Suspensory Ligaments of the Female Genital Organs: MRI Evaluation with Intraoperative Correlation

Kaniewska, Malwina; Gołofit, Piotr; Heubner, Martin; Maake, Caroline; Kubik-Huch, Rahel A

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SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- Identify the anatomy of the suspensory ligaments of the female genital organs on MR images.
- Describe the compartmental nature of the female pelvis by using MR images.
- Discuss common pathologic conditions that can affect the suspensory ligaments of the female genital organs as well as the pelvic spaces.

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The uterus, which plays an important role in the reproductive process, provides a home for the developing fetus and so must be in a stable, though flexible, location. Various structures with suspensory ligaments help provide this berth. MRI with high spatial resolution allows us to detect and evaluate these relatively fine structures. Under physiologic conditions, MRI can be used to depict uterine and ovarian ligaments (ie, the uterosacral, cardinal, and round ligaments, as well as the suspensory ligament of the ovary). In the presence of pathologic conditions (inflammation, endometriosis, tumors), the suspensory ligaments may appear thickened or invaded, which makes their delineation easier. Understanding the normal anatomy of the suspensory ligaments of the female genital organs and using a standardized nomenclature are essential for identifying and reporting related pathologic conditions. The female pelvic anatomy and the suspensory ligaments of the female genital organs are described as depicted with MRI. Also, the compartmental anatomy of the female pelvis is explained, including the extraperitoneal pelvic spaces. Finally, a checklist is provided for structured reporting of the MRI findings in the female pelvis.

Online supplemental material is available for this article.

Introduction

In the pelvis, the female genital organs are suspended by various structures that can usually be depicted on MR images obtained with high spatial resolution (1). MRI is the modality of choice for evaluating the anatomy and pathologic conditions of the female genital organs. Technical advances and the excellent resolution and soft-tissue depiction offered by MRI allow identification of such fine structures as the uterine and ovarian suspensory ligaments. Thin-section CT also allows depiction of the normal ligamentous anatomy of the female pelvis, but CT is associated with radiation exposure (2). Transabdominal US plays a role in the imaging of the pelvic spaces, although MRI is clearly superior.

Pathologic processes (ie, endometriosis, inflammation, tumors) may involve ligamentous structures, so it is necessary to recognize their normal appearance at MRI. A standard MRI protocol for exploring the female pelvis includes high-resolution T2-weighted sequences (sagittal plus axial and/or coronal and/or oblique) and T1-weighted axial sequences.

TEACHING POINTS

- Under physiologic conditions, the uterine and ovarian suspensory ligaments are generally detectable on MR images, including the uterosacral ligament, the cardinal ligament, the broad ligament, the round ligament, and the suspensory ligament of the ovary.
- In the case of endometriosis with deep retroperitoneal lesions, the uterosacral ligaments are important sites that should be evaluated carefully. On T2-weighted MR images, even discrete hypointense thickening of the proximal attachment of the uterosacral ligament (torus uterinus) may indicate the presence of endometriosis.
- It is important to evaluate the cardinal ligament and parametrial invasion with MRI in cases of cervical cancer because MRI is more accurate in the assessment of parametrial invasion than the findings at physical examination, especially when the latter findings are negative for parametrial invasion. Invasion of the cardinal ligament results in upstaging the malignancy to International Federation of Gynecology and Obstetrics (FIGO) stage IIB or higher, which may affect the oncologic treatment strategy.
- The ovarian suspensory ligament is a good anatomic landmark for localizing the ovary and particularly for differentiating between intra- and extraovarian pathologic conditions. When a pelvic mass leads to or shows direct connection with this suspensory ligament, an ovarian origin can be suspected. In cases of large pelvic tumors or lesions arising from the fallopian tubes, however, depicting the ovarian suspensory ligament with MRI or CT remains challenging. In addition, after hysterectomy without adnexectomy, the ovaries often change locations.
- Because of the deep location of the rectouterine space, metastases of the peritoneum may seed there, especially metastases from ovarian and colon carcinomas. MRI allows complete depiction of the rectouterine space, with further characterization of the lesions. The radiologist should evaluate this region carefully and report any tumor extension.

Under physiologic conditions, the uterine and ovarian suspensory ligaments are generally detectable on MR images, including the uterosacral ligament, the cardinal ligament, the broad ligament, the round ligament, and the suspensory ligament of the ovary. In this article, the suspensory ligaments of the female genital organs are described as depicted with MRI, together with the compartmental anatomy of the female pelvis, including the extraperitoneal pelvic spaces.

Suspensory Ligaments of the Female Genital Organs

The uterus and adnexa are held in place by ligamentous structures, fixing the female reproductive organs to the pelvic wall. Together with the pelvic floor muscles, the uterosacral, cardinal, broad, round, and pubocervical ligaments support the uterus, cervix, vagina, and parts of the fallopian tubes. The suspensory ovarian and utero-ovarian ligaments attach the ovary to the lateral pelvic wall and the uterus, respectively (Fig 1). The pubovesical ligament stabilizes the position of the bladder in the pelvis. The broad ligament, utero-ovarian ligament, and ovarian suspensory ligament contain the main vessels of the female reproductive tract, whereas the uterosacral and cardinal ligaments are basically confined to mechanical functions. The Table (3) offers an overview of the anatomic and clinical terms for the uteropelvic ligaments. All of the MR images in this article have been acquired by using a high-resolution MRI protocol for the female pelvis, as described in Table E1.

The cardinal and uterosacral ligaments, which support the uterus and upper part of the vagina, are critical structures in the female pelvis (3,4). These ligaments also play a crucial role in pelvic organ prolapse with anterior vaginal wall descent (5).

Uterosacral Ligament

The uterosacral ligament is a complex structure composed of a superficial part (smooth muscle and connective and adipose tissue) and a deep part comprising nerve fibers (hypogastric nerve, inferior hypogastric plexus) and vessels (6–8). The uterosacral ligament is attached proximally by the torus uterinus to the lateral aspect of the cervix and the upper part of the vagina and distally to the coccygeus muscle, sacrospinous ligament, ischial spine, and presacral fascia, between the S2 and S4 vertebrae (Fig 1) (3,8). No direct connection exists between the uterosacral ligament and the sacral bone—only a connection to presacral tissues (9). The S2 to S4 nerve roots cross under the uterosacral ligaments, and thus an impending risk of sacral nerve entrapment exists, especially in the case of uterosacral ligament suspension (10). The uterosacral ligaments, located lateral to the rectum and medial to the ureters, provide the lateral boundaries of the rectouterine and rectovaginal spaces (Fig 2).

Figure 3 shows the uterosacral ligament and the round ligament. In most cases, knowing the anatomy and the insertional points of the uterosacral ligament is enough to allow its proper identification at MRI (11). T2-weighted sagittal and coronal MR images are the best images on which to evaluate the uterosacral ligaments. Scrolling among MR images enables the assessment of the uterosacral ligaments (Fig 4; Movies 1, 2).

In the case of endometriosis with deep retroperitoneal lesions, the uterosacral ligaments are important sites that should be evaluated carefully. On T2-weighted MR images, even discrete hypointense thickening of the proximal attachment of the uterosacral ligament (torus uterinus) may indicate the presence of endometriosis (12) (Figs 5, 6).

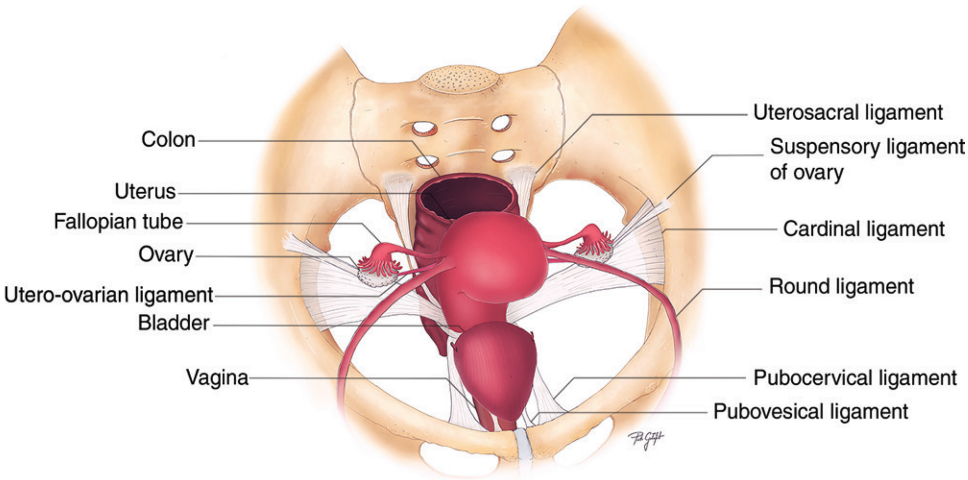


Figure 1. Female pelvis. Anatomic drawing shows a superoanterior view of the female pelvis. The ureters have been coronally sectioned, and the peritoneum has been removed. The colon has been sectioned transversely. The pelvic floor has been removed.

