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Magnetic resonance and diffusion-weighted imaging in categorization of uterine sarcomas: correlation with pathological findings☆

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ABSTRACT

Objectives: We investigated the utility of magnetic resonance imaging (MRI) and diffusion-weighted imaging (DWI) in the categorization of uterine sarcoma (US) and compared them with pathological findings.
Methods: The baseline and MRI characteristics were recorded and compared across the subtypes of USs.
Results: There were no differences in the conventional or DWI signals among the four subtypes of US, except in the heterogeneity of T_2-weighted imaging. A difference in the mean apparent diffusion coefficient value for USs and uterine fibroids differed significantly ($P = .019$).
Conclusions: MRI characteristics showed no specific differences between any subtypes of US.

1. Introduction

Uterine sarcoma (US) is rare malignant tumors of mesenchymal origin, accounting for about 1%–3% of uterine malignancies [1]. They are histologically categorized into four common variants: leiomyosarcoma (LS), endometrial stromal sarcoma (ESS), adenosarcoma (AS), and carcinosarcoma (CS) [2]. USs display aggressive biological behavior, and the prognosis is very poor, with a reported 5-year survival rate of only 22%–39%, even when they are detected at an early stage [3]. Because the prevalence of US is low, a preoperative diagnosis is often difficult, although it is critical for stratifying patients to case-effective treatments.

Magnetic resonance imaging (MRI) has been widely used in obstetrics and gynecology in recent decades [4–10]. Because it offers the advantages of superb soft-tissue resolution, no radiation, and multiplanar imaging, MRI plays a key role in determining the etiology of any suspected malignancy in the female genital tract detected with ultrasound or computed tomography [11–13].

Diffusion-weighted imaging (DWI) is a functional imaging technique currently available in the majority of clinical MRI units. By displaying water molecule mobility (Brownian motion), DWI permits the quantitative evaluation of tumor tissues and has shown promising results in distinguishing malignancies from benign gynecological lesions in several recently reported studies [6,12,14–17].

However, research that uses MRI or DWI to image USs is still limited. Therefore, the purpose of the study was twofold: first, to clarify the MRI and DWI-MRI findings for the four subtypes of US in a relatively large sample and to compare them with the pathological findings at our single institution; and second, to determine whether DWI-MRI is useful in discriminating USs from other benign uterine conditions.

2. Materials and methods

2.1. Study subjects

From June 2010 to December 2012, 437 consecutive patients with clinically suspected gynecological disease underwent prospective MRI examinations before pelvic or laparoscopic surgery at our institution. Twenty-two patients (19–73 years of age; average age, 52.7±12.3 years) with pathologically proven US were included in this study. To compare the apparent diffusion coefficients (ADCs) values of benign and malignant uterine lesions, we also selected a limited numbers of leiomyomas and adenomyomas for the comparative group. The criteria were as follows: first, to minimize the selection bias caused by multiple lesions in one patient, we chose only patients with a solitary lesion for either the leiomyoma or adenomyoma group; second, patients with any previous pelvic surgery or radiation history were arbitrarily excluded because the inherent structure of the uterus may have been altered. Thus, 21 leiomyomas (24–72 years of age; average age, 47.7±13.9years) and 20 adenomyomas (34–51 years of age; average age, 41.4±5.2years) were included. Our institutional review board approved the study, and the requirement for informed consent was waived for all participants.

☆ We declare that we have no conflicts of interest.

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Table 1
Details of parameters for MRI protocols

Parameters	T_1WI	T_2WI	FS-T_2WI	DWI	Contrast-enhanced MRI
Repetition/Echo time (msec)	550/10	4000/83	8000/83	2800/81	4.89/2.38
Echo trains per slice	44	19	19		
Sequence	TSE	TSE	TSE	EP2D	VIBE[c]
Bandwidth (Hz)	178	260	260	1250	400
Thickness (mm)	4	4	4	5	3
Field of view (mm)	350 (AP[a])	350 (LR[b])	350 (LR, AP)	300 (AP)	380 (LR, AP)
Voxel size (mm)	1.5×1.1×4.0	1.1×1.1×4.0	1.4×1.4×4.0	2.7×1.9×5.0	1.7×1.2×3.0
Flip angle (degrees)	150	144	150		10

[a] AP indicated that the scan plane was from anterior to posterior.
[b] LR indicated that the scan plane was from left to right.
[c] Volumetric Interpolated Breath-hold Examination.

