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MAGNETIC RESONANCE IMAGING IN THE DIAGNOSIS OF ADENOMYOSIS: A NARRATIVE REVIEW

ARIELA MAULLER VIEIRA PARENTE[1], WALDEMAR NAVES DO AMARAL[2], JUAREZ ANTÔNIO DE SOUSA[2], IZADORA CAIADO OLIVEIRA[3], FERNANDA HEIRICH PISTORI[3], GEOVANA ALMEIDA SPIES[3], JOÃO FLORENTINO SILVA SÁ TELES[3], AMANDA VIEIRA PARENTE[4].

1. Grupo Fertile, Goiânia, Goiás, Brazil.
2. Departamento de Ginecologia e Obstetrícia da Faculdade de Medicina da Universidade Federal de Goiás - UFG, Goiânia, Brazil.
3. Faculdade de Medicina, Universidade Federal de Goiás, Goiânia, Goiás, Brazil.
4. Faculdade Alfredo Nasser – UNIFAN, Goiânia, Goiás, Brazil.

ABSTRACT

Adenomyosis is a gynecological condition characterized by the ectopic presence of endometrial tissue within the uterine myometrium, and it can present in either focal or diffuse forms. This narrative review aims to evaluate the role of magnetic resonance imaging (MRI) in the diagnosis and clinical management of adenomyosis. Studies published between 2005 and 2025 were analyzed from databases including PubMed, Scopus, Google Scholar, and Lilacs, focusing on the application of MRI in identifying adenomyosis. MRI stands out as a non-invasive imaging modality with high sensitivity and specificity, surpassing transvaginal ultrasound (TVUS), particularly in inconclusive cases. The main diagnostic feature is a thickened junctional zone (>12 mm), although additional findings—such as small cysts, low-signal-intensity striations on T2-weighted images, and hemorrhagic foci on T1—are also relevant. MRI allows for differentiation between disease subtypes, including focal adenomyosis, diffuse adenomyosis, adenomyoma, and cystic adenomyosis, and provides comprehensive evaluation of adjacent pelvic structures. It also assists in ruling out differential diagnoses, such as leiomyomas and endometrial tumors. Despite its higher cost, MRI is recommended as a second-line imaging modality according to the 2017 guidelines of the European Society of Urogenital Radiology (ESUR), especially in the assessment of endometriosis and complex pelvic pathologies. In conclusion, MRI is an essential tool for accurate diagnosis and therapeutic planning in adenomyosis.

Keywords: Adenomyosis, Magnetic resonance imaging, Diagnostic imaging, Junctional zone, Gynecology.

INTRODUCTION

Adenomyosis is a condition that occurs in the body of the uterus, characterized by the presence of endometrial tissue, with ectopic endometrial glands and stroma within the myometrium. It can present in two forms: focal, in which the foci are located in a limited area of the myometrium, and diffuse, in which the foci are distributed throughout the myometrium. Magnetic resonance

imaging (MRI) is an excellent exam, more specific than ultrasonography, for detecting adenomyosis, as it highlights the zonal uterine anatomy, allowing visualization of the uterus's three layers: the endometrium, the junctional zone, and the myometrium. It is important to remember that the junctional zone is part of the myometrium, but due to being less hydrated, it appears hypointense on MRI. The assessment of uterine size and junctional zone thickening is essential for confirming the diagnosis of adenomyosis.[1,2]

METHODS

This narrative review aims to evaluate the role of magnetic resonance imaging (MRI) in the diagnosis and clinical management of adenomyosis. For the selection of studies, articles published between 2005 and 2025 in English, Portuguese, and Spanish were included, provided they discussed the application of MRI in the evaluation of adenomyosis. The literature search was conducted in the PubMed, Scopus, Google Scholar, and Lilacs databases, using keywords such as "adenomyosis," "magnetic resonance imaging," "diagnostic imaging," among other related terms. Only studies that directly addressed the use of MRI in the identification of adenomyosis were considered for this review, including clinical trials, systematic reviews, and guidelines. Articles that focused on alternative diagnostic methods, other gynecological conditions, or studies conducted in non-human populations were excluded.

