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Comparison of 1.5 T (Tesla) and 3.0 T (Tesla) Magnetic Resonance Imaging for Evaluating Local Extension of Endometrial Cancer

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Abstract: Magnetic resonance imaging (MRI) is an important means of evaluating local extension of endometrial cancer. The 3.0 Tesla (T) MRI system introduced in 2005 improved the diagnostic capabilities of this modality due to an increased signal to noise ratio; however, it was also susceptible to artifacts and debate remains regarding the clinical applicability of 3.0 T MRI in the pelvic region. A few reports have compared 1.5 T and 3.0 T MRI for determining the degree of progression of endometrial cancer. Therefore, we conducted a comparative study of the diagnostic capability of 1.5 T and 3.0 T MRI for the local extension of endometrial cancer. Over the 6 years and 8 months from 1 January 2008 to 30 August 2014, preoperative MRI has been conducted at our hospital including T2-weighted imaging, diffusion-weighted imaging, and dynamic contrast-enhanced MRI for cases of endometrioid adenocarcinoma requiring surgery. We investigated 60 subjects after excluding cases for which the tumor could not be imaged and cases that underwent surgery 2 months or more after undergoing MRI. Two radiologists used magnetic resonance images taken preoperatively to determine local extension using T2-weighted, diffusion-weighted, and dynamic-study images. Results for local extension were compared with those of postoperative histopathology. Results indicated no significant difference in accurate diagnosis rates between 1.5 T and 3.0 T MRI for any of the imaging modalities examined by both radiologists.

Key words: MRI, endometrial cancer, 3.0 T MRI, extension of endometrial cancer

Introduction

As of 2013, endometrial cancer was the seventh most common site-specific cause of mortality in women in Japan[1]. Most cases of endometrial cancer are adenocarcinoma, with endometrioid adenocarcinoma the most prevalent. Statistics from the Japan Society of Obstetrics and Gynaecology in 2009 indicated that more than 80% of malignant tumours of the uterine body are endometrioid adenocarcinomas[2].

The degree of histological differentiation and myometrial infiltration correlate with prognosis, prompting the International Federation of Gynaecology and Obstetrics (FIGO) to take these

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factors into account in recommending a surgical staging system. In Japan, rules for handling endometrial cancer have been established based on these FIGO classifications and TNM classification.

Diagnostic imaging plays an important role in the initial staging, which is essential for determining treatment strategy. Until recently, magnetic resonance imaging (MRI) was an important method of preoperative evaluation for endometrial cancer, used in assessing the depth of myometrial invasion. Contrast-enhanced MRI is superior to non-contrast-enhanced MRI, computed tomography (CT), and ultrasound imaging for evaluating myometrial and cervical infiltration[3-6].

In recent years, the use of 3.0 Tesla (T) MRI, which uses a strong magnetic field (two times stronger than that of 1.5 T MRI), has spread rapidly and 3.0 T MRI is being clinically applied in various fields. Compared to 1.5 T systems, the 3.0 T system offers increased signal to noise ratio (SNR), magnetic susceptibility, chemical shift, and specific absorption rate (SAR), with the increased SNR constituting a significant advantage. However, as magnetic susceptibility effects are proportional to static magnetic field intensity, their enhancement with 3.0 T MRI intrduces new artifacts and distortion. Increased chemical shift also leads to prominent chemical shift arteficts. Thus, 3.0 T MRI offers both advantages and disadvantages for diagnostic imaging and its superiority for diagnosis in the abdominal and pelvic regions has not been sufficiently proven.

Thus far, few studies have compared 1.5 T and 3.0 T MRI diagnosis of local extension in endometrial cancer[6-8], thus we undertook such a comparative study in cases of endometrioid adenocarcinoma.

Materials and methods

Ethics approval for this retrospective study was granted by the institutional review board, and patient consent was not required.

Subjects comprised endometrioid adenocarcinoma patients diagnosed with endometrial cancer via MRI who underwent a surgical procedure within 2 months from diagnosis during the period from 1 January 2008 to 30 August 2014. None of the selected patients had a history of uterine surgery including caesarean section.

