Adenomyosis: MRI of the Uterus Treated with Uterine Artery Embolization

OBJECTIVE. The purpose of this study was to determine the MRI features seen after uterine artery embolization and to evaluate the clinical response in patients with adenomyosis.

MATERIALS AND METHODS. Thirty women with adenomyosis underwent uterine artery embolization and follow-up MRI for 1 year. Of the 30, 27 patients were diagnosed with uterine fibroids and adenomyosis on the basis of MRI before uterine artery embolization. In six of the 27 patients, the dominant disease was adenomyosis. Three of the 30 patients had adenomyosis alone. The distribution, thickness, and enhancement of adenomyosis were analyzed in each patient. Patients completed a symptom questionnaire.

RESULTS. After uterine artery embolization, the junctional zone–myometrial ratio did not change significantly. There were regions of devascularization of adenomyosis on contrast-enhanced images in 12 patients, all with a junctional zone thickness before uterine artery embolization of more than 20 mm (mean thickness, 39.2 mm). Eleven of the 12 patients had focal or asymmetric distribution patterns of adenomyosis. All three patients with pure adenomyosis and all six patients with dominant adenomyosis reported an improvement in symptoms.

CONCLUSION. In patients treated with uterine artery embolization, MRI shows changes in areas of adenomyosis with a decrease in junctional zone vascularity in patients with thickening of the junctional zone greater than 20 mm. Devascularization may be related to the distribution of adenomyosis. The presence of adenomyosis should not be used as a contraindication to uterine artery embolization because most patients show clinical improvement after undergoing this procedure.

Adenomyosis is a common benign disorder, with an incidence of 40% or less in extirpated uteri reported [1]. Pathologically, adenomyosis is ectopic endometrial glands and stroma interdigitating with the underlying myometrium [1, 2]. Uterine fibroids represent the most common benign tumor of the uterus, affecting 20–50% of the female population [3]. These two diseases may present identical symptoms and often coexist. It has been reported that between 35% and 80% of adenomyotic uteri are accompanied by fibroids [2, 4, 5].

Although minimally invasive therapies have been used to treat adenomyosis, the definitive treatment remains hysterectomy [2, 3]. For patients concerned about fertility, hormonal manipulation has been used to decrease junctional zone thickness and provide symptomatic relief, but these effects are temporary, and symptoms tend to recur within 1 year of treatment cessation [1]. Recently, uterine artery embolization has become an effective minimally invasive alternative for treatment of symptomatic fibroids, rather than the traditional approach of hysterectomy and myomectomy [6, 7]. Although there have been many reports of its effectiveness for fibroids, the response of adenomyosis to uterine artery embolization is mixed [8, 9].

MRI is an excellent tool for characterizing adenomyosis and is highly accurate in the differential diagnosis relating to fibroids [10–12]. The MRI features of fibroids treated with uterine artery embolization have been described, but description of coexisting adenomyosis is limited [13–15].

The purpose of this study was to describe the MRI features of adenomyosis at 3 months and up to 1 year after uterine artery embolization and to evaluate the clinical response after uterine artery embolization in patients with adenomyosis.
Materials and Methods

At our institution, all patients who are potential candidates for uterine artery embolization are evaluated with MRI. Between October 1997 and May 2001, 30 patients (age range, 41–52 years; mean age, 45.9 years) treated with uterine artery embolization were diagnosed with adenomyosis and coexistent fibroids. In six of these patients, the predominant disease was adenomyosis, with small fibroids also identified, none of which were submucosal. Three patients were diagnosed with adenomyosis alone.