Magnetic resonance imaging

First described in 1946, nuclear magnetic resonance is defined as the ability of the nuclei of certain chemical elements to emit radiofrequency signals when exposed to a strong magnetic field. These signals can be detected and transformed into images. Initially developed and used for the analysis of chemical and physical molecules, magnetic resonance imaging (MRI) gradually shifted from the scientific to the clinical context—especially after the 1980s. With excellent spatial resolution, high tissue differentiation capability, and the possibility of multiplanar and three-dimensional reconstructions, MRI has become one of the main non-invasive techniques for anatomical visualization and the diagnosis of various diseases.[3-5]

The particles responsible for the emitted radiofrequency signal are hydrogen protons and water molecules in the tissue. The signal and contrast are determined by differences in proton density and in the signal decay properties of different tissues.[5] The magnetically excited nucleus returns to its initial state by releasing energy in the form of electromagnetic waves. This process is called relaxation and is defined by two time constants: the energy release time or longitudinal relaxation time, T1, and the oscillation time of the protons during the process, or transverse relaxation time, T2. These constants are recorded as spatially localized signals by a coil installed in the MRI machine and are processed by computerized algorithms to produce anatomical images. Factors such as the individual characteristics of each molecule and tissue composition affect the generation of different proton relaxation times, and therefore, images can be appropriately weighted in T1 or T2, depending on the features of interest to be analyzed.[3]

Magnetic resonance imaging in the diagnosis of adenomyosis

In 1970, American physician Raymond Damadian conducted an experiment on rats and observed different responses to magnetic excitation between normal and tumorous tissues. These signals

varied in their contrast characteristics due to differences in tissue composition and relaxation times, allowing the identification of changes in the analyzed tissues. From this perspective, magnetic resonance imaging (MRI) stands out as an excellent diagnostic method for the involvement of organs and tissues by various diseases, including adenomyosis.[4,6] For decades, the diagnosis of adenomyosis relied exclusively on histopathological examination, which involves the identification of endometrial glands within the myometrium, at least 2.5 mm from the junctional zone, through the collection and analysis of myometrial tissue. Advances in gynecological techniques introduced imaging criteria into the process and facilitated diagnosis, making it less invasive. Currently, transvaginal ultrasonography (TVUS) and magnetic resonance imaging (MRI) are the main methods used for the diagnosis of adenomyosis. Due to its wide availability and relatively low cost, TVUS is the first-choice examination to identify adenomyosis. However, ultrasonography is operator-dependent, which may result in variability between different exams.[6] Thus, in the case of inconclusive ultrasound findings, MRI is the recommended imaging method. Unlike ultrasonography, MRI is less available, more expensive, and therefore less accessible, being considered a second-line examination in the investigation of conditions such as adenomyosis. On the other hand, MRI offers greater accuracy in detecting adenomyosis due to its higher sensitivity and specificity, and reduced operator dependency. Additionally, MRI demonstrates a high capacity for soft tissue differentiation and is capable of identifying different subtypes of adenomyosis. It also enables the evaluation of surrounding anatomical structures and the detection of other pathological conditions that may be present simultaneously in the pelvic region, such as fibroids and endometriosis.[6] The MRI protocol used for detecting adenomyotic disease may vary depending on the clinic or the type of equipment used. In 2017, the European Society of Urogenital Radiology (ESUR) developed a set of standard guidelines for performing MRI in the investigation of endometriosis, which should also be applied when analyzing adenomyosis. It is recommended that patients follow a low-fiber diet for two to three days prior to the exam, fast for two to three hours, and take an antiperistaltic agent immediately before the MRI. Patients should also be instructed not to urinate for at least one hour before the procedure, in order to maintain moderate bladder filling. This avoids detrusor muscle contraction due to a full bladder and prevents poor visualization of the ureters caused by an empty bladder.[6] The MRI imaging protocol recommended by ESUR should include high-resolution, fat-unsaturated T2-weighted sequences in sagittal and axial planes (or oblique planes, if necessary) and axial T1-weighted sequences with and without fat saturation. T1-weighted sequences with contrast and fat saturation are not required for diagnosis but are recommended in cases of atypical features seen on T2-weighted images. In this way, T1- and T2-weighted images complement each other, providing information that supports pathological definition.[6] The most frequently used characteristic in the diagnosis of adenomyosis is a junctional zone thickness greater than 12 mm. However, this thickening may occur physiologically due to hormonal changes during the menstrual cycle; therefore, the exam is preferably performed in the postmenstrual period. T2-weighted sequences are essential for the diagnosis of adenomyosis, as they highlight the anatomy of the junctional zone. Increased thickness may appear on T2 as a poorly defined area with low signal intensity, characterizing smooth muscle hyperplasia adjacent to ectopic endometrial tissue. T1-weighted imaging also contributes to diagnosis, as it reveals foci of high signal intensity representing the presence of methemoglobin, indicating hemorrhage — a highly specific predictive sign of adenomyotic disease.[2,7]

