Many faces of adenomyosis: Usual, unusual MR manifestations, pitfalls and problem-solving techniques

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Learning objectives

To demonstrate various MR manifestations of adenomyosis.
To describe problem-solving MR techniques for the diagnosis of adenomyosis: Diffusion-weighted imaging (DWI), Susceptibility-weighted imaging (SWI), 1H-MR spectroscopy (MRS), Cine-MRI, and Highresolution MRI at 3T.

Background

Adenomyosis is characterized by the presence of ectopic endometrium within the myometrium. Typical adenomyosis shows characteristic MR imaging: diffuse or focal thickening of junctional zone, ill-demarcated low intense myometrial lesion on T2-weighted images. However, adenomyosis may exhibit various MR manifestations and mimic benign or malignant gynecologic pathologies.

Imaging findings OR Procedure details

[MR manifestations with pathologic correlation]

Adenomyosis may affect the uterine myometrium diffusely or focally. Adenomyosis is characterized by the presence of ectopic endometrium (endometrial glands and stroma) with hypertrophy and hyperplasia of smooth muscle (Fig. 1 on page ).

Typical adenomyosis appears as ill-demarcated low intense lesion on T2-weighted images with uterine enlargement due to abundant smooth muscle proliferation (Fig. 2 on page ) (Fig. 3 on page ).

Because adenomyotic endometrium looks alike the basalis endometrium which seldom responds to hormonal stimuli, cyclic changes including degeneration, bleeding, and regeneration are less common in adenomyosis. On T2-weighted images ectopic endometrium may appear as high intense spots like normal endometrium (Fig. 2 on page ) (Fig. 3 on page ). Small cysts may also appear as high intense spots on T2-weighted images. Sometimes hemorrhagic foci may appear as high intense spots on T1-weighted images due to T1-shortening effects of methemoglobin. Susceptibility-weighted imaging (SWI) is sensitive for obsolete hemorrhagic foci as spotty signal voids due to T2*-shortening effects of hemosiderin.

Because adenomyosis may show various degrees of contrast enhancement (CE), CE study do not attribute to diagnostic accuracy (Fig. 4 on page ). Heterogeneous contrast enhancement of adenomyosis may cause misdiagnosis in evaluating the depth of myometrial invasion of endometrial cancer.

[Problem-solving Techniques]

- Diffusion-weighted imaging (DWI)

DWI visualizes the local microstructural characteristics of water diffusion. In oncologic imaging, various malignant tumors may show high signal intensity on DWI due to their high cellularity and long T2 relaxation time. Apparent diffusion coefficient (ADC) measurement yields quantitative information regarding tissue structure based on the
molecular motion of water. Malignant lesions with increased cellularity show low ADC values, whereas relative hypocellular benign pathologies and normal structures tend to show higher ADC values.

-Susceptibility-weighted imaging (SWI)
SWI combines magnitude and phase information, and visualizes the magnetic susceptibility effects generated by local inhomogeneity of the magnetic field caused by hemosiderin or deoxyhemoglobin as signal voids. SWI is more sensitive to the susceptibility difference between tissues than conventional T2*-weighted imaging. In body imaging, SWI consisting of using both magnitude and phase images from 2D-FSPGR (fast spoiled gradient recalled acquisition in the steady state sequence). To enhance the visibility of signal voids caused by the magnetic susceptibility effects, post-processing is applied to the magnitude images multiplied with a phase mask generated from the filtered phase data.

-1H-MR Spectroscopy (MRS)
1H-MRS is used to measure various metabolites in body tissues and provides information on tumor metabolites in patients. In gynecologic tumors, choline peak reflects metabolic activity of cell membrane in solid tumors. High grade malignant tumors tend to show higher choline peaks.

-Cine MRI
Cine MRI visualizes uterine motion by using serial ultrafast T2-weighted imaging. Cine MRI is useful indistinguishing transient myometrial contraction from focal adenomyosis, and in determining the origin of exophytic uterine lesions.

-High resolution MRI at 3T
The increase in signal-to-noise ratio (SNR) at 3T offers high resolution MR imaging. Anatomically detailed structures are visualized on high resolution MRI and may improve the diagnostic accuracies in differential diagnosis, in detecting small lesions, and in evaluating tumor extent for the cancer staging.

[Atypical MR manifestations and problem-solving techniques]
Various physiologic or pathologic states may influence MR appearances of adenomyosis; amount of functional endometrial tissue, phase of the menstrual cycle, endogenous hormonal abnormality, and exogenous hormonal stimulation.

