In intrinsic ureteral endometriosis, endometriotic infiltration of the muscularis and lamina propria of the ureter may cause luminal narrowing, leading to dilatation and eventual

Fig. 13. Deep infiltrating endometriosis involving the ureter.

A, B. On enhanced CT scan of a 50-year-old female patient with the chief complaint of menorrhagia and dysmenorrhea. A soft tissue lesion with poor enhancement (asterisk, **A**) is visible on the right side of the pelvic cavity, between the right adnexa and uterus, showing infiltration into the right distal ureter (asterisk, **B**), associated with right hydronephroureterosis (arrow, **B**). A total hysterectomy with right salpingo-oophorectomy and left salpingectomy was performed, and the final pathological report confirmed marked adenomyosis in the uterine myometrium and an endometrial cyst in the right ovary with deep infiltrating endometriosis.



obstruction. More than 50% of cases show intrinsic involvement when there is complete encasement around the ureter (25).

DEEP INFILTRATING ENDOMETRIOSIS: APPENDIX AND CECUM

Endometriosis involving the appendix is uncommon and occurs in 5%–6% of patients with bowel endometriosis (28). Appendiceal endometriosis may cause both acute and chronic appendicitis symptoms, as well as cyclic right lower quadrant pain (25). Involvement of the cecum in endometriosis is also rare, representing less than 5% of bowel cases (29). The diagnosis of appendiceal and cecal endometriosis is indicated by T2 hypointense thickening (25), and cecal endometriosis may present as a tumor-like lesion with heterogeneous internal density and moderate enhancement (Fig. 14) (29).

SUPERFICIAL PERITONEAL ENDOMETRIOSIS

Superficial peritoneal endometriosis is characterized by the invasion of ectopic endometrial tissue into the visceral or parietal pelvic peritoneal surface and typically measures less than 5 mm (30). The typical manifestations of endometriosis are often described as superficial “powder-burn” or “gunshot” lesions, which appear in shades of black, dark brown, or blue during laparoscopy. Additionally, subtle lesions that are red or clear, small in size, and cysts displaying hemorrhage or white areas of fibrosis may also suggest endometriosis (31). Owing to their minute size, which often falls below the resolution of MRI, these lesions are infrequently detected on MRI scans. T1 hyperintense foci along the peritoneal surface may represent the only imaging indicator of their presence, as noted by radiologists (Fig. 15) (25).

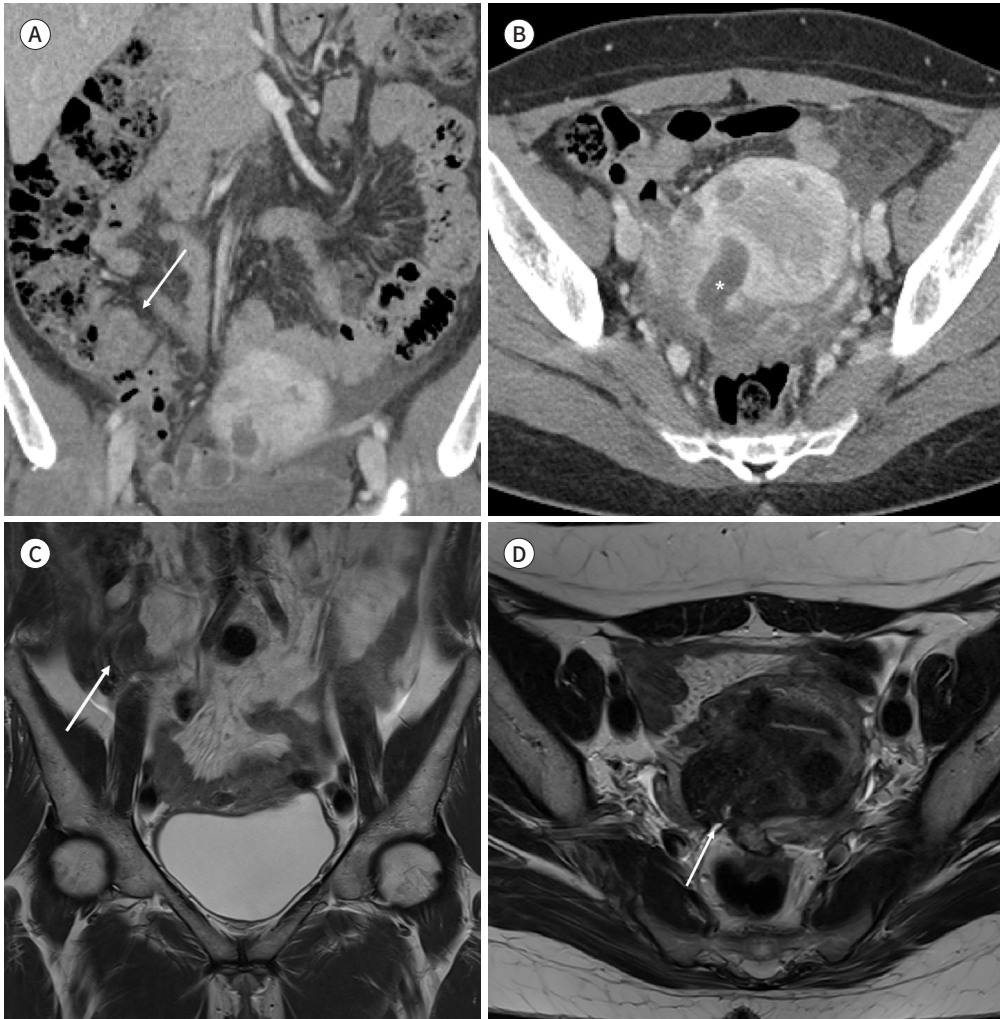
Fig. 14. Deep infiltrating endometriosis involving cecum and appendix.

A. A coronal contrast-enhanced CT image of a 43-year-old female with a recent history of myomectomy (a week ago) shows a lobulated, heterogeneously enhancing mass abutting the cecum (arrow).

B. The axial image illustrates an irregular low-density lesion in the posterior myometrium (asterisk) extending to the posterior cul-de-sac, likely related to changes from a previous myomectomy.

C. A lobulated T2 intermediate signal intensity mass is observed at the medial aspect of the cecum (arrow), but the appendix is not well visualized.

D. A T2 low-signal intensity lesion with T2 hyperintense foci is seen in the posterior myometrium (arrow), with adhesion to the posterior peritoneum. A right hemicolectomy was performed under the suspicion of an appendiceal tumor, and the final pathological report confirmed endometriosis of the appendix and cecum.