MRI findings in adenomyosis

On magnetic resonance imaging, adenomyosis presents as an irregular enlargement of the uterus and thickening of the junctional zone greater than 12 mm. When the junctional zone measures less than 8 mm, the possibility of adenomyosis can be excluded. It is important to note that recent literature has emphasized the need to include additional indirect criteria for diagnosing adenomyosis, rather than relying solely on junctional zone thickness, due to potential hormonal influences. The thickening may appear regular or irregular, homogeneous or heterogeneous, and may also present small cysts within it. Small hemorrhagic foci may be identified as hyperintense foci on fat-saturated T1-weighted images. In addition, changes in the pattern of the adjacent myometrium are common, appearing either diffusely or with striated features. These characteristics on MRI help confirm the diagnosis of adenomyosis (Figure 1).[8,9] To perform MRI for adenomyosis detection, it is recommended to use a primary high-resolution sagittal T2-weighted sequence with a high matrix, oriented along the longitudinal axis of the uterus. Additionally, a second T2-weighted sequence in the coronal plane, and a T1-weighted fat-saturated sequence to identify hemorrhagic foci, should be obtained—this last sequence can be performed in either the sagittal or coronal plane. It is important to note that motion artifacts are quite common and can cause visual "noise" in the exam. To minimize respiratory motion artifacts, a compression band may be applied to the anterior abdominal wall of the patient. To reduce artifacts caused by peristalsis, some healthcare services administer injectable antispasmodics, such as Buscopan. The use of contrast is not necessary for the detection of adenomyosis.[1,6] When investigating adenomyosis through MRI, it is crucial to consider that physiological factors, such as hormonal variations during the menstrual phase, can cause thickening of the junctional zone. Therefore, it is recommended to perform the exam during the late proliferative phase. Additionally, transient uterine contractions, which appear as hypointense bands, and conditions such as postmenopause (Figure 2) or hormonal contraception, in which the junctional layer may not be measurable, can also produce findings that do not reflect pathological changes. It is also essential to recognize that adenomyosis may appear on MRI as a pseudo-widening (Figure 3) of the endometrium, visualized as hyperintense linear striations on T2-weighted images radiating from the endometrium toward the myometrium, similar to myometrial invasion seen in carcinoma. This highlights the need for a detailed analysis of MRI results to confirm the diagnosis of adenomyosis.[1,2,10]

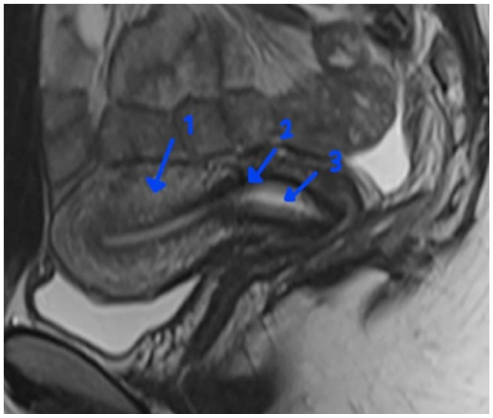


FIGURE 1. Sagittal T2-weighted image of a normal postpubertal uterus: (1) myometrium, (2) junctional zone, and (3) endometrium.[10]

