Submitted: 30 October, 2023 Accepted: 13 December, 2023 Published: 15 February, 2024 DOI:10.22514/ejgo.2024.017

European Journal of Gynaecological Oncology

ORIGINAL RESEARCH

Comparison of the diagnostic efficacy of DWI and DCE-MRI in depth of myometrial invasion, cervical invasion and FIGO staging in patients with endometrial cancer

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Abstract

This study aims to compare the diagnostic efficacy of DWI (Diffusion Weighted Imaging) and DCE-MRI (Dynamic Contrast Enhancement-Magnetic Resonance Imaging) in the depth of myometrial invasion, cervical invasion and FIGO (Federation International of Gynecology and Obstetrics) staging in patients with endometrial cancer. 128 patients were selected for preoperative diagnosis with DWI and DCE-MRI techniques. The diagnostic efficacy of the two diagnostic methods on the depth of myometrial invasion, cervical invasion and FIGO staging was compared. Receiver operating characteristic curves were plotted for the two diagnostic methods to further compare the differences between the two diagnostic methods. The accuracy, sensitivity, positive predictive value and negative predictive value of DWI were conspicuously higher than that of DCE-MRI in the diagnosis of depth of myometrial invasion and cervical invasion ($p < 0.05$). ROC (Receiver Operating Characteristic Curve) analysis demonstrated that the diagnostic effect of DWI was better than that of DCE-MRI in the diagnosis of depth of myometrial invasion and cervical invasion, and the difference in the area under the curve between the two diagnostic methods was statistically significant ($p < 0.05$). In terms of FIGO staging diagnosis, the accuracy of DWI was 86.72%, which was higher than 65.63% of DCE-MRI ($\chi^2 = 15.689$, $p < 0.001$). For patients with endometrial cancer, preoperative depth of myometrial invasion, cervical invasion and FIGO staging have critical guiding significance for clinical diagnosis and treatment. Compared with DCE-MRI, DWI has better diagnostic efficacy for depth of myometrial invasion, cervical invasion and FIGO staging, which is worthy of clinical application.

Keywords

DWI; DCE-MRI; Endometrial cancer; Depth of myometrial invasion; Cervical invasion; FIGO staging

1. Introduction

Endometrial carcinoma (EC), also known as cervix carcinoma in clinical practice, is located in the endometrium and belongs to one of the common malignant tumors in clinical practice [1]. According to statistics [2], about 7% of female patients with cancerous diseases have endometrial cancer; while 20~30% of female patients with cancerous diseases in reproductive system had EC. EC has remained as one of the serious threats to the life and health of the female population. For patients with EC, surgical treatment is one of the most ideal clinical treatment therapy [3]. The evaluation of the overall condition of patients is important for the judgment of surgical methods, the selection of surgical timing and the prediction of clinical prognosis. Among them, the depth of myometrial invasion, cervical invasion and staging of patients with EC are essential preoperative evaluation indicators [4].

At present, magnetic resonance imaging (MRI) is often used to diagnose the condition of patients with various diseases [4]. Studies have shown that dynamic contrast enhancement magnetic resonance imaging (DCE-MRI) can clearly show the extent of intrauterine or endocervical lesions and bilateral inguinal lymph node metastasis in patients with endometrial cancer. Diffusion-weighted magnetic resonance imaging (DWI) in patients with endometrial cancer can clearly reveal the location of intrauterine or endocervical lesions [5]. For DCE-MRI, its clinical advantages are mainly to improve the diagnostic efficacy of MRI and dynamically present the specific shape of the tumor; for DWI, its clinical advantages are mainly to distinguish the infiltration status and tumor stage [6]. At present, the advantages and disadvantages of the above two solutions are applied in clinical practice, but there are few reports on comparative studies [7]. Given that, to further compare the diagnostic efficacy of DWI and DCE-MRI in the depth of myometrial invasion, cervical invasion and FIGO staging of patients with EC, patients with EC admitted to our hospital were included as the study subjects. The examination results of the two methods were compared with the pathological results. The outcomes of relevant study were reported as follows.

