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Endometrial carcinoma detection with 3.0 Tesla imaging: which sequence is more useful

L. KARACA[1], Z.M. ÖZDEMIR[1], A. KAHRAMAN[1], E. YILMAZ[2], A. AKATLI[3], H. KURAL[2]

[1]Department of Radiology, [2]Department of Gynecology, [3]Department of Pathology, Medical Faculty, Inönü University, Malatya, Turkey

Abstract. – OBJECTIVE: Detection of endometrial cancer (EC) is crucial in pre-operative EC management. The study aimed at determining the most reliable sequence in magnetic resonance imaging (MRI) evaluation at the EC. Different sequences were compared using histopathological results as the gold standard.

PATIENTS AND METHODS: In this retrospective study, 62 women diagnosed with EC were examined using 3 Tesla MR and post-hysterectomy histopathological examination. The MRI protocol included diffusion-weighted imaging (DWI), T2 weighted images, Dynamic Contrast T1 weighted images, and ZOOMit DWI. Apparent diffusion coefficient (ADC) maps were also obtained. ADC maps were calculated for both DWI and ZOOMit DWI. All serial images were analyzed by endometrial distance to account for myometrial invasion and tumor size. All sequences and histopathological results were compared using the paired sample *t*-test.

RESULTS: In all 32 women, post-hysterectomy histopathological confirmation was obtained. Mean myometrial invasion values were not significantly different after comparing DWI, ZOOM it DWI, and Dynamic contrast enhancement (DCE)-T1WI (p=0.054, p=0.039). The first strong correlation was found between DWI and ZOOMit DWI (0.943). The second was between ZOOMit DWI and DCE-T1 WI (0.949). Comparing each set of sequences, no statistically significant differences in tumor size ($p > 0.05$) were found. Also, no statistically significant differences between images and histopathological size were found. The ADC values of ZOOMit DWI indicated that this method detected significant differences between EC histological subtypes.

CONCLUSIONS: Each sequence is essential and valuable, whereas priorities may vary depending on the desired information. The most valuable sequences for the myometrial invasion were ZOOMit and conventional DWI. T2WI and DCE T1 WI were more valuable sequences the size of EC.

Key Words:
Endometrium, Cancer, MR sequences.

Introduction

Endometrial cancer (EC) is the most common invasive gynecological malignancy of the female genital tract in industrialized countries[1]. The assessment of the depth of the myometrial invasion is critical in evaluating EC using magnetic resonance imaging (MRI) because it closely correlates with the prevalence of nodal metastasis and patient prognosis[2]. Some prospective trials showed no survival benefit from the usage of MRI after lymphadenectomy in patients with early-stage adenocarcinoma[3]. MRI is influential for patients' management. Radiologists should know which parameters are considered essential for each case when reporting the results.

Many studies[4-6] were conducted concerning the evaluation of EC, showing that intra- and inter-observer differences exist. In addition, some technical and patient-related problems with radiological imaging at the EC have been described.

T2-weighted imaging, DWI, and dynamic contrast-enhanced T1-weighted (DCE) MR imaging can provide valuable information for the assessment of myometrial invasion in the literature[5-7].

According to current literature, it is believed that the interpretation of radiological imaging depends on many factors. If technical, structural, and reader-related factors were excluded, how would the results differ? In addition, previous studies[4-7] were conducted mainly as semi-quantitative measurement techniques, whereas our study was conducted as a completely quantitative measurement.

The present study aimed at determining a reliable sequence of MRI reflections at the EC by comparing different sequences using gold standard pathological specimens as the reference. Our results can assist radiologists in the choice of the best sequence to determine the management of EC.

Corresponding Author: Leyla Karaca, MD; e-mail: karacaleyla@gmail.com

Patients and Methods

Study Population

The institutional review board of The Medical Hospital of Inönü University (Malatya, Turkey) approved this retrospective study and waived the requirement for written informed consent. This study was conducted between 2017 and 2021.

A total of 62 women with a mean age of 55 years (range: 44-80 years) were included in the current prospective study with histopathologically proven endometrioid adenocarcinomas.

Special preparations were not performed for optimal bladder distention. Anticholinergic agents were not administered to any patient.

Patients who received pathological diagnosis of proven EC were included in the study. MR imaging was obtained within two weeks after the diagnosis of EC. Patients with EC lesions of at least 15 mm were included in this study.

