Imaging features of adenomyosis

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This review focuses on non-invasive imaging techniques that have proven useful in diagnosing adenomyosis, including hysterosalpingography, transabdominal and endovaginal ultrasound, as well as magnetic resonance imaging. An understanding of the histopathological features of this disease is crucial when attempting to interpret the associated imaging findings. The muscular hyperplasia accompanying the heterotopic endometrial tissue actually produces the typical gross appearance of adenomyosis and corresponds to areas of decreased echogenicity or signal intensity on ultrasound and magnetic resonance imaging respectively. The heterotopic endometrial tissue also contributes to the imaging appearance of adenomyosis, and with the advent of high resolution imaging techniques, these changes are being detected with increasing frequency, including the presence of myometrial nodules, linear striation, poor definition and nodularity of the endo-myometrial junction, pseudowidening of the endometrium, and myometrial cysts or haemorrhagic foci. The purpose of this review is to (i) present the spectrum of imaging findings of adenomyosis, (ii) illustrate potential pitfalls in diagnosis and (iii) review the accuracy and role of currently available noninvasive imaging techniques.

Key words: Adenomyosis/endometriosis/uterus/uterus abnormalities

Introduction

Adenomyosis uteri is a common gynaecological disorder that is characterized by the presence of heterotopic endometrial glands and stroma in the myometrium with adjacent smooth muscle hyperplasia. The presenting symptoms of pelvic pain, dysmenorrhea, and menorrhagia are non-specific and can also be seen in disorders such as dysfunctional uterine bleeding, leiomyomas and endometriosis, among others (Aziz, 1989; Thomas and Clark, 1989; Muse, 1990). It is not unexpected, therefore, that the rate of pre-operative diagnosis of adenomyosis based on clinical findings is poor, ranging from 2.6 to 26%; and until recently, this diagnosis was rarely established prior to hysterectomy (Benson and Sneeden, 1958; Israel and Woutersz, 1959; Molitor, 1971; Owolabi and Strickler, 1977).

The role of imaging in evaluating patients with a suspected diagnosis of adenomyosis is 3-fold. First, the diagnosis of adenomyosis must be made with a high degree of accuracy. In particular, adenomyosis must be differentiated from a number of other conditions that may mimic its appearance with imaging. Establishing the correct diagnosis pre-operatively is essential, since uterine-conserving therapy is possible with leiomyomas, whereas hysterectomy is the definitive treatment for debilitating adenomyosis. However, as addressed elsewhere in this review, a number of conservative operative and non-operative treatment options are available to women who desire to maintain their childbearing capacity (Siegl and Camilien, 1994). In addition, because clinical suspicion continues to be the mainstay of pre-operative diagnosis and adenomyosis is often used as a diagnosis of exclusion, symptomatology may not improve with hysterectomy (Lee et al., 1984; Stovall et al., 1990). A diagnostic test with a high negative predictive value for adenomyosis would prevent unnecessary surgery. Second, the degree of involvement and depth of myometrial penetration must be assessed with imaging, because symptomatology has been shown to correlate with extent.
of disease (Benson and Sneed, 1958). Caution must be exercised before attributing a patient’s symptoms to adenomyosis particularly in the presence of mild disease, since adenomyosis may be diagnosed at histopathology in up to 70% of unselected hysterectomy specimens (Bird et al., 1972; Seidman and Kjerluff, 1996). Co-existing conditions that may account for the patient’s symptomatology must be excluded at the time of imaging. Determining the depth of myometrial penetration is also important for treatment planning, since superficial adenomyosis responds significantly better to endometrial ablation than the deep form (Siegler and Camilien, 1994; McCausland and McCausland, 1996). Third, for patients receiving conservative therapy, the evolution of the disease must be monitored with imaging.