Pretreatment MRI was performed in all patients, and almost all patients underwent uterine artery embolization within 1 month of the initial MRI examination (mean, 33.3 days; range, 0–106 days). Follow-up MRI was performed at 3 months after uterine artery embolization in 26 patients (range, 40–140 days; mean interval, 108.3 days) and at 1 year in 11 patients (range, 357–471 days; mean interval, 396.7 days) with seven patients imaged at both 3 months and 1 year. At the time of entry into this study, the presenting complaint was menorrhagia and pelvic pain in 22 patients, menorrhagia alone in seven, and pelvic pain alone in one. Eleven patients had a history of hormonal therapy before uterine artery embolization, with no patient receiving treatment 6 weeks before undergoing this procedure.

An experienced angiographer performed bilateral selective uterine artery embolization by using 500- to 710-µm diameter polyvinyl alcohol particles (Contour, Boston Scientific/Medi-tech, Natick, MA; Ivalon, Cook, Bloomington, IN; or Trufill, Cordis, Miami, FL). The institutional review board gave approval for the entire study, and the patients gave written informed consent.

MRI was performed with a 1.5-T superconducting unit (Magnetom Vision; Siemens Medical System, Iselin, NJ) and a standard phased array torso coil in 62 examinations. Orthogonal T2-weighted half-Fourier acquisition single-shot turbo spin-echo images (TR/TE, 4,464/flip angle, 150°), axial T1-weighted fat-saturated spoiled gradient-echo images (150/4; flip angle, 180°), and sagittal T1-weighted spoiled gradient-echo unenhanced and contrast-enhanced images (150/4; flip angle, 180°) were obtained in these studies. Gadopentetate dimeglumine–enhanced images (Magnevist, Berlex Laboratories, Monteville, NJ) were acquired at a dose of 0.1 mmol/kg of body weight. MRIs of four patients were performed at outside institutions and represented two separate procedure examinations and two follow-up ones. These were performed with T1-weighted spin-echo unenhanced and gadolinium-enhanced images (500/4) and T2-weighted fast spin-echo images (5000/120) in the axial or sagittal plane.

All 30 patients completed a symptoms questionnaire before and 3 months after uterine artery embolization. At 1 year after patients underwent this procedure, 20 symptoms questionnaires were completed and were available for analysis.

Two experienced MRI radiologists independently analyzed MRIs for each patient. Each reviewer was given T1- and T2-weighted and delayed gadolinium-enhanced T1-weighted images of the uterus obtained before and after uterine artery embolization. Disagreements in interpretation were resolved by consensus.

The volume of the uterus and of two index fibroids was measured by using a prolate ellipse equation (length × width × height × 0.523). In patients with more than two fibroids, the two index fibroids were generally selected on the basis of size, with the exception that the largest submucosal lesion, if present, should be included in the analysis. A total of 43 fibroids were evaluated before and 3 months after uterine artery embolization, with 22 fibroids analyzed at 1-year follow-up. The percentage reduction in uterine and fibroid volume was calculated.

Adenomyosis was diagnosed and classified on the basis of T2-weighted images obtained before uterine artery embolization. A junctional zone thickness of 12 mm or more was used to define the presence of adenomyosis [16, 17]. The region of maximal thickness of the junctional zone, as well as the total myometrial thickness in the same location, was measured by a hand caliper in each patient before and after uterine artery embolization. A ratio of junctional zone thickness to myometrial thickness was derived. The pattern of adenomyosis was also subdivided into three categories: focal, symmetric, and asymmetric (Fig. 1). Focal adenomyosis, or an adenomyoma, refers to adenomyosis that is localized and often presenting as a rounded or oval low-signal-intensity mass. Symmetric adenomyosis was defined as showing diffuse widening of the junctional zone that circumscribes both the anterior and posterior aspects of the uterus in a fairly even distribution. Asymmetric adenomyosis refers to a diffuse pattern of adenomyosis that predominates on one side of the endometrial canal. Before and after therapy, images were also analyzed for high-signal-intensity foci embedded in the adenomyosis on both T1- and T2-weighted images, as well as for irregularity of the junctional zone, both of which are ancillary features helpful in making the diagnosis of adenomyosis.

To assess the change of vascularity, unenhanced and gadolinium-enhanced images were compared in each case.