Eligible MRI tests were T2-weighted axial views, diffusion-weighted images and dynamic contrast-enhanced imaging. A total of 59 patients (mean age : 58.67 years, range : 33–92 years) were registered for this study, all of whom had not undergone chemotherapy or radiation therapy prior to the surgical procedure.

Selection of MRI equipment was randomly determined without consultation of the radiologist or gynaecologist.

MRI Testing

The 59 patients underwent testing using a body coil MRI system (SIEMENS Ltd.) ; of these, 37 patients underwent imaging with 3.0 T MRI (Magnetom Trio A Tim 3.0T, SIEMENS), 18 underwent imaging with 1.5 T MRI (Magnetom Avanto 1.5T, SIEMENS), and 4 patients underwent imaging with 1.5 T MRI (Magnetom ESSENZA 1.5T, SIEMENS). All patients underwent

MRI before undergoing surgery, and compression bands were used in every patient to reduce motion artefact.

Spin echo T2-weighted axial view images were taken perpendicular to the endometrial body and the scan parameters were as follows : TR/TE, 6000-4500/103-94 msec; slice thickness, 5 mm ; field of view (FOV), 22 cm ; matrix, 384 × 307 (3.0 T), 384 × 269 (1.5 T). Spin echo T2-weighted sagittal view images were taken parallel to the endometrial body and the scan parameters were as follows : TR/TE, 4000-6000/91-112 msec ; slice thickness, 5 mm ; FOV, 19.4-26 cm ; matrix, 320 × 242 (3.0 T), 320 × 256 (1.5 T).

Diffusion-weighted images were taken perpendicular to the body axis and the scan parameters were as follows : TR/TE, 4500-3100/97-77 msec ; slice thickness, 3-5 mm ; FOV, 17.5-27.3 × 35-40 cm ; matrix size, 128 × 72 (3.0 T), 128 × 72 (1.5 T) ; b-values, 50, 500, 1000 and 2000 s/mm^2 imaging (sensitivity encoding [SENSE]), and a refocusing flip angle.

Dynamic contrast-enhanced images were performed with volumetric interpolated breath-hold sampling (VIBE) in 56 cases and fast low-angle shot (FLASH) was performed for 3 cases, in accordance with the following sequence : 1) VIBE ; TR/TE, 3.2-7.8/1.24-4.76 msec ; slice thickness, 2.5-5 mm ; FOV, 25-30 cm ; matrix size, 288-448 × 268-259 (3.0 T), 256-320 × 224-228 (1.5 T), 2) FLASH ; TR/TE, 160-200/2.46 msec; slice thickness, 3-5 mm ; FOV, 23-30 cm ; matrix size, 256-320 × 224-262 (3.0 T). In the dynamic contrast-enhanced study, images were acquired at different phases relative to the IV injection of gadolinium contrast agent (0.2 ml/kg) : before and 30 seconds and 120 seconds after intravenous administration of intaravenous contrast.

Imaging analysis

On T2-weighted images, tumors exhibited stronger signal intensity than normal myometrium and lower signal intensity than normal endometrium. On diffusion-weighted images, tumors exhibited higher signal intensity than normal myometrium and lower signal intensity than the ADC (apparent diffusion coefficiennt map). In the dynamic-contrast images, tumors were rendered as areas with less contrast than normal myometrium.

Local extension diagnosis was evaluated using T2-weighted axial and sagittal view images, diffusion-weighted images, and dynamic contrasted images. Two physicians (each with 4 years of experience in diagnostic imaging) independently determined local tumor extension using UICC version 7 and TNM classifications. We compared their results for T classification on the three MRI types, and then investigated consistency between each patient's histopathological results and the MRI-diagnosed local extension.

SPSS version 17.0 was used for statistical analysis, together with the chi-squared test. A P-value < 0.05 was considered statistically significant.