Secretory transformation of adenomyotic endometrium including stromal decidualization may cause heterogeneous signal increase on T2-weighted imaging (Fig. 5 on page ). These phenomena may be encountered during gestation and exogenous postgestational therapy, or even in patients without specific hormonal stimulation. Congestion or edematous change may also increase the signal intensity of adenomyosis diffusely or focally (Fig. 5 on page ). In such conditions, MR manifestations may fluctuate, and follow-up MR study may be helpful for the diagnosis (Fig. 5 on page ). Diffusion-weighted imaging (DWI) with apparent diffusion coefficient (ADC) measurement may be another clue for the diagnosis, because these conditions (secretory transformation, decidualization, congestion or edema) usually increase the ADC in tissues. Relatively high ADC in T2-high intense adenomyotic lesions may be distinguishable from malignant pathologies with low ADC due to their high cellularity (Fig. 6 on page ). 1-H MR spectroscopy (MRS) may also be a clue for the
diagnosis, because these benign adenomyotic conditions do not show high metabolic activity. Relatively low choline peak adenomyotic lesions may be distinguishable from malignant tumors showing high choline peak due to their high metabolic activity (Fig. 7 on page ).

After hormonal therapy or menopause, adenomyosis may shrink with decreased signal intensity on T2-weighted images (Fig. 8 on page ).

**[Pitfalls and problem-solving techniques]**

- **Physiological changes of the uterine body during menstrual cycle**
  Uterine body may show physiologic changes during menstrual cycle. Low intense junctional zone and adenomyosis are well visualized due to increased signal intensity of the myometrium on the secretory phase (luteal phase). Decreased signal intensity of the myometrium on the menstrual - early proliferative phase (follicular phase) may cause the widening of junctional zone mimicking diffuse adenomyosis. So MRI for the evaluation of uterine myometrial lesion should be obtained on late proliferative - secretory phase (Fig. 9 on page ).

- **Adenomyosis mimickers**
  Benign and malignant adenomyosis mimickers; physiological myometrial contraction, myometrial involvement of pelvic endometriosis, low-grade endometrial stromal sarcoma, and myometrial metastases should be differentiated.

  **Transient myometrial contraction** as a physiological phenomenon may mimic adenomyosis, which may disappear in subsequent images or during cine-MRI (Fig. 10 on page ) (movie 1 on page ), whereas focal adenomyosis persists in subsequent images or during cine-MRI (movie 2 on page ). In pregnant uterus myometrium adjacent to the implant site may show low intensity mimicking physiological contraction or focal adenomyosis reflecting blood supplying contraction (Fig. 10 on page ). SWI is also helpful in differentiating adenomyosis from focal contraction by demonstrating small hemorrhagic foci in adenomyosis as spotty signal voids (Fig. 11 on page ).

  Adenomyosis is caused by benign invasion of ectopic endometrium into the myometrium, and is a different entity from endometriosis. However, some adenomyosis may be situated in the subserosal region apart from the junctional zone. These lesions may be caused by myometrial involvement of pelvic endometriosis, and patients tend to complain severe menstrual pain due to adhesion (Fig. 12 on page ). Some primary or secondary malignant tumors may appear as ill-demarcated myometrial masses with uterine enlargement mimicking adenomyosis.

  **Low-grade endometrial stromal sarcoma (LG-ESS)** is a rare malignant mesenchymal tumor affecting young women, and usually occurs in the endometrium with extensive myometrial invasion. LG-ESS may occasionally be situated almost within the myometrium. Myometrial invasion of LG-ESS is very infiltrative, and preserved low intense muscle bundles within high intense tumor on T2-weighted images are characteristic MR finding. However, intra-myometrial tumor may simulate adenomyosis, and preoperative diagnosis is occasionally difficult (Fig. 13 on page ). High-resolution T2-weighted imaging at 3T-MRI is helpful for the diagnosis of LG-ESS by demonstrating preserved fine muscular fibers within the tumor as worm-like low intense structures (Fig. 13 on page ). High signal intensity with decreased ADC on DWI
and high choline peak on MRS are another clues for the diagnosis of this rare malignant tumor (Fig. 14 on page ). DWI is also useful in evaluating tumor extension along the vessels, which is another characteristic of LG-ESS (Fig. 14 on page ). Secondary uterine myometrial involvement of malignant tumors may mimic adenomyosis. Especially, breast cancer and malignant lymphoma may cause diffuse infiltrative myometrial involvement with uterine enlargement (Fig. 15 on page ). Destruction of normal structures such as endometrium may suggest malignant nature of uterine enlargement. DWI and MRS may also useful for the diagnosis of malignant uterine involvement.