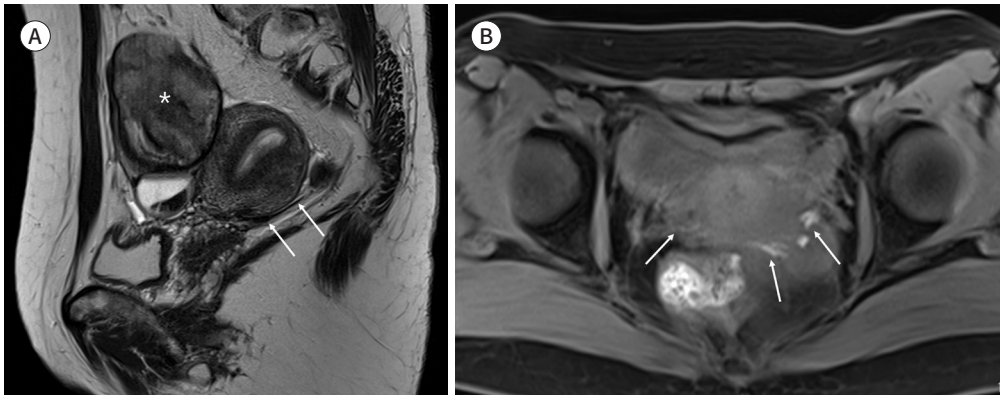
ADENOMYOSIS

Adenomyosis is defined as ectopic endometrial glands and stroma within the myometrium, leading to thickening of the junctional zone, adjacent smooth muscle hyperplasia, and potential diffuse uterine enlargement (32). Histopathologically, endometrial glands deeper than 1/4 of the myometrium indicate adenomyosis (33). The term “adenomyosis” reflects the histology of the disease: “adeno” refers to ectopic endometrial glands, and “myosis” indicates muscular hyperplasia (34). TVUSG typically shows poorly defined hypoechoic and heterogeneous areas

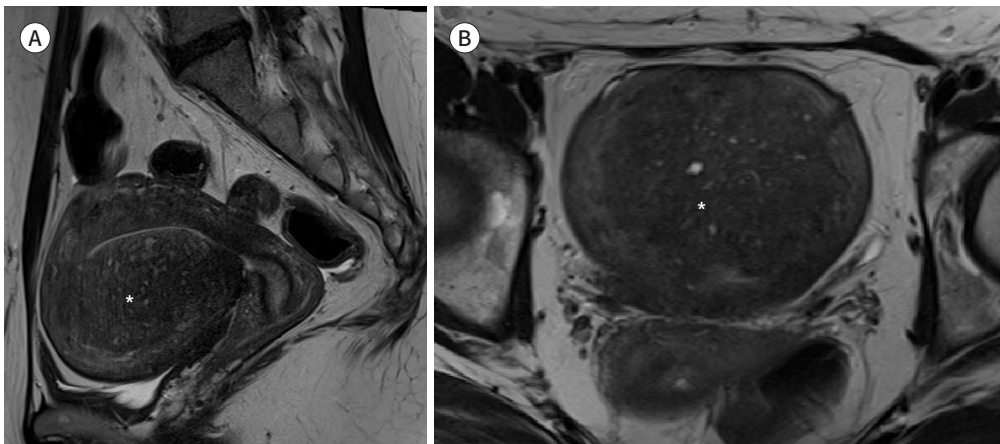
Fig. 15. Superficial endometriosis.

A. Sagittal T2-weighted image showing a thin, hypointense line along the posterior pelvic peritoneum (arrows). Note the cystic lesion with T2 shading at the anterior aspect of the uterus (asterisk), suggesting an endometrioma.

B. Axial T1-weighted image with fat suppression shows punctate or linear hyperintense implants along the posterior pelvic peritoneum (arrows).

**Fig. 16.** Adenomyosis.

A, B. Pelvic MR imaging of a 38-year-old female with menorrhagia. Both sagittal and axial T2-weighted images show diffuse enlargement of the uterus with widening of the junctional zone and T2 high-signal intensity foci (asterisks) located at the anterior body of the uterine myometrium, indicative of typical adenomyosis.



within the myometrium and may reveal an asymmetrically or diffusely enlarged uterus. The junctional zone corresponds to the innermost layer of the myometrium. It appears as a delineated region of low signal intensity on T2-weighted MR, serving as a boundary that separates the high-signal endometrium from the intermediate-signal outer myometrium. Normally, the thickness of the upper uterine myometrium ranges from 2 mm to 8 mm, with variations (35), and a junctional zone thickness >12 mm can suggest adenomyosis (34). On pelvic MR, adenomyosis is characterized by junctional zone thickening and indistinct areas of low signal intensity on T2-weighted images, reflecting associated smooth muscle hyperplasia and the presence of heterotopic endometrial tissue. T2 bright foci represent ectopic endometrial tissue and cystic glandular dilatation, whereas T1 bright foci correspond to hemorrhagic sites (Fig. 16) (32, 33). The vascularity of the myometrium is typically increased in adenomyosis because of muscular hyperplasia and hypertrophy, which is evident as tortuous penetrating vessels

traversing the myometrium, a hallmark distinguishing adenomyosis from the pattern seen in leiomyomas (34). It is crucial to recognize that adenomyosis and DIE involving the uterus are distinct disorders. Adenomyosis manifests as glands and stroma from the endometrium invading the inner myometrium in an “inside-out” sequence, appearing as echogenic striations or nodules extending from the endometrium into the inner myometrium, initiated at the interface between the endometrium and the subjacent myometrium. In contrast, DIE involves the invasion of ectopic endometrial tissue into the uterine myometrium in an “outside-in” sequence, primarily when the uterine serosa is involved while sparing the normal endometrial-myometrial interface (Fig. 17) (32, 34).

ADENOMYOSIS: ATYPICAL APPEARANCE

ADENOMYOMA

Adenomyoma, or focal adenomyosis, is a localized form of adenomyosis characterized by clusters of adenomyotic glands and may manifest as mass-like formations (36). Distinction points between adenomyomas and leiomyomas include variable signal intensities on T2-weighted images for leiomyomas. In contrast, adenomyomas exhibit low signal intensity on T2-weighted images accompanied by high-signal intensity foci, indicative of ectopic endometrial tissue (Fig. 18). Second, adenomyomas present with ill-defined margins. In contrast, leiomyomas appear as discrete, well-defined masses with pseudocapsules. Additionally, adenomyomas tend to interdigitate with the adjacent smooth muscle, exerting a minimal mass

Fig. 17. Comparison between adenomyosis and deep infiltrating endometriosis.

A. On pelvic MR of a 46-year-old female, sagittal T2-weighted image reveals an indistinct T2 low SI lesion with internal high SI foci (asterisks) in the myometrium of both the anterior and posterior uterine body accompanied by diffuse thickening of the junctional zone, indicative of adenomyosis.

B. In the sagittal T2-weighted image of a 43-year-old female, an indistinct T2 low-SI lesion was observed in the myometrium of the posterior uterine body (arrowheads), with a preserved junctional zone (asterisk). MRI also shows obliteration of the posterior cul-de-sac with adhesion of the posterior pelvic peritoneum, myometrium, and right ovary, characteristic of deep infiltrating endometriosis. The small cystic mass with T2 shading in the right ovary (arrow) is an endometrioma. In adenomyosis (**A**), endometrial tissue proliferates “into” the myometrium, involving the junctional zone, whereas in deep infiltrating endometriosis (**B**), ectopic endometrial tissue extends “outside” from the uterus.