2. Materials and methods

2.1 Clinical data

Patients admitted to our hospital between December 2019 and December 2020 were selected for a retrospective study. A total of 128 patients admitted to our hospital from December 2019 to December 2020 were selected as study subjects.

Inclusion criteria: (1) All patients met the clinical diagnostic criteria of endometrial cancer by postoperative pathological diagnosis; (2) All patients met the clinical criteria of surgical treatment; (3) All patients underwent surgical treatment 2 weeks after clinical examination; (4) The clinical data were complete. Exclusion criteria: (1) Patients with other tumors; (2) Patients with neurological diseases; (3) Patients with low compliance; (4) Patients who are intolerant to relevant clinical examinations.

According to the inclusion and exclusion criteria, out of 205 patients, a total of 128 patients were finally included in this study. The age of 128 patients ranged from 39 to 69 years (mean: (55.14 $\pm$ 6.12) years), with a body mass index (BMI) of 22~32 kg/m^2 (mean: (27.45 $\pm$ 2.12) kg/m^2). There were 96 postmenopausal patients and 32 premenopausal patients.

2.2 Imaging method

Magnetic resonance imaging system (model: Discovery MR750w 3.0T; manufacturer: General Electric Co. Boston, MA, USA) in all patients were examined as follows.

The patient was placed in a supine position and underwent routine pelvic magnetic resonance plain scan sequence, DWI sequence, and DCE-MRI sequence before surgery. Plain scan sequences included conventional axial T1WI (T1-weighted imagingT1), T2WI, sagittal and coronal fat-suppressed T2WI, axial fat-suppressed T1-VIBE, and DWI sequences at levels corresponding to axial views. The enhanced sequences included T1-VIBE-FS-TRA-10, T1-VIBE-FS-COR, and T1-VIBE-FS-SAG. 7.5 mL of Gadovist (gadobutrol) was taken as the contrast medium. Contrast medium injection was performed simultaneously with the dynamic sequence T1-VIBE-FS-TRA-10.

Scanning parameters: T1-TSE-TRA sequence: TR/TE = 600/11 ms; T2-TSE-TRA sequence: TR/TE = 5100/98 ms; T2-TSE-FS-SAG sequence: TR/TE = 4200/87 ms; T2-TSE-FS-COR sequence: TR/TE = 3250/77 ms; slice thickness/slice spacing of the above sequence = 4/4 mm, slice number = 20, field of view (FOV) = 260 $\times$ 360 mm. DWI sequences corresponding to axial slices, b = 200, 1200 s/mm^2. T1-VIBE-FS-TRA: slice thickness = 3 mm, number of slices = 48, field of view (FOV) = 260 $\times$ 360 mm, TR/TE = 3.22/1.18 ms, flip angle = 9°. The parameters of the enhanced VIBE sequence were consistent with that of the plain scan.

2.3 Image analysis

DWI images were analyzed by GE image post-processing workstation Functool software package. DCE-MRI parameters were analyzed using O.K. software (2.0, GE Healthcare, London, UK). Volume transfer constant (Ktrans), rate constant (Kep), and extravas-cular extracellular space volume fraction (Ve) were calculated with an extended Tofts pharmacokinetic model. Regions of interest (ROIs) avoiding necrosis, hemorrhage, and cystic tissue were placed on diffusion and perfusion parameter maps for automatic analysis.

2.4 Result interpretation

According to the outcome of DWI and DCE-MRI, the depth of myometrial invasion, cervical invasion and FIGO staging of the patients were determined. The examination results are interpreted by the same group of imaging physicians with 10 years of clinical experience. The conclusion should be based on the unified opinion of the two. If the two don't reached an agreement, the final conclusion should be obtained after discussion.

