Section A-Research paper

Role of MRI in Diagnosis of adenomyosis

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Abstract

Background: Magnetic resonance has a significant role in evaluation of the pelvic abnormalities, including uterine, ovarian, cervical, adnexal, and congenital abnormalities. A better understanding of anatomy remains crucial in the evaluation of congenital abnormalities as well as in characterization of a lesion and its extent. Endometriosis and adenomyosis are diseases that affect many women predominantly during the reproductive period of life. With the cardinal symptoms, such as pelvic pain, bleeding disorders, and infertility, the disease has a tremendous impact on women's well-being and health. In most of the women affected the first symptoms can be traced back to adolescence. T2-weighted sequences are key for diagnosing adenomyosis since the sequences highlight the uterine zonal anatomy. T1-weighted imaging (T1-WI) also contributes to the diagnosis, by depicting high-signal intensity foci that represent haemorrhage. Gadolinium contrast enhancement does not aid in the diagnosis of diffuse adenomyosis but should be considered in particular scenarios. Our protocol consists of pelvic T2-WI sagittal, axial and coronal planes and T1 3D fat-suppressed axial and sagittal planes. We use contrast when in doubt about the nature of a uterine nodule or to characterise associated findings, such as an adnexal mass. Adenomyosis appears as increased thickness of the junctional zone, forming an ill-defined area of low signal intensity on T2, representing the smooth muscle hyperplasia accompanying the heterotopic endometrial tissue. This aspect is frequently associated with bright foci on T2-weighted images, which represent foci of heterotopic endometrial tissue, cystic dilatation of endometrial glands or haemorrhagic foci. If haemorrhagic, the foci are also bright on T1 FSWI images. Adenomyosis may mimic other pathologic conditions. An example is the pseudo-widening of the endometrium a feature of adenomyosis that mimics endometrial carcinoma. Pseudo-widening of the endometrium represents an invasion of the myometrium by the basal endometrium and has a similar appearance to endometrial carcinoma invading the myometrium.

Keywords: MRI, Diagnosis, adenomyosis

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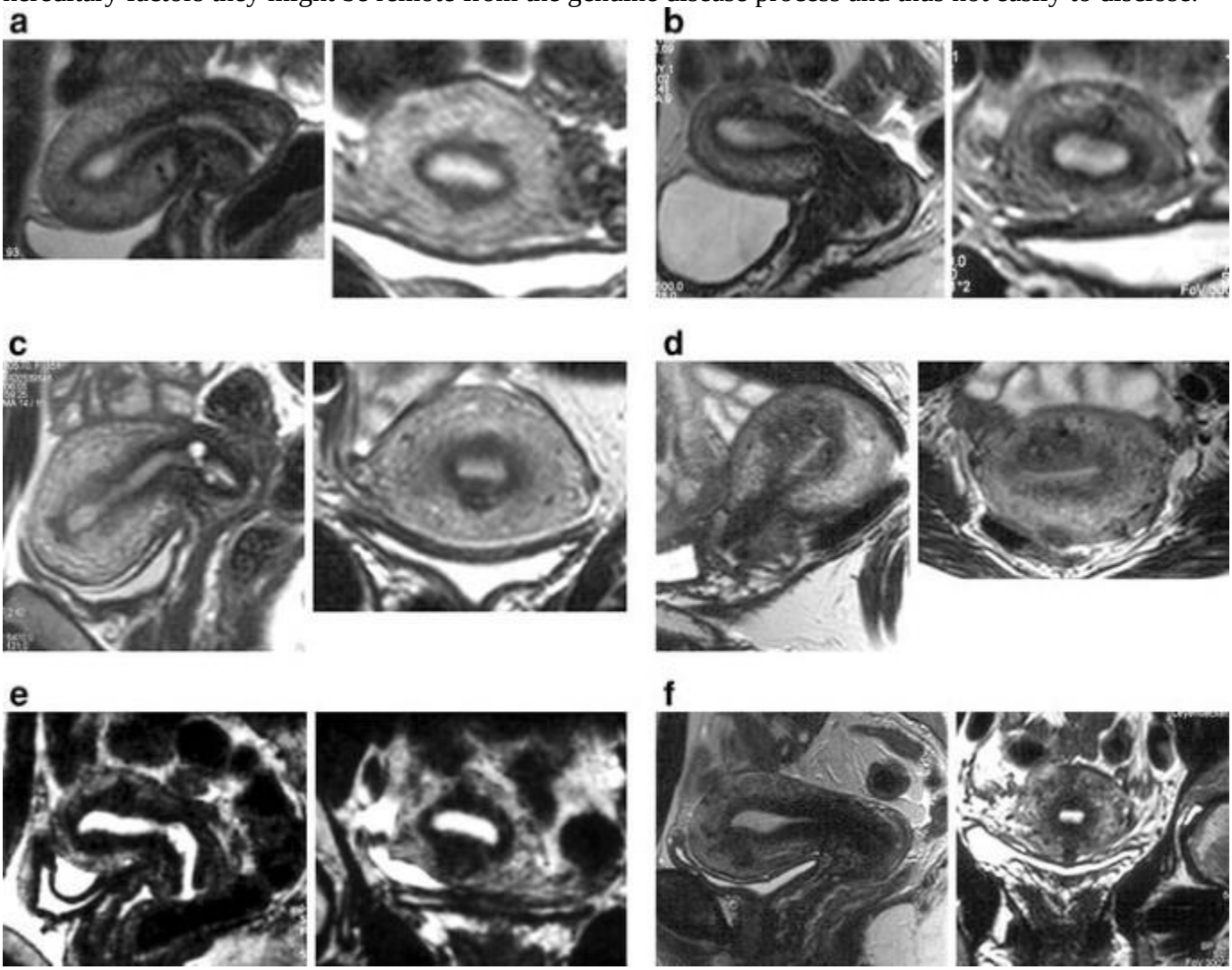
Endometriosis and adenomyosis are diseases that affect many women predominantly during the reproductive period of life. With the cardinal symptoms, such as pelvic pain, bleeding disorders, and infertility, the disease has a tremendous impact on women's well-being and health. In most of the women affected the first symptoms can be traced back to adolescence **[1].** Many women, however, remain free of symptoms or exhibit only minor complaints. Moreover, in cases with the development of the disease after childbearing, the condition may remain undiagnosed. Not infrequently, at laparoscopy for tubal sterilization **[2]** and hysterectomy for fibroids and adenomyosis, endometriotic implants and scars, respectively, can be observed. Thus, the current estimates of prevalence are probably too low.