SI = signal intensity

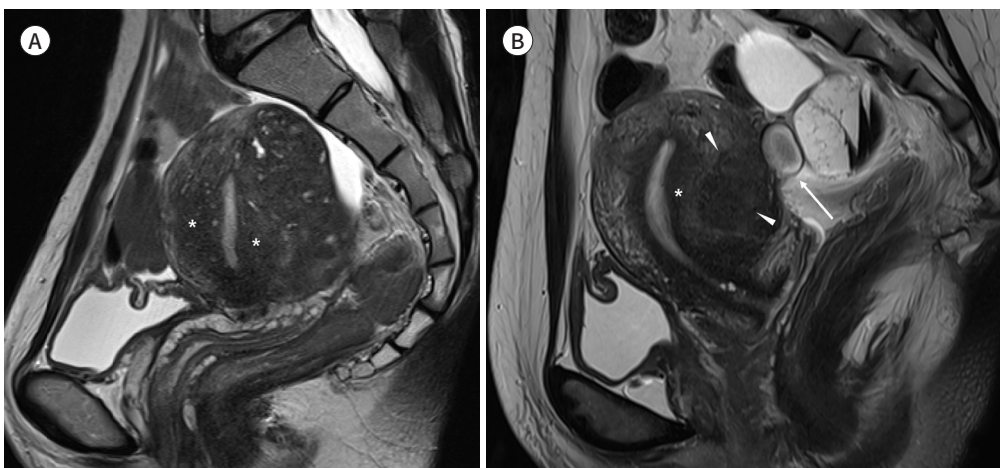
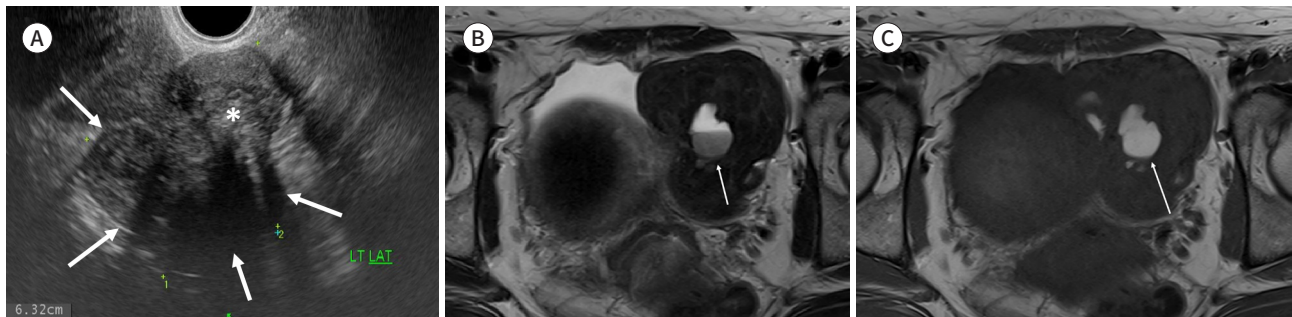


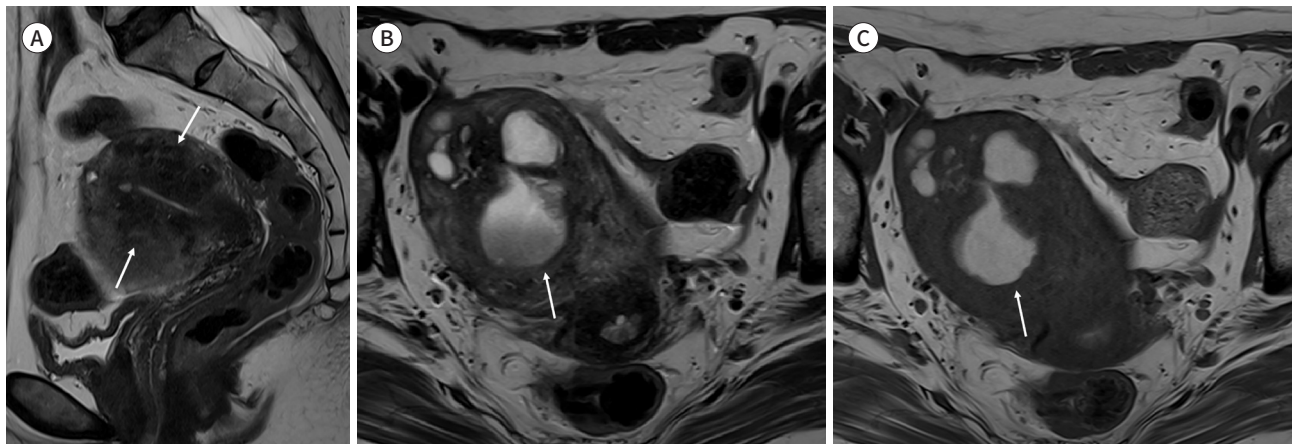
Fig. 18. Unusual manifestation of adenomyosis: adenomyoma.

A. Transvaginal ultrasonography of a 31-year-old female with menorrhagia reveals a subserosal mass >6 cm in diameter (arrows) arising from the left lateral uterine fundus (asterisk).

B, C. Pelvic MRI illustrates a T2 hypointense subserosal mass in the left lateral wall of the uterus, displaying an internal cystic portion with a fluid-fluid level (arrow, **B**) and a high signal intensity on a T1-weighted image (arrow, **C**). The lesion was diagnosed as an adenomyoma after surgical excision.

**Fig. 19.** Unusual manifestation of adenomyosis: adenomyotic cyst.

A-C. The sagittal T2-weighted image (**A**) reveals diffuse thickening of the junctional zone with ill-defined T2 hypointensity and internal T2 high foci (arrows), suggesting adenomyosis. A cystic lesion >7 cm in size with fluid-fluid level on the axial T2-weighted image (arrow, **B**) and high signal intensity on the axial T1-weighted image (arrow, **C**) is evident in the anterior uterine myometrium, indicative of an adenomyotic cyst.



effect, while leiomyomas compress the surrounding myometrium. A retrospective review of MR images revealed that leiomyomas typically exhibited a circular shape, whereas adenomyomas frequently displayed an oval configuration aligned with the long axis of the uterus (37).