All patients received surgical treatment, and the pathological specimens obtained during surgery were submitted for examination, and the results of pathological examination were served as the gold standard.

2.5 Outcome measures

To observe and compare the diagnostic efficacy of DWI and DCE-MRI on pathological findings (depth of myometrial invasion, cervical invasion, FIGO staging), which included sensitivity, specificity, accuracy, positive predictive value as well as negative predictive value. Receiver Operating Characteristic (ROC) Curve was used to assess the diagnostic accuracy of the two methods.

(1) Sensitivity = number of true positive/(number of true positive + number of false negative) $\times$ 100%;

(2) Specificity = number of true negative/(number of true negative + number of false positive) $\times$ 100%;

(3) Accuracy = (number of true positive + number of true negative)/total number of cases $\times$ 100%;

(4) Positive predictive value = number of true positive/(number of true positive + number of false positive) $\times$ 100%;

(5) Negative predictive value = number of true negatives/(number of true negative + number of false negative) $\times$ 100%.

2.6 Statistical analysis

Data were analyzed and processed using SPSS 27.0 (International Business Machines Corporation, Armonk, NY, USA). Measurement data were expressed as ($\bar{x} \pm s$), and t-test was used for comparison; enumeration data were expressed as cases (%), and χ^2 test was used for comparison. $p < 0.05$ indicated that the differences were statistically significant.

ROC (receiver operating characteristic curve) curves were plotted utilizing SPSS to further compare the differences between the two diagnostic methods.

3. Results

3.1 Pathological diagnosis results of study subjects

The results of postoperative pathological diagnosis of 128 patients with endometrial carcinoma in this study showed that endometrioid adenocarcinoma accounted for the highest proportion in terms of pathological type; superficial myometrial invasion accounted for the highest proportion in terms of depth of primary invasion; negative type accounted for the highest proportion in terms of cervical invasion; and stage IA accounted for the highest proportion in terms of FIGO stage, as implied in Table 1.

TABLE 1. Pathological diagnosis results of study subjects.

Pathological diagnosis results	n	%
Pathological type		
Endometrioid adenocarcinoma	111	86.72
Serous papillary adenocarcinoma	5	3.91
Uterine poorly differentiated adenocarcinoma	4	3.13
Others	8	6.25
Depth of myometrial invasion		
No invasion	12	9.38
Shallow myometrial invasion	80	62.50
Deep myometrial invasion	36	28.13
Cervical invasion		
Positive	40	31.25
Negative	88	68.75
FIGO staging		
IA	83	64.84
IB	16	12.50
II	15	11.72
IIIA	7	5.47
IIIB	5	3.91
IIIC	2	1.56

FIGO: Federation International of Gynecology and Obstetrics.

3.2 Comparison of DWI and DCE-MRI in the diagnosis of depth of myometrial invasion

In the diagnosis of depth of myometrial invasion, the accuracy, sensitivity, positive predictive value and negative predictive value of DWI were higher than that of DCE-MRI ($p < 0.05$). The outcomes were revealed in Tables 2 and 3.

ROC curve manifested that the area under ROC curve and its 95% confidence interval (CI) corresponding to DWI and DCE-MRI were 0.902 (95% CI: 0.845–0.960) and 0.720 (95% CI: 0.634–0.807), respectively. It indicated that the diagnostic effect of DWI was superior to DCE-MRI. The outcomes were revealed in Fig. 1 and Table 4.

Comparison on the area differences of paired samples under the ROC curve between DWI and DCE-MRI implied that $z = 4.852$, $p < 0.001$, unveiling that there was a significant difference in the area under the curve between the two diagnostic methods. The outcomes were demonstrated in Table 5.

3.3 Comparison of DWI and DCE-MRI in the diagnosis of cervical invasion

In terms of the diagnosis of cervical invasion, the accuracy, sensitivity, specificity, positive predictive value, and negative predictive value of DWI were higher than that of DCE-MRI ($p < 0.05$). The outcomes were implied in Tables 6 and 7.