Results

Of the 59 patients, 42 were classified as T1a, 11 as T1b, 4 as T2, 1 as T3a, and 1 as T3b.

According to radiologist 1, the accurate diagnosis rates were 18/22, 20/22, and 20/22 for 1.5 T and 32/37, 35/37, and 33/37 for 3.0 T from the T2-weighted, diffusion-weighted, and dynamic

contrasted images, respectively, with no significant difference found ($P = 0.833$, 0.586, and 0.833). These results are presented in Tables 1.

According to Radiologist 2, the accurate diagnosis rate was 16/22, 18/22, and 18/22 for 1.5 T and 29/37, 29/37, and 33/37 for 3.0 T from the T2-weighted, diffusion-weighted, and dynamic contrasted images, respectively, with no significant difference found ($P = 0.622$, 0.921, and 0.424). These results are presented in Tables 2.

The significant difference of the accurate diagnosis rate of the stage progress was not recognized by Radiologist 1 (Table 3–5).

The significant difference of the accurate diagnosis rate of the stage progress was not also recognized by Radiologist 2 (Table 6–8).

Analysis using the chi-squared test indicated no significant difference between T-factor determination with 1.5 T and 3.0 T MRI and the κ -statistics indicated a good degree of agreement between the two observers ($\kappa = 0.64$).

Discussion

Diagnostic imaging plays an important role in initial staging of tumors, which is essential for determining treatment strategy. MRI T2-weighted images are mainly used to evaluate local extension of endometrial cancer. However, accurate evaluation is difficult with T2-weighted images alone, and often contrast-enhanced MRI is necessary. The European Society for Urological Research recommends using T2-weighted images in combination with dynamic contrast-enhanced images for endometrial cancer staging and it has been reported in the past that this combination can increase the accurate diagnosis rate for myometrial infiltration[9].

The higher SNR of 3.0 T MRI was expected to improve the diagnostic capability and its superiority for angiography, contrast-enhanced T1-weighted imaging, imaging bony and soft regions, and coronary angiography during respiratory arrest[10–17]. Although 3.0 T MRI offers a high SNR (Fig 1, 2), problems associated with it in comparison to 1.5 T MRI are inferior high frequency uniformity, different organ and tissue relaxation time, tendency for high SAR, high chemical shift, and strong magnetic susceptibility; all of which could potentially erode image quality. Accordingly, another disadvantage of 3.0 T MRI is susceptibility to artifacts in the abdominal region and the clinical usefulness of 3.0 T MRI in the pelvic region[10].

In this study, we found no difference in superiority between 3.0 T and 1.5 T MRI on T2-weighted images, diffusion-weighted images, or contrast-enhanced dynamic images for determining myometrial infiltration, and both systems offered comparable diagnostic capability. These results are consistent with those of past studies[6, 7]. In routine clinical practice, the validity of using 3.0T MRI for diagnosing the degree of infiltration of endometrial cancer appears to have been proven. Moreover, intestinal peristalsis depressants were used in all of the studies reporting the usefulness of 3.0 T MRI[7, 8]. As we do not use peristalsis inhibitors at our hospital, a compression band was used in every patient to reduce motion artifacts. Thus one limitation of this study is the lack of comparison between patients with and without peristalsis depressants. However, it has also been suggested that 3.0 T MRI may offer the same diagnostic capability as

Table 1. Accurate diagnosis rate assessment for Radiologist 1

MRI (n = 59)	1.5 T (n = 22)	3.0 T (n = 37)	*P*-value
T2WI	18/22	32/37	0.833
DWI	20/22	35/37	0.586
Dynamic study	20/22	33/37	0.622

Table 2. Accurate diagnosis rate assessment for Radiologist 2

MRI (n = 59)	1.5 T (n = 22)	3.0 T (n = 37)	*P*-value
T2WI	16/22	29/37	0.622
DWI	17/22	29/37	0.921
Dynamic study	18/22	33/37	0.424

Table 3. Radiologist 1 - accurate diagnosis rate for pT1a vs. pT1b cases with T2WI