The significance of the changes in uterine volume, fibroid volume, junctional zone thickness, and myometrial thickness seen after uterine artery embolization was assessed by using the Wilcoxon’s signed rank test. To assess the significance of pre–junctional zone thickness as a determinant of avascularity after uterine artery embolization, a Mann-Whitney U test was used. Statistics were obtained using the StatView software, version 5.0 (Abacus Concepts, Berkeley, CA). Significance was assessed in all cases at the 0.05 or 0.01 level.

Results

Changes in Uterine and Fibroid Volume

The mean uterine volume decreased at 3 months by 40% from 551 to 329 cm3 (p < 0.0005), with a 1-year decrease of 48% from 563 to 292 cm3 (p < 0.004).

There was a significant decrease in mean fibroid volume at 3 months by 47% from 97 to 51 cm3 (p < 0.0001) and at 1 year by 39% from 75 to 46 cm3 (p < 0.001).

Characteristics and Changes in Size of Adenomyosis

There was a significant decrease in mean junctional zone thickness at 3 months by 22%, from 32 to 25 mm (p < 0.005), with a 1-year decrease of 33% from 30 to 20 mm (p < 0.05). The junctional zone thickness showed a slight further decrease when followed in seven patients from 3 months to 1 year, in the order of 15% from 26 to 22 mm (p < 0.05).

Mean myometrial thickness also showed significant decrease of 18% from 40 to 33 mm (p < 0.0005) at 3 months and of 20% from 40 to 32 mm (p < 0.001) at 1 year. No significant decrease was seen between the thickness at 3 months and 1 year (p = 0.92).

Regarding the junctional zone–myometrial ratio, the average ratio was 0.80 before uterine artery embolization, 0.76 at 3 months, and 0.63 at 1 year. These ratios did not reach statistical significance.

Focal adenomyosis was observed in seven patients (23%). In the remaining 23 patients, 10 (33%) showed asymmetric diffuse type and 13 (43%) showed symmetric diffuse type.
High-signal-intensity foci were noted on T1-weighted images before treatment in 12 patients and on T2-weighted images before treatment in 19 patients. High-signal-intensity foci on T1-weighted images were increased in six patients and decreased in two patients. High-signal-intensity foci on T2-weighted images were increased in three patients and decreased in nine patients. These changes were not statistically significant.

The patterns of enhancement of adenomyosis were assessed and compared before and after treatment with uterine artery embolization. In 12 (40%) of 30 patients treated with uterine artery embolization, lack of enhancement was seen in the regions of adenomyosis (Figs. 2 and 3). Of these, four patients had focal adenomyosis, seven patients had asymmetric adenomyosis, and one patient had a symmetric pattern. Overall, these 12 patients had a significantly greater junctional zone thickness (range, 21–63 mm; mean, 39.2 mm) than the remaining patients (range, 13–47 mm; mean, 25.2 mm; \( p < 0.005 \)) (Fig. 3). All five patients with a junctional zone thickness of greater than 48 mm before treatment showed a prominent avascular region after uterine artery embolization. In the nine patients with a junctional zone thickness of less than 20 mm, none were noted to have regions of devascularization (Fig. 4).

The data of nine patients with pure or dominant adenomyosis are detailed in Table 1. Although one patient showed no change in imaging features after uterine artery embolization, her clinical symptoms improved.