An understanding of the gross and histopathological features of this disease is crucial when attempting to interpret the associated imaging findings. Although a detailed description of the pathological features of adenomyosis is provided elsewhere in this review, it is important to emphasize that the smooth muscle hyperplasia accompanying the heterotopic endometrial tissue actually produces the characteristic gross appearance of this disease (Azziz, 1989). Nevertheless, the heterotopic endometrial tissue also contributes to the imaging appearance of adenomyosis, and with the advent of high-resolution imaging techniques these changes are being detected with increasing frequency. The varied appearance of adenomyosis on imaging relates directly to the distribution of the heterotopic endometrial tissue, the amount of associated muscular hyperplasia, and the presence of haemorrhagic foci or cysts within the heterotopic endometrial tissue. Cyclic haemorrhage, however, is infrequently observed with adenomyosis, since the heterotopic endometrial tissue originates from the stratum basale and is typically unresponsive to hormonal stimuli. Recently it has been suggested that endometriotic nodules of the rectovaginal septum are more appropriately classified as a form of adenomyosis, and represent a disease entity distinct from peritoneal endometriosis. The histological basis for these adenomyotic nodules is unclear; however, it has been postulated that they develop from Müllerian rests present in the rectovaginal septum. This review will focus on adenomyosis solely as it relates to the uterine corpus (Donnez et al., 1995).

Several investigative techniques have been advocated for diagnosing adenomyosis. We will limit our discussion to non-invasive imaging techniques that have proven useful in diagnosing this disease, including hysterosalpingography, transabdominal sonography, endovaginal sonography, and magnetic resonance imaging. The purpose of this review is to present the imaging findings, diagnostic pitfalls, and accuracy of these imaging techniques in diagnosing adenomyosis.

**Hysterosalpingography**

Hysterosalpingography (HSG) was the first imaging modality used to diagnose adenomyosis. As early as 1949, Goldberger et al. reported the characteristic findings of adenomyosis on HSG as multiple spicules, 1–4 mm in length extending from the endometrium into the myo-
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Figure 3. Normal uterus on endovaginal sonography. The normal myometrium (M) is moderately echogenic and has a homogeneous echotexture. Note the arcuate veins in the outer myometrium dorsally. The subendometrial halo is not visualized in this patient. The patient is midcycle and has a trilaminar endometrium (E).

metrium and ending in small sacs (Figure 1). However, only 38 of the 150 patients (25%) who subsequently were proven to have adenomyosis were noted to have this sign at HSG (Goldberger, 1949). A localized accumulation of contrast material in the myometrium with a honeycomb appearance has also been demonstrated in patients with adenomyosis (Figure 2). However, areas of adenomyosis that do not communicate with the endometrial cavity will not be diagnosed with HSG, accounting in part for the low sensitivity of this test (Marshak and Eliasoph, 1955; Slezak and Tillinger, 1976). In addition, the accumulation of contrast material in the myometrium either as spicules or in a honeycomb pattern can be non-specific on HSG, and may be encountered during vascular or lymphatic extravasation (Wolf and Spataro, 1988). Therefore, due to its low overall accuracy, HSG is no longer used in the evaluation of patients with suspected adenomyosis.

Transabdominal sonography

In the literature to date, little emphasis has been placed on the role of sonography in diagnosing adenomyosis. Initial reports, using transabdominal sonography (TAS), were not able to reliably diagnose adenomyosis nor to consistently differentiate it from leiomyomas (Bulic et al., 1986; Bohlman et al., 1987). This is not surprising since the resolution obtained with TAS limits detailed evaluation of the myometrium. Probes for TAS generally employ frequencies on the order of 3.5–5 MHz, which provide the necessary penetration to image organs posterior to the urinary bladder, but have limited spatial resolution. In 1979, Walsh et al. published the first report on the gray-scale sonographic findings of adenomyosis in nine women, four of whom had histopathological confirmation. In all nine patients, the myometrium demonstrated a focal honeycomb appearance with 5–7 mm irregular ‘cystic’ spaces disrupting the normal fine, speckled echo pattern of the uterus. Similarly, Bohlman et al. (1987), using TAS, found that the myometrium of six patients with adenomyosis was slightly more hypoechoic than the normal myometrium, although they were unable to resolve small cystic lesions. Additional sonographic findings in this small series of patients included uterine enlargement, posterior wall thickening, and anterior displacement of the endometrial cavity (Bohlman et al., 1987). These signs, however, are non-specific and do not allow the diagnosis of adenomyosis to be made conclusively. In addition, the number of patients studied in the above series is too small for meaningful reporting of diagnostic accuracy. In a retrospective review, Siedler et al. (1987) examined 80 patients with TAS and diagnosed adenomyosis with a sensitivity of 63%, a specificity of 97%, and a positive predictive value of 71%.