Anatomic and Clinical Terms for the Uteropelvic Ligaments

Uteropelvic Ligament	Anatomic Terms	Unofficial Terms
Uterosacral ligament	Uterosacral ligament Rectouterine ligament	Sacrouterine ligament Posterior parametrium
Broad ligament with three components: Mesometrium Mesosalpinx Mesovarium	Ligamentum latum uteri	...
Cardinal ligament	Parametrium Paracervix	Cardinal ligament Lateral parametrium Mackenrodt ligament Transverse cervical ligament Retinaculum uteri The web
Round ligament	Ligamentum teres uteri Round ligament of the uterus	Hunter ligament
Suspensory ligament of the ovary	Suspensory ligament of the ovary Ligamentum suspensorium ovarii	...

Source.—Reference 3.

Cardinal Ligament

The cardinal ligament, which forms at the base of the broad ligament, is covered by visceral pelvic fascia (3,13). The cardinal ligament is composed of *(a)* a vascular (ventral) part, including the internal iliac artery, the uterine artery and vein, vaginal and vesical arteries, smooth muscle, connective and adipose tissue, and lymph nodes; and *(b)* a neural (dorsal) part, including nerve fibers (hypogastric nerve and inferior hypogastric plexus) and vessels (14,15). The ureters traverse the cardinal ligament at the point where the ligament passes under the uterine vessels (16) (Fig 7).

The part of the cardinal ligament above the ureter (cranial portion of the cardinal ligament) is known as the parametrium, and the part below the ureter is known as the paracervix (caudal portion of the cardinal ligament). The cardinal ligament can be described as connective tissue surrounding blood vessels near the internal iliac arteries and the pelvic side wall laterally, and then coursing medially to the cervix and the upper part of the vagina (16,17) (Fig 7).

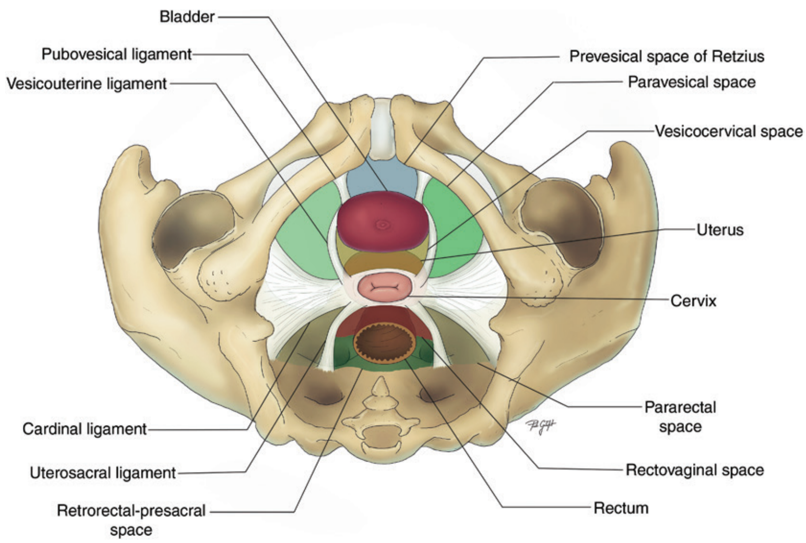


Figure 2. Pelvic spaces. Anatomic drawing shows a view of the pelvic spaces from below. The pelvic floor has been removed.

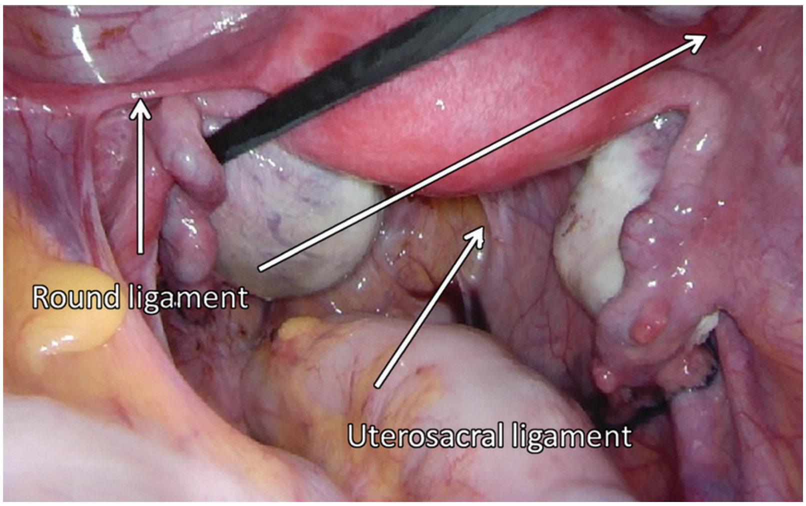


Figure 3. Uterosacral and round ligaments. Intraoperative photograph shows the uterosacral ligament and the round ligament.

The cardinal ligament is best depicted on coronal T2-weighted MR images. Because of the ligament's complex structure (containing vessels, nerve fibers, and adipose tissue), however, it is difficult to differentiate the parametrium from the paracervix radiologically (1,18) (Fig 8; Movies 3, 4). T2-weighted MR images show dot-shaped structures with low T2 signal intensity within the cardinal ligament that are consistent with vessels, whereas areas with high T2 signal intensity are consistent with connective and adipose tissues.

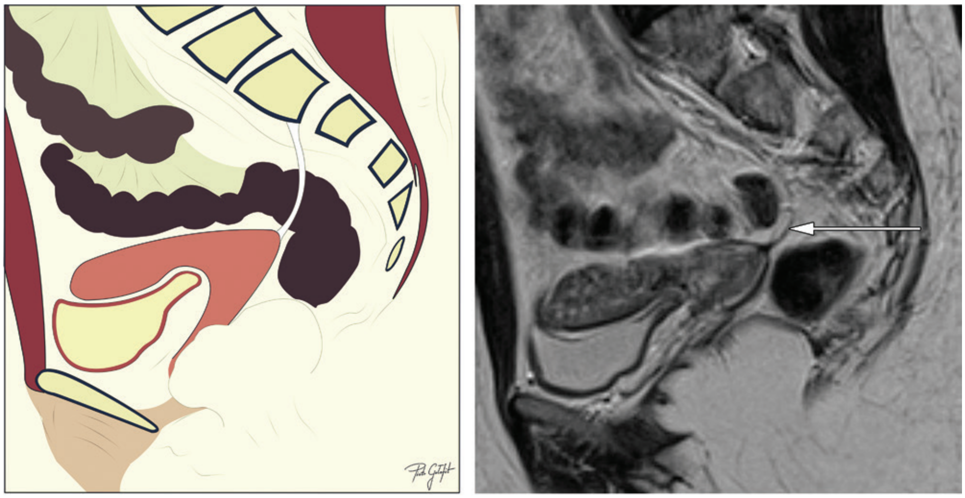
It is important to evaluate the cardinal ligament and parametrial invasion with MRI in cases of cervical cancer because MRI is more accurate in the assessment of parametrial invasion than the findings at physical examination, especially when the latter findings are negative for parametrial invasion (19). Invasion of the cardinal ligament results in upstaging the malignancy to International Federation of Gynecology and Obstetrics (FIGO) stage IIB or higher, which may affect the oncologic treatment strategy (19,20). Examples of cervical cancer with invasion of the cardinal ligament are shown in Figures 9–11.

Figure 12 shows the intraoperative appearance of the cardinal ligament in the pararectal and paravesical spaces, with uterine vessels that include lymphatic vessels.

Broad Ligament

The broad ligament, composed of a double layer of peritoneum, suspends the female reproductive organs and is connected to the extraperitoneal space (21,22). The broad ligament extends bilaterally between the lateral borders of the uterus and the pelvic walls anteriorly, and posteriorly it covers the surfaces of the uterus and fallopian tubes (21).

Anatomically, the broad ligament is divided into three segments: *(a)* the mesometrium—the largest part, which provides lateral support to the uterus and enables some uterine mobility (eg, during urinary bladder filling); *(b)* the mesosalpinx—the cranial part of the broad ligament,



a. b.

Figure 4. Uterosacral ligament. Anatomic drawing in the sagittal plane **(a)** and sagittal T2-weighted MR image **(b)** show the normal position of the uterosacral ligament (arrow on **b**).