ROC curve disclosed that the area under ROC curve and its 95% CI corresponding to DWI and DCE-MRI were 0.886 (95% CI: 0.825–0.947) and 0.585 (95% CI: 0.493–0.678), respectively. It indicated that the diagnostic effect of DWI was better than DCE-MRI. The results were presented in Fig. 2 and Table 8.

Comparison on area differences of paired samples under the ROC curve between DWI and DCE-MRI, which exhibited $z = 6.722$ and $p < 0.001$. It indicated that there was a significant difference in the area under the curve between the two diagnostic methods. The outcomes were presented in Table 9.

3.4 Comparison of diagnostic results of DWI and DCE-MRI on FIGO staging

In terms of FIGO staging diagnosis, the accuracy of DWI was 86.72% ((80 + 13 + 8 + 5 + 4 + 1)/128), which was higher than 65.63% ((63 + 12 + 4 + 1 + 3 + 1)/128) of DCE-MRI ($\chi^2 = 15.689$, $p < 0.001$). The results were presented in Tables 10 and 11.

4. Discussion

Imaging related clinical examination has important guiding significance for preoperative evaluation of patients with endometrial cancer. Among them [7], the depth of myometrial invasion, the degree of cervical invasion and clinical staging of patients with endometrial cancer have important reference and guiding significance for the selection of surgical methods and surgical timing. In the past, the traditional MRI technique could compare the signal of myometrium with the signal of endometrium and analyze. However, the accuracy of overall clinical judgment was not satisfactory [8, 9]. Therefore, with the continuous maturity and progress of MRI technology, the use of enhanced methods can improve the clinical diagnostic efficacy.

Both DCE-MRI and DWI are common types of enhanced magnetic resonance techniques, both of which have their own advantages in the clinical diagnosis and practice in cancer [10]. However, there are few comparative studies on the application of the two in the clinical diagnosis of patients with EC. In view of this, this study applied the above two methods in the clinical diagnosis of EC, and comparative studies were performed on the pathological results (depth of myometrial invasion, cervical invasion, FIGO staging) in patients. The diagnostic efficacy

TABLE 2. Contrast of DWI and DCE-MRI on pathological findings (depth of invasion) (n).

Methods	Pathological findings	Shallow myometrial invasion (n = 80)	Deep myometrial invasion (n = 36)	Total
DWI				
	Shallow myometrial invasion	71	3	74
	Deep myometrial invasion	9	33	42
DCE-MRI				
	Shallow myometrial invasion	53	8	62
	Deep myometrial invasion	27	28	55

DWI: Diffusion Weighted Imaging; DCE-MRI: Dynamic Contrast Enhancement-Magnetic Resonance Imaging.

TABLE 3. Comparison of DWI and DCE-MRI in the diagnostic efficacy indicators of depth of myometrial invasion (%).

Methods	Accuracy	Sensitivity	Specificity	Positive predictive value	Negative predictive value
DWI	89.66 (104/116)	88.75 (71/80)	91.67 (33/36)	95.95 (71/74)	78.57 (33/42)
DCE-MRI	69.83 (81/116)	66.25 (53/80)	77.78 (28/36)	86.89 (53/62)	50.91 (28/55)
χ^2 value	14.115	11.613	2.683	4.590	7.808
p value	<0.001	<0.001	0.102	0.032	0.005

DWI: Diffusion Weighted Imaging; DCE-MRI: Dynamic Contrast Enhancement-Magnetic Resonance Imaging.