To date, TAS remains unable to reliably diagnose adenomyosis or to consistently differentiate it from leiomyomas (Bohlman et al., 1987; Arnold et al., 1995). In our experience, the resolution afforded by TAS is insufficient to demonstrate the more subtle sonographic features of adenomyosis in a reproducible and consistent fashion.

Endovaginal sonography

The advent of endovaginal sonography (EVS) in 1985, with its improved resolution, has renewed interest in diagnosing adenomyosis using ultrasound. Transducers used for EVS operate at higher frequencies, on the order of 5–7 MHz, in contrast to the lower frequency instruments used for the transabdominal approach. The use of higher frequency transducers improves spatial resolution and reduces imaging artefacts. It has been well established that the greater resolution afforded by EVS renders it invaluable in the work-up of multiple gynecological disorders (Coleman et al., 1988; Timor-Tritsch et al., 1988; Lyons et al., 1992).

Patients with clinically suspected adenomyosis should routinely undergo sonographic examination using the endovaginal approach, since a detailed depiction of the myometrium is needed to accurately detect the imaging features associated with adenomyosis. In addition, the sonographic signs of adenomyosis may be subtle and
Figure 4. Adenomyosis. (LEFT) Oblique transverse section through the uterus with endovaginal sonography. There is thickening of the ventral myometrium. Note the decreased echogenicity and heterogeneity of the ventral (curved arrows) relative to the dorsal myometrium. A small myometrial cyst (arrow) is also present. There is poor definition of the endo-myometrial junction. (RIGHT) Sagittal T2-weighted magnetic resonance image through the uterus in the same patient demonstrates a poorly defined low signal intensity mass (curved arrows) with numerous foci of high signal representing the heterotopic endometrium in the ventral myometrium. Note the striated or ‘finger-like’ appearance of the heterotopic endometrium in some areas. E = endometrium, Bl = bladder.

Figure 5. Adenomyosis, predominantly hypoechoic. Sagittal section through a retroverted uterus with endovaginal sonography. There is a poorly defined, homogeneous area of decreased echogenicity (arrows) in the ventral myometrium. At histopathology (not shown), the bulk of the lesion consisted of muscular hyperplasia with sparse islands of microscopic endometrial tissue. Note the absence of mass effect of the lesion on the endometrium (E).

cannot be reliably diagnosed from hard-copy images but must be diagnosed during the course of the real-time examination.

The normal uterus shows zones of differing echogenicity on transvaginal sonography (TVS) (Lyons et al., 1992) (Figure 3). To briefly review the pertinent anatomy: the myometrium of the normal uterine corpus has three distinct sonographic layers, referred to as the outer, middle, and inner layers. The middle layer is the most echogenic and is separated from the thin outer layer by the arcuate venous and arterial plexus. The inner layer consists of longitudinal and circular smooth muscle fibres and is hypoechoic relative to the middle and outer layers. This layer is referred to as the subendometrial or myometrial halo. The endometrium consists of a superficial functional layer and a deep basal layer (stratum basale). It is the stratum basale
that gives rise to the heterotopic endometrial tissue in adenomyosis. However, this layer is very thin and cannot be identified sonographically as a distinct entity. The presence of adenomyosis can alter and distort the sonographic appearance of these uterine zones.