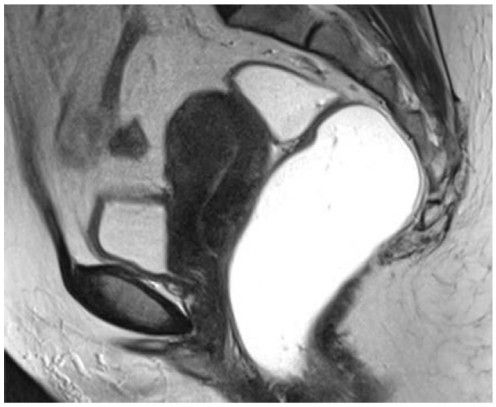


FIGURE 2. Postmenopausal uterus: sagittal T2-weighted images of a postmenopausal uterus in which the junctional zone is not measurable.[10]

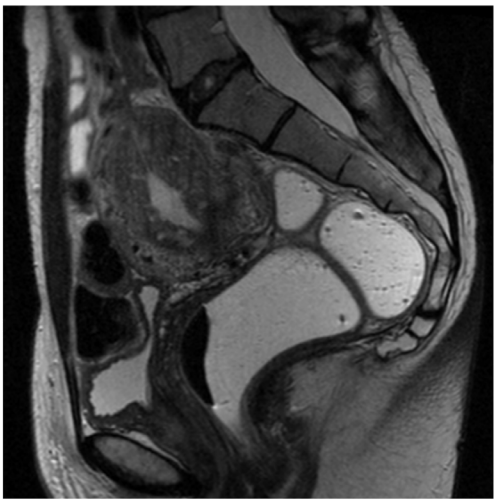


FIGURE 3. Pseudo-widening of the endometrium: sagittal T2-weighted images showing a thickened junctional zone with striated high-signal areas radiating from the endometrium toward the myometrium, resembling the appearance of endometrial carcinoma invasion.[10]

Focal adenomyosis

Focal adenomyosis (Figure 4) is characterized by small intramyometrial cysts, which may or may not be associated with edema of the junctional zone. These cysts can be distributed as single or multiple foci within the myometrium. It is important to note that, unlike diffuse adenomyosis, focal adenomyosis is generally not associated with significant changes in uterine thickness or myometrial texture. In many cases, focal adenomyosis is asymptomatic and may be diagnosed incidentally during imaging exams performed for other reasons. However, in other cases, the condition may be associated with symptoms such as pelvic pain and dysmenorrhea.[1,8]

Diffuse adenomyosis

Diffuse adenomyosis (Figure 5) is characterized by the presence of small diffuse cysts in the inner myometrium, along with thickening of the junctional zone (JZ). Both symmetric and asymmetric distributions can be observed in this type of adenomyosis. The distribution may be symmetric, affecting the anterior and posterior uterine walls equally, or asymmetric, when it predominantly affects only one of the walls.[2,6]

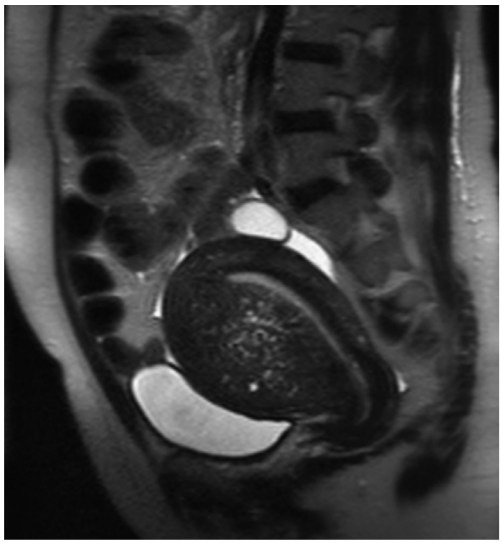


FIGURE 4. Focal adenomyosis. Sagittal T2-weighted FSE image (1100/123 repetition time/echo time). Focal diffuse thickening of the junctional zone along the anterior surface of the uterine body with associated pinpoint foci of increased T2 signal.