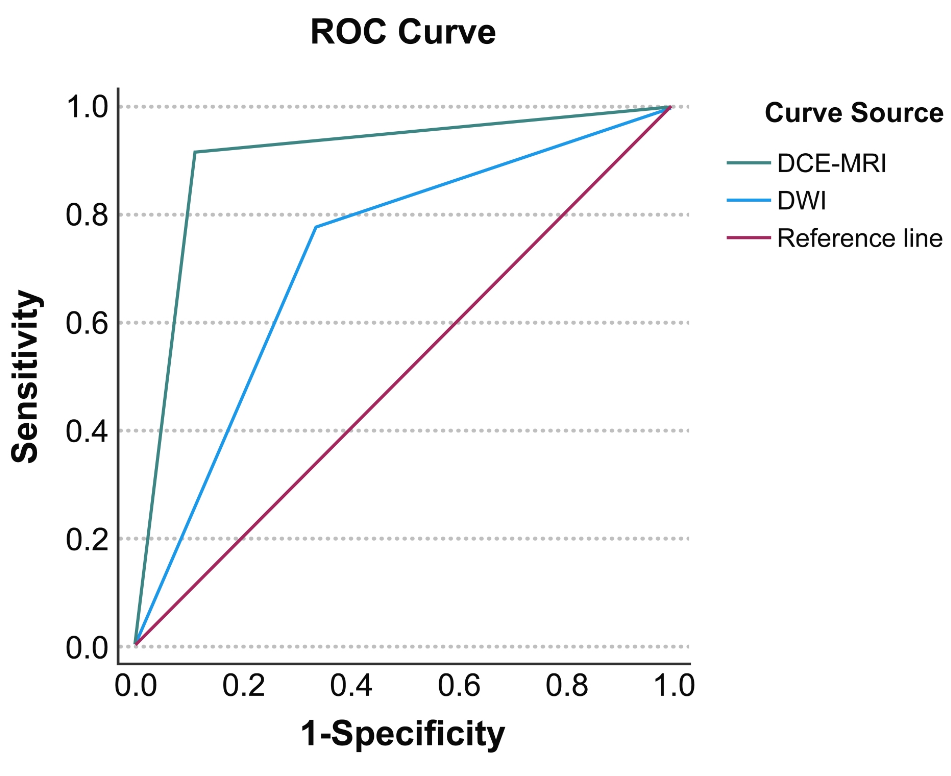

FIGURE 1. ROC curve of DWI and DCE-MRI for depth of invasion. ROC: Receiver Operating Characteristic Curve; DCE-MRI: Dynamic Contrast Enhancement-Magnetic Resonance Imaging; DWI: Diffusion Weighted Imaging.

TABLE 4. Comparison of area under ROC curve of DWI and DCE-MRI for depth of invasion.

Test result variables	Area under the curve	Standard error	Asymptotic significance	Asymptotic 95% confidence interval	
				Lower limit	Upper Limit
DWI	0.902	0.029	0.000	0.845	0.960
DCE-MRI	0.720	0.044	0.000	0.634	0.807

DWI: Diffusion Weighted Imaging; DCE-MRI: Dynamic Contrast Enhancement-Magnetic Resonance Imaging.

TABLE 5. Comparison on the area differences of paired samples under the ROC curve between DWI and DCE-MRI.

Test results	*z*	Asymptotic		Standard Error of Difference	Asymptotic 95% confidence interval	
		Sig. (2-tailed)	AUC difference		Lower limit	Upper Limit
DWI—DCE-MRI	4.852	0.000	0.182	0.268	0.108	0.255

DWI: Diffusion Weighted Imaging; DCE-MRI: Dynamic Contrast Enhancement-Magnetic Resonance Imaging; AUC: Area Under Curve.

TABLE 6. Comparison of DWI and DCE-MRI on pathological findings (cervical invasion) (n).

Methods	Pathological findings	Positive (n = 40)	Negative (n = 88)	Total
DWI				
	Positive	35	9	44
	Negative	5	79	84
DCE-MRI				
	Positive	20	29	49
	Negative	20	59	79

DWI: Diffusion Weighted Imaging; DCE-MRI: Dynamic Contrast Enhancement-Magnetic Resonance Imaging.

TABLE 7. Comparison of diