Pelvic endometriosis: a comparison between low-field (0.2 T) and high-field (1.5 T) magnetic resonance imaging*

Endometriose pélvica: comparação entre imagens por ressonância magnética de baixo campo (0,2 T) e alto campo (1,5 T)

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Abstract **OBJECTIVE: To compare low-field (0.2 T) with high-field (1.5 T) magnetic resonance imaging in the assessment of pelvic endometriosis and adenomyosis. MATERIALS AND METHODS: Twenty-seven female patients with clinically suspected endometriosis were prospectively evaluated by means of high-field and low-field magnetic resonance imaging. The reading of the images was performed by a single radiologist, initiating by the low-field, followed by the high-field images. High-field magnetic resonance imaging was utilized as the golden-standard. RESULTS: Among the 27 patients included in the present study, 18 (66.7%) had some type of lesion suggesting the presence of endometriosis demonstrated at high-field images. In 14 of these patients the diagnosis was correctly established by low-field magnetic resonance imaging. Endometriomas, tubal lesions, and endometriotic foci > 7 mm identified at the high-field images were also identified at low-field images with 100% accuracy, sensitivity and specificity. Among the nine patients diagnosed with adenomyosis by high-field images, eight were correctly diagnosed by low-field images with 88.9% accuracy, specificity and sensitivity. CONCLUSION: Low-field magnetic resonance imaging demonstrated a low sensitivity in the detection of small endometriotic foci, high sensitivity in the detection of endometriomas and large endometriotic foci, and high accuracy in the detection of adenomyosis when compared with high-field magnetic resonance imaging.**
Keywords: Magnetic resonance imaging; Endometriosis; Adenomyosis; Diagnosis.

Resumo **OBJETIVO: Comparar a ressonância de baixo campo (0,2 T) com a de alto campo (1,5 T) na avaliação da endometriose pélvica e adenomiose. MATERIAIS E MÉTODOS: Foram estudadas, prospectivamente, 27 pacientes do sexo feminino com suspeita clínica de endometriose, realizando-se exames de ressonância magnética de alto campo e baixo campo. Um mesmo radiologista realizou a leitura dos exames, iniciando pelo baixo campo, seguido pelo alto campo, usando como padrão-ouro o alto campo. RESULTADOS: Das 27 pacientes estudadas, 18 (66,7%) apresentaram alguma lesão indicativa de endometriose nos exames realizados no alto campo. Foram corretamente diagnosticados pelo baixo campo 14 destas pacientes. Endometriomas, lesões tubárias e focos de endometriose maiores do que 7 mm identificados pelo alto campo foram também identificados no baixo campo, com acurácia, sensibilidade e especificidade de 100%. Das nove pacientes com adenomiose caracterizadas pelo alto campo, oito foram corretamente identificadas pelo baixo campo, com acurácia, sensibilidade e especificidade de 88,9%. CONCLUSÃO: A ressonância de baixo campo apresentou baixa sensibilidade na detecção de pequenos focos de endometriose, alta sensibilidade na detecção de endometriomas e focos de endometriose grandes, e boa acurácia na detecção da adenomiose quando comparada com a ressonância de alto campo.**
Unitermos: Imagem por ressonância magnética; Endometriose; Adenomiose; Diagnóstico.

Minaif K, Shigueoka DC, Minami CCS, Sales DM, Ruano JMC, Noguti AS, Ajzen S, Szejnfeld J. Pelvic endometriosis: a comparison between low-field (0.2 T) and high-field (1.5 T) magnetic resonance imaging. Radiol Bras. 2008;41(6):367–372.

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Received January 3, 2008. Accepted after revision September 22, 2008.

0100-3984 © Colégio Brasileiro de Radiologia e Diagnóstico por Imagem

INTRODUCTION

Pelvic endometriosis affects about 10% of women in childbearing age[1,2], causing pelvic pain and discomfort. This disease is associated with infertility and psychological alterations such as depression[3,4]. Laparoscopy is the golden-standard in the diagnosis of endometriosis, but this is an invasive and expensive method besides involving risks for morbidity and mortality[5–7]. Other methods utilized in the evaluation of endometriosis are the following: CA125 test, ultrasonography (US) and magnetic resonance imaging (MRI).

The majority of studies in the literature evaluating the efficacy of MRI in the assessment of pelvic endometriosis has reported the utilization of sequences acquired in high-field systems (> 1T)[8–10]. However, an increasing number of low-field systems (< 1T) have been offered to the global market, among other reasons, because of their lower acquisition and maintenance costs as compared with high-field systems[11].