The syndrome of dislocated basal endometrium (SDBE), a term that comprises the pathophysiological continuum of endometriosis, endometriosis in association with adenomyosis and premenopausal

adenomyosis, thus appears to be a very common phenomenon **[3].** We had, therefore, a decade ago, suggested that its cause or causes may be unspectacular and closely related to the physiologic process of reproduction. Trauma followed by tissue specific hyper reactive inflammatory response and repair involving specific physiological cellular, biochemical, and molecular mechanisms may be considered the major events in the development of the disease **[4].**

to extend our previous views and to elaborate a comprehensive model of the pathophysiology of endometriosis and adenomyosis. This attempt is undertaken with the idea that all phenotypes of endometriosis share in principal the same pathophysiology and that no parallel and separate mechanisms of their development do exist. This does, however, not exclude various and different etiologies at the very onset of the disease process including iatrogenic **[5],** exogenous **[6, 7],** and hereditary **[8]** factors. With respect to hereditary factors they might be remote from the genuine disease process and thus not easily to disclose.



Examples of uterine adenomyosis in six patients as presented by magnetic resonance imaging (MRI). Representative sagittal and coronary scans are shown. In the infertile, non-parous women (**a**–**e**) (30–32 years of age) pelvic endometriosis of grade I–IV was demonstrated by laparoscopy. In the parous woman (**f**) (40 years of age) no laparoscopy was performed. In all scans preponderance of the adenomyotic lesions (expanded junctional zone) in the midline close to the fundo-cornual raphe of the archimyometrium can be demonstrated. In the first three scans (**a**–**c**) the diagnosis of adenomyosis would not meet the established radiologic criteria for MRI. In a scientific context, however, the irregularities of the junctional zone are characteristic of beginning adenomyosis

MRI anatomy

Magnetic resonance has a significant role in evaluation of the pelvic abnormalities, including uterine, ovarian, cervical, adnexal, and congenital abnormalities. A better understanding of anatomy remains crucial in the evaluation of congenital abnormalities as well as in characterization of a lesion and its extent **[9].**

Female genital anatomy is displayed on T2-weighted images. The sagittal plane is ideal for demonstrating the uterine zonal anatomy and vaginal anatomy and for showing the relationship of the abnormalities of these organs to the bladder and rectum; therefore, imaging in this plane and one other plane, usually axial, is important to adequately evaluate the female pelvis.T1-weight images, offering information somewhat similar to that obtained from CT scanning, show poor soft tissue contrast; however these images are important for defining fat planes, adenopathy and hemorrhage in large pelvic masses **[9].**

Transvaginal ultrasonography (TVUS) and magnetic resonance imaging (MRI) are the main radiologic tools for the diagnosis of adenomyosis **[10].** MRI has a diagnostic accuracy of 85% **[11],** with added value in confirming the diagnosis and determining disease characteristics and extent and additional uterine lesions **[9–12]**

Examination by TVS constitutes an acceptable, moderately accurate and minimally invasive first-line test to detect adenomyosis (23).

Several direct features are related to the presence of endometrial tissue within the myometrium (**10).** Tiny myometrial cysts (2 mm–9 mm) corresponding to cystic or hemorrhagic endometrial glands, mainly located in the superficial myometrium, are highly specific (98%), but of low sensitivity (50%–65%) (10, 13). Non-cystic endometrial tissue gives rise to hyperechoic nodules or striations, of irregular or nodular aspect, or poor definition of the endometrial-myometrial interface **(10, 14).**