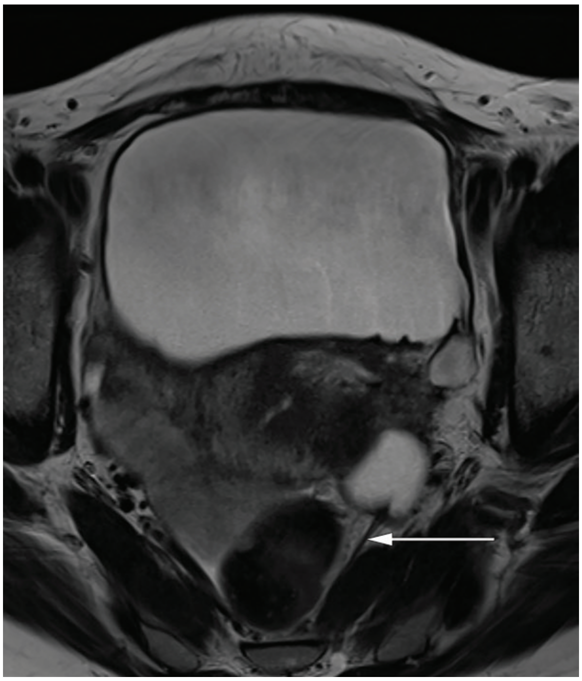


Figure 5. Endometriosis in a 35-year-old woman. Axial T2-weighted MR image shows thickening of the proximal part of the uterosacral ligament (arrow) caused by endometriosis.

Figure 6. Endometriosis with infiltration of the torus uterinus (proximal attachment of the uterosacral ligament) in a 40-year-old woman. Sagittal T2-weighted MR image shows infiltration of the torus uterinus (arrow).

which provides support to the fallopian tubes; and *(c)* the mesovarium—the most posterior part of the broad ligament, which forms the mesentery for the ovaries (21) (Figs 13, 14).

The broad ligament encompasses the fallopian tubes with their blood vessels, the round ligament and ligamentum ovarii proprium (the latter not demonstrated at MRI), uterine and some ovarian blood vessels, lymphatic vessels, and nerves to the pelvic organs. These structures course within the broad ligament and are thus located extraperitoneally (22), which allows lesions to spread easily among compartments. Hence, radiologists should be aware of this pathway for the spread of disease. Inflammation can advance via the broad ligament to the sigmoid mesocolon and/or from the base of the cecum or the right inferolateral termination of the small bowel mesentery (23). In rare cases, when there is a defect in the broad ligament, intestinal obstruction could result from an internal hernia (which can be diagnosed with CT or MRI) (24,25).

The broad ligament is normally not easily demonstrated on MR images unless it is surrounded by ascites (2,26). Knowing which

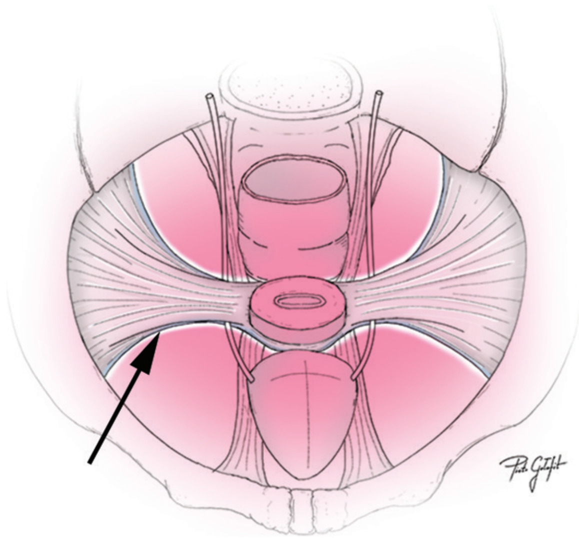
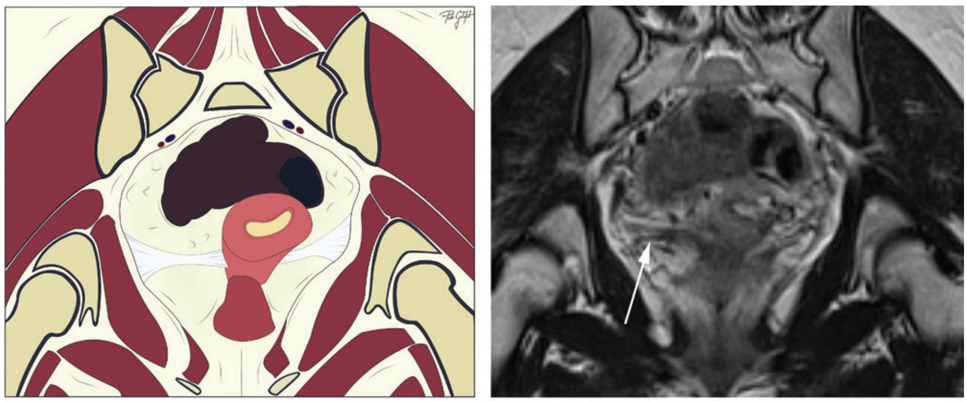


Figure 7. Cardinal ligament. Anatomic drawing shows the cardinal ligament (arrow), as well as the correlation between the cardinal ligament and the ureter. The part of the cardinal ligament above the ureter is known as the parametrium, and the part below the ureter is known as the paracervix.



a. b.

Figure 8. Cardinal ligament. Anatomic drawing in the coronal plane **(a)** and coronal T2-weighted MR image **(b)** show the normal position of the cardinal ligament (arrow on **b**).

structures are contained within it, however, helps identify the broad ligament even without the presence of pathologic conditions (Figs 13–15; Movies 5, 6).

Round Ligament

The round ligament, composed of fibromuscular tissue, attaches to the anterolateral uterine fundus below the fallopian tubes. It is covered proximally by the broad ligament and then courses through the inguinal canal and terminates in the labium majorum (27,28) (Fig 16).

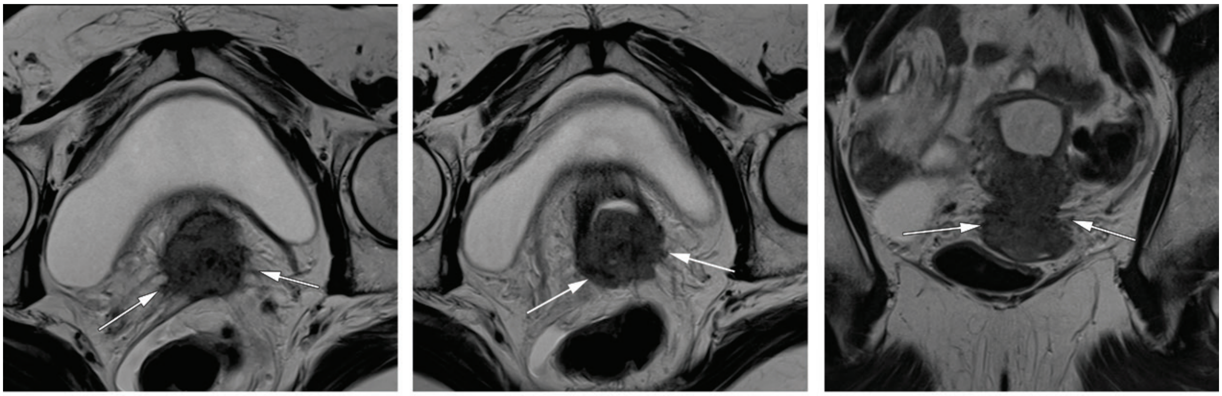
The round ligament is responsible for maintaining the anteflexed position of the uterus in the pelvis, providing little support to the genital organs (27). Pain along the course of the round ligament may occur during pregnancy because these structures are stretched during fetal growth.

The round ligament can be identified as a thin fibrous structure with low signal intensity on axial T2-weighted MR images. The ligament courses anteromedially to the external iliac vessels (Fig 17, Movie 7). Careful scrolling between sagittal T2-weighted MR images enables depiction of the round ligament (Movie 8).

Round ligaments are affected in up to 14% of patients with endometriosis, underlining the importance of systematic radiologic assessment of these ligaments (29). Endometriosis may cause the round ligament to be thickened and have irregular contours and nodular changes (Fig 18). Because of the hemorrhagic component of endometriosis, the round ligament may demonstrate high signal intensity on T1-weighted MR images with and without fat suppression, although when the round ligament is purely fibrotic, it may also show low signal intensity on T1- and T2-weighted MR images (30,31).

Suspensory Ligament of the Ovary

The suspensory ligament of the ovary, also known as the infundibulopelvic ligament, is a thin fold of peritoneum connecting the lateral margin of the ovary to the lateral pelvic wall



a. b. c.