During the study, 11 patients were excluded because of technical problems or motion-related artifacts, lack of surgery after MRI, no contrast media injection, and incomplete or incorrect MRI sequence protocol. In addition, 19 patients were excluded due to: endometrial polyps, myoma, clear adenomyosis, previous history of surgery, cases with very low myometrial thickness, the unclear endometrial myometrial junction (also in cases in which the endometrial myometrial junction could not clearly be seen). The remaining 32 women constituted the study population.

Imaging Acquisition

All patients underwent MRI with a 3.0-T system (MAGNETOM Skyra, Siemens Healthcare 14, Germany) and with a body coil in the supine position. The MR sequence protocols were conducted using a pelvic protocol.

Turbo spin-echo (TSE) T2 weighted imaging was performed in the sagittal, axial, and coronal planes set at TR/TE 6000/100; matrix, 256 x 256; NEX: 2; field of view, 25 cm; section thickness, 3 mm; intersection gap, 1 mm; and bandwidth, 250 Hz. After obtaining T2-WI, precontrast T1-WI and DCE T1-WI were obtained with the three-dimensional (3D) GRE VIBE with fat suppression sequences (TR/TE: 4.8/2.3 ms,15 flip angles, 320x 250 matrix, 1.6-mm section thickness, FOW 25 cm). DWI was obtained with TR/TE=5,500/56, FoV=380x78, slice thickness=3 mm, and NEX=2. A set of five b values (0, 50, 100, 400, 800) was applied. ZOOMit DWI was obtained with TR/TE=5,600/74, FOW=150/48 slice thickness=3 mm, NEX=2. A set of five b values (0, 50, 100, 400, 800) was also applied to ZOOMit DWI.

Image Analysis

MR images were reviewed with a Picture Archiving and Communication System (PACS) by a gynecological oncology specialist radiologist. The reader (L.K., with 20 years of experience) was aware of the presence of EC but was not knowledgeable of the final histological results. Depth of myometrial invasion of endometrial cancer was assessed on T2-weighted imaging, DWI, ZOOMit DWI, and contrast-enhanced T1-weighted imaging. The reader measured the same patient with the same methods after a 6-month break. The average of the measurement taken at different times was used (6 months).

In all patients, the observer initially started with the analysis of the T2WI sequence. He separately analyzed each T2WI, DWI, ZOOMit-DWI, and DCE-T1 WI sequence. The reader was analyzed to determine myometrial invasion in the semi-axial plane, as shown in Figure 1. A line was drawn parallel to the presumed inner section of the myometrium. One perpendicular line was drawn, and measurement of myometrial invasion was obtained.

In the semi-axial and sagittal planes, measurements of means tumor distances were obtained. In addition, the mean tumor distance at each sequence was calculated (Figure 2). At least three measurements were obtained for each value, and then averaged. On the axial DWI, apparent dif-

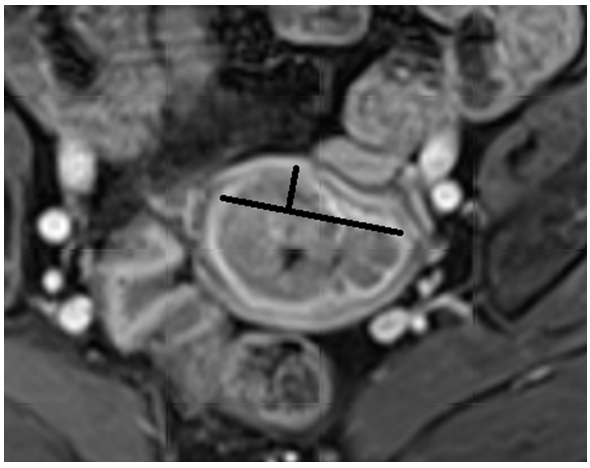

Figure 1. A line was drawn parallel to the presumed in inner of the myometrium. One perpendicular line was drawn, and a measurement of myometrial invasion was obtained.