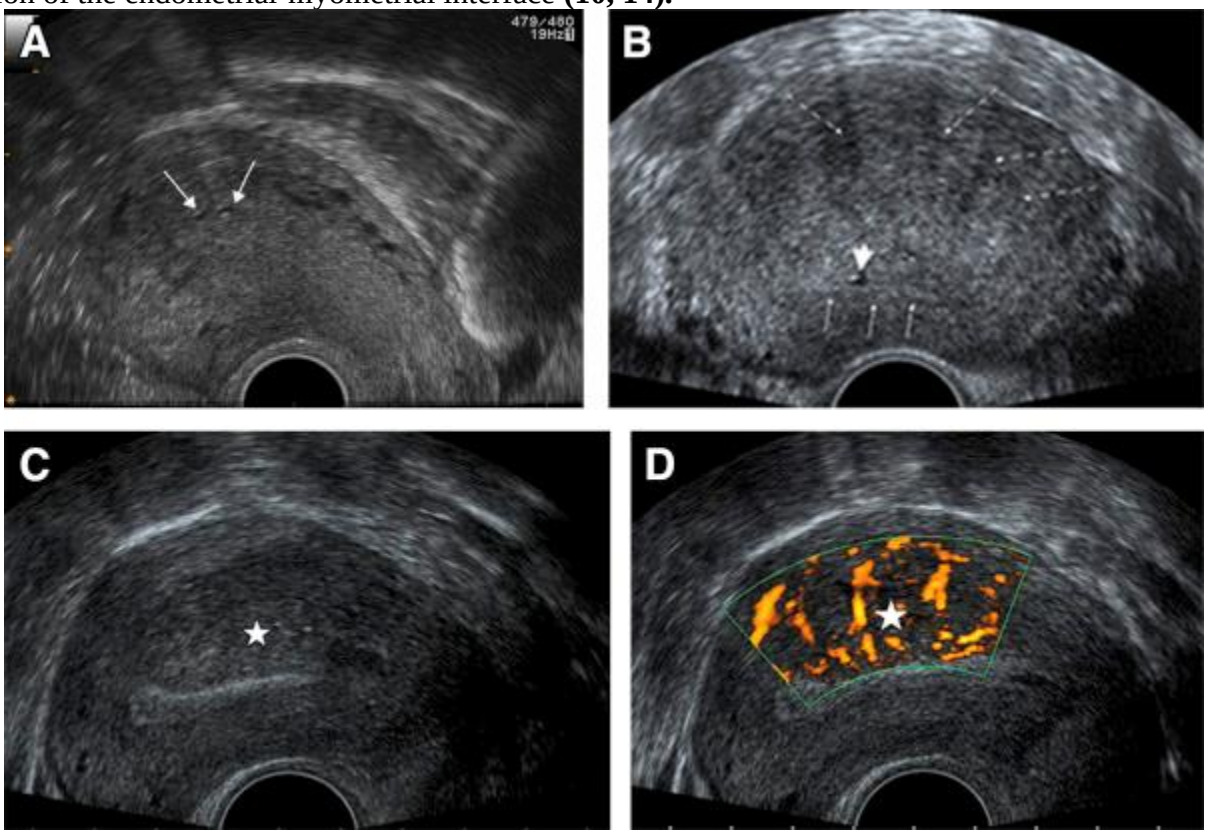


Figure 1 TVS examinations in different patients showing
(A) tiny subendometrial cysts (arrows) related to focal internal adenomyosis;

(B) regular enlarged asymmetric heterogeneous myometrium containing multiple hypoechoic striations (dotted arrows), tiny myometrial cystic (short arrow) adjacent to poor definition of the endometrial-myometrial interface (thin arrows) related to diffuse adenomyosis.
(C, D) large posterior hypoechoic myometrial area (star) containing vessels following their course perpendicular to the endometrial interface due to diffuse adenomyosis.

Indirect features are related to hypertrophic myometrial reaction **(10).** Diffuse myometrial heterogeneity is common and has a high sensitivity (80.8%–100%), but low specificity (30%–65%) **(12, 13, 15).** Associated thin hypoechoic linear striations within a heterogeneous myometrium reinforce the diagnosis of internal adenomyosis, this criterion being of low sensitivity (3.8%–66.6%), but high specificity (90%–98.7%) These hypoechoic linear striations are easily detected in the absence of leiomyomas and during the reproductive age **(12).**
Diffuse asymmetric or symmetric widening of the myometrial wall(s) is secondary to myometrial hypertrophy and mainly related to deep diffuse internal adenomyosis.

MRI features

T2-weighted sequences are key for diagnosing adenomyosis since the sequences highlight the uterine zonal anatomy. T1-weighted imaging (T1-WI) also contributes to the diagnosis, by depicting high-signal intensity foci that represent haemorrhage. Gadolinium contrast enhancement does not aid in the diagnosis of diffuse adenomyosis **[13],** but should be considered in particular scenarios. Our protocol consists of pelvic T2-WI sagittal, axial and coronal planes and T1 3D fat-suppressed axial and sagittal planes. We use contrast when in doubt about the nature of a uterine nodule or to characterise associated findings, such as an adnexal mass.
Adenomyosis appears as increased thickness of the junctional zone, forming an ill-defined area of low signal intensity on T2, representing the smooth muscle hyperplasia accompanying the heterotopic endometrial tissue. This aspect is frequently associated with bright foci on T2-weighted images, which represent foci of heterotopic endometrial tissue, cystic dilatation of endometrial glands or haemorrhagic foci. If haemorrhagic, the foci are also bright on T1 FSWI images. This sign has the higher positive predictive value (95%) for the diagnosis of adenomyosis, however, with a low sensitivity (47.5%) **[9].**
Adenomyosis is mainly located in the fundus **[9]** and commonly observed in the posterior wall. The typical appearance is a large globular uterus, with a maximum junctional zone thickness of at least 12 mm and punctate high-intensity myometrial foci **[14].**
There are two forms of adenomyosis: diffuse, in which foci of adenomyosis are distributed throughout the uterus, and focal form, also named adenomyoma, when it affects a limited area. The most frequent finding for the diagnosis of adenomyosis is thickening of the junctional zone, with a thickness exceeding 12 mm being highly predictive of the diagnosis **[16, 17].**

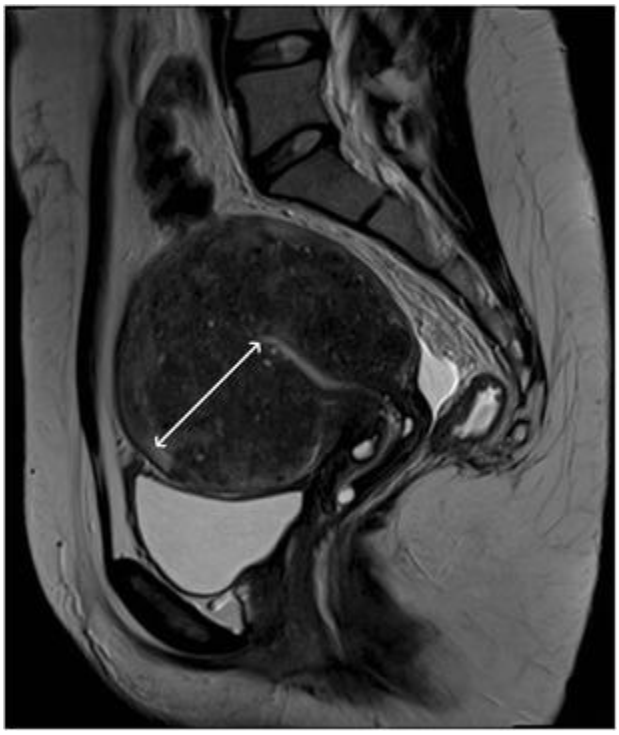


Fig. 2
Diffuse adenomyosis: Sagittal T2-weighed image; thickening of the junctional zone forming an ill-defined area of low signal intensity, with punctate high-intensity myometrial foci (white arrow)