To date, several findings suggestive of adenomyosis on TVS have been reported in the literature. Criteria used for diagnosing adenomyosis include uterine enlargement not explained by the presence of leiomyomas (Brosens et al., 1995b), asymmetric thickening of the anterior or posterior myometrial walls (Ascher et al., 1994; Brosens et al., 1995b; Hirai et al., 1995), lack of contour abnormality or mass effect (Brosens et al., 1995b), heterogeneous, poorly circumscribed areas within the myometrium (Fedele et al., 1992a,b; Ascher et al., 1994; Brosens et al., 1995b; Hirai et al., 1995; Reinhold et al., 1995), anechoic lacunae or cysts of varying size (Hirai et al., 1995; Reinhold et al., 1995; Fedele et al., 1992a,b), and increased echotexture of the myometrium (Ascher et al., 1994; Hirai et al., 1995). Uterine enlargement and asymmetric thickening of the anterior or posterior wall are indirect sonographic signs that were originally described with TAS (Bohlman et al., 1987). Taken in isolation, these signs are neither sensitive nor specific, and Brosens et al. (1995b), using EVS, emphasized that myometrial heterogeneity was a better predictor of adenomyosis. These findings are in keeping with our own observations. In a prospective study of 100 consecutive women undergoing hysterectomy, of whom 29 were proven to have adenomyosis, 84% of true positive cases demonstrated poorly defined areas of heterogeneous and hypoechogenic echotexture within the myometrium (Reinhold et al., 1995) (Figure 4). In the remaining 16% of cases, the myometrial echotexture was felt to be either predominantly hypoechogenic or heterogeneous (Figure 5). In ~50% of cases with proven adenomyosis, small myometrial cysts were noted (Figure 6). No correlation, however, was found between the independent variable of uterine weight and the dependent variable adenomyosis (Reinhold et al., 1995). As previously discussed, the findings of hypoechogenic and heterogeneous areas within the myometrium associated with cystic spaces were first described by Walsh et al. in 1979 using TAS. However, the limited resolution of TAS resulted in inconsistent depiction of these features, and only myometrial cysts >5 mm in size were imaged (Walsh et al., 1979; Bulic et al., 1986). Using EVS, we found the typical diameter of myometrial cysts associated with adenomyosis to be smaller (mean diameter of 3 mm; range of 2–6 mm). Similarly, in a series of 43 hysterectomy patients, of whom 20 were proven to have adenomyosis, Fedele et al. (1992a) diagnosed adenomyosis in the presence of one or more heterogeneous myometrial areas containing 1–3 mm round anechoic lacunae. Another diagnostic feature of diffuse adenomyosis that merits emphasis is the lack of contour abnormality or mass effect in association with the abnormal myometrial echotexture (Brosens et al., 1995b). This is an important consideration when differentiating adenomyosis from leiomyomas.

To summarize, the most common findings of the myometrium in patients with adenomyosis on EVS are poorly margined hypoechogenic and heterogeneous area(s) with or without the presence of small myometrial cysts (Figures 4, 7). These findings are not unexpected given the histopathology of this disease. We have shown that the overall decreased echogenicity of the myometrium is due to the smooth muscle hyperplasia accompanying the heterotopic endometrial tissue (Atri et al., 1997). It is our hypothesis that the heterogeneous appearance of the myometrium on EVS is due to multiple small echogenic islands disrupting the hypoechogenic background. These hyperechogenic islands represent the heterotopic endometrial tissue at histopathology. In the majority of cases these hyperechogenic islands are small; however, at times they can measure ≥5 mm, presenting as hyperechogenic nodules, frequently located in the inner myometrium (Atri et al., 1997) (Figure 8). Occasionally, the heterotopic endometrium can be seen to extend out from the endometrium into the inner myometrium as echogenic ‘finger-
like’ projections or linear striations. When these striations are not distinct, the sonographic appearance is that of widening and poor definition of the endo-myometrial junction (Figures 4, 7, 9). The varied appearance of adenomyosis on imaging relates directly to the distribution of the heterotopic endometrial tissue and the amount of associated muscular hyperplasia. This may explain the variable criteria used to diagnose adenomyosis by different authors ranging from poorly defined heterogeneous areas, which are predominantly hypoechoic relative to normal myometrium, to areas that are predominantly hyperechoic (Figure 10). The presence of dilated cystic glands or haemorrhagic foci within the heterotopic endometrial tissue results in the presence of small myometrial cysts in ~50% of patients with adenomyosis (Reinhold et al., 1995). Cyclic haemorrhage, however, is infrequently observed with adenomyosis, since the stratum basale is typically unresponsive to hormonal stimuli.