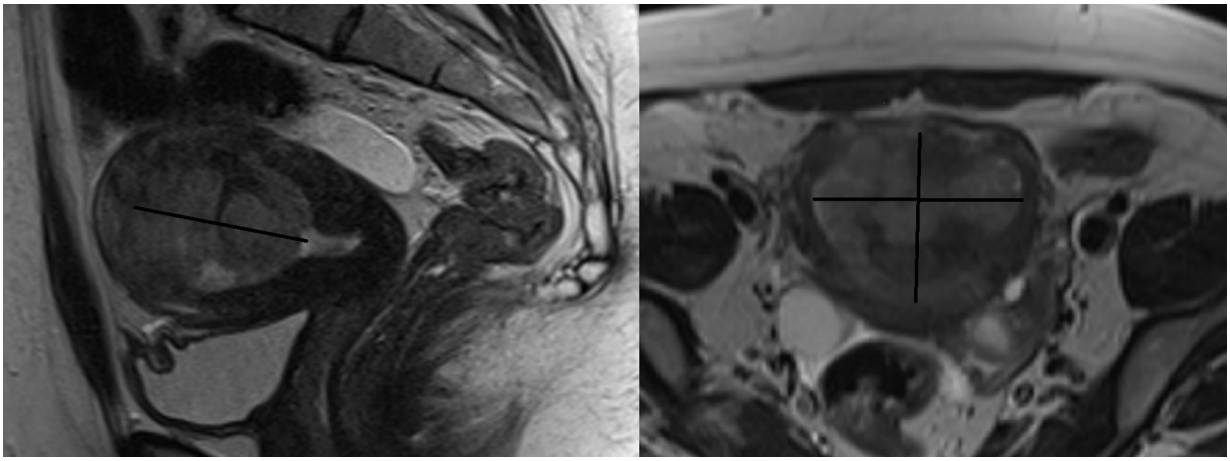

Figure 2. A measurement at the three planes endometrial cancer (EC).

fusion coefficient (ADC) values were calculated for regions of interest (ROI) in the tumor. ROIs were placed at possible locations within solid components. Three ROI measurements were obtained (Figure 3), which allowed the correction of intra-observer changes. Inter-observer changes were not included in this study. The patient population was chosen to eliminate inter-observer changes.

Statistical Analysis

Continuous variables were expressed as the mean ± standard deviation (SD). The statistical analyses were performed with SPSS 17. 0 (SPSS Inc., Chicago, IL, USA). Continuous variables were compared with paired *t*-test and analysis of variance (ANOVA) tests. A paired *t*-test was used for comparison of distance on different sequence MR images and also for surgical-pathological findings. One-way ANOVA and repeated measures of ANOVA were used for Mauchly's test. The level of significance was set as $p<0.05$.

Results

Histological Findings

In all 32 women, post-hysterectomy histopathological confirmation was obtained. Mean myometrial invasion values were recorded. Mean tumor distance (in three planes) was measured for each specimen.

Depth of Myometrial Invasion

Mean myometrial invasion values were not significantly different when DWI and ZOOMit DWI were compared ($p=0.619$). Mean myome-

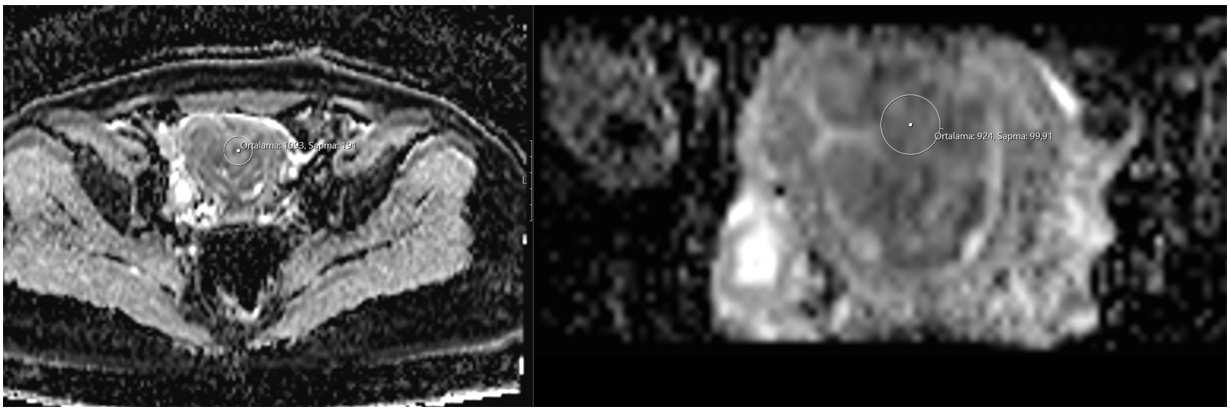

Figure 3. Measurements of regions of interest (ROI) on the apparent diffusion coefficient (ADC) map image.

Table I. Paired Samples Statistics.