2.2. Image acquisition

MRI was performed using a 1.5-T MR system (Magnetom Avanto, Siemens, Erlangen, Germany) with a phased-array coil. The routine MRI protocols used for the assessment of pelvic masses included the axial turbo spin-echo (TSE) T_1-weighted imaging (T_1WI), sagittal TSE T_2-weighted imaging (T_2WI), and axial/sagittal TSE fat-suppressed T_2WI (FS T_2WI). For axial images, the transverse plane was perpendicular to the long axis of uterine body; for sagittal images, the longitudinal plane was parallel to the main body of uterus. DWI using an echo-planar imaging two-dimensional (EP2D) sequence performed in the axial plane with parallel acquisition technique by using *b* value=0, 100, and 800 s/mm^2. Contrast-enhanced pelvic imaging was acquired at multiple phases of contrast medium enhancement in both sagittal and axial planes. The detailed MRI acquisition parameters were listed in Table 1.

2.3. Image analysis

The location, size (largest dimension in two orthogonal planes), shape (round, oval, and lobulated), and margin (clear or ambiguous); visibility of endometrium and hemorrhage component (high signal on T_1WI) within the lesion; and presence of pelvic-free fluid and lymph nodes were noted. Further, the homogeneity of T_1WI/T_2WI signals, accompanying lesions and extrauterine extension were separately evaluated and recorded. On T_1WI, hypo-, *iso*-, and hyperintensity were similar for the pelvic fluid, pelvic wall muscle, and fat signal; on T_2WI, hypo-, *iso*-, and hyperintensity were similar for the pelvic bone, pelvic wall muscle, and fat signal; on b=800 mm^{-2}/s DWI images, the low, intermediate, and high-signal intensities were similar for the pelvic bone, myometrium, and endometrium. After the intravenous injection of the contrast medium, the degree of lesion enhancement was graded as follows: 1, weak enhancement (less than the myometrium); 2, mild enhancement (equal to the myometrium); 3, avid enhancement (superior to the myometrium). ADCs were measured manually on postprocessing workstation (Leonardo, Siemens, Germany) by one reviewer (H.Z.).

Two observers (G. F. Z. and H.Z., with 10 and 6 years of experience in gynecological imaging, respectively), who were blinded to the histological results independently, analyzed MRI datasets of each participant. At the end of the study, two observers were also required to give the tumor stage according to new FIGO system for US [18]. For interobserver discrepancies in the evaluation of uterine lesions, consensus was achieved.

2.4. Statistical analyses

Continuous variables were expressed as the means±standard deviation (S.D.) and compared with the unpaired *t* test if normally distributed or the Mann–Whitney test if not normally distributed. A nonparametric test (Mann–Whitney) was used to test other nonparametric variables within each group. Kappa statistics were used to

Table 2
The details of baseline and MRI characteristics of four subtypes of the histologically proven 22 USs

Baseline characteristics	Pathology group			Total	*P* value
	LS	ESS+AS	CS		
Age (years)	53±10.6	51±16.8	55±6.7		
Menstruation					
Premenopause	3	2	2	7	
Perimenopausal	2	1	2	5	
Menopause	2	6	2	10	
Symptoms[a]					.034
Pelvic mass	4	1		5	
Virginal bleeding (discharge)	3	7	5	15	
Menstruation disorder		1	1	2	
MRI characteristics[b]					
Maximum diameter (mm)	55.6±49.7	49.4±31.9	36.3±19.5		
Component					
Solid	6	6	5	17	
Cyst					
Mixed	1	2		3	
Hemorrhage					
Present/Absent	5/2	2/6	1/4	8/12	
Margin					
Clear/Unclear	3/4	6/2	3/2	12/8	
Extrauterine extension					
Yes/No	4/3	0/8	0/5	4/16	
Accompanying lesion					
Present/Absent	4/3	1/8	1/5	6/16	
Normal endometrium					
Present/Absent	3/4	3/5	3/2	9/11	
T_1WI signal character					
Low	3			3	
Intermediate	1	8	4	13	
High				3	
Mixed	3		1	4	
Homogeneous/ Inhomogeneous	2/5	5/3	4/1	11/9	
T_2WI signal character					
Low					
Intermediate	1	4	1	6	
High		2	2	4	
Mixed	6	2	2	10	
Homogeneous/ Inhomogeneous	0/7	4/4	1/4	5/15	.021
DWI signal character					
Low					
Intermediate	1	1		2	
High	4	5	5	14	
Mixed	2	2		4	
ADC value (10^{-3}/mm^2/s)[c]	0.93±0.30	1.19±0.33	1.05±0.22		
Enhancement					.05
Avid enhancement	6	3		9	
Moderate enhancement		5	5	10	
Weak enhancement	1			1	

[a] If both symptoms were observed, then the virginal bleeding (discharge) was seemed as the primary symptom.
[b] One CS and one AS could not be evaluated at MRI for the undetected lesion.
[c] ADC values could not been calculated in one case in AS and two cases in CS group because the small-sized (<10 mm) lesions were not detected on DWI-MRI images.