ADENOMYOTIC CYST

Adenomyotic cysts, a rare manifestation of adenomyosis, result from extensive menstrual bleeding into the ectopic endometrium and consist of a large hemorrhagic cyst surrounded by a solid wall (33). The fluid content in the hemorrhagic cyst displays high signal intensity on both T1-weighted and T2-weighted images and is encased by a T2 low-signal intensity solid wall, indicative of reactive myometrial hypertrophy. A fluid-fluid level may be observed (Fig. 19) (33, 38, 39). Using fat-suppression imaging, the hemorrhagic content of the cyst can be easily differentiated from that of fat (38). Histopathologically, the cyst lacks communication with the uterine cavity, is lined by the endometrium, and is enveloped in the myometrium (32). The

thick solid wall surrounding the adenomyotic cyst can evolve into two zones consisting of an inner low and an outer high signal intensity resembling the junctional zone and a brighter outer myometrium, respectively, often referred to as a miniature uterus (33).

OVARIAN TUMORS ASSOCIATED WITH ENDOMETRIOSIS

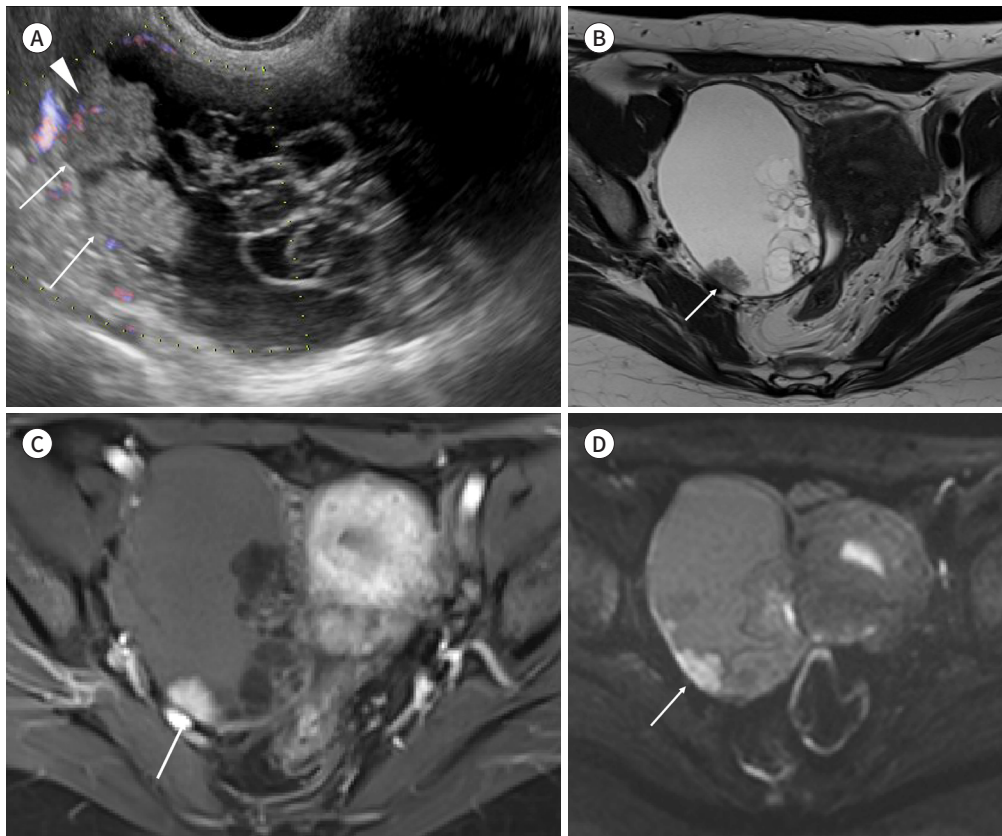
ENDOMETRIOSIS-ASSOCIATED OVARIAN CARCINOMA (EAOC)

Endometriotic cysts notably increase the risk of malignant transformation. Patients with endometriosis have a relative risk of developing ovarian cancer that is 1.2 to 1.8 times higher compared to the general population (40). Those diagnosed with EAOCs typically present at a younger age than those without endometriosis and display a higher proportion of early-stage tumors. Factors such as long-standing endometriosis, cysts larger than 10 cm, rapid enlargement of the endometriotic cyst, postmenopausal status, and early recurrence after treatment are associated with an elevated risk of malignancy in endometriosis (41-43). Clear cell carcinoma and endometrioid adenocarcinoma are the predominant histological types of ovarian

Fig. 20. Clear cell carcinoma arising from pre-existing endometrioma.

A. Transvaginal ultrasonography of a 35-year-old female shows a 9.5 cm-sized multilocular cystic mass containing a papillary solid component (arrows) in the right adnexa. Note the internal vascularity of the solid component (arrowhead).

B-D. On pelvic MRI, the axial T2-weighted image (**B**) and contrast-enhanced fat-suppressed T1-weighted image (**C**) show an enhancing solid component with diffusion restriction (**D**) in the right ovary (arrows in **B-D**). The mass was diagnosed as a clear cell carcinoma, presumably originating from a pre-existing endometrioma after surgery.



endometriomas. Approximately 50%–74% of clear cell carcinomas have been found with endometriotic cysts (Fig. 20) (44). Endometrioid carcinomas, which are the second most common ovarian malignancy, arise from endometriosis in approximately 85%–90% of cases (43).

Furthermore, 20% to 30% of patients with endometrioid carcinomas exhibit concurrent endometrial pathology, such as endometrial hyperplasia or carcinoma of the uterus (Fig. 21). The most sensitive MR indicator of EAOC is an enhancing mural nodule in endometriotic cyst (19). However, it is crucial to acknowledge that benign lesions such as polypoid endometriosis or decidualized endometrioma may also display enhanced mural nodules (43). A critical distinguishing feature is the size of endometriotic cysts. According to recent studies, the