Diagnosis (n = 53)	1.5 T (n = 19)	3.0 T (n = 34)	*P*-value
pT1a (n = 42)	14/16	24/26	0.558
PT1b (n = 11)	3/3	7/8	0.521

Table 4. Radiologist 1 - accurate diagnosis rate for pT1a vs. pT1b cases with DWI

Diagnosis (n = 53)	1.5 T (n = 19)	3.0 T (n = 34)	*P*-value
pT1a (n = 42)	16/16	26/26	-
PT1b (n = 11)	3/3	8/8	-

Table 5. Radiologist 1 - accurate diagnosis rate for pT1a vs. pT1b cases with dynamic contrast imaging

Diagnosis (n = 53)	1.5 T (n = 19)	3.0 T (n = 34)	*P*-value
pT1a (n = 42)	16/16	25/26	0.442
PT1b (n = 11)	3/3	7/8	0.521

Table 6. Radiologist 2 - accurate diagnosis rate for pT1a vs. pT1b cases with T2WI

Diagnosis (n = 53)	1.5 T (n = 19)	3.0 T (n = 34)	*P*-value
pT1a (n = 42)	12/16	23/26	0.215
PT1b (n = 11)	3/3	4/8	0.125

Table 7. Radiologist 2 - accurate diagnosis rate for pT1a vs. pT1b cases with DWI

Diagnosis (n = 53)	1.5 T (n = 19)	3.0 T (n = 34)	*P*-value
pT1a (n = 42)	13/16	23/26	0.460
PT1b (n = 11)	3/3	5/8	0.214

Table 8. Radiologist 2 - accurate diagnosis rate for pT1a vs. pT1b cases with dynamic study

Diagnosis (n = 53)	1.5 T (n = 19)	3.0 T (n = 34)	*P*-value
pT1a (n = 42)	13/16	25/26	0.110
PT1b (n = 11)	3/3	5/8	0.214

1.5 T MRI even without peristalsis depressants.

This study had a number of other limitations. First, the same patients did not undergo both 1.5 T and 3.0 T MRI so comparisons could not be made between the results for each patient. It is not beneficial for patients to undertake an MRI examination twice, because of the extra cost and possibility of adverse reaction to the contrast agent. Accordingly, results only indicate no significant difference in diagnostic capability of local extension of endometrial cancer in a population using 1.5 T and 3.0 T MRI and do not indicate differences for individual cases. Second, T2-weighted images were taken in sagittal and axial views, whereas diffusion-weighted