Figure 9. Cervical cancer with bilateral infiltration of the cardinal ligament (parametrium and paracervix) in a 57-year-old woman. It is difficult to distinguish the parametrium and paracervix with MRI. **(a)** Axial T2-weighted MR image shows bilateral infiltration of the cranial portion of the cardinal ligament (arrows). **(b)** Axial T2-weighted MR image shows bilateral infiltration of the caudal portion of the cardinal ligament (arrows). **(c)** Coronal T2-weighted MR image shows bilateral infiltration of the cardinal ligament (arrows).

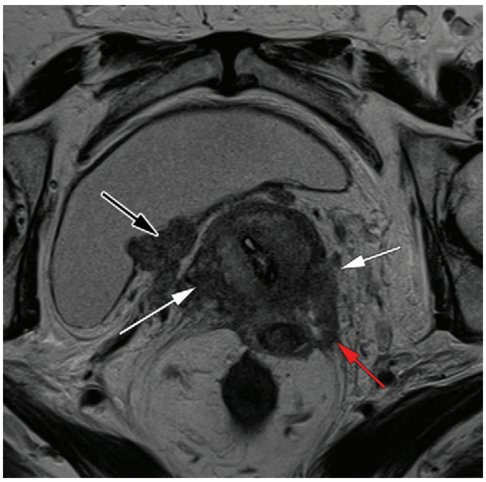


Figure 10. Cervical cancer with bilateral infiltration of the cardinal ligament in a 51-year-old woman. Axial T2-weighted MR image shows bilateral infiltration of the cardinal ligament (white arrows), infiltration of the left uterosacral ligament (red arrow), and infiltration of the urinary bladder (black arrow).

(32,33) (Figs 19–21). The suspensory ligament of the ovary provides the superior border of the broad ligament and, as its name indicates, suspends the ovary in the pelvis. The ovarian suspensory ligament contains an ovarian artery and vein, the ovarian nerve plexus, and lymphatic vessels (34). This ligament is identified on axial and sagittal T2-weighted MR images as a narrow soft-tissue band extending from the ovary along the direction of the external or common iliac vessels (26). Tracking the course of the ovarian artery downward from the retroperitoneum to the ovary may help in the detection of the ovarian suspensory ligament.

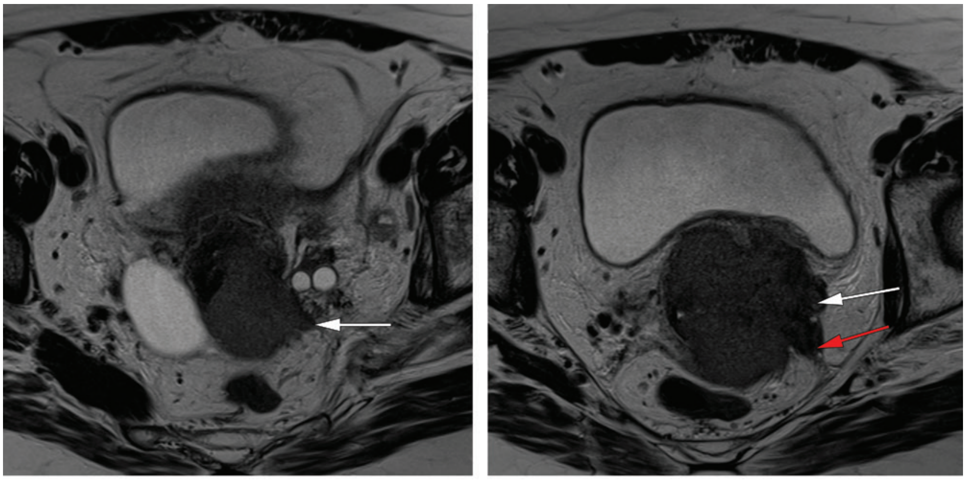
The ovarian suspensory ligament is a good anatomic landmark for localizing the ovary and particularly for differentiating between intra- and extraovarian pathologic conditions (26,34) (Fig 22). When a pelvic mass leads to or shows direct connection with this suspensory ligament, an ovarian origin can be suspected (26). In cases of large pelvic tumors or lesions arising from the fallopian tubes, however, depicting the ovarian suspensory ligament with MRI or CT remains challenging. In addition, after hysterectomy without adnexectomy, the ovaries often change locations. Probably owing to the fine structure of the suspensory ligament of the ovary and the challenges with its delineation at MRI examinations, most radiologists prefer to describe masses of ovarian origin by referring to the neighboring vessels.

Pelvic Spaces

The female pelvis can be divided into intraperitoneal and extraperitoneal compartments, with the adnexa, small intestine, sigmoid colon, and upper rectum located intraperitoneally and with the pelvic spaces located extraperitoneally (35,36).

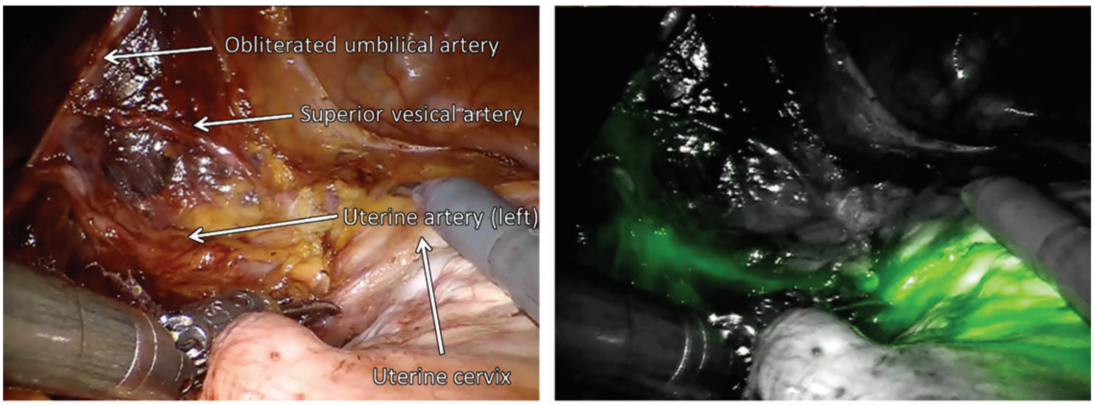
The extraperitoneal compartment contains the prevesical space of Retzius; the vesicocervical, vesicovaginal, and vesicouterine spaces; the rectovaginal and rectouterine spaces; and the presacral-retrorectal space. The urinary bladder, cervix, vagina, and lower part of the rectum are also located extraperitoneally.

To determine the cause of a pelvic fluid collection and the possible pathway of disease spread, it is important to understand the compartmental anatomy of the female pelvis and its communication pathways. Various retroperitoneal processes (eg, pancreatitis, retroperitoneal injury, and infection) can lead to the development of fluid collections, both retroperitoneally and extraperitoneally (37). The anatomy of the pelvic extraperitoneal spaces, however, has been studied less than that



a. b.

Figure 11. Cervical cancer with infiltration of the cardinal and uterosacral ligaments in a 62-year-old woman. **(a)** Axial T2-weighted MR image shows left-sided infiltration of the cranial portion of the cardinal ligament (arrow). **(b)** Axial T2-weighted MR image shows left-sided infiltration of the caudal portion of the cardinal ligament (white arrow) and the uterosacral ligament (red arrow).



a. b.

Figure 12. Normal appearance of the cardinal ligament. **(a)** Intraoperative photograph shows the exposed cardinal ligament with the uterine vessels, including lymphatic vessels. **(b)** Intraoperative photograph obtained after administration of indocyanine green dye shows that the cardinal ligament is clearly depicted, along with uterine and lymphatic vessels.

of the abdominal retroperitoneum (35,36,38,39). It is important to understand the meaning of anatomic terms used to describe the pelvic spaces. For instance, the term *space* (Latin, *spatium*) implies an extraperitoneal location, and an *excavation* (Latin, *excavation*) is per se situated intraperitoneally.

Some of the ligaments of the female pelvis are natural borders within the extraperitoneal pelvic spaces: The pubovesical ligament provides the lateral margins of the prevesical space of Retzius and separates it from the paravesical space. The vesicouterine ligament provides a lateral border for the vesicocervical and vesicovaginal spaces and is the medial border of the paravesical space. The cardinal ligament separates the paravesical space from the pararectal space, and the uterosacral ligament provides lateral margins for the rectovaginal and retrorectal spaces (40,41) (Fig 2). Although the vesicouterine and pubovesical ligaments are not identifiable with MRI, the vesicocervical, vesicovaginal, and prevesical spaces can be easily depicted.

The various spaces that one should pay attention to are the prevesical space of Retzius, the vesicocervical and vesicovaginal spaces, the vesicouterine space (anterior cul-de-sac), the rectovaginal space, the rectouterine space (pouch of Douglas, posterior cul-de-sac), the pararectal space, and the retrorectal-presacral space.