Studies published on the accuracy of EVS suggest that this technique represents a substantial improvement over TAS in the pre-operative diagnosis of adenomyosis. Fedele et al. (1992b) using EVS, reported an 87% sensitivity and 99% specificity in diagnosing 23 adenomyomas in 405 patients undergoing surgery for symptomatic uterine masses. In addition, the same group of investigators evaluated the accuracy of EVS in diagnosing diffuse adenomyosis in 43 patients undergoing surgery for menorrhagia (Fedele et al., 1992a). The endovaginal sonographic criteria for diagnosing adenomyosis included poorly defined heterogeneous area(s) containing 1–3 mm

**Figure 8.** Adenomyosis, hyperechoic nodules. (TOP LEFT) Sagittal section through the uterus with endovaginal sonography. The inner myometrium is hypoechoic and heterogeneous. Several echogenic nodules (arrows) consistent with large islands of heterotopic endometrium can be seen within the areas of abnormal myometrial echotexture. (TOP RIGHT) Sagittal T2-weighted magnetic resonance image in the same patient, at a slightly different level, demonstrates the heterotopic endometrium as areas of high signal (arrows) within the thickened junctional zone. (BOTTOM LEFT) Oblique section through the uterus in a different patient shows a 6 mm hyperechoic nodule (arrow) in the inner myometrium. The myometrial echotexture is decreased and heterogeneous, consistent with adenomyosis. E = endometrium.
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Figure 9. Adenomyosis, poor definition of endo-myometrial junction. Oblique section through the uterus with endovaginal sonography shows decreased echogenicity and heterogeneity of the myometrium. The endometrium (E) is weakly echogenic with ill-defined borders, resulting in poor definition of the endo-myometrial junction.

Figure 10. Adenomyosis, variable echogenicity. Sagittal section through the uterus in a patient with diffuse adenomyosis extending into the outer myometrium. The endovaginal sonography shows the ventral myometrium (VM) to be of increased echogenicity and heterogeneous, while the dorsal myometrium (DM) is hypoechoic and heterogeneous. At histopathology, the ratio of heterotopic endometrial tissue relative to smooth muscle hyperplasia was greater in the ventral myometrium, probably accounting for the relative difference in echogenicity. Note that the border of the endometrium (E) is obscured, particularly ventrally due to the increased echogenicity of the adjacent myometrium.

round anechoic lakes within the myometrium. Using these criteria, Fedele et al. achieved an 80% sensitivity and 74% specificity in diagnosing diffuse adenomyosis. Using similar criteria, we achieved a sensitivity of 86% [95% confidence interval (CI): 74–98%], a specificity of 86% (95% CI: 78–94%), a negative predictive value of 94% (95% CI: 88–99%), and a positive predictive value of 71% (95% CI: 56–86%) in diagnosing diffuse adenomyosis in 100 consecutive women undergoing hysterectomy for a variety of clinical indications (Reinhold et al., 1995). Similar results were achieved by others using a combination of abnormal myometrial echogenicity with poorly defined contours and uterine asymmetry (Brosens et al., 1995b; Hirai et al., 1995). Using one or more of the following criteria: asymmetry of the anterior and posterior myometrial walls, increased myometrial echogenicity, and heterogeneous indistinctly marginated areas in the myometrium, Ascher et al. (1994) reported a lower sensitivity compared to our results and those of others (Fedele et al., 1992a; Brosens et al., 1995b; Reinhold et al., 1995). In their series, EVS only diagnosed nine of 17 patients (53%) with adenomyosis (Ascher et al., 1994). All eight cases missed at EVS were falsely interpreted as representing leiomyomas. Differences in study design might account for this variability. There was a high prevalence of disease (17 of 20 patients or 85%) in their study, perhaps due to a bias in patient recruitment as well as possible sampling errors associated with myometrial biopsy. In addition, Ascher et al. (1994) used hard copy images, whereas we and Fedele et al. (1992a,b) used real-time imaging to diagnose adenomyosis. The findings associated with adenomyosis, including the small myometrial cysts, may be subtle and may only be appreciated during real-time imaging. However, Ascher et al. (1994) encountered a significantly higher number of patients with focal adenomyosis in their study population, which can more readily be confused with leiomyomas on EVS.