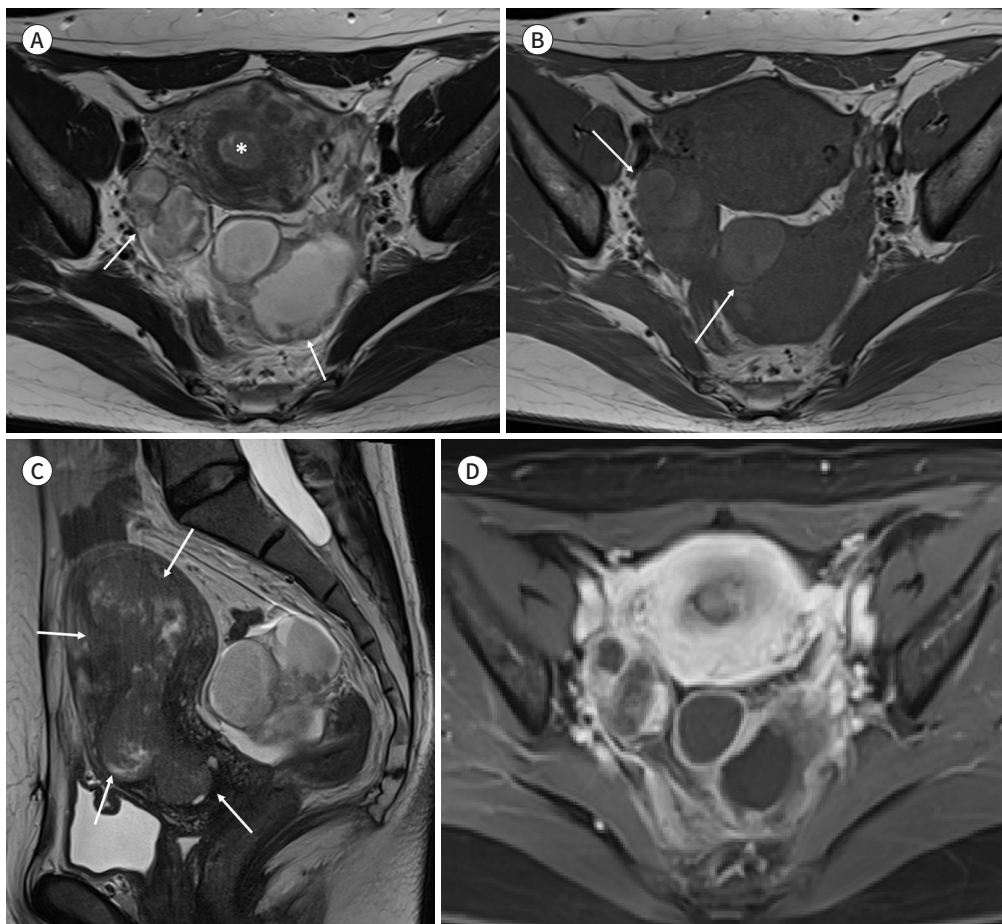
Fig. 21. Synchronous endometrial cancer and endometrioid carcinoma of both ovaries.

A. On pelvic MR of a 49-year-old female with lower abdominal pain, the axial T2-weighted image shows cystic lesions with thick irregular septa and eccentric solid mural nodules in both ovaries (arrows) and an endometrial mass (asterisk).

B. Some cystic mass locules show hyperintensity contents on the T1-weighted image (arrows), suggesting the presence of endometriomas in both ovaries.

C. The sagittal T2-weighted image shows solid masses involving the endometrial cavity extending to the endocervical lumen (arrows).

D. Axial contrast-enhanced T1-weighted image showing enhancement of the solid components of cystic masses of both ovaries and endometrial mass. The patient was diagnosed with synchronous endometrial cancer and endometrioid carcinoma of both ovaries associated with endometriosis following hysterectomy with bilateral salpingo-oophorectomy.



mean diameter of endometriotic cysts associated with malignancy is 11.2 cm, which is markedly larger than that of nonmalignant cysts (43). Another noteworthy finding is the absence of T2 shading, which results from the dilution of hemorrhagic fluid by non-hemorrhagic fluid produced by malignant tumors (45). Tanaka et al. (43) reported T2 shading in 81% of benign conditions as opposed to only 33% in cases of EAOC.

SEROMUCINOUS TUMOR AND ENDOMETRIOSIS

Seromucinous tumors, introduced as one of the seven categories of ovarian epithelial tumors in the 2014 World Health Organization (WHO) classification, exhibit a microscopic structure characterized by papillary architecture and are considered ovarian neoplasms associated with endometriosis, alongside endometrioid and clear cell tumors (46). Seromucinous borderline tumors, the most common form of seromucinous ovarian tumors, have an association with endometriosis in 30%–70% of cases. Seromucinous borderline tumors typically develop into atypical endometriotic cysts that undergo mucinous differentiation (47). These tumors are often multiloculated and may exhibit a cyst and mural nodule, referred to as the “nodule in cyst appearance” (Fig. 22) (48). Seromucinous adenofibroma, a rare benign ovarian neoplasm characterized by a fibromatous stromal component, has also been associated with and may develop from, endometriosis or endometriotic cysts according to recent studies (Fig. 23) (49).

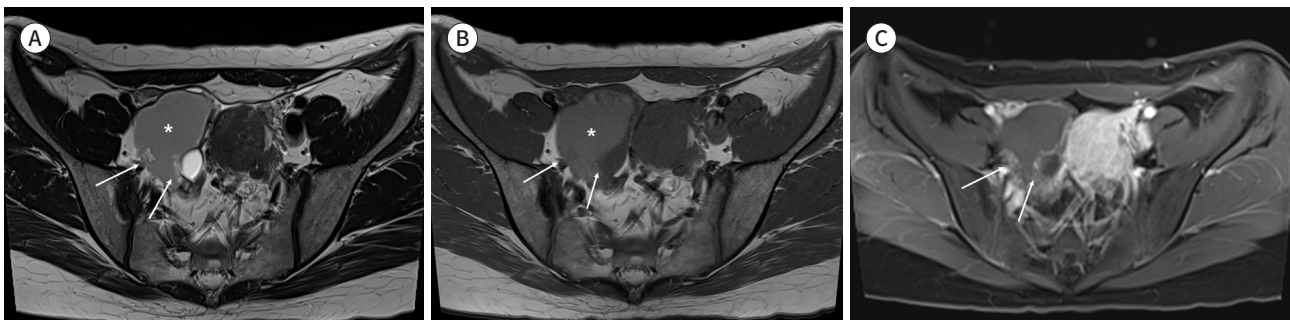
CHALLENGING CASES: ATYPICAL PRESENTATION OF ENDOMETRIOSIS

DECIDUALIZATION OF ENDOMETRIOSIS

Decidualization involves the hypertrophy of endometrial stromal cells, resulting in the formation of decidual tissue in the gravid uterus in response to progesterone to support pregnancy. Pregnant women with endometriosis undergo a similar process in the ectopic endometrial tissue. Decidualization can occur outside the uterus during pregnancy, particularly in ovarian endometriomas (50). Decidualized endometriotic cysts may present with mural nodules, with or without vascularity on US and MRI, complicating the differentiation between

Fig. 22. Seromucinous borderline tumor.

- A.** On pelvic MR of an asymptomatic 35-year-old female, the axial T2-weighted image shows a cystic mass with internal contents showing intermediate signal intensity (asterisk) and hyperintense papillary projections along the wall (arrows).
B. Axial T1-weighted image shows isointense internal content (asterisk) and hypointense papillary projections (arrows).
C. Solid papillary projections show homogeneous enhancement on fat-suppressed contrast-enhanced T1-weighted images (arrows).



malignant ovarian tumors and ovarian endometriotic cysts (19, 51). However, this condition is temporary and resolves during the follow-up. On T2-weighted images, decidualization is characterized by linear, broad-based nodular, or polypoid structures with a high signal intensity

Fig. 23. Seromucinous adenofibroma and deep infiltrating endometriosis.