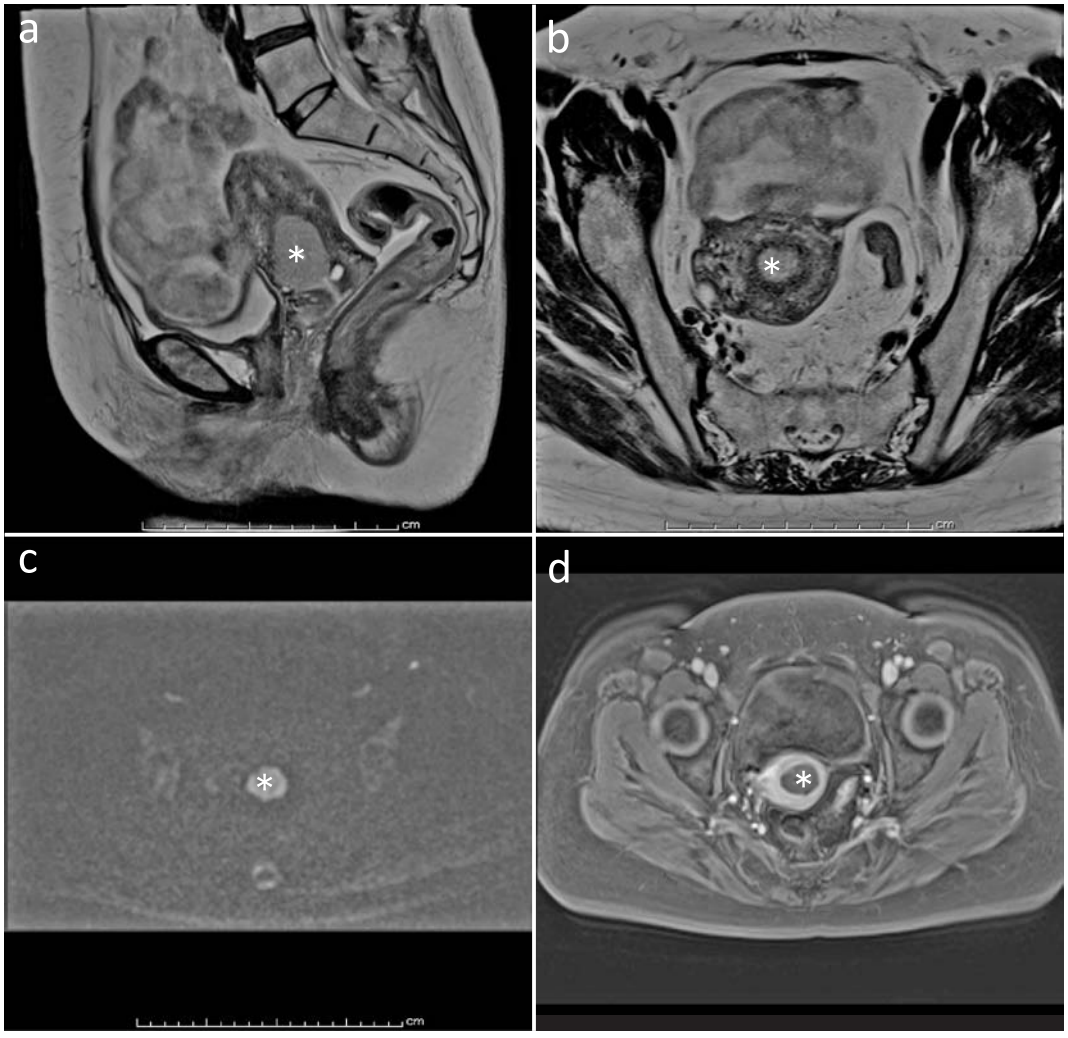

Fig. 1. A 33-year-old woman diagnosed with pT1b carcinoma (1.5 T MR images)
a. T2-weighted sagittal image, b. T2-weighted axial image, c. Diffusion-weighted axial image, d. Dynamic contrast images with 1.5 T MRI.

images were only taken in the axial view. Therefore, evaluation of vertical tumor extension was limited with diffusion-weighted images. Third, the dynamic contrast-enhanced MRI was only taken in one direction ; however, we do not believe this was a significant problem as this imaging direction was determined to be the optimal direction for determining local infiltration by the radiologist during testing. Finally, a detailed background of each patient, including risk factors of endometrial cancer and medical histories is not included in this study, and it is possible that a patient's background might influence the evaluation of MR images. However, no cases of previous uterine surgery such as caesarian section were included in this study and the influence of MRI diagnosis on the local invasion of the tumor could be minimized between the cases performed with 1.5 T MRI and 3.0 T MRI.

Recently, multi-channel RF transmitter MRI has been introduced as a means of compensating

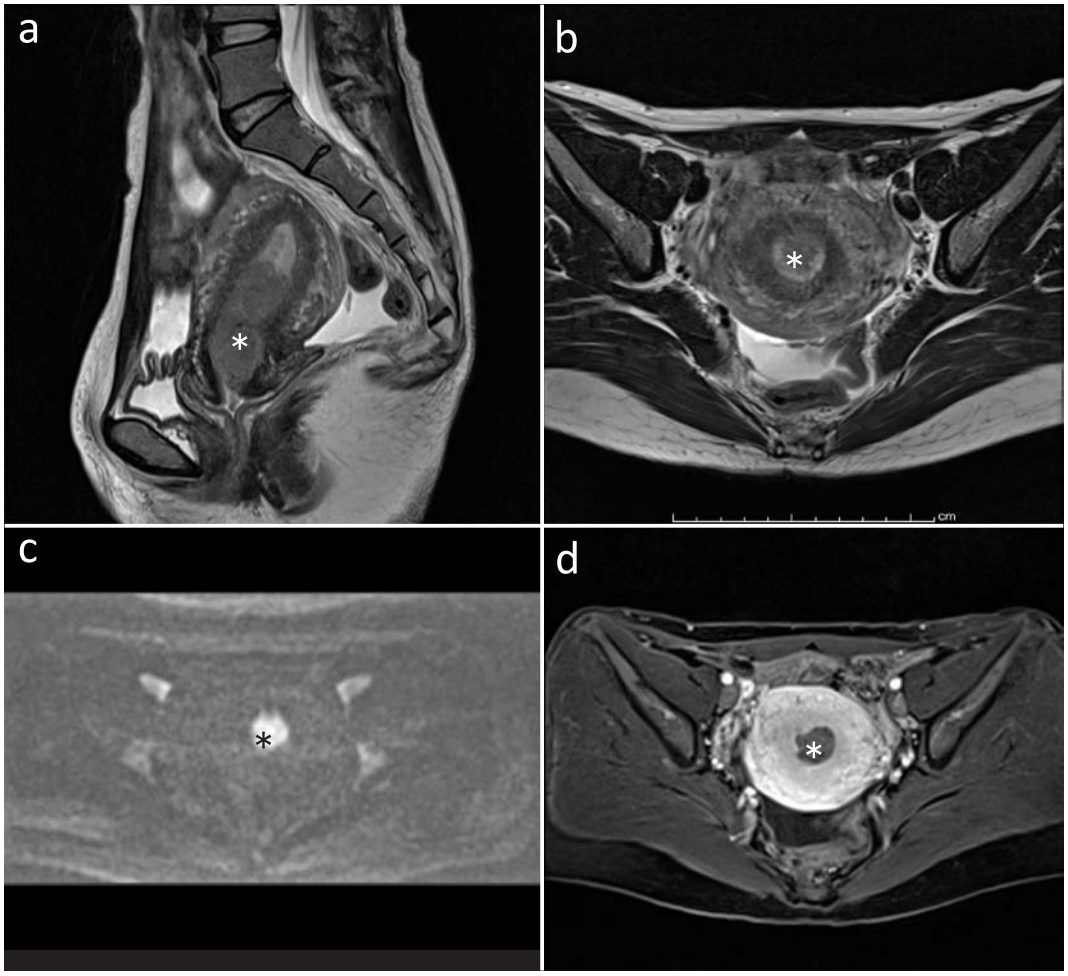

Fig. 2. A 53-year-old woman with pT1b carcinoma (3.0 T MR images)
a. T2-weighted sagittal image, b. T2-weighted axial image, c. Diffusion-weighted axial image, d. Dynamic contrast images with 3.0 T MRI; * = tumor.

T2-weighted sagittal images and axial images, diffusion-weighted images and dynamic contrast images are shown with 1.5 T (Fig. 1) and 3.0 T MRI (Fig. 2).
Images of 3.0 T MRI show higher S/N compared with those of 1.5T, although no difference is seen for determining the myometrial infiltration between 3.0 T and 1.5 T MRI.

for the disadvantages of 3.0 T MRI, and RF uniformity has increased dramatically. This technology has made it possible to acquire images utilizing the 3.0 T MRI characteristic of high SNR. Thus, expectations remain high for the future of MRI technology[18].

In conclusion, no significant difference was observed between 3.0 T and 1.5 T MRI in the diagnostic capability for evaluating the local extension of endometrial cancer. This suggests strong possibilities for MRI diagnosis in the future with superior time and spatial resolution utilizing the high 3.0 T MRI SNR.

Conflict of interest disclosure

The authors have declared no conflict of interest.

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