It is important to be aware of potential pitfalls when diagnosing adenomyosis using EVS. In practical terms, the most important differential diagnosis of adenomyosis is leiomyoma. Although EVS has been shown to be accurate in differentiating adenomyosis from leiomyomas (Fedele et al., 1992b), the imaging characteristics may overlap, particularly in the case of adenomyomas, which are better circumscribed than the diffuse form and demonstrate mass effect (Ascher et al., 1994; Reinhold et al., 1995). Features that favour the diagnosis of adenomyosis include: (i) a lesion with poorly defined borders, (ii) minimal mass effect on the endometrium or serosa relative to the size of the lesion, (iii) elliptical rather than a globular shape, (iv) lack of calcification, (v) lack of edge shadowing or whorled appearance of the myometrium, (vi) small myometrial cysts, and (vii) echogenic nodules or linear striations.
Figure 11. Adenomyosis versus leiomyoma. Transverse sections through the uterus with endovaginal sonography in two different patients demonstrate (LEFT) extensive adenomyosis (curved arrows), and (RIGHT) a mural leiomyoma (curved arrows) involving the dorsal myometrium. Distinguishing features of adenomyosis include poor definition of lesion borders, elliptical shape and lack of mass effect on the endometrium (small arrows). In contradistinction, the leiomyoma demonstrates mass effect on the endometrium (small arrows), has a round shape with well-defined borders and edge shadowing.

EVS offers several advantages in the evaluation of patients with suspected adenomyosis. The technique is well tolerated by most patients and generates high-resolution images that are not limited by obesity or retroversion of the uterus. As opposed to MR imaging, EVS is relatively inexpensive and is readily available. However, a number of limitations in diagnosing adenomyosis with EVS must be emphasized. The technique is operator-dependent and the sonographic signs of adenomyosis may be subtle. Therefore, the accuracy of EVS in this diagnosis may depend to a much greater extent on the sonologist’s experience than it would when evaluating other pelvic pathology. As discussed earlier in this review, adenomyosis cannot be reliably diagnosed from hard-copy images, but must be diagnosed during the course of the real-time examination. The presence of mural leiomyomas can limit the assessment of the adjacent myometrium, particularly when they are multiple or large. Finally, EVS may not be suitable for monitoring the evolution of adenomyosis in patients receiving hormonal therapy, since identical views for comparison from one examination to the next may be difficult to reproduce.

Magnetic resonance imaging

The excellent soft tissue differentiation of magnetic resonance (MR) imaging makes it an ideal tool in the evaluation of uterine pathology. Compared to EVS, MR imaging is considerably less operator-dependent and provides images that are standard and reproducible from
Figure 12. Adenomyosis versus myometrial contraction. Sagittal section through the uterus with endovaginal sonography. (LEFT) There is a hypoechoic, elliptical shaped mass (arrows) situated within the inner half of the ventral myometrium. This mass results in marked distortion of the endometrial cavity (E). (RIGHT) A repeat scan 15 min later shows complete resolution of the mass, consistent with a myometrial contraction. The heterogeneous contents within the endometrial cavity represent menstrual blood.

one examination to another. In addition, the presence of mural leiomyomas can limit the assessment of the adjacent myometrium with EVS. Several studies have demonstrated MR imaging to be highly accurate in diagnosing adenomyosis, with a sensitivity and specificity ranging from 86 to 100% (Mark et al., 1987; Togashi et al., 1988; Togashi et al., 1989; Mitchell et al., 1990; Ascher et al., 1994; Reinhold et al., 1996). However, the high cost and limited availability of MR imaging makes it an impractical tool for the initial evaluation of all patients with symptoms suggestive of adenomyosis, as these are non-specific and are the presenting complaints for a large proportion of the gynaecological population. Nevertheless, MR imaging is an important adjunctive tool in the management of patients with clinically significant adenomyosis.