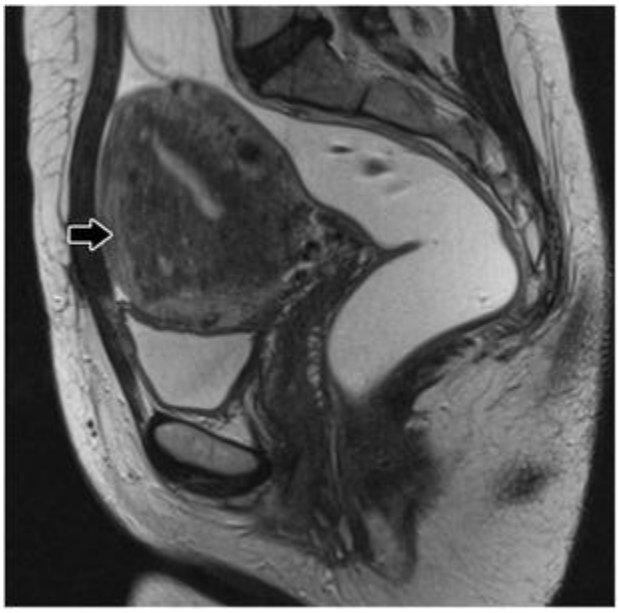


Fig. 3
Focal adenomyosis: Sagittal T2-weighed image; focal asymmetric thickening of the junctional zone forming an ill-defined area of low signal intensity (black arrow)

A junctional zone thickness of less than 8 mm generally permits exclusion of the diagnosis **[12, 16].** According to some authors, a junctional zone thickness between 8 and 12 mm can be diagnosed as adenomyosis, but requires specific criteria **[17, 18].** These include a maximal junctional zone thickness to myometrium thickness ratio over 40% such as a relative thickening of the junctional zone in a localised area

[17], and a difference between the maximum and the minimum thickness of the junctional zone in both anterior and posterior portions of the uterus of more than 5 mm **[19].** One should also look for poorly defined limits of the junctional zone, the presence of high-signal intensity foci on T2- or T1-weighted sequences and linear striations of high T2 signal radiating from the endometrial zona basalis into the myometrium.

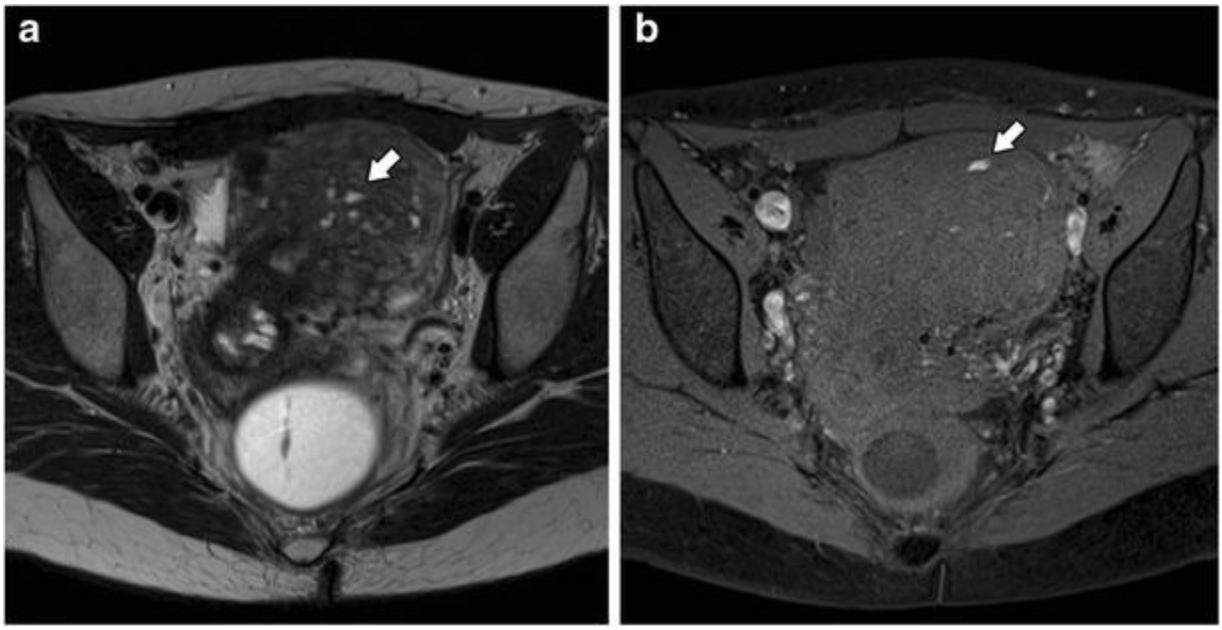


Fig. 4
Focal adenomyosis: **a** Axial T2- and **b** Axial T1 3D FS-weighted images, showing embedded bright foci on T2- and T1 3D FS-weighted images representing haemorrhagic foci (white arrows)

Pitfalls in diagnosis

There are some pitfalls one should recognise when interpreting this type of examination, especially due to its frequent everyday occurrence. These pitfalls are mainly related to the menstrual phase effect on the junctional zone, postmenopausal condition, use of hormonal contraception and the presence of transient uterine contractions.