A-E. A 55-year-old female with a right ovarian mass. Axial T2-weighted pelvic MR captures a multilocular cystic mass with a locule with T1 and T2 hyperintensity (arrows, **A, B**) and an internal solid component (dotted arrow, **A**) in the right adnexa, demonstrating enhancement (dotted arrow, **C**) and diffusion restriction (arrows, **D, E**). A T2 dark signal intensity mass-like lesion with internal hyperintensity foci (asterisk, **A**) is associated with adhesion bands between the right adnexa, posterior uterine body, and anterior wall of the rectum (arrowhead, **A**), consistent with deep-infiltrating endometriosis. A bilateral salpingo-oophorectomy was performed, and the patient was subsequently diagnosed with seromucinous adenofibroma and endometriosis.

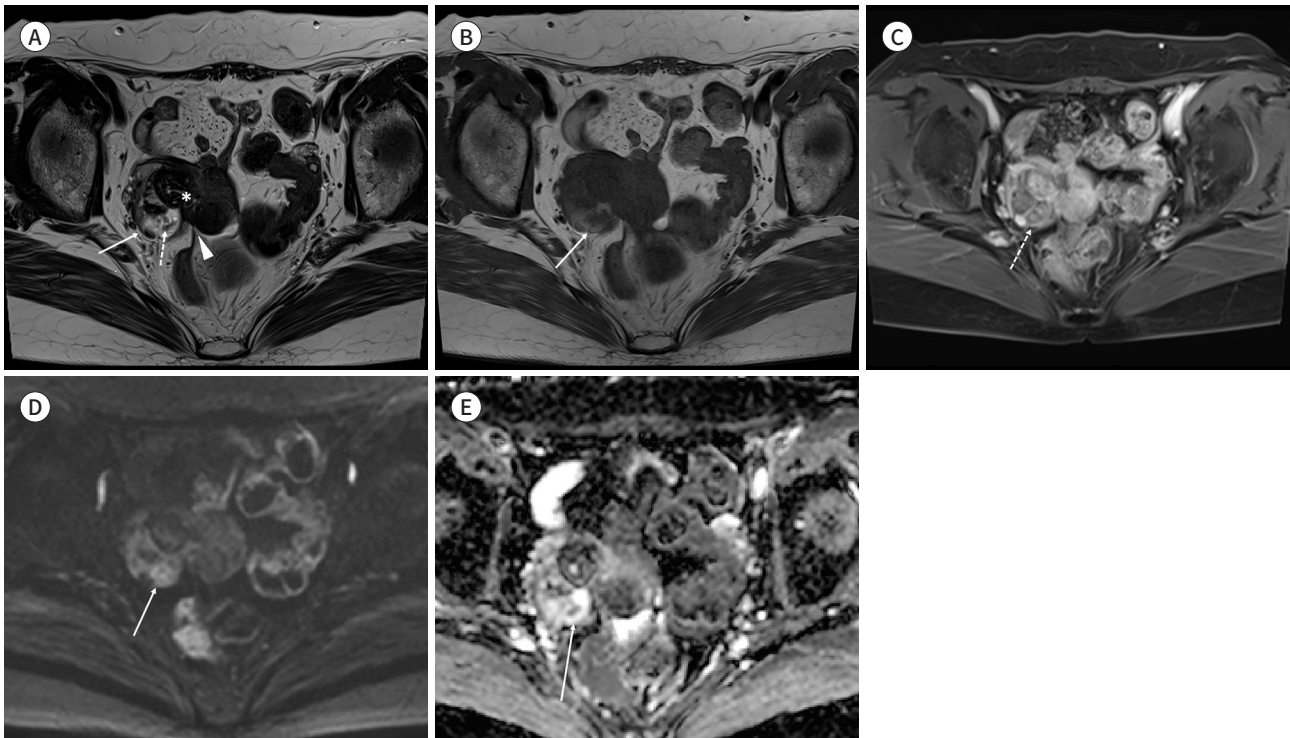
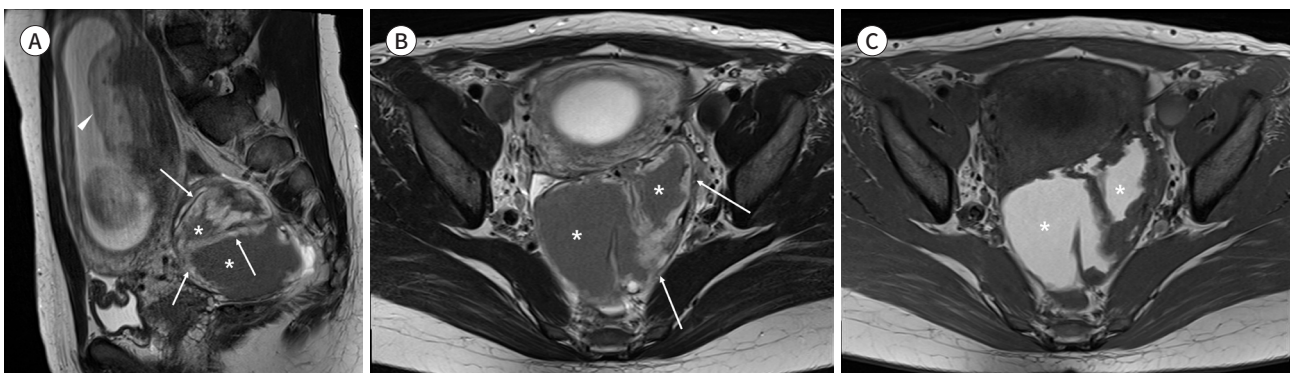


Fig. 24. Decidualization of endometrioma.

A. A 36-year-old asymptomatic female patient. A sagittal T2-weighted image showing a septated cystic mass with hypointense contents (asterisks) and a thick irregular solid component along the wall and septa (arrows) showing the same signal intensity as the placenta (arrowhead), suggestive of a decidualized endometrioma.

B. Axial T2-weighted image showing a cystic mass arising from the right ovary with hypointense internal contents (asterisks) and a thick hypointense irregular solid component along the wall and septa (arrows).

C. Axial T1-weighted image shows hyperintense internal contents of the cystic lesion (asterisks).



akin to placental tissue (Fig. 24) (19). There are several distinguishing features of decidualization in endometriosis compared to ovarian tumors. According to Morisawa et al. (52), solid components within decidualized endometriotic cysts exhibit reduced height (less than 11 mm) compared to ovarian cancers.