The uterus is optimally depicted with MR imaging using T2-weighted sagittal sequences. In women of reproductive age, three different zones can be identified within the uterine corpus on T2-weighted images (Lee et al., 1985; McCarthy et al., 1989; Lange et al., 1991) (Figure 13). A high signal-intensity stripe representing the normal endometrium and secretions within the endometrial cavity is present centrally. Immediately subjacent to the endometrial stripe, a band of low signal intensity referred to as the junctional zone (JZ) is seen. Histological studies have demonstrated that this zone represents the innermost layer of the myometrium (Mitchell et al., 1990; Brown et al., 1991). The histological basis for the low signal of the JZ has not yet been established; however, a number of factors probably contribute to this imaging appearance. The outer layer of the myometrium is of intermediate signal intensity on T2-weighted images. Considerable variation in the normal thickness of the JZ has been reported, with a mean thickness ranging from 2 to 8 mm (Lee et al., 1985; Wiczyk et al., 1988; Mitchell et al., 1990; Brown et al., 1991; Reinhold et al., 1996). The normal range of JZ thickness is relevant to our discussion, since abnormal widening or silhouetting of the JZ is one of the MR imaging features associated with adenomyosis.

Previous studies using MR imaging report a high sensitivity and specificity (88 and 100% respectively) for diagnosing adenomyosis in the symptomatic patient population (Mark et al., 1987; Togashi et al., 1988; Togashi et al., 1989; Mitchell et al., 1990; Ascher et al., 1994). Diagnostic criteria used in these studies include focal or diffuse thickening of the uterine JZ or the presence of a low signal intensity myometrial mass with ill-defined borders. These abnormal areas of low signal have been shown to correlate with the myoproliferative changes occurring in adenomyosis (Togashi et al., 1989). In addition, some investigators recommended that a cut-off value for JZ thickness be used to differentiate patients with and without adenomyosis: a JZ thickness of >5 mm was felt to be diagnostic of adenomyosis while a JZ thickness of of 3–5 mm was considered indeterminate (Mark et al., 1987; Ascher et al., 1994). However, the total number of patients studied in these series was relatively small and little has been published on the observed range of JZ thickness in the normal population. Brown et al. (1991) studied the mean JZ thickness in various groups of women. The lowest values obtained were in a group of healthy women on oral
contraceptives whose mean JZ thickness was 4.95 ± 1.77 mm, and the highest values obtained were in a group of women with irregular menstrual cycles whose JZ measured 8.0 ± 1.18 mm. These findings are in keeping with our own observations. In a prospective study of 119 patients undergoing hysterectomy, of whom 28 were proven to have adenomyosis, the mean JZ thickness was 7.7 ± 3.3 mm in patients without adenomyosis, and 15 ± 4.9 mm in patients with adenomyosis (Reinhold et al., 1996). Kang et al. (1996) found that in eight (40%) of 20 clinically normal volunteers, at least one region of the JZ measured >5 mm by two independent observers.

In practice, we have found that a maximal JZ thickness ≥12 mm is highly predictive of the presence of adenomyosis, while a JZ thickness ≤8 mm usually excludes the disease (Reinhold et al., 1996; Kang et al., 1996) (Figure 14). In patients with a JZ thickness measuring between 8 and 12 mm, ancillary findings such as relative thickening of the JZ in a localized area (Figure 15), poor definition of the JZ borders, or the presence of high signal foci on T2- or T1-weighted sequences can be used to diagnose adenomyosis (Reinhold et al., 1997) (Figure 16). High signal foci within an area of low signal on T2-weighted sequences have been reported in 50–88% of cases and may represent islands of ectopic endometrium, cystically dilated endometrial glands, and/or haemorrhagic fluid (Togashi et al., 1988, 1989; Reinhold et al., 1996). In some patients, linear striations of increased signal can be seen radiating out from the endometrium into the myometrium on T2-weighted sequences (Figure 4b). These striations probably represent direct invasion of the basal endometrium into the myometrium. On T1-weighted sequences, adenomyosis is isointense to the surrounding
Figure 16. Adenomyosis, high signal foci. Axial (LEFT) T2-weighted and (RIGHT) T1-weighted magnetic resonance images through the uterus in the same patient. (LEFT) There is an ill-defined low signal intensity mass (curved arrows) replacing the left myometrium with numerous foci of increased signal consistent with islands of ectopic endometrium, cystically dilated endometrial glands, and/or haemorrhagic fluid. These findings are also present, to a lesser extent, around the right cornua (arrows). (RIGHT) The T1-weighted image demonstrates several foci of increased signal (arrows) corresponding to areas of haemorrhage. C = corpus luteal cyst.

myometrium except for the presence of bright foci, which have been shown to correspond to small areas of haemorrhage at histopathology (Togashi et al., 1989). In summary, the bulk of the adenomyotic lesion with MR imaging consists of a low signal intensity area on T2-weighted images, which frequently gives the appearance of diffuse or focal widening of the JZ. These areas of low signal intensity have been shown to correspond to the smooth muscle hyperplasia accompanying the heterotopic endometrial tissue. High signal intensity foci or linear striations representing the heterotopic endometrial tissue are being identified with increasing frequency using high resolution MR imaging techniques.