Thickness of the junctional zone is a hormone-dependent feature and changes according to the menstrual cycle. The uterus during menstruation may demonstrate marked thickening of the junctional zone, mimicking adenomyosis **[18].** Preferably, MRI studies for adenomyosis should be performed in the late proliferative phase, avoiding the menstrual phase.

The junctional zone may not be measurable in approximately 30% of postmenopausal uteruses **[20]** and in women using contraceptive drugs, lowering the MRI sensitivity for the diagnosis.

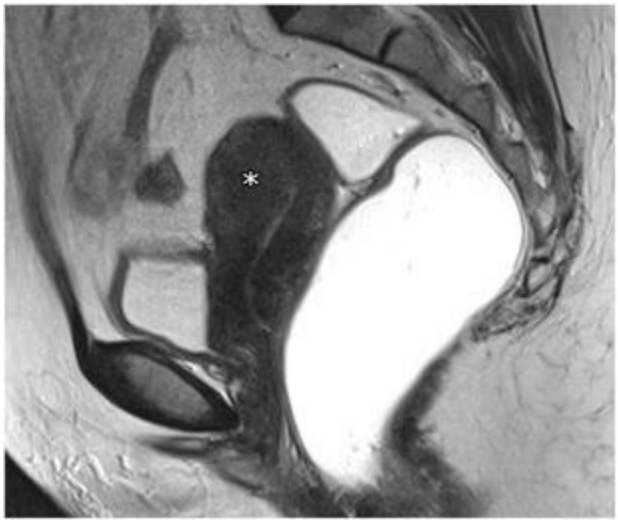


Fig. 5
Postmenopausal uterus: Sagittal T2-weighted images; the junctional zone is not measurable (asterisk)
Transient uterine contractions appear as T2-weighted hypointense bands perpendicular to the junctional zone or focal thickening of the junctional zone, mimicking focal adenomyosis **[21].** Repeating the acquisition of images within a few minutes may demonstrate their transient nature.

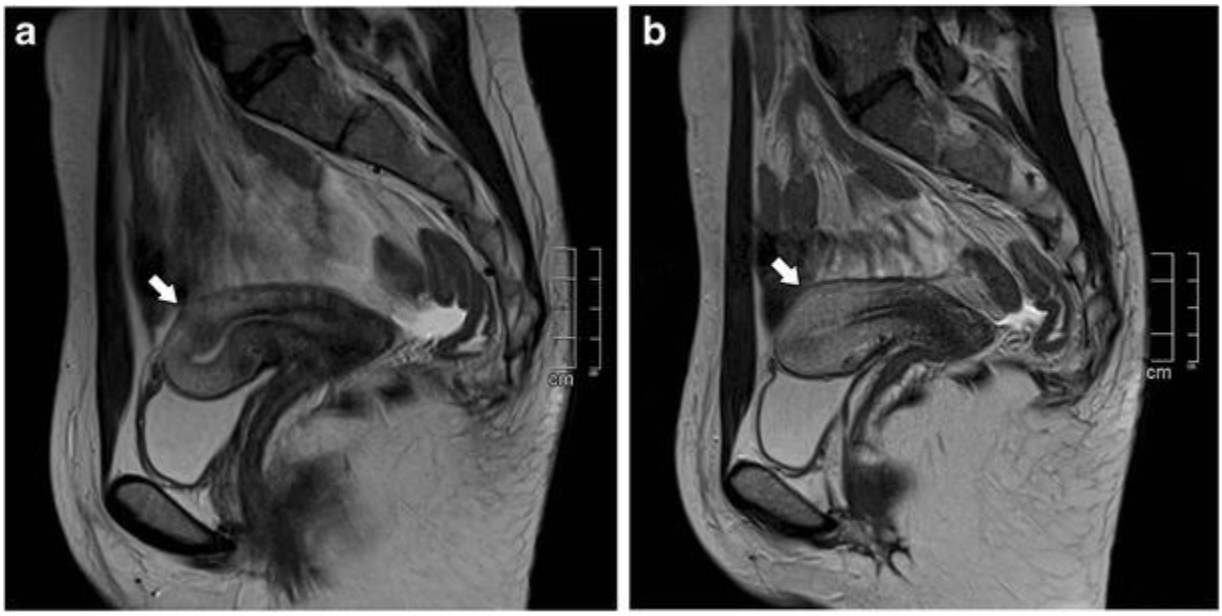


Fig. 6
Uterine contractions mimicking adenomyosis: **a** and **b** Sagittal T2-weighted images; hypointense bands perpendicular to the junctional zone that modify after a few minutes (white arrows), and representing physiologic uterine contractions
On the other hand, adenomyosis may mimic other pathologic conditions. An example is the pseudo-widening of the endometrium, a feature of adenomyosis that mimics endometrial carcinoma. Pseudo-widening of the endometrium represents an invasion of the myometrium by the basal endometrium and has a similar appearance to endometrial carcinoma invading the myometrium **[14, 15].**

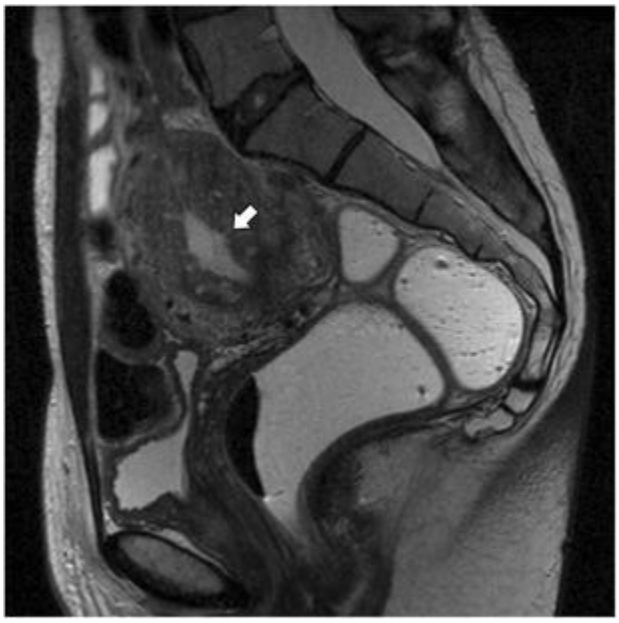


Fig.7
Pseudo-widening of the endometrium: Sagittal T2-weighted images; thickened junctional zone with striated high-signal intensity areas radiating from the endometrium toward the myometrium (white arrow), an appearance that simulates invasion by endometrial carcinoma