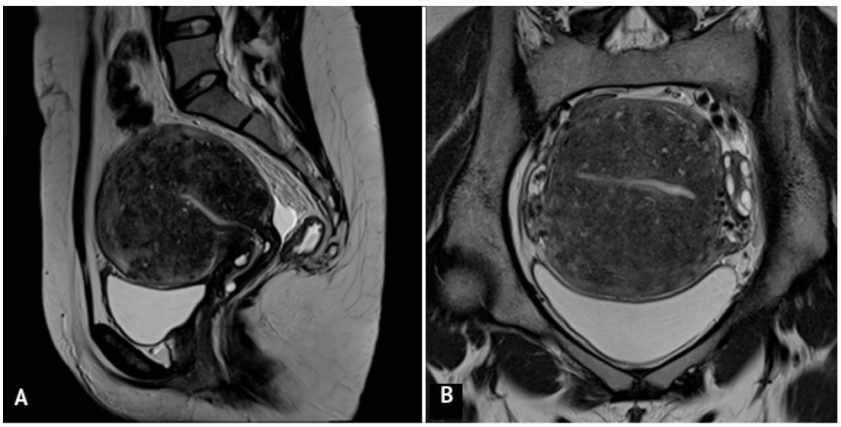


FIGURE 5. Diffuse adenomyosis: A. Sagittal and B. Coronal T2-weighted images showing thickening of the junctional zone forming a poorly defined low-signal area, with punctate foci of high intensity in the myometrium.[10]

UNCOMMON MRI FINDINGS IN ADENOMYOSIS

Adenomyoma and adenomyotic polyp

Adenomyoma (Figure 6) is a form of adenomyosis that consists of a confluence of adenomyotic glands resembling a mass. This type of adenomyosis may appear as an intramyometrial mass,

primarily located in the uterine body. In some cases, the adenomyoma may deform the endometrium, characterizing a submucosal adenomyoma. Another possibility is that it projects into the endometrial cavity, growing as a polypoid mass, thus forming a polypoid adenomyoma (Figure 7).[9]

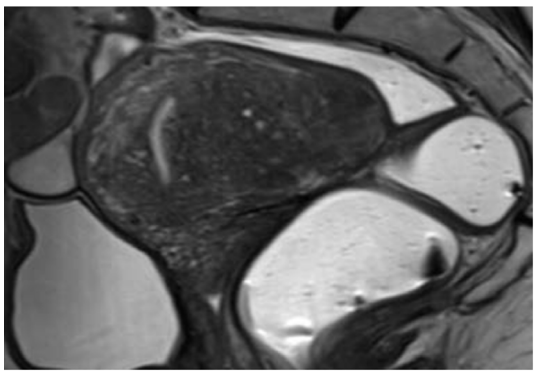


FIGURE 6. Adenomyoma on MRI: sagittal T2-weighted image showing a circumscribed hypointense intramyometrial mass with ill-defined margins, minimal mass effect, and foci of high signal intensity.[10]

Swiss cheese appearance

Diffuse adenomyosis may be identified on magnetic resonance imaging by a "Swiss cheese" appearance (Figure 8), characterized by myometrial cysts and nodules on contrast-enhanced and T2-weighted sequences. This appearance is caused by the dilation of endometrial glands within the myometrium. In addition, the junctional zone appears thickened and poorly defined, along with the presence of linear striations.[2,8]

Cystic adenomyosis

Cystic adenomyoma (Figure 9) is usually asymptomatic, but in some cases, it may cause pelvic pain and abnormal bleeding. Cystic adenomyoma is a lesion characterized by a large hemorrhagic cyst, resulting from extensive menstrual bleeding within ectopic endometrial tissue. This condition may be located within the myometrium, submucosal, or subserosal. On magnetic resonance imaging, the surrounding adenomyotic tissue can be identified by a high signal on T1 and low signal on T2. This finding is important for distinguishing cystic adenomyoma from other uterine masses, such as fibroids or carcinomas.[2]