In clinical practice, the most important differential diagnosis of adenomyosis is leiomyoma. In a prospective study of 21 patients with a strong clinical suspicion of adenomyosis, MR imaging correctly diagnosed all cases of adenomyosis and 10 of 12 patients with leiomyomas (Mark et al., 1987). Similarly, in a series of 93 patients with an enlarged uterus at physical examination (71 enlarged uteri due to leiomyoma, 16 due to adenomyosis, and six with co-existence of both lesions), Togashi et al. (1989) were able to correctly diagnose the cause of uterine enlargement with MR imaging in 92 of 93 cases. Although MR imaging has been shown to be highly accurate in differentiating adenomyosis from leiomyomas, the imaging characteristics may overlap, particularly in the case of adenomyomas. Features that favour the diagnosis of adenomyosis include: (i) a lesion with poorly defined borders, (ii) a lesion that extends along endometrium and usually has an elliptical shape, (iii) minimal mass effect on the endometrium relative to the size of the lesion, (iv) linear striations radiating out from endometrium into the myometrium, and (v) absence of large vessels at the margins of lesions, which can at times be seen with leiomyoma but are not seen with adenomyosis (Mark et al., 1987; Kier, 1994; Reinhold et al., 1997) (Figure 17).

Myometrial contractions may closely resemble the appearance of focal adenomyosis on MR imaging. Contractions can be differentiated from true myometrial pathology on sequential imaging acquisitions, by their transient nature and changing appearance over time (Togashi et al., 1993). Other potential diagnostic pitfalls include muscular hypertrophy, and rarely lymphovascular metastases to the myometrium (Reinhold et al., 1996). The presence of muscular hypertrophy of the uterus at histopathology may result in thickening of the JZ at MR imaging, mimicking the appearance of diffuse adenomyosis (Brosens et al., 1995a).

Although several studies have independently reported on the accuracy of EVS and MR imaging in the diagnosis of adenomyosis, few studies have compared the results of both modalities in the same patient population. We compared the results of EVS and MR imaging in 119 consecutive patients undergoing hysterectomy, of whom 28 were proven to have adenomyosis, and found no significant difference in the sensitivity and specificity of these two modalities (Reinhold et al., 1996). Our results
differ somewhat from those of Ascher et al. (1994), who also studied the accuracy of EVS and MR imaging in the same patient population, and found the results of MR imaging to be superior \( (P < 0.02) \). In their series, EVS only diagnosed nine of 17 patients (53%) with adenomyosis, while MR imaging correctly diagnosed 15 of 17 patients (88%). In our series, MR imaging correctly detected the presence of adenomyosis in 24 of 28 patients (86%), which compares favourably with the 88% reported by Ascher et al. (1994); however, our sensitivity in detecting adenomyosis using EVS was considerably higher, 89% versus 53%. In addition, we found an excellent rate of agreement between the depth of myometrial involvement at histopathology and the findings at EVS or MR imaging.

**Conclusion**

With the recent advent of high resolution imaging techniques, the diagnosis of adenomyosis is no longer a surgical diagnosis made only at hysterectomy. We suggest that EVS be used as the initial imaging modality in patients suspected of having adenomyosis. Sonologists and sonographers should familiarize themselves with the EVS appearance of this disease, since the presenting symptoms of adenomyosis overlap with those of other common gynaecological disorders. The sonographic results may not be generally applicable unless the technique is performed meticulously and in real time. MR imaging is indicated for indeterminate cases on EVS and for monitoring the evolution of disease in patients who are receiving hormonal therapy. In addition, for patients undergoing uterus-sparing surgery, MR imaging can play an important complementary role.

**References**


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