The fat-saturation (fat-sat) technique utilized in high-field (> 1T) MRI systems increases the rate of detection of hemorrhagic lesions < 5 mm resulting from endometriosis[6,8,9]. However, the utilization of this technique is not feasible in low-field MRI systems.

The water-image technique available in some low-field MRI systems is aimed at separating the signals of water and fat from determined tissues, demonstrating an effect that could be similar to the fat-sat technique in high-field systems. However, no study has been found in the literature about the utilization of this technique in the evaluation of pelvic endometriosis. For this reason the authors have decided to develop the present study.

MATERIALS AND METHODS

Twenty-seven female patients with clinical suspicion of endometriosis were included in the present observational, cross-sectional, prospective study in the period from October 2005 to March 2007. The patients' age ranged from 18 to 44 years (mean = 32 years).

The inclusion criteria were the patients referral by the Unit of Laparoscopy of the Division of General Gynecology, clinical suspicion of endometriosis and age > 18 years. Exclusion criteria were: formal contraindication for MRI (including presence of metal clips and pacemakers), and previous history of gynecological surgeries (excepting Cesarean section and tubal sterilization) and claustrophobia.

All the patients underwent MRI examination in a low-field 0.2T Signa Profile (General Electric Medical Systems; Milwaukee, USA) equipment with one-channel body flex II (L) coil, and in a high-field HD 1.5 T (General Electric Medical Systems; Milwaukee, USA) equipment with eight-channel body phased array coil, according to respective, specific protocols (Table 1), in a private clinic. Both examinations were performed in a single day for each patient with an approximate duration of 50 minutes (low-field) and 20 minutes (high-field).

A venous puncture was performed for intravenous administration of scopalamine butylbromide (one vial) for reducing peristalsis. The same access was utilized for intravenous administration of paramagnetic contrast agent (l0 ml gadoteric acid).

The images were evaluated by a single radiologist, initiating by the low-field, followed by the high-field images. Both studies were compared through all the sequences acquired to evaluate the conspicuity of the low-field images.

The studies were evaluated for the presence or absence of endometriotic foci, ovarian endometriomas, peritoneal foci, tubal alterations and adenomyosis.

Table 1 Description of sequence parameters utilized in high- and low-field MRI systems.

	Sequence	TR (ms)	TE (ms)	Matrix	Thickness/ /spacing
High-field	Sagittal T1 fat-sat	275	3	256 × 192	5.0 / 1.0
	Sagittal T2	5,226	116	256 × 224	5.0 / 1.0
	Axial T1	250	63	256 × 224	5.0 / 1.0
	Axial T2	5,000	146	256 × 224	5.0 / 1.0
	Axial T1 fat-sat	250	3	256 × 192	5.0 / 1.0
Low-field	Sagittal T1 water-image	433	10	224 × 160	5.0 / 1.0
	Sagittal T2	3,250	108	224 × 160	5.0 / 1.0
	Axial T1	600	14	224 × 192	5.0 / 1.0
	Axial T2	4,700	110	224 × 192	5.0 / 1.0
	Axial T1 water-image	440	10	224 × 160	5.0 / 1.0

Figure 1. Ovarian focus of endometriosis. Axial MRI T1-weighted water-image acquired with a 0.2 T scanner, demonstrating hypersignal intensity on the right ovary.

The presence of peritoneal or ovarian endometriotic foci corresponded to foci of hypersignal on T1-or T1-weighted fat-sat images generated by the high-field equipment[12] and on T1-weighted water-image images generated by the low-field equipment (Figures 1 and 2).

Endometriomas were characterized by the presence of encapsulated cystic lesions with a hyperintense content on T1-weighted or T1-weighted fat-sat sequences generated by the high-field equipment, and T1-weighted water-image generated by the low-field equipment; and signal loss on T2-weighted sequences, showing the characteristic shadowing signal (Figures 3 to 6)[12].

Tubal alterations were characterized by distention of the uterine tube cased by the presence of fluid generally with hematic content.

The presence of adenomyosis corresponded to a diffuse of focal thickening (> 12 mm) of the junctional zone on T2-weighted images[13], or focal alteration of the myometrium with hypersignal on T1- and hyposignal on T2-weighted images (Figure 7).

The results were statistically analyzed to evaluate prevalence rate, accuracy, sensitivity, specificity, positive and negative predictive values.