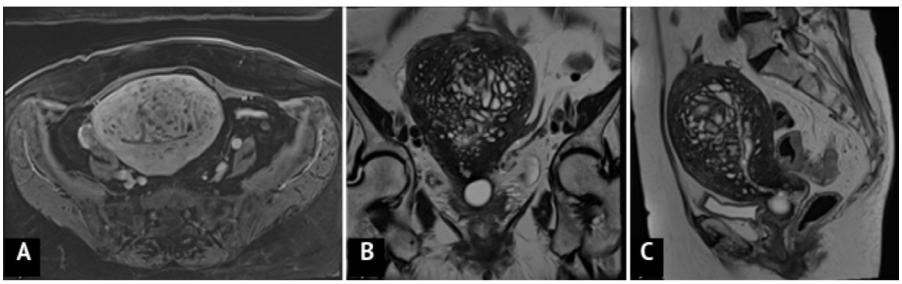


FIGURE 7. Swiss cheese appearance in adenomyosis: A. Axial T1 3D fat-saturated image, B. Coronal T2, and C. Sagittal T2-weighted images showing poor definition of the endometrial junctional zone with prominent glandular myometrial cysts, myometrial nodules, and linear striations.[10]

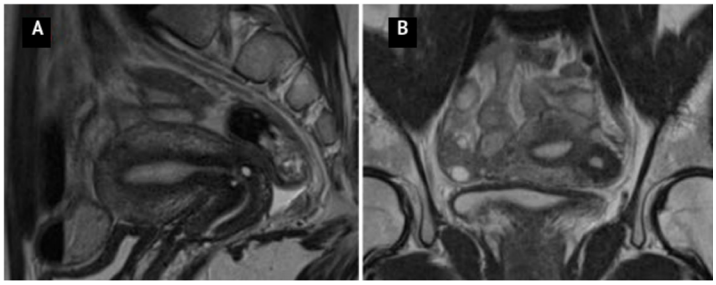


FIGURE 8. T2-weighted images: A. Sagittal and B. Coronal views showing a nodular uterine lesion with a centrally located high-signal cavity, alongside a normal uterus.[10]

DIFFERENTIAL DIAGNOSIS

Leiomyoma

Leiomyomas (Figure 10) are benign tumors composed of smooth muscle cells and are the most common type of tumor in the female genital tract. Adenomyomas and leiomyomas both appear as low-signal-intensity lesions on T2-weighted images, but they present differently on MRI. Adenomyomas typically appear as ill-defined lesions with minimal mass effect, whereas leiomyomas usually present as well-defined masses associated with prominent peripheral vessels. The differential diagnosis becomes even more challenging in cases of cystic or hemorrhagic degeneration of leiomyomas.[1,2,10]

Accessory cavitated uterine mass (ACUM)

ACUM (Figure 11) is a rare uterine anomaly that presents as a cystic or hemorrhagic mass that does not communicate with the uterine cavity and is located within the myometrial wall. The diagnosis of ACUM requires the presence of a T1 hyperintense cavitated mass, completely isolated from the endometrial cavity. The differential diagnosis should include several gynecological conditions, such as rudimentary or cavitated uterine horns, intramural cystic adenomyoma, and red degenerating leiomyomas. Diagnosis may be guided by clinical data, such as patient age and the presence of severe dysmenorrhea and chronic cyclic pain.[2,10,11]

Endometrial carcinoma with melf pattern

A differential diagnosis includes a fibromyxoid stromal reaction. This tumor is often associated with myometrial invasion, lymphovascular involvement, and lymph node metastasis, despite having a low histological grade. On magnetic resonance imaging, it appears as a hypointense thickening on T2-weighted images in the inner myometrium, with a small cystic component resembling adenomyosis. MRI is an important tool for assessing myometrial invasion and identifying pathologic lymph nodes.[6,9]