**Clinical Prognostic Features**

No significant correlation between improvement in symptoms and imaging findings was identified. On the 3-month questionnaires, 25 of 30 patients reported improvement in either bleeding or pain symptoms; all 20 patients who submitted 1-year questionnaires reported stability or improvement in presenting symptoms. Three patients had presented with both symptoms and reported no change in one symptom but improvement in another. One patient...
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experienced no improvement in either bleeding or pain. This patient had a dominant subserosal fibroid located anteriorly, which enlarged after uterine artery embolization (4.1 cm³ before and 5.7 cm³ after uterine artery embolization). The thickness of the junctional zone in the area of focal adenomyosis, however, decreased (35 mm before and 26 mm after uterine artery embolization), and this decrease resulted in a hysterectomy 6 months after treatment. One patient reported a lack of improvement of bleeding at 3 months but improvement at 1 year. In two patients, the severity of presenting symptoms improved slightly at 3-month follow-up but recurred, requiring hysterectomy within 1 year after uterine artery embolization. One patient presented with a large cervical fibroid, producing severe distortion of the endocervical canal and uterine body. This fibroid showed a slight decrease in volume (380.5 cm³ before and 216.6 cm³ after uterine artery embolization) but an increase in thickness of focal adenomyosis (21 mm before uterine artery embolization, 47 mm after uterine artery embolization). The other patient had a pedunculated submucosal fibroid that enlarged after uterine artery embolization (15.4 cm³ before and 24 cm³ after uterine artery embolization) although adenomyosis was slightly decreased (19 mm before uterine artery embolization, 16 mm after uterine artery embolization). Symptoms improved in all three patients with pure adenomyosis and in six patients with dominant adenomyosis.

Discussion

Previous reports have suggested a mixed clinical response for patients with adenomyosis [8, 9, 18–20]. Goodwin et al. [19] reported that three of six patients with fibroids and concomitant adenomyosis required hysterectomy after uterine artery embolization. Transvaginal sonography is widely used for the evaluation of the uterus before uterine artery embolization because of its availability and low cost and but has a lower sensitivity and specificity in the diagnosis of adenomyosis versus fibroids compared with MRI [10–12, 21–23]. This is further complicated by the coexistence of these two diseases in up to 80% of pathologic specimens [2, 4, 5]. In this study, there may have been an underreporting of adenomyosis in our patients due to the limits of sonography in making an accurate diagnosis. Therefore, adenomyosis may not have been the dominant cause of clinical failure because patients with undetected adenomyosis would respond like patients with clinical improvement. Siskin et al. [9] described significant clinical improvement in 12 of 13 patients with adenomyosis and concomitant fibroids diagnosed with MRI.

The thickness of the junctional zone of the uterus significantly decreased after uterine artery embolization. Prior evidence suggests that the severity of clinical symptoms corre-
lates with the degree of intramyometrial involvement by the ectopic endometrium [5]. Although we could not find significant correlation between improvement in symptoms and imaging features, the decrease of junctional zone thickness may relate to the improvement in symptoms. A minimal decrease in junctional zone–myometrial ratio was seen, which may reflect the decrease in adenomyosis, as well as a substantial reduction in myometrial thickness, because the fibroids showed significant shrinkage.

Our study shows significant reduction in mean uterine and fibroid volumes, similar to the degree found in other studies reporting reduction at up to 6 months after uterine artery embolization of 33.5–49.5% for uterine volume and 40.4–71.0% for fibroid volume [9, 13–15]. A larger endometrial surface area that accompanies an enlarged uterus has been implicated as a contributing factor in the bleeding associated with adenomyosis [2]. Thus, the reduction of the uterine size may also be contributing to the reduction in symptoms seen in our patients.

The thickness of the junctional zone, as well as the mean fibroid volume, showed a further slight reduction at 1-year follow-up. This has been previously reported for fibroids treated with uterine artery embolization [13, 24]. Hormonal therapy for adenomyosis often has only a temporary effect, with the disease recurring within 1 year. In our study, in the seven patients followed up for 1 year, no evidence of either clinical or imaging recurrence or progression was seen.

In our study, in 12 (40%) of 30 patients, regions of adenomyosis showed areas of devascularization on contrast-enhanced images obtained after uterine artery embolization. Most of these regions also showed increased signal intensity on the T1-weighted images and decreased homogeneous signal on the T2-weighted images. These signal-intensity changes are typical of blood products and are suggestive of hemorrhagic infarction. Kobayashi et al. [25] identified endometrial ischemia or infarction on the basis of a cytologic smear in

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<th>TABLE I</th>
<th>Patients with Pure or Dominant Adenomyosis Showing Clinical Improvement</th>
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*Adenomyosis without fibroid.