Furthermore, these components display high signal intensities on T2-weighted images, indicating decidualized tissues. They also exhibit high SI on DWI because of the T2 shine-through effect, and the ADC values of decidualized endometriotic cysts are higher than those of ovarian cancers. On T1-weighted images, intracystic fluid shows higher signal intensity in decidualized endometriotic cysts than in ovarian cancer (52, 53). Serious bleeding complications can occur due to pronounced vascularization in decidualized endometriotic implants. The exact cause of hemorrhage in patients with ectopic decidualosis is not well understood. It has been suggested that invasion of decidualized stroma into the vessel lumen and increased

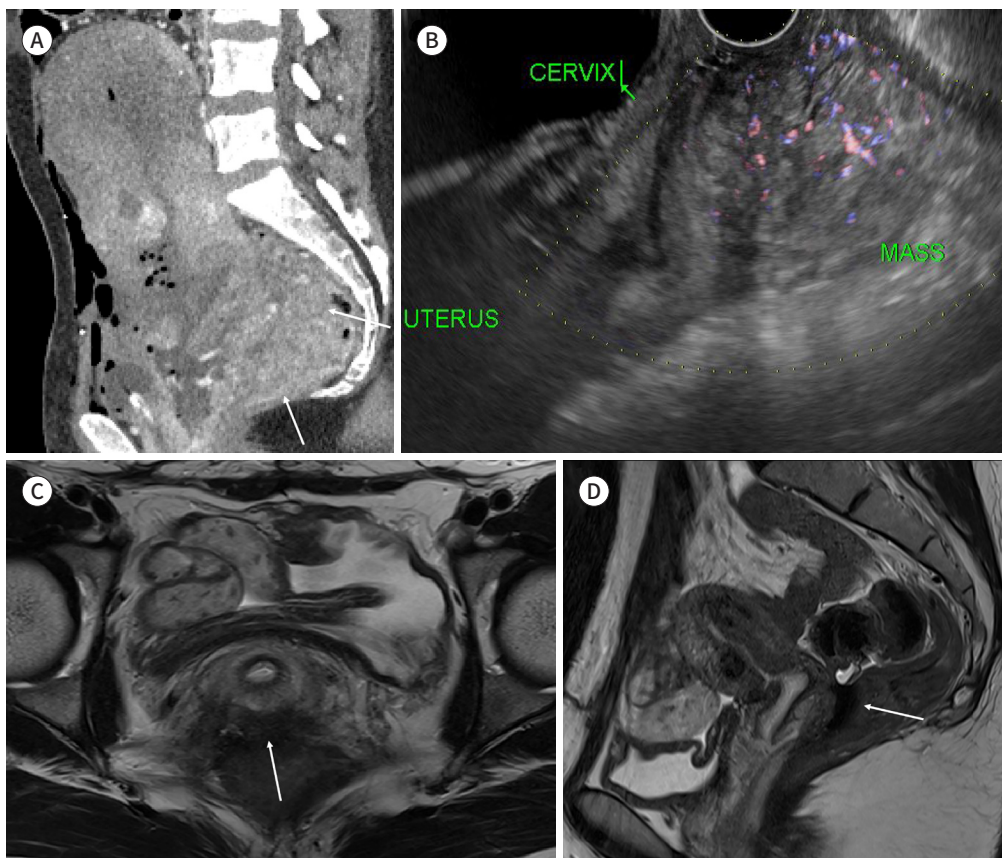
Fig. 25. Decidualization of deep infiltrating endometriosis associated with post-partum bleeding.

A 33-year-old female with vaginal bleeding after cesarean section.

A. A sagittal CT scan reveals a soft tissue lesion with indistinct margins in the rectovaginal pouch (arrows), closely abutting the posterior vaginal wall and rectum, with active bleeding from the posterior vaginal wall.

B. A vaginal biopsy confirmed endometriosis with a decidual reaction. One week after uterine artery embolization, transvaginal ultrasonography reveals a hypervascular lesion in the rectovaginal pouch.

C, D. After two months, axial and sagittal T2-weighted images display an indistinct T2 dark signal intensity lesion in the rectovaginal pouch and posterior vaginal wall (arrows) with internal T2 high foci and adhesions to the rectum, consistent with deep infiltrating endometriosis. This is a rare case of decidualization of a pre-existing deep infiltrating endometriosis involving the rectovaginal pouch, leading to post-partum bleeding. Adapted from Oh et al., *J Korean Soc Radiol* 2022;83:1121-1127 (55), licensed under CC BY-NC.



backpressure can lead to vessel rupture (54). The symptoms of DIE vary depending on the location, and rectovaginal DIE may cause significant vaginal bleeding (Fig. 25) (55).

SCAR ENDOMETRIOSIS

Endometrial implants within abdominal and pelvic wall scars are uncommon. They typically originate from gynecological procedures such as cesarean sections or hysterectomies (56). Patients with scar endometriosis often experience a palpable mass at the site of a previous surgical incision and pain that may correlate with the menstrual cycle (57). Two mechanisms have been proposed for the development of scar endometriosis. The first is the iatrogenic implantation of endometrial cells into ectopic sites during surgical procedures, where they proliferate within the surgical scar under the influence of hormones. Alternatively, primitive pluripotent

Fig. 26. Scar endometriosis.

A. A 36-year-old female with a painful mass on the right side and a history of cesarean section 5 years prior to presentation. A grayscale USG image reveals an irregularly shaped, heterogeneously hypoechoic mass with small calcifications located in the subcutaneous fat layer and the rectus abdominis muscle on the right side of the pubic area near the previous cesarean section scar.

B. Color Doppler study reveals internal and peripheral vascularity. Considering the patient's cyclic pain and clinical history, the lesion was presumed to be scar endometriosis.

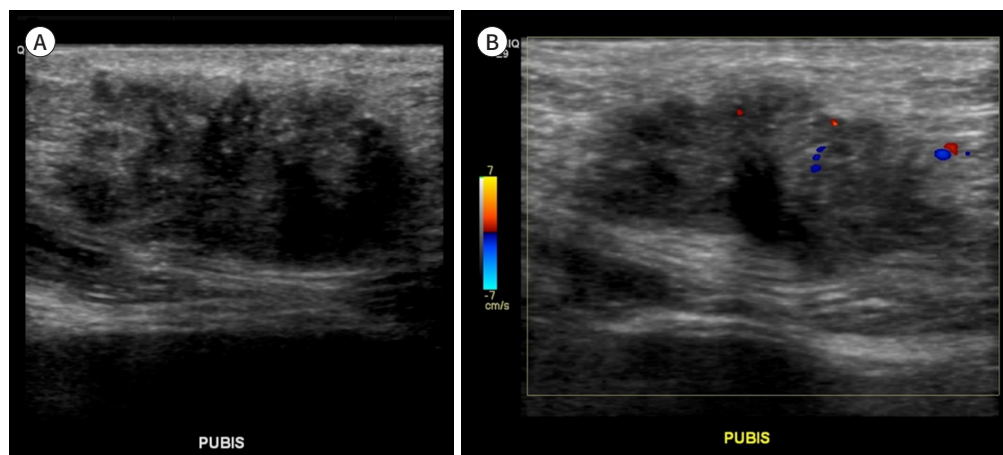


Fig. 27. Scar endometriosis.