We believe that understanding the compartmental structure of the female pelvis and the evaluation of these pelvic spaces by radiologists can lead to more accurate diagnosis of extraperitoneal processes, thereby resulting in more precise treatment and interventions.

Prevesical Space of Retzius

The space of Retzius, defined by Retzius in 1858, is a prevesical space that is separated from the an-

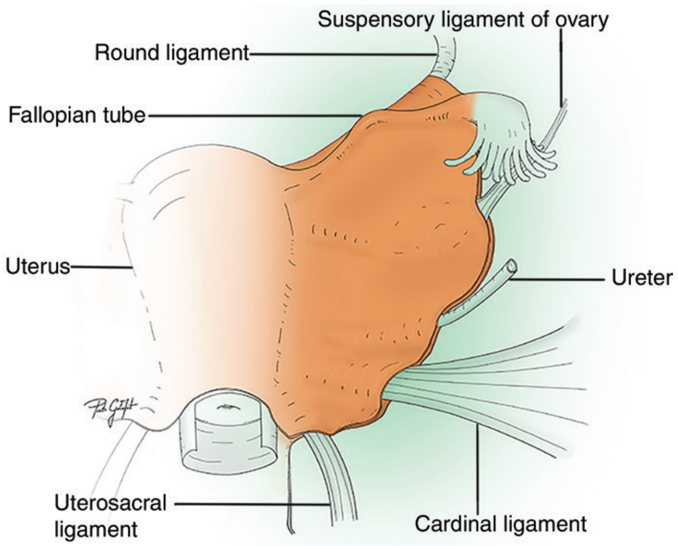


Figure 13. Broad ligament. Anatomic drawing shows the broad ligament in the coronal view.

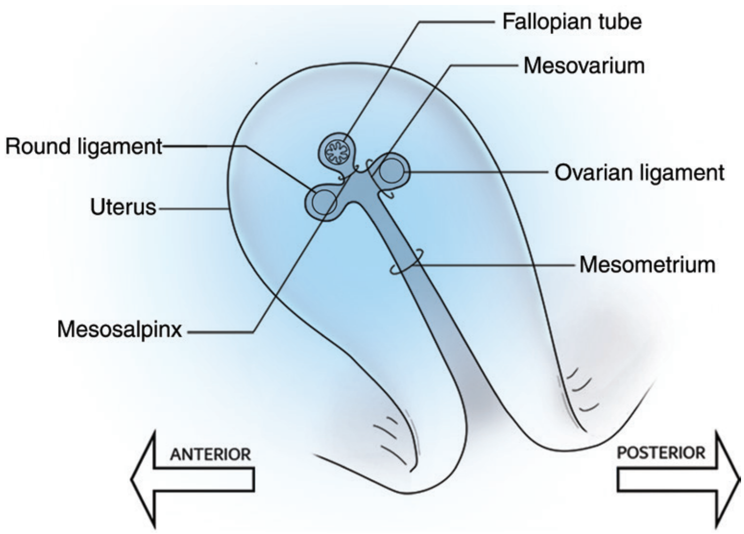


Figure 14. Broad ligament. Anatomic drawing of the broad ligament in the parasagittal view shows the part of the broad ligament adjacent to the uterus.

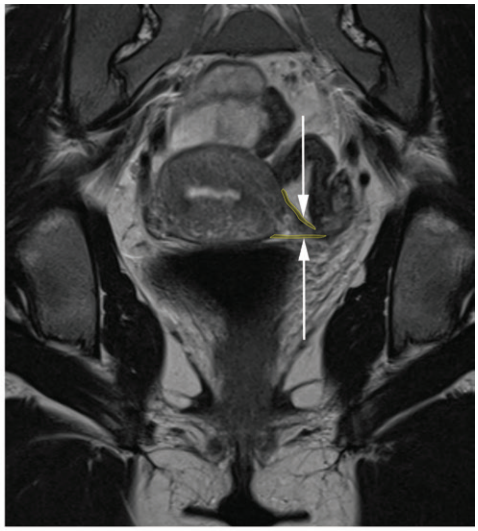
terior abdominal wall by the fascia transversalis. The space of Retzius extends from the umbilicus to the pelvis (36,42).

The prevesical space of Retzius is part of the extraperitoneal compartment located ventral to the urinary bladder, limited anteriorly by the pubic symphysis and laterally by the pubovesical ligaments (42). This space, which contains adipose and connective tissue and lies near the obturator vessels (43,44), plays an important role in various surgical procedures. In male patients, preservation of this space after robot-assisted radical prostatectomy has been shown to be associated with a lower incidence of postoperative inguinal hernia (45).

The prevesical space of Retzius can be identified with MRI in the axial and sagittal planes (Figs 23, 24; Movies 9, 10). In case reports describing malpositioning of various catheters in the space of Retzius, investigators have emphasized that knowledge of the normal anatomy and the radiologic appearance of this compartment is of utmost importance for radiologists and surgeons (44). Moreover, the prevesical space of Retzius communicates with the posterior pararenal space around the abdominal wall and flanks and so is a potential pathway for the spread of disease, such as pyelonephritis (35). Hematomas may occur in the prevesical space after cesarean delivery or urogynecologic procedures (eg, placement of tension-free vaginal tapes for urethral suspension).

The paravesical space (Fig 2) is located between the pubovesical, vesicouterine, and cardinal ligaments and is limited laterally by the pelvic wall. The connections among the prevesical, paravesical, and presacral spaces have been revealed in the findings from anatomic cadaver studies (35,36). Under physiologic conditions with no fluid collection, however, the paravesical space cannot be depicted by using MRI.

a.



b.

Figure 15. Broad ligament. **(a)** Anatomic drawing in the coronal plane shows the broad ligament. **(b)** Coronal T2-weighted MR image shows the broad ligament outlined in yellow (arrows). Distinguishing between the cardinal ligament and the broad ligament is difficult by using MRI.

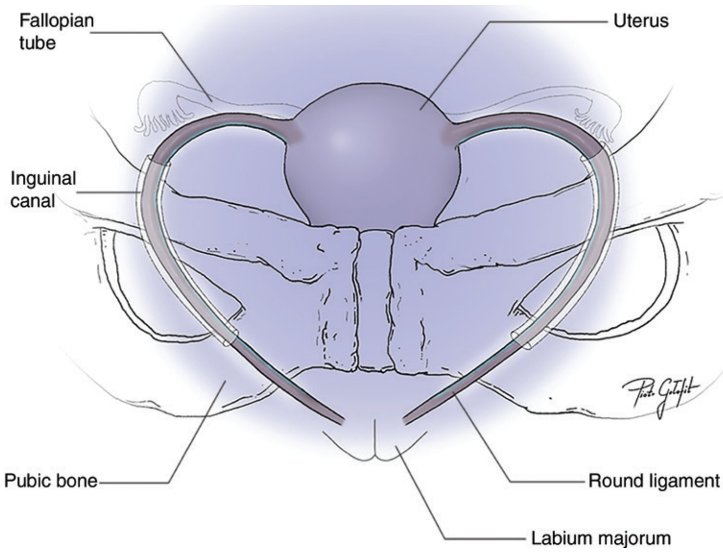


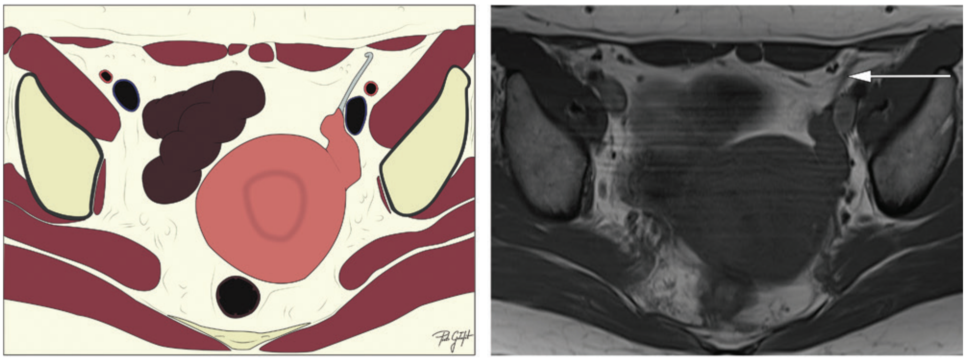
Figure 16. Round ligament. Anatomic drawing shows the round ligament in the coronal view.

Vesicocervical and Vesicovaginal Spaces

The vesicocervical and vesicovaginal spaces lie between the urinary bladder and the cervix and the upper vagina, respectively. These spaces can be evaluated on axial and sagittal MR images, where they appear as areas of fatty tissue displaying high signal intensity on both T1- and T2-weighted images (Movies 11, 12).