RESULTS

Among the 27 patients included in the sample of the present study, whose selec-

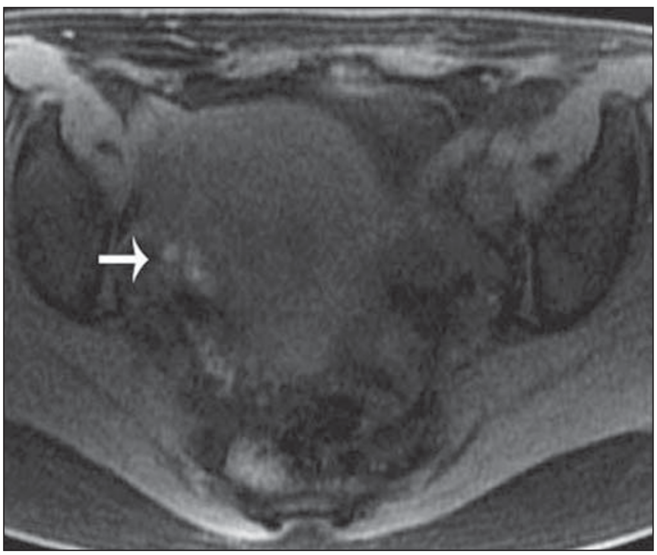

Figure 2. Ovarian focus of endometriosis. Axial MRI T1-weighted fat-sat image acquired with a 1.5 T scanner, demonstrating a focus of hypersignal intensity on the right ovary.

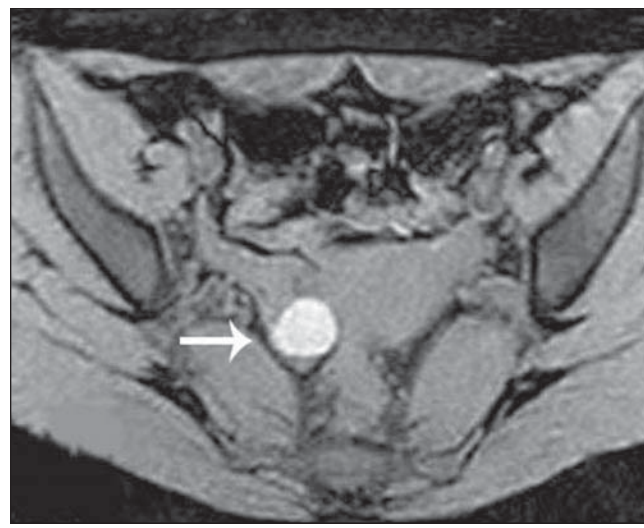

Figure 3. Endometrioma. Axial MRI T1-weighted water-image acquired with a 0.2 T scanner, demonstrating a focus of hypersignal intensity on the right ovary.

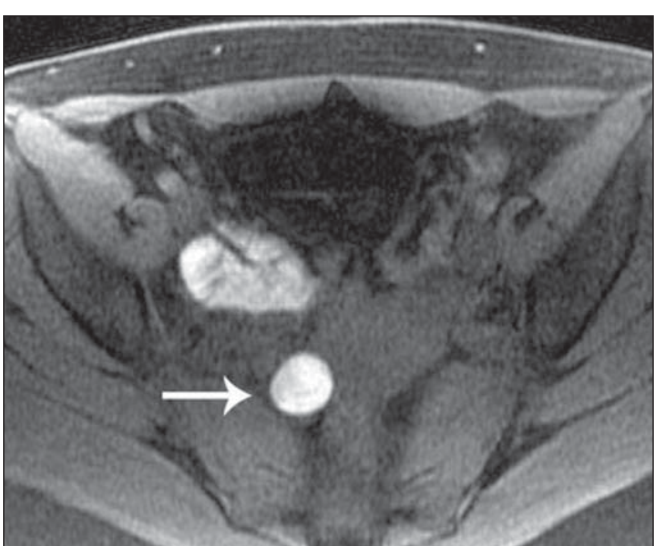

Figure 4. Endometrioma. Axial MRI T1-weighted fat-sat image acquired with a 1.5 T scanner, demonstrating a focus of hypersignal intensity on the right ovary.

Figure 5. Endometrioma. Axial MRI T2-weighted sequence acquired with a 0.2 T scanner, representing signal loss as compared with T1-weighted water-image.