[Atypical morphologic appearances of adenomyosis]

-Adenomyoma

Adenomyoma is characterized as a solid mass-like localized form of adenomyosis. Adenomyoma may appear as intra-cavital or subserosal polypoid masses, or as an intramyometrial mass. Subserosal polypoid adenomyoma may mimic subserosal leiomyoma or leiomyosarcoma (Fig. 16 on page ). Adenomyomatous polyp, which is often associated with tamoxifen therapy, is an endometrial polyp with significant amounts of smooth muscle and is histologically identical to polypoid adenomyoma in the uterine cavity (Fig. 17 on page ). Adenomyoma may show heterogeneous signal intensity on T2-weighted imaging like adenomyosis and may mimic sarcomas. Relative low signal intensity on DWI with high ADC and low choline peak on MRS may besuggestive for its benign nature and can differentiate adenomyoma from sarcomas, which show high signal intensity on DWI with low ADC and high choline peak on MRS (Fig. 16 on page ).

-Adenomyotic cyst

Adenomyotic cyst (cystic adenomyosis) is a rare variation of adenomyosis appearing as an endometrioma-like intramyometrial hemorrhagic cystic mass surrounded by adenomyotic tissue. Adenomyotic cyst may appear as intra-cavital or subserosal polypoid cystic masses, or as an intramyometrial mass. High intense hemorrhagic cyst on T1-weighted images surrounded by low intense cyst wall corresponding to adenomyotic tissue on T2-weighted images is characteristic(Fig. 18 on page ). Subserosal adenomyotic cyst may mimic ovarian tumor. Demonstrating the continuity to the myometrium as "beak sign" suggests its uterine origin (Fig. 18 on page ). Synchronous motion of cystic mass and uterus on cine-MRI may also suggestive for the diagnosis of subserosal adenomyotic cyst (movie 3 on page ).

-Pseudowidening of the endometrium

On T2-weighted images, endometrial junction may be obscure due to high intense linear striations radiating from the endometrium to adenomyosis. Occasionally, "pseudowidening" of the endometrium may occur resulting from the blending of striations. These phenomena may fluctuate according to the hormonal state of patients (Fig. 19 on page ). When endometrial cancer-exists adjacent to adenomyosis, these phenomena may cause over-staging in evaluating the depth of myometrial invasion and DWI may be helpful for the correct staging (Fig. 19 on page ) (Fig. 20 on page ).

[Co-existing endometrial cancer/ Malignant transformation]
**-Co-existing endometrial cancer**
Because adenomyosis may show heterogeneous signal intensity on T2-weighted images and gadolinium-enhanced T1-weighted images, the boundaries between endometrial cancer and adjacent adenomyosis may be obscure. It may cause staging errors in evaluating the depth of myometrial invasion. DWI can demonstrate the tumor margins clearly and may improve the staging accuracies (Fig. 20 on page ).

**-Malignant transformation**
*Malignant transformation of Adenomyosis* is quite rare and may reveal as a predominantly intramyometrial mass. Imaging findings of *Adenomyotic cyst* with malignant transformation are similar to those of endometrial cyst with malignant transformation. DWI can demonstrate the malignant foci as high signal intensity (Fig. 21 on page ).

Images linked within the text of this section:
Typical Adenomyosis: MR manifestations

T2WI  Diffuse low intensity w/wo high intense spots on T2WI

T1WI  Spotty high intense hemorrhagic foci on T1WI

Fig. 2

Low - intermediate intensity on DWI  ADC map

ADC: 1.25
**Fig. 3**

**Typical Adenomyosis on T2WI**

Small high intense spots corresponding to active endometrial tissue and cysts

May appear as irregularly thickened junctional zone

Larger cysts are less common

Often endometriosis co-exists

Ill-defined low intense lesion with myometrial enlargement due to hypertrophy/hyperplasia of smooth muscle
Fig. 4

Typical Adenomyosis: contrast enhancement

May show various degrees of contrast enhancement

May show various vascularity on Dynamic study

T2WI

CE-fsT1WI Intense CE like myometrium

T2WI

CE-fsT1WI Weak CE

Dynamic MRI

Heterogeneous CE: weak to intense
Adenomyosis: Signal increase on T2WI

MR manifestation may fluctuate

Hyperemia or focal edematous changes

Signal decrease on follow-up T2WI.

Secretory transformation, or stromal decidualization

Fig.
Problem-solving technique: DWI

Adenomyosis with focal edema

T2-high intense mass  Iso -slt. High on DWI  Relative High ADC: 1.7 ($\times 10^{-3}$ mm$^2$/sec)

T2WI ........................... DWI ........................... ADC map ...........................