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Zoom-it_invasion	8.1906	32	5.89239	1.04164
	DCE_invasion	8.1094	32	5.28549	0.93435
Pair 2	DWI_invasion	8.3688	32	5.95680	1.05302
	T2_invasion	10.5531	32	7.16681	1.26693

Zoom-it: Zoom-it diffusion sequence. DCE: Dynamic contrast enhancement sequence. DWI: Diffusion weighted image. T2: T2 weighted image.

trial invasion values were not significantly different in comparisons of DWI, ZOOMit DWI, and DCE-T1WI (p=0.054 and p=0.039). The highest correlation was found between DWI and ZOOMit DWI (0.943). The second highest was between ZOOMit DWI and DCE-T1WI (0.949), as shown in Table I.

No statistically significant differences (p>0.05) were found between the performance of the various MRI sequences. No statistically significant differences (p>0.05) were found between the performance of DWI and ZOOMit DWI (myometrial invasion, pathological results), as shown in Table II.

No statistically significant differences the between all sequence images and histopathological myometrial invasion size (Mauchly's W: 0.47, p=0.000).

With respect to tumor size, no statistically significant differences (p>0.05) were found between the performance of the various MRI sequences.

No statistically significant differences for tumor size (p>0.05) were found comparing each set of sequences. Also, no statistically significant differences between any sequence of images and histopathological size were found (Mauchly's W: 0.98, p=0.023)

ADC values

No statistically significant differences (p > 0.05) were found between the performance of DWI and ZOOMit DWI ADC values. Scatterplots of ADC map values are shown in Figure 4. No statistically significant differences (p>0.05) were found between performance of ADC values and histological grade.

Discussion

Many researchers[4,5,7-10] have suggested that the depth of myometrial invasion and size of EC is important in evaluating EC. In addition, different sequences were compared to each other, and their weaknesses and their strengths were revealed. Most of these studies[4-7] evaluated myometrial invasion using qualitative measurements.

In this article, it was confirmed that all MR sequence images are helpful in detecting the presence of EC and myometrial invasion for quantitative measurement. Currently, scholars[10] have been reported concerning the correlation of between different MRI sequences and tumor size. None of the current studies compared all sequences.

Table II. Paired samples test.

	Paired differences			95% confidence interval of the difference		t	df	Sig. (2-tailed)
	Mean	Std. deviation	Std. error mean	Lower	Upper			
Pair 1 DWI_ pathology invasion	1.52500	4.00371	.70776	.08151	2.96849	2.155	31	.039
Pair 2 T2_ pathology invasion	3.70937	7.31006	1.29225	1.07382	6.34493	2.870	31	.007
Pair 3 DCE_ - pathology invasion	1.26563	3.88941	.68756	-.13666	2.66791	1.841	31	.075

DCE: Dynamic contrast enhancement sequence. DWI: Diffusion weighted image. T2: T2 weighted image.

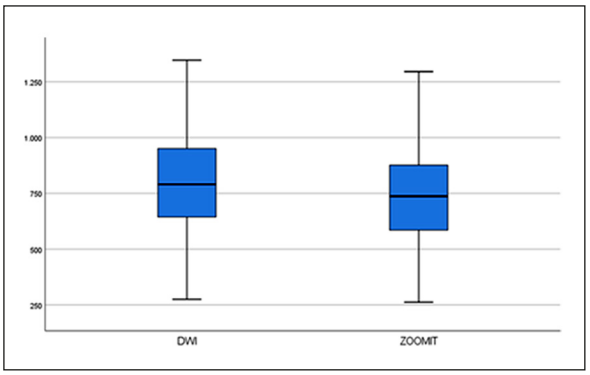

Figure 4. Scatterplot of ADC map values.

In our study, it has been demonstrated that ZOOMit DWI/conventional DWI and DCE yielded better results than T2WI with respect to myometrial invasion by EC. All sequences, except for T2WI, were strongly correlated. Lee et al[4] suggested that contrast-enhanced T1-weighted imaging was superior not only to T2-weighted imaging but also to the combination of T2-weighted imaging and contrast-enhanced T1-weighted imaging for the assessment of myometrial invasion in women with EC. Song et al[10] found that the sensitivity of T2WI in the qualitative diagnosis of EC was lower than conventional DWI. Although T2WI shows the clearest anatomy, its success in evaluating myometrial invasion seems to be relatively lower than other sequences. Similar results were obtained using the 1.5 T or 3 Tesla device[5-11]. This finding could be due to the tissue anatomy of DCE T1 WI and the high contrast resolution of the DWI.

Conventional DWI is a molecular technique that displays information about the Brownian mobility of water. Currently, some researchers[7,11] have reported that T2WI+DWI can be changed to T2WI+DCE for assessing myometrial invasion. Our study found that ZOOMit DWI and also conventional DWI are the sequences that best show myometrial invasion. DWI is the most powerful contrast resolution sequence. Our results also comply with the Guidelines of the European of Urogenital Radiology[12].

ZOOMit DWI is used for EC staging[13]. Because of higher spatial resolution and less susceptibility distortion, ZOOMit DWI presents more image quality than conventional DWI[14,15]. In our study, in accordance with literature, the most similar data to the pathological results in the ZOOMit DWI sequences were obtained. In the evaluation of myometrial invasion, it was found that DCE WI was also a powerful sequence, in accordance with the current literature.

When the size of EC was evaluated by pathological specimens, strong correlation with DCE T1 WI and T2 WI sequences was found. No statistically significant differences between these sequence images were noted. Song et al[10] reported that the tumor size obtained by conventional DWI was indeed larger. In addition, they found that T2 WI was more useful than DWI sequences for assessing tumor sizes; however, no comparison to other sequences was obtained (ZOOMit DWI, DCE T1 WI)[10]. In our current study, all pathologically measured sizes were larger than the tumor sizes measured on all sequences. This finding was consistent with the current literature[11-16]. Bhosale et al[16] reported that the size of the tumor measured with reduced FOW yielded a better correlation with pathological findings than the sagittal T2WI sequence did; however, no comparison to other sequences was made. According to our knowledge, our study is the first to compare the tumor size of EC with the DCE T1 WI sequence.

The mean tumor ADC values obtained *via* ZOOMit DWI were not significantly different from conventional DWI. Ota et al[13] showed that the mean tumor ADC values obtained with reduced FOW imaging were significantly higher than those obtained with fFOW DW imaging. Some researchers[15,17,18] reported that ADC value measurements from reduced FOW DWI did not present statistically significant differences, and other researchers[19] found significantly higher values than those obtained by fFOW DWI. No complete consensus on this issue in the literature could be found, but these findings were similar to ours. According to our study, no difference between ZOOMit DWI and conventional DWI was found. Takeuchi et al[9] reported that the mean tumor ADC value obtained with rFOW DW imaging was significantly higher than that obtained with fFOW DW imaging (0. 81 *vs.* 0. 79x10^{-3} mm^2/s, p=0.023). In our study, only images that visualized EC were used. We did not include patients with adenomyosis or distortion of the endometrial myometrial zone. It has been reported in previous studies[4] that such structural differences could affect measurements. No correlation between the pathological invasion and both ADC values was found in our work. When the ADC values were compared with pathological subtypes, it was found that ZOOMit DWI was

more sensitive than conventional DWI ADC values. In our opinion, this difference may be partly explained by artifact/partial volume effect reduction and good contrast resolution with ZOOMit DWI. Other studies[15-19] reported that ADC values of ZOOMit DWI showed more sensitive ADC values than conventional DWI.

Limitations

The limitations of our study should be recognized. The patient population was relatively small. Our results will need to be confirmed in a larger population and with a larger distribution of patients. Some patients in this study were elderly, which could have affected the myometrial enhancement and DCE sequences. Thus, our results cannot be generalized. The second limitation is that the operator experience may have had a significant influence on the test results. The failure to evaluate the relationship between the measurement of each sequence and the pathological specimen are other limitations of this study.

Conclusions

In conclusion, as for the answer to the question of which sequence is more useful, the most accurate information about the myometrial invasion appeared to be obtained using ZOOMit DWI and conventional DWI. If it is desired to provide information about the size of EC, DCE T1 WI and T2 WI, sequences should be selected. In our experience, if a uterus is clean and has no additional problems, these sequences can be given priority in evaluation. ADC values based on ZOOMit DWI have more sensitivity than ADC values based on conventional DWI. As reported in the literature, each of these sequences is important and valuable; however, the priority of the radiologist may vary depending on the desired information. It is hoped that our results will be useful to clinicians in pre-operative MRI evaluation of EC.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Ethics Approval

The institutional review board of The Medical Hospital of Inönü University (Malatya, Turkey) approved this study.

Informed Consent

The informed consent of patients was waived because of the retrospective nature of the study.

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ORCID ID

Leyla Karaca: 0000-0001-9150-3823; Zeynep Maraş Özdemir: 0000-0003-1085-8978; Ayşegül Kahraman: 0000-0002-2147-1181; Ercan Yılmaz: 0000-0003-3821-4621; Ayşenur Akatlı: 0000-0002-9677-2456.

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