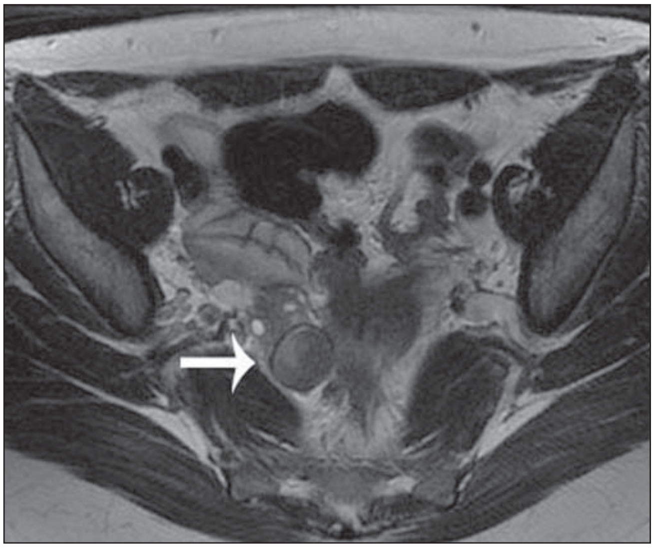

Figure 6. Endometrioma. Axial MRI T2-weighted sequence acquired with a 1.5 T scanner, demonstrating signal loss as compared with the T1-weighted sequence.

Figure 7. Adenomyosis. Sagittal MRI T2-weighted sequence acquired with a 0.2 T scanner, demonstrating focal myometrial alteration.

tion was based on the clinical suspicion of endometriosis, alterations associated with this disease were observed in 18 (66.7%) patients, 14 of them (51.8%) diagnosed by both the high-field and low-field images. The results were described according to the sites of involvement.

Ovarian lesions including endometriomas or endometriotic foci were identified on high-field images of 11 patients. Low-field images demonstrated lesions in seven of these patients, determining 81% accuracy, 58% sensitivity, 100% specificity, 100 positive predictive value and 75% negative predictive value.

Among the patients with ovarian lesions, eight presented only one lesion and four, more than two lesions with different sizes, so these patients were divided into two groups according to the size of the lesions: larger than 7 mm and smaller than 7 mm.

In the group of patients with lesions > 7 mm (6), 100% accuracy, sensitivity and specificity of low-field MRI as compared with high-field MRI.

In the group of patients with lesions = 7 mm (tem patients) a sensitivity of only 10% was observed, considering that only one lesion was also detected by Low-field MRI. Accuracy was 66.7%, positive predictive value, 100%, and negative predictive value, 65.4%.

Peritoneal foci of endometriosis were identified in two patients by both high- and low-field MRI. One of the patients had only one endometriotic focus of 25 mm, and another, three foci of approximately 20 mm, 10 mm and 5 mm. The low-field equipment failed in detecting only the focus of 5 mm, determining 100% accuracy, specificity and sensitivity for lesions > 7 mm.

Adenomyosis was identified in nine patients by high-field MRI, and among these patients, eight were identified by low-field MRI. However, two false-positive results were found by this method, with 88.9% accuracy, 88.9% sensitivity, 88.9% specificity, 80% positive predictive value and 94.1% negative predictive value.

DISCUSSION

According to the World Health Organization, approximately 50% of the global population does not have access to imaging diagnosis methods. The utilization of high-field MRI systems is observed predominantly in developed countries with higher purchase Power which can afford the acquisition of state-of-art equipment[11], but a great number of low-field MRI scanners are found in several countries such as China and Japan.

Studies in the literature approaching pelvic endometriosis have been developed with high-field MRI scanners (> 1 T). On the other hand, no study utilizing low-field scanners (0.2 T) has been found in the literature, except for references related to ovarian tumors and uterine alterations[14,15]. The present study is one of the first to approach pelvic endometriosis findings with low-field MRI scanners (0.2 T).

It is already known that lower spatial resolution, low signal/noise ratio[11], as well as the impossibility of fat-saturation pulse sequencing, represent limitations of low-field MRI. However, the cost of investing in a low-field equipment is 2.7 times lower than those for high-field scanners[11]. Another advantage is represented by the lower maintenance costs, considering that low-field scanners require only an air-conditioning system instead of helium gas for magnet cooling. Additionally, the open design of low-field scanners (and for this reason also called open field scanners) allows a higher acceptability by claustrophobic patients.

Many studies have demonstrated a better visualization of endometriotic foci with the utilization of sequences with fat-saturation[2,6,8,9], considering that, on T1-weighted sequences, hemorrhagic lesions present hypersignal confused with the hypersignal produced by adjacent fat, so that the detection of endometriotic foci is impaired. With the utilization of T1-weighted sequences with fat-saturation, the hypersignal generated by the fat can be selectively saturated, so that the hypersignal produced by hemorrhagic lesions is not lost.

In the present study, the fat-saturation (fat-sat) sequence in low-field MRI was replaced by a post-processing sequence called water-image. This post-processing technique allows the separation between water and fat signals based on the difference between the phases achieved at a determined acquisition time. This post-processing technique can be utilized on T1-weighted sequences, allowing the utilization of intravenous paramagnetic contrast injection, besides the benefits resulting from fat-suppression. Among other indications, the utilization of gadolinium-based contrast agents includes the evaluation of inflammatory pelvic diseases, leiomyomas vascularization, and characterization of adnexal masses, particularly as regards their malignancy[16]. These agents also are useful for differentiation between hemorrhagic cysts and endometriomas, considering that, besides their signal characteristics, peripheral enhancement can be observed.

Tubal alterations characterized by distention of the uterine tube caused by the presence of fluid, generally with hematic content, were identified by both low- and high-field MRI with high sensitivity and specificity, demonstrating that loss in characterization of large lesions because of decreased signal/noise ratio is not observed at low-field MRI. Despite the non-specificity of this finding, in the present clinical context, tubal alterations are associated with endometriosis, and hence the relevance of their identification.

MRI plays a significant role in the evaluation of deep endometriosis, particularly for allowing the identification of lesions intermingled with adhesions and evaluation of subperitoneal lesions[17]. However, in the present study, deep endometriosis could not be evaluated by low-field MRI.

Initially, demonstration of adenomyosis was not included in the objective of the present study but the authors have decided to include it, considering clinical and physiopathological aspects in common with endometriosis, besides the high prevalence (33%) of this disease in the group evaluated.

Adenomyosis was identified by low-field MRI in eight patients and confirmed by high-field MRI, with a good specificity and sensitivity. The false-positive rate in the detection of adenomyosis by low-field MRI was 11%, probably because of the presence of artifacts, decrease in the signal/noise ratio, decrease in the acquisition matrix size and consequential loss of definition of low-thickness areas such as the junctional zone. This could mislead the radiologist, generating doubts about the area characteristic of the junctional zone, besides impairing the identification of focal alterations of the myometrium, likewise in two of the cases identified by high-field MRI and not observed on low-field images.

Patients identified with ovarian and peritoneal endometriotic foci, and endometriomas were divided into two groups: patients with large endometriotic foci (> 7 mm) and patients with small endometriotic foci (< 7 mm). Sensitivity and specificity, as well as positive and negative predictive values for large ovarian or peritoneal endometriotic foci were 100%. The sensitivity for detecting small endometriotic foci was low, probably because of decrease in the signal/noise ratio, lower spatial resolution and presence of artifacts impairing the differentiation of lesions < 7 mm from other tissues.

Among the 27 patients included in the present study, 18 (66.7%) had some lesion indicative of endometriosis identified by high-field MRI. Low-field MRI identified these lesions in 14 patients (51.8%). Small endometriotic foci (= 7 mm) could not be identified by this method.

The method allows the identification of additional findings such as functional and hemorrhagic cysts and one teratoma which were not included in the scope of the present study.

One of the limitation of the present study was the relatively small casuistic. A higher number of patients could add information for a better characterization of limitations and applications of low-field magnetic resonance imaging.

Nine patients with negative results for endometriosis were included in the present study, since clinical suspicion with indication for laparoscopy was the inclusion criterion adopted. So, the negative predictive value was estimated, considering that high-field MRI represented the golden-standard.

Although the present study has demonstrated that more clinically significant lesions such as endometriomas, tubal alterations and adenomyosis can be identified by low-field MRI, the authors do not intend to recommend the replacement of high-field MRI – a method already validated and widely available – but rather to present an useful alternative method for investigating endometriomas or tubal alterations, in cases where only low-field equipment is available.

The method is applicable for evaluation of pelvic endometriosis, with the limitations described in the present study, particularly in cases of endometriotic foci < 7 mm.

CONCLUSION

Low-field magnetic resonance imaging presented low sensitivity for detection of small foci of endometriosis, high sensitivity for detection of endometriomas and large endometriotic foci, and a good accuracy in the detection of adenomyosis as compared with high-field MRI.

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