T2-high intense mass  Very high on DWI  Low ADC: 0.56 ($\times 10^{-3}$ mm$^2$/sec)

Malignant Lymphoma
Fig. 7

Problem-solving technique: MR Spectroscopy

Adenomyosis with local edema

Low choline peak

T2-high intense masses

High choline peaks

Uterine sarcoma

Malignant lymphoma
Hormone-related changes of Adenomyosis

Volume and T2-signal decrease in Adenomyosis

Spontaneous shrinking after menopause

Total uterine volume and T2-signal intensity of the myometrium is decreased
Fig. 9

**Pitfalls: Physiologic changes of uterine body during Menstrual cycle**

- **Menstrual phase**
  - Decreased signal intensity may cause the widening of junctional zone mimicking diffuse adenomyosis

- **Secretory phase (Luteal phase)**
  - Low intense junctional zone is well visualized due to increased signal intensity of the myometrium

- **Secretory phase (Luteal phase)**
  - Adenomyosis

**MRI should be obtained on** late proliferative - secretory phase**

**NOT on menstrual phase!**
Fig. 10

**Pitfalls: Uterine myometrial contraction**

*Fig. 10*

- **Transient myometrial contraction** may mimic **adenomyosis**, which may **disappear** in subsequent images.
- **Pregnant uterus**: T2-low implant site reflecting blood supplying contraction, mimicking physiological contraction or focal adenomyosis.
- **Adenomyosis** does not disappear in subsequent images or during cine-MRI.

**Fig.**
Susceptibility-weighted imaging (SWI)

Fig. 11

Hemorrhagic foci are not always clear on T1-/T2WIs. Signal voids due to blood products are clearly visualized on SWI.

No signal voids in Contraction

Signal voids in Adenomyosis

Contraction with pregnancy

Focal Adenomyosis

Fig.
Subserosal adenomyosis

Endometrioma

Fibrous adhesive changes suggesting the myometrial involvement of pelvic endometriosis

Deformed uterus due to adhesion

Adenomyosis situated in the subserosal region apart from junctional zone
Low-grade Endometrial Stromal Sarcoma

Intra-myometrial LG-ESS may mimic adenomyosis

Characteristic worm-like low intense muscle fibers are clear on high resolution T2WI at 3T, however, not clear at 1.5T and mimicking adenomyosis.
Low-grade Endometrial Stromal Sarcoma

Involvement of bilateral vessels are clearly revealed on DWI as high intense dilated vascular structures.

Relative high intensity on DWI with low ADC
High choline peak on MRS

High Uptake(-)
SUV max: 2.1

High choline peak
Secondary myometrial involvement of malignancy

Pathy, ill-demarcated low intense areas in the myometrium on CE-T1WI

Breast cancer

Cancer cells are scattered within the myometrium

Slight low intense myometrial thickening with No definite mass on T2WI

T2WI

CE-fsT1WI

Diffuse uterine enlargement with heterogeneous contrast enhancement

Diffuse B cell lymphoma

Normal endometrium is obscure

Malignant lymphoma

Fig.
Subserosal Polypoid Adenomyoma

Huge exophytic mass exhibiting heterogeneous signal intensity on T2WI

Relative low intensity on DWI with high ADC and low choline peak on MRS suggest its benign nature
Adenomyomatous Polyp (Polypoid adenomyoma)

Low intense fibrous - muscular components and cystic dilated glands

Low intense thick fibrous stalk suggests endometrial polyp

Abundant smooth muscle components with endometrial glands
**Adenomyotic cysts**

Intra-myometrial hemorrhagic cyst surrounded by T2-low intense adenomyotic area

Subserosal hemorrhagic cystic mass containing clots - fibrous scar

Fig.
Fig.

**Linear striation - Pseudowidening of the Endometrium**

- **T2WI**
  - Striate high intense areas causing "pseudo-widening" of endometrium

- **DWI**
  - DWI can demonstrate high intense tumor margin clearly

**"pseudo-widening" simulating invasion**

- **T2WI**
  - Co-existing endometrial cancer
  - No myometrial invasion
Endometrial cancer co-existing with Adenomyosis

Endometrial cancer with myometrial invasion

Endometrial cancer with No myometrial invasion

Tumor extent may be overestimated due to Co-existing adenomyosis on CE-images, whereas DWI can correctly evaluate.

Tumor and Co-existing adenomyosis show similar low intensity on CE-images, whereas DWI can differentiate them.
Malignant transformation

Endometrioid carcinoma arising from Adenomyosis

T2WI

CE-fsT1WI

Ill-defined weak CE area

T2WI

DWI

Ill-defined malignant area within adenomyosis shows High on DWI

Endometrioid Carcinoma arising from Adenomyotic Cyst

Small Malignant focus is not clear due to High intensity on T1-T2-WI

Subtraction imaging may be useful for detecting malignant transformation.
Fig.
Conclusion

To recognize various MR manifestations of adenomyosis and making accurate diagnosis by using problem-solving MR techniques are important for appropriate management of the patients.

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References