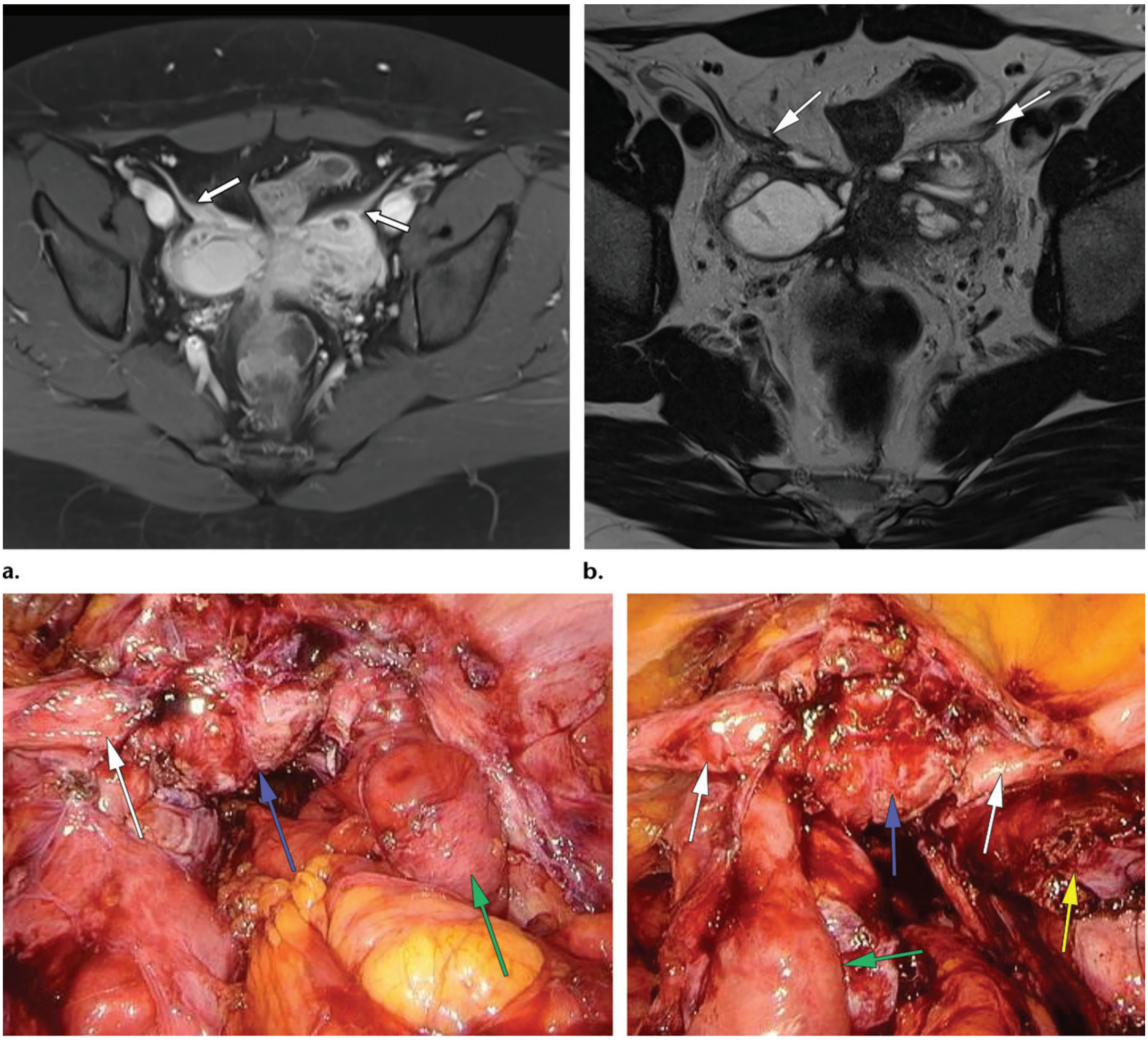
The vesicovaginal space is triangular, with its apex at the dorsal part of the bladder trigone and its lateral margins formed by the vesicouterine ligaments. When addressing pelvic organ prolapse, the urogynecologist must be familiar with the anatomy of the vesicovaginal space (46). Nowadays, multidisciplinary teams of clinicians and radiologists work together, so radiologists should be acquainted with the anatomy of these spaces. Unfortunately, for some diseases, such as advanced cervical carcinoma, complete MRI assessment of the vesicovaginal space is difficult, and laparoscopic surgical staging is preferred (47).

Radiologic and surgical identification of the vesicocervical space can be challenging in patients with a history of cesarean delivery and subsequent adhesions in the vesicocervical space (48). Because solid adhesions in the vesicocervical space are a significant risk factor for bladder injury during hysterectomy, this space should be carefully evaluated by a radiologist before surgery (49).



a. b.

Figure 17. Round ligament. Anatomic drawing in the axial plane **(a)** and axial T2-weighted MR image **(b)** show the round ligament (arrow on **b**).



a. b. c. d.

Figure 18. Endometriosis with bilateral infiltration of the round ligaments in a 27-year-old woman. **(a, b)** Axial fat-saturated T1-weighted MR image obtained after administration of a gadolinium-based contrast material **(a)** and axial T2-weighted MR image **(b)** show bilateral infiltration of the round ligaments (arrows). **(c)** Laparoscopic view from above shows the left round ligament (white arrow), the uterus (blue arrow), and the right fallopian tube with fimbriae obliterated by adhesions (green arrow). **(d)** Laparoscopic view from above shows the round ligaments (white arrows), the uterus (blue arrow), the edematous left fallopian tube (green arrow), and the right ovary after cyst enucleation (yellow arrow).

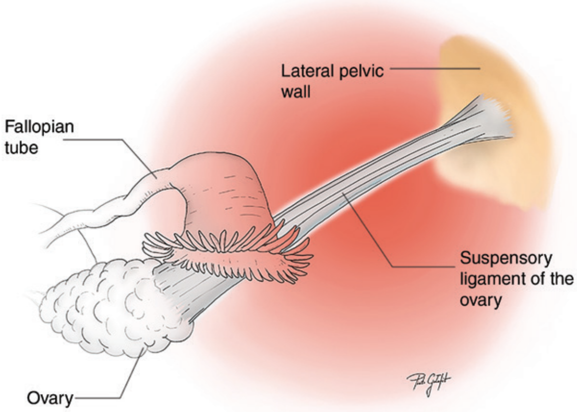


Figure 19. Suspensory ligament of the ovary. Anatomic drawing shows the suspensory ligament of the ovary.

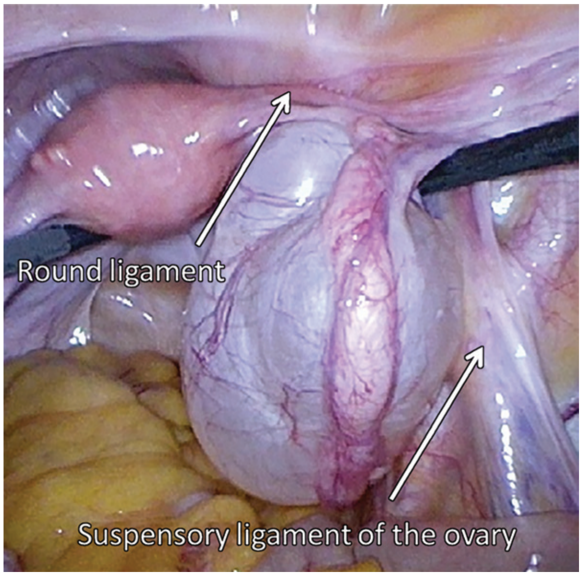


Figure 20. Suspensory ligament of the ovary. Intraoperative photograph shows the suspensory ligament of the ovary and also the round ligament.

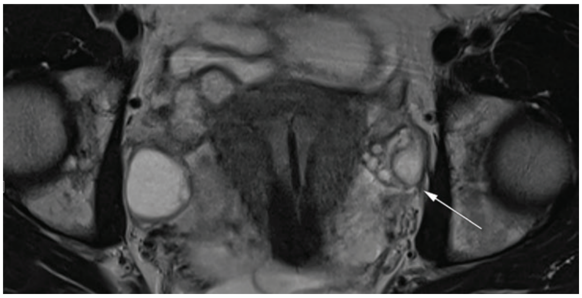


Figure 21. Suspensory ligament of the ovary. Axial T2-weighted MR image shows the suspensory ligament of the ovary (arrow). An intrauterine device is depicted in the uterus.

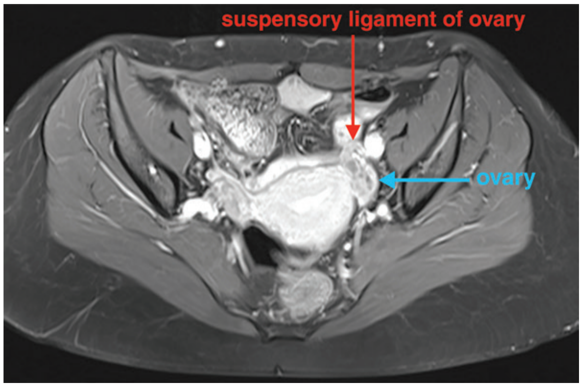


Figure 22. Suspensory ligament of the ovary. Axial contrast material–enhanced T1-weighted fat-saturated MR image shows the suspensory ligament of the ovary and the ovary.

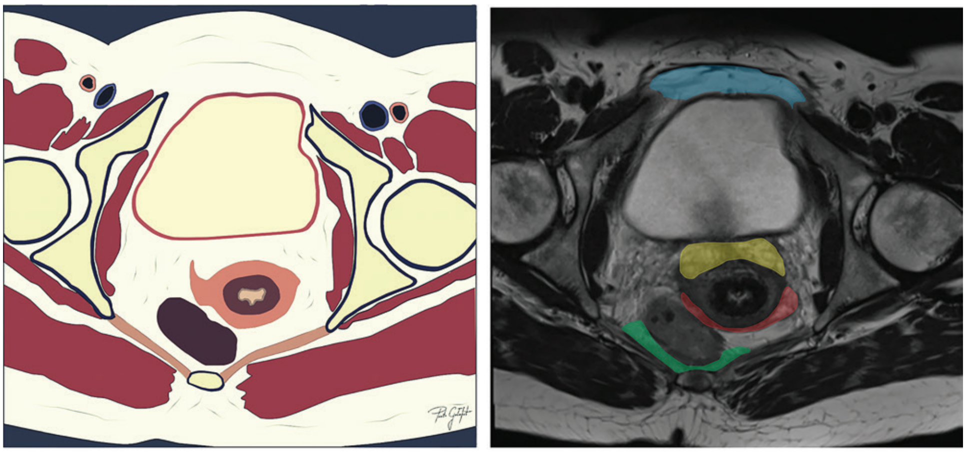
Vesicouterine Space (Anterior Cul-de-sac)

The area where the peritoneum extends over the dome of the urinary bladder through the ventral lower uterine segment is called the anterior cul-de-sac, also known as the vesicouterine space. The vesicouterine space can be identified on axial and sagittal MR images as a deep narrow recess between the urinary bladder and the uterus (Figs 23, 24; Movie 13). The vesicouterine space is a common site for deep infiltrating endometriosis and therefore should be cautiously evaluated (50) (Fig 25). Patients with pelvic pain and nodular changes in the anterior cul-de-sac with low signal intensity on T2-weighted MR images should be considered to have a high probability of having endometriosis (12).

Rectovaginal Space

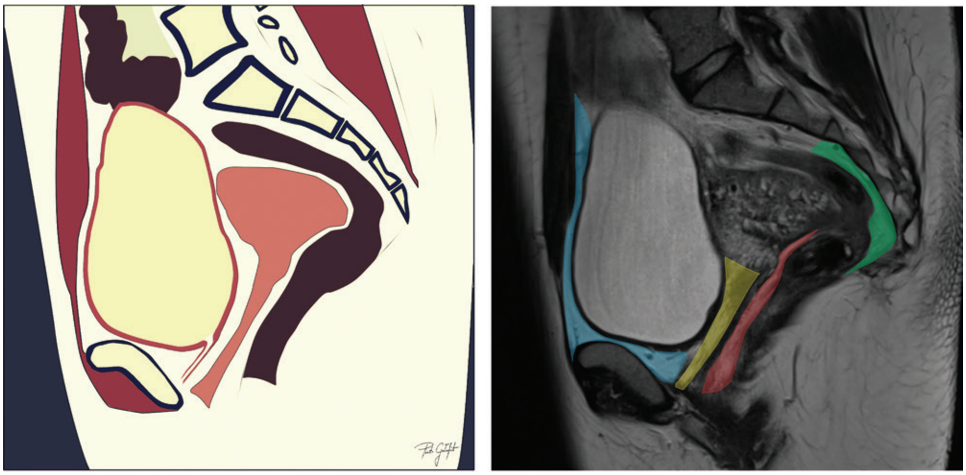
The rectovaginal space is a narrow area between the rectum and vagina, limited anteriorly by the rectovaginal septum and posteriorly by the anterior rectal wall. Among patients with endometriosis, 3%–37% of them have endometrial implants in the rectovaginal space. An MRI examination before surgery is often requested for these patients, to diagnose potential involvement of the rectal wall, a factor of crucial relevance for the surgeon. Hence, radiologists should be aware of the normal MRI appearance of this space when reporting the findings from MR examinations of the female pelvis (51,52). The rectovaginal space can be identified on axial and sagittal T1- and T2-weighted MR images as a region of high signal intensity (Movies 14, 15).

Rectovaginal endometriosis is considered one of the most severe forms of deeply infiltrating endometriosis that affects the vagina, rectum, and rectovaginal space (53). T2-weighted MR images show bands of high signal intensity, indicating fibrotic tissue, in the rectovaginal space, which are typical for endometrial involvement in this region (54). MRI is the modality of choice for evaluating deep infiltrating endometriosis in the rectovaginal space because it allows a more thorough assessment of the neighboring structures, compared with transvaginal US



a. b.

Figure 23. Pelvic spaces in the axial view. **(a)** Anatomic drawing shows an axial view of the pelvic spaces. **(b)** Axial T2-weighted MR image shows the space of Retzius (blue), the vesicouterine space (yellow), the rectouterine space (red), and the presacral space (green).



a. b.

Figure 24. Pelvic spaces in the sagittal view. **(a)** Anatomic drawing shows a sagittal view of the pelvic spaces. **(b)** Sagittal T2-weighted MR image shows the space of Retzius (blue), the vesicouterine space (yellow), the rectouterine space (red), and the presacral space (green).

(55). Moreover, in cases of a soft-tissue mass in the rectovaginal space, MRI allows an accurate evaluation of the components of the mass and yields information on tumor extension and involvement of adjacent structures (56,57).

Rectouterine Space (Pouch of Douglas, Posterior Cul-de-sac)

The intraperitoneal area between the posterior part of the uterus and the anterior part of the rectum is the rectouterine space, or posterior cul-de-sac, and is clinically known as the pouch of Douglas, because it was described by James Douglas in 1730 (58,59). The rectouterine space is the deepest region in the peritoneal cavity, which makes it a favorable location for fluid and abscess collections and metastatic peritoneal deposits, mostly from ovarian cancer (60). Usually, a physical examination, including a thorough rectovaginal investigation, is the procedure of choice to assess the rectouterine space. Transabdominal or transvaginal US may be performed as well, especially when an ectopic pregnancy in the rectouterine space is suspected.

The pouch of Douglas (rectouterine space) is easily identified on axial and sagittal MR images (Figs 23, 24; Movie 16). Because of the deep location of the rectouterine space, metastases of the peritoneum may seed there, especially metastases from ovarian and colon carcinomas (60,61). MRI allows complete depiction of the rectouterine space, with further characterization of the lesions. The radiologist should evaluate this region carefully and report any tumor extension.