Unusual features of adenomyosis

Adenomyoma and adenomyotic polyp

Occasionally an adenomyoma bulges the endometrium, representing a submucosal adenomyoma. It can also protrude into the endometrium to grow as a polypoid mass, forming a polypoid adenomyoma **[22].** Some authors distinguish between focal adenomyosis and adenomyoma, defining adenomyoma as a focal form of adenomyosis which is not in direct continuity with the junctional zone **[23].**

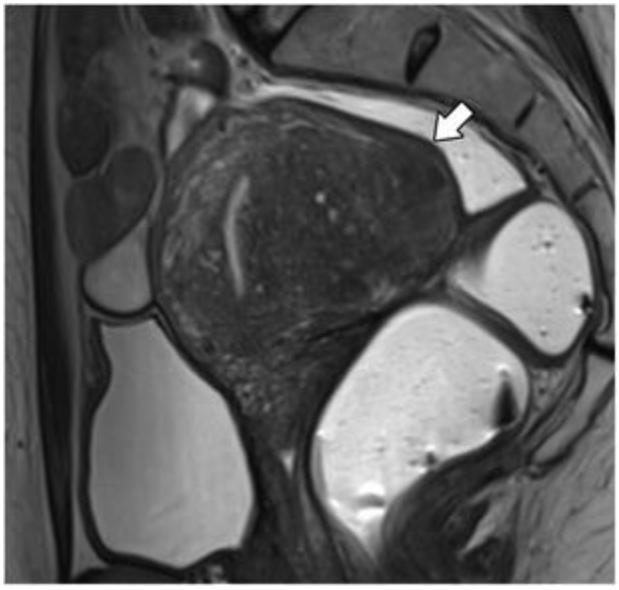


Fig. 8
Adenomyoma: Sagittal T2-weighted image; circumscribed intra-myometrial hypointense mass with ill-defined margins and minimal mass effect with high-signal foci (white arrow)

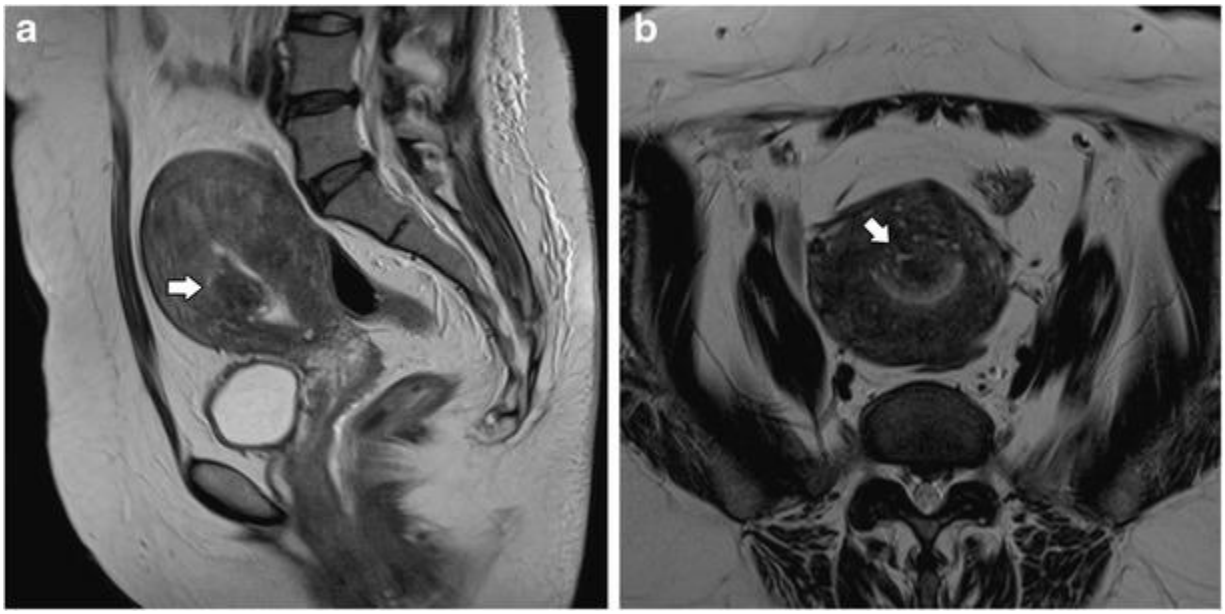


Fig. 9
Polypoid adenomyoma: **a** Sagittal T2- and **b** Axial T2-weighted images; projection of junctional zone into the endometrial cavity with nodular morphology and ill-defined borders (white arrows)

Cystic adenomyosis

Histopathologic criteria for the diagnosis of an adenomyotic cyst include a cavity filled with haemorrhagic fluid that has no communication with the uterine cavity, is lined by endometrium and surrounded by myometrium **[24].** It may be intramural, submucosal or subserosal. The cystic component appears with high-signal intensity on T1-weighted images and low signal on T2-weigted images, with surrounding adenomyotic tissue.

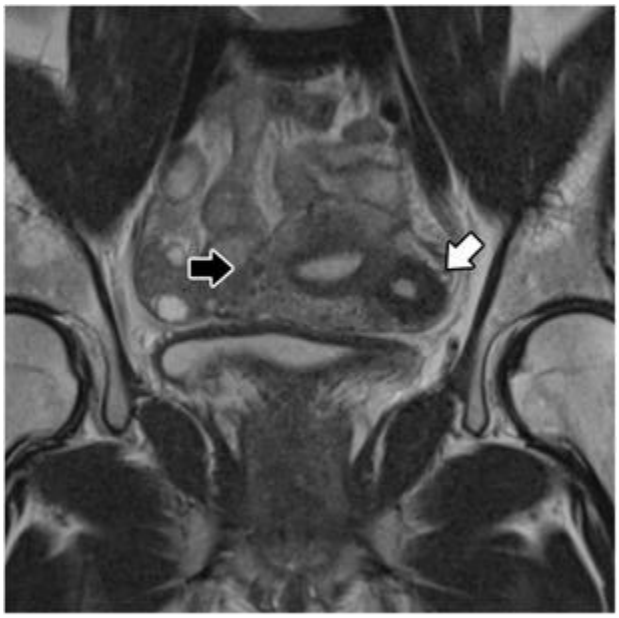


Fig. 10
Isolated or juvenile cystic adenomyoma: Coronal T2-weighted images; nodular uterine lesion with a central cavity with hyperintense signal (white arrow), without connection to the endometrial cavity in an otherwise normal uterus (black arrow)

Swiss cheese appearance

This is a type of diffuse adenomyosis that may appear as a "Swiss cheese" appearance, with exuberant myometrial cysts and nodules on T2 sequence. This "Swiss cheese" appearance is secondary to cross-sectional imaging of dilated endometrial glands within the myometrium **[25].** With a Swiss cheese appearance, there is also widening and poor definition of the junctional zone and linear striations.

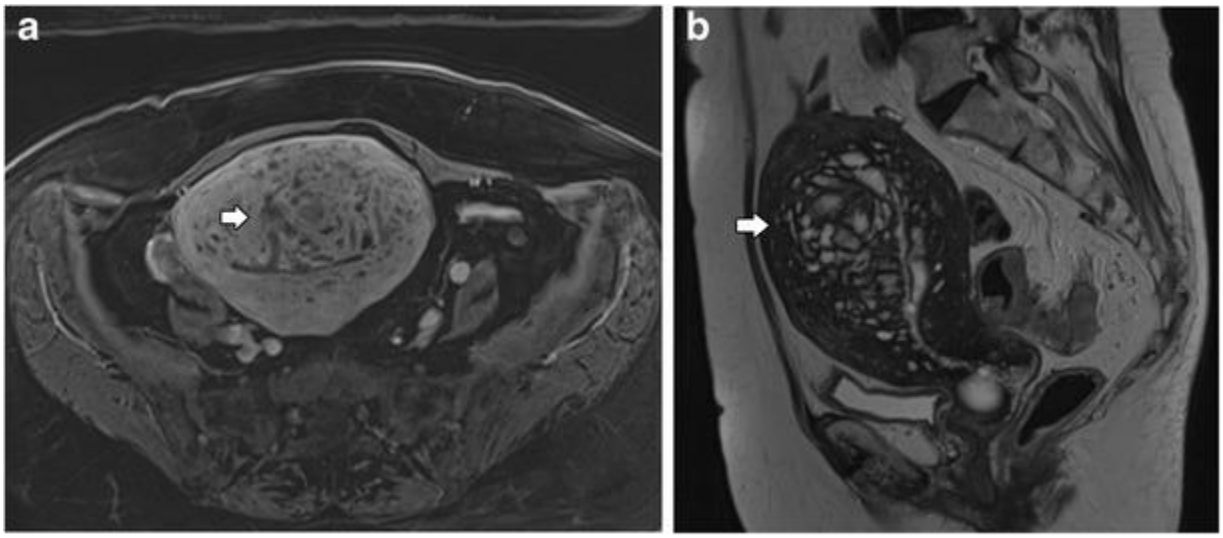


Fig. 11

Swiss cheese appearance in adenomyosis: **a** Axial T1 3D FS- and **b** Sagittal T2-weighted images; poor definition of the endometrial junctional zone with exuberant glandular myometrial cysts, myometrial nodules and linear striations (white arrows)

Differential diagnosis

Leiomyoma

The main differential diagnosis of adenomyoma is leiomyoma. Adenomyoma appears as a hypointense mass on T2- weighted images with ill-defined borders, minimal mass effect and, in some cases, with multiple bright foci. In counterpoint, leiomyomas mostly have well-defined borders, despite also being hypointense on T2-weighted images. The presence of large vessels at the periphery may also favour this diagnosis **[26].**

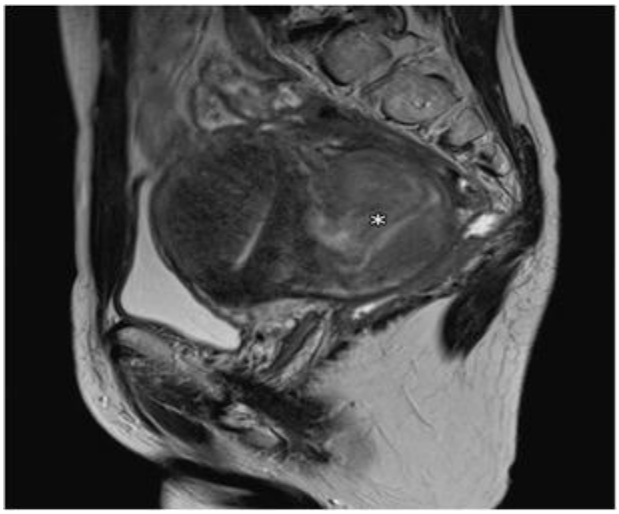


Fig. 12

Leiomyoma: Sagittal T2-weighted image; heterogeneous and hypointense mass with well-defined borders, with mass effect on adjacent tissues (asterisk) representing leiomyoma. There are also features suggestive of adenomyosis

Associated conditions

Adenomyosis is frequently associated with hormone-dependent pelvic lesions. Leiomyomas are present in almost 50% of cases involving adenomyosis of the uterus **[27],** while one third of young women with clinically suspected, deeply infiltrating endometriosis had MRI features of uterine adenomyosis **[28]**. Adenomyosis also seems to be correlated with severe endometriosis **[29].**

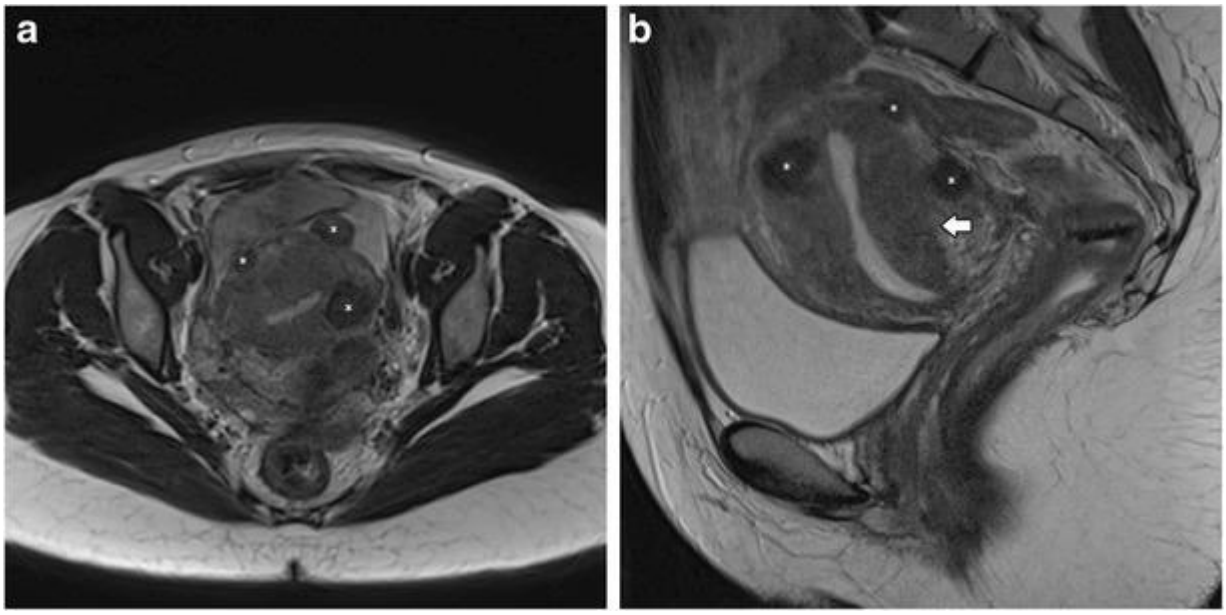


Fig. 13

Diffuse adenomyosis and leiomyomas: **a** Axial T2 and **b** Sagittal T2-weighted images; diffuse thickening of the junctional zone (white arrow) in relation to diffuse adenomyosis and multiple hypointense masses representing leiomyomas (asterisks) **[30].**

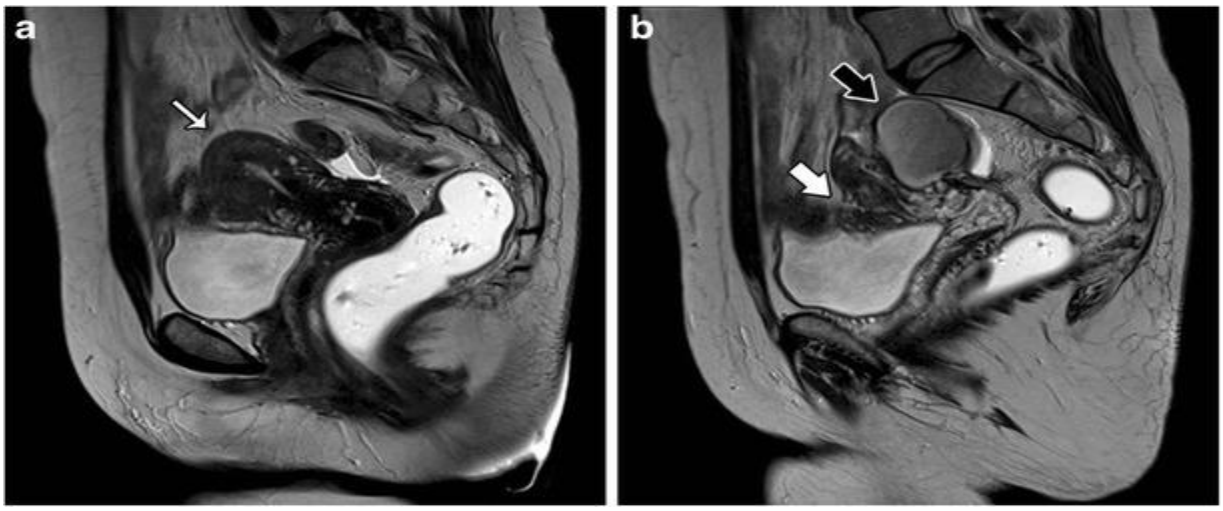


Fig. 14

Adenomyosis and endometriosis: **a** and **b** Sagittal T2-weighted images; broadened junctional zone forming an ill-defined area of low signal intensity, with punctate high-intensity myometrial foci indicating

adenomyosis (thin white arrow); endometriotic nodule in the bladder wall (white arrow); endometrioma in the left ovary (black arrow)

Conclusion

MRI represents an accurate evaluation tool for adenomyosis, allowing its diagnosis and detection of associated pathologies. It is important to recognise the usual and unusual characteristics of adenomyosis and be aware of pitfalls in order to make a correct diagnosis.

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