A-D. Pelvic MR imaging in a 42-year-old female with dysmenorrhea and a history of cesarean section 3 years ago. Sagittal and axial T2-weighted images (**A, B**) show widening of the junctional zone with ill-defined T2 low signal intensity in the uterine myometrium interspersed with internal high T2 foci, suggesting adenomyosis. Additionally, the axial T2-weighted image shows a T2 low-signal-intensity nodular lesion with internal T2 high-signal-intensity foci (arrows, **B, C**) and enhancement (arrow, **D**) located in the right lower anterior abdominal wall at the site of a prior cesarean section scar (arrowheads, **C**), indicative of scar endometriosis. The abdominal wall mass was diagnosed as endometriosis following surgical excision.

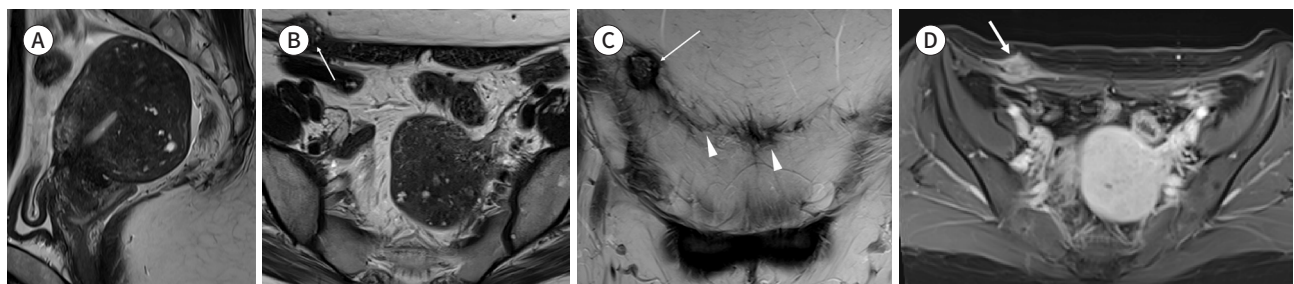
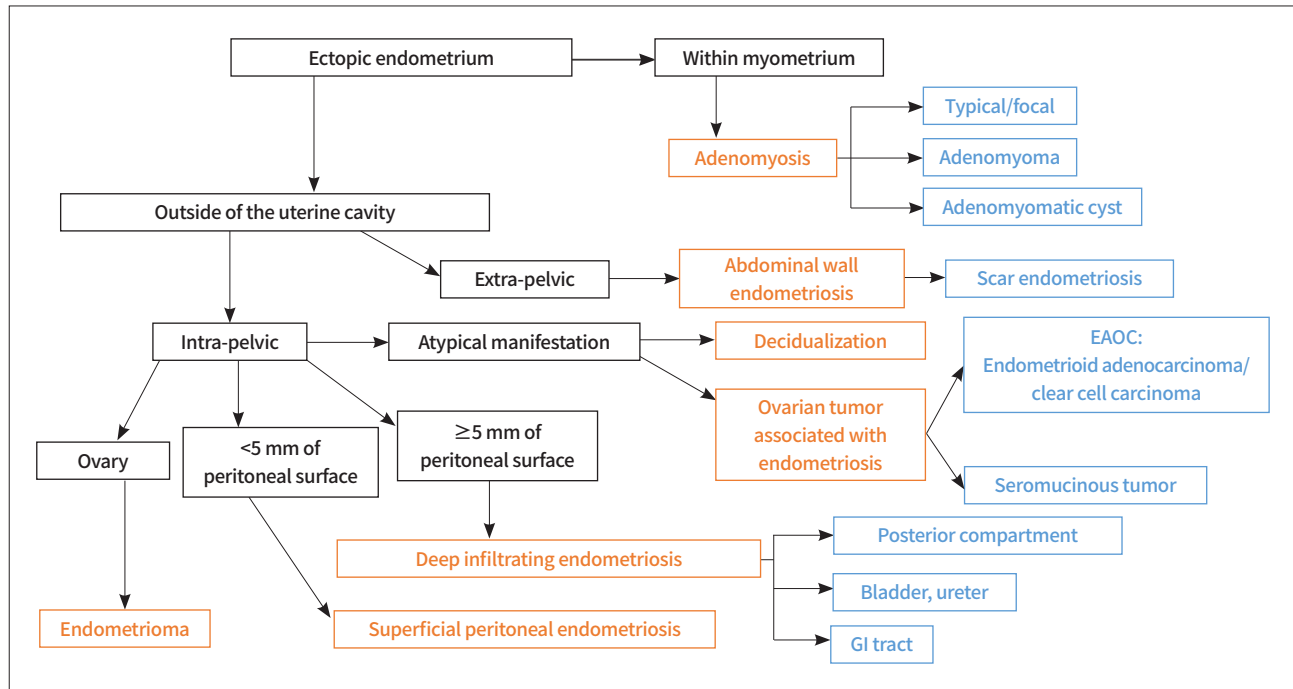


Fig. 28. Schematic overview of endometriosis manifestations.

This flowchart visually summarizes the various manifestations of endometriosis, depending on its location and atypical presentation.



EAOC = endometriosis-associated ovarian carcinoma, GI = gastrointestinal

mesenchymal cells may differentiate into endometrial tissue, leading to scar endometriosis (56). US is the primary imaging modality used to evaluate patients with abdominal pain localized at a surgical scar. Scar endometriosis typically appears as a heterogeneous hypoechoic mass with echogenic strands indicative of fibrosis and internal vascularity (Fig. 26) (57). On pelvic MR, these lesions are characterized as hypointense nodular lesions with hyperintense foci on T2-weighted images associated with abdominal or pelvic wall scarring (Fig. 27) (19).

CONCLUSIONS

Endometriosis presents clinically in a heterogeneous manner and poses diagnostic challenges. Enhancing our understanding of endometriosis through the analysis of clinical imaging findings across various conditions can facilitate more accurate diagnosis and effective management (Fig. 28).

Author Contributions

Conceptualization, K.H.J., L.E.J.; data curation, K.H.J., J.J.; formal analysis, K.H.J., H.J.; investigation, K.H.J.; methodology, C.Y.W., N.B.; resources, J.J., B.S.H.; software, H.S.S.; supervision, L.E.J.; visualization, K.H.J.; writing—original draft, K.H.J., L.E.J.; and writing—review & editing, K.H.J., L.E.J.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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영상 소견에 기반한 자궁내막증에 대한 전반적 고찰

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자궁내막증은 자궁 외부에 존재하는 자궁내막 조직을 특징으로 하는 질환으로 복잡하고 때로 비전형적인 모습을 보여 진단에 어려움이 있을 수 있다. 골반 자기공명영상은 병변의 특성화와 질병의 범위 평가에 중요한 영상 진단 기법이다. 자궁내막증이 발생할 수 있는 다양한 부위와 비전형적인 양상을 고려하여, 이와 관련된 여러 질환과 영상 소견에 대해 잘 알고 있는 것은 임상적으로 정확한 진단과 효과적인 치료 계획을 수립하는 데 도움이 된다.

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