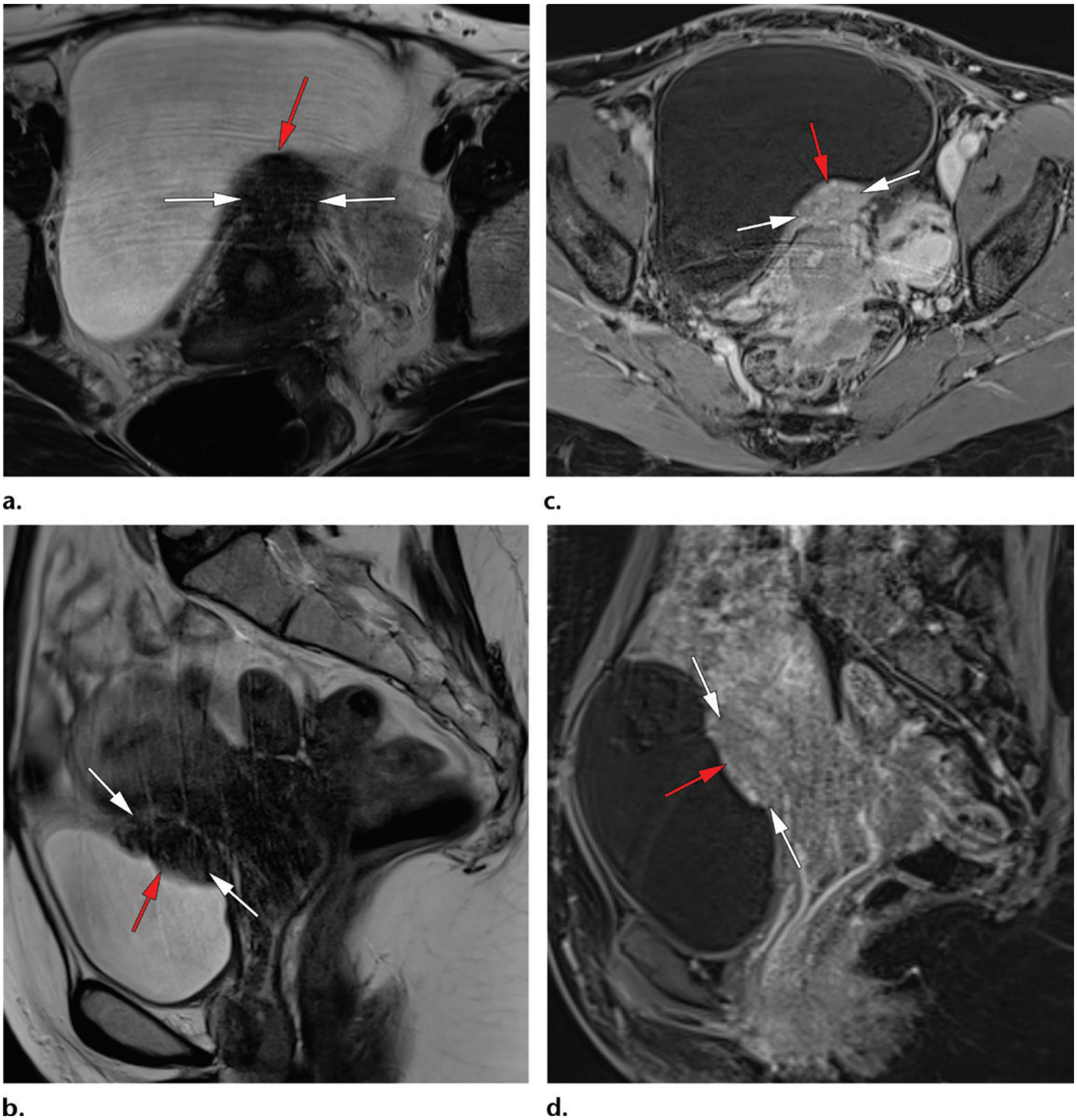


Figure 25. Endometriosis with infiltration of the vesicouterine space and urinary bladder in a 32-year-old woman. **(a, b)** Axial **(a)** and sagittal **(b)** T2-weighted MR images show infiltration of the vesicouterine space (white arrows) and urinary bladder (red arrow). **(c, d)** Axial **(c)** and sagittal **(d)** gadolinium-enhanced T1-weighted fat-saturated MR images show infiltration of the vesicouterine space (white arrows) and urinary bladder (red arrow).

When the pouch of Douglas is affected by a tumor, T1- and T2-weighted MR images may demonstrate areas of low signal intensity, representing necrosis or fibrous components; and T1-weighted MR images may demonstrate high-signal-intensity foci owing to local hemorrhage (62). Nevertheless, signal intensities may vary, depending on various conditions (ie, chronic hemorrhage resulting in low signal intensity on T1-weighted MR images). These characteristics should be provided in the radiology report because they are essential for surgical planning and patient management.

Physiologically, 2–4 mL of fluid may be present in the rectouterine space. However, the pouch of Douglas should be evaluated in correlation with clinical information (63). Fluid can accumulate in the rectouterine space in a variety of medical situations, such as pregnancy, ascites, peritonitis, or a ruptured ovarian cyst (64). Abscess collections may also be found in the pouch of Douglas in patients with appendicitis or pelvic inflammatory disease or after surgery for deeply infiltrating endometriosis (65). The aforementioned medical conditions emphasize the importance of anatomic knowledge of the pouch of Douglas. Radiologists should thus be acquainted with the normal imaging appearance of the rectouterine space and be able to evaluate it with confidence.

Pararectal Space

The pararectal space is found between the uterosacral and cardinal ligaments and the presacral fascia. Controversies still exist among radiologists and anatomists, however, regarding

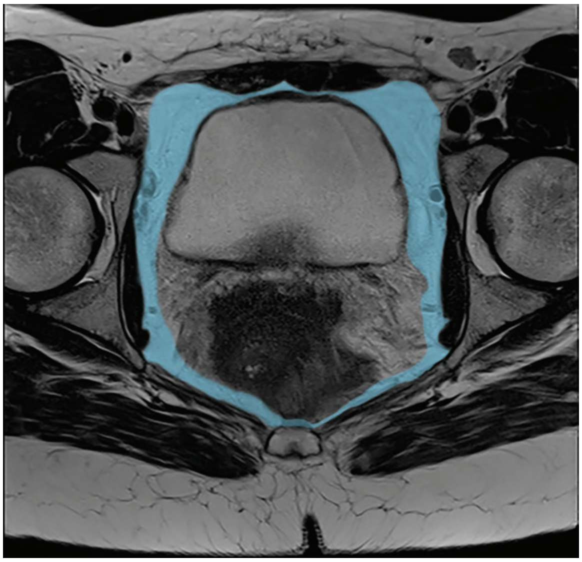


Figure 26. Axial T2-weighted MR image shows the connection between the pararectal and prevesical spaces (blue).

this rectal extraperitoneal space (66) (Fig 2). Although the pararectal space could be divided into perirectal and pararectal spaces at cadaver studies, it appears challenging radiologically. The pararectal space includes loose connective tissue and fat tissue and has connections with the prevesical space of Retzius and the extraperitoneal space around the greater psoas muscle (39,66,67) (Fig 26).

Primary lesions in the pararectal space are rare, and most of the changes in this space are due to abdominal pathologic conditions (68,69). Therefore, the communications between various extraperitoneal compartments should be known radiologically, especially when evaluating fluid collections in the pararectal space.

Retrorectal-Presacral Space

The area between the dorsal part of the rectum, which is covered by mesorectal fascia, and the sacral bone is known as the retrorectal-presacral space (70,71) (Figs 23, 24). Anatomically, it is divided by presacral fascia into anterior retrorectal and posterior presacral spaces (71). Under physiologic conditions, however, the radiologic delineation between these two spaces appears challenging. In the literature, "retrorectal" and "presacral" are used interchangeably, which may be confusing for radiologists. To clarify, we use the term *retrorectal-presacral space,* as proposed by Hosseini-Nik et al (70). This space contains a complex network of nerves and vessels and connective and lymphatic tissues. It is depicted as a hyperintense region on axial and sagittal T2-weighted MR images (72) (Figs 23, 24; Movies 17, 18). A width of the retrorectal-presacral space up to 1 cm is considered normal, although the width may vary depending on rectal filling and the patient's clinical status and sex (70,73,74).

The radiologist should evaluate the retrorectal-presacral space carefully when there are pathologic conditions of the sacrum or coccyx (eg, fracture, infection, neoplasm) or in cases of rectal pathologic conditions with extension into the retrorectal-presacral space. In these cases, the retrorectal-presacral space could be invaded and could appear obliterated or displaced by the tumor.

MRI enables preoperative assessment of pathologic conditions located in the retrorectal-presacral space. MRI allows a detailed morphologic evaluation of the mass (signal intensity characteristics, contrast enhancement pattern, involvement of adjacent structures).

Report Checklist

Various structures (female genital organs, ligaments, spaces) should be evaluated and included in the final report of the findings at MRI examination of the female pelvis. Even with the increasing number of examinations, radiologists are required to provide precise reports within a short time. To help radiologists prepare such structured reports and to enhance their efficiency, we offer an MRI reporting checklist for the female pelvis, including assessment of female reproductive organs with important imaging features. A step-by-step interactive tool for reporting MRI findings of the female pelvis is provided in our mobile application as well (Appendix E1, Movie 19).

Conclusion

MRI is an important noninvasive imaging modality for evaluating the ligaments of the female genital organs and the pelvic spaces. The radiologic assessment of the ligaments and the pelvic spaces could be of clinical interest with regard to benign or cancerous conditions of the female genital tract. Because of its excellent soft-tissue depiction, MRI enables identification of ligamentous structures and pelvic spaces even under physiologic conditions. An understanding of the anatomy and an acquaintance with the normal imaging appearance of these structures are prerequisites for radiologists who report the findings from MRI examinations of the female pelvis. In the presence of pathologic conditions, the ligaments of the female genital organs and the pelvic spaces are often affected, and their imaging appearances change. In such situations, the role of the radiologist is paramount. With enough practice, including with structured reporting and use of checklists, procedures can be learned more rapidly, resulting in reports that have been prepared with confidence.

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