Fig. 4.—48-year-old woman with uterine fibroids and coexisting symmetric adenomyosis.  
A, T2-weighted HASTE sagittal image of uterus obtained before uterine artery embolization shows uterine fibroids (asterisk) and irregular thickening of junctional zone (straight arrows) along anterior and posterior aspect of endometrium, representing symmetric adenomyosis. Scattered foci of high signal intensity are also seen (curved arrow).  
B, Contrast-enhanced T1-weighted image obtained before treatment shows fibroid (asterisk) and junctional zone (arrows) as areas of decreased signal compared with outer myometrium.  
C, T2-weighted image obtained 3 months after treatment shows decrease of dominant fibroid (asterisk), with no change in junctional zone (arrows).  
D, Contrast-enhanced T1-weighted image obtained after treatment shows fibroids as regions of devascularization (asterisk), whereas junctional zone vascularity is unchanged (arrows).
a patient with adenomyosis treated with uterine artery embolization. The mechanism of infarction is unclear. Prior reports have proposed that the differential perfusion of myometrium and fibroids after uterine artery embolization may be related to differing responses of these tissues to vascular occlusion [26, 27]. The initial response is vascular thrombosis, but the vessels in normal myometrium subsequently dissolve the thrombus, whereas vessels in fibroids are unable to do so and undergo infarction. On angiography and histology, adenomyosis has been described as having an arterial pattern that is less dense than that of adjacent myometrium [28]. However, on the basis of microscopic pathologic studies, evidence suggests an increase in microvessel density in adenomyosis [29–31]. Therefore, the changes in enhancement patterns seen in our study may be attributed to differing responses to ischemic injuries, similar to those of fibroids.

The pattern of distribution of adenomyosis may also be a factor in the use of uterine artery embolization. In our patients, areas of avascularity were seen in 57% (47) of patients with focal adenomyosis and in 70% (71/10) of patients with asymmetric adenomyosis. Conversely, only 8% (1/13) of patients with symmetric adenomyosis were noted to have this feature. Furthermore, the patients with greater thickness of the junctional zone tended to show ischemic change after uterine artery embolization. This may reflect a different pathophysiology of disease and perhaps different degrees of microvascularity.

Uterine artery embolization appears to be effective in alleviating the symptoms in patients with pure or dominant adenomyosis or adenomyosis coexisting with fibroids. In this study, all nine patients with pure or dominant adenomyosis had positive outcomes. In eight of nine, there was an associated reduction in junctional zone thickness, whereas in one patient, no change was seen in the junctional zone, but a decrease in accompanying small fibroids was seen.

There are limitations to this study. The junctional zone thickness and degree of enhancement have been reported to vary minimally with the menstrual cycle [32, 33]. We did not record the stage of menses in these patients. Furthermore, the pattern of enhancement of adenomyosis has not been widely reported in the MRI literature because it has not been considered to be of any particular diagnostic value [23]. Therefore the true range of normal variation in the junctional zone enhancement is unknown. We also recognize that the small sample size of this study precludes strict statistical analysis. The results must be validated with ongoing research. A final limitation is the lack of histopathologic correlation with the imaging findings. Such a correlation would help in understanding the mechanism of changes in junctional zone thickness and vascularity of adenomyosis.

In conclusion, uterine artery embolization results in reduction in the junctional zone thickness and may produce ischemic change, particularly in patients with focal, asymmetric, and severe adenomyosis. Because most patients report an improvement in symptoms, the presence of concomitant adenomyosis should not be considered a contraindication to treatment with uterine artery embolization for fibroids. Furthermore, our limited experience suggests that this procedure may be a viable treatment for patients with pure or dominant adenomyosis.

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