Effectiveness of magnetic resonance imaging in the diagnosis of adenomyosis

Currently, ultrasonography is used as the first-line imaging method for the initial diagnosis of adenomyosis. However, due to its high operator dependence, MRI is recommended in

inconclusive cases because of its high sensitivity and specificity and low operator dependence. Additionally, magnetic resonance imaging offers excellent soft tissue differentiation, allowing the identification of coexisting diseases, evaluation of structures adjacent to the pelvic region, and detection of adenomyosis subtypes.[6] Furthermore, the subendometrial myometrium, which is composed of densely packed smooth muscle cells, is clearly visualized on MRI as a low-signal-intensity zone, known as the junctional zone (JZ). In this context, MRI has been shown to be superior to transvaginal ultrasonography (TVUS) in the diagnosis of adenomyosis based on imaging studies. However, the combination of MRI and TVUS provides a high level of accuracy for ruling out adenomyosis. Measuring the difference in junctional zone thickness may further optimize the diagnosis of adenomyosis by MRI.[12] Another important factor to consider is the high cost of MRI, which limits its use as a first-line investigation. According to the 2017 guidelines of the European Society of Urogenital Radiology (ESUR), MRI should be considered a second-line imaging technique for female pelvic disease when TVUS results are inconclusive. In addition, MRI is recommended in cases of endometriotic disease due to its accurate preoperative staging.[13]

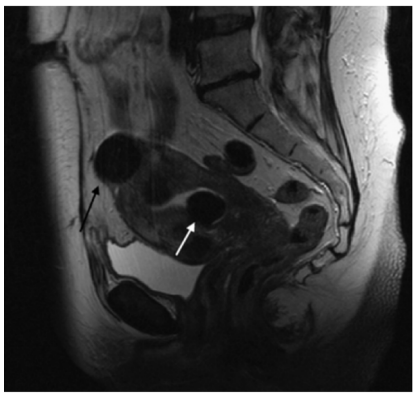


FIGURE 9. Subserosal and submucosal leiomyomas. Sagittal T2-weighted FSE image (1100/121 repetition time/ echo time). Well-circumscribed subserosal (black arrow) and submucosal (white arrow) leiomyomas, both showing low signal intensity.[1]

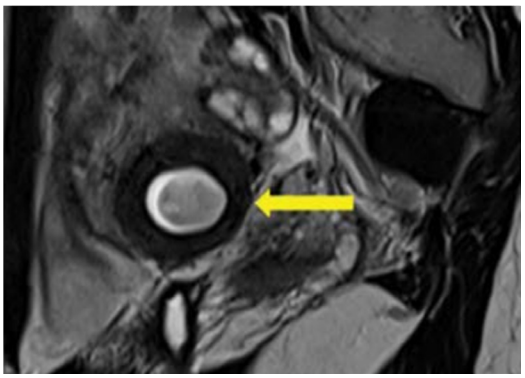


FIGURE 10. Sagittal magnetic resonance image showing a cavitated lesion on the left side of the uterus, with its wall formed by T2 hypointense myometrium (yellow arrow) and intermediate signal with "shading." There is no communication between this lesion and the normal endometrial cavity.[11]



FIGURE 11. Endometrial carcinoma with MELF pattern. Sagittal T2-weighted image showing thickening of the inner anterior myometrium and a low-signal mass resembling adenomyosis, with small cystic components.

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MAILING ADDRESS

JUAREZ ANTÔNIO DE SOUSA
Departamento de Ginecologia e Obstetrícia, Faculdade de Medicina,
Universidade Federal de Goiás, 5ª Avenida, Goiânia - GO, Brasil.
E-mail: juarez_antonio@ufg.br

EDITORIAL AND REVIEW

Chief editors:

Waldemar Naves do Amaral - http://lattes.cnpq.br/4092560599116579 - https://orcid.org/0000-0002-0824-1138
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Authors:

Ariela Mauller Vieira Parente - http://lattes.cnpq.br/0780896170758778 - https://orcid.org/0000-0001-8353-833X

Waldemar Naves do Amaral - http://lattes.cnpq.br/4092560599116579 - https://orcid.org/0000-0002-0824-1138

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Izadora Caiado Oliveira - http://lattes.cnpq.br/3881728533555375 - https://orcid.org/0000-0001-8597-8347

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Amanda Vieira Parente - http://lattes.cnpq.br/8284453419124489 - https://orcid.org/0009-0009-8266-740X

Library Review: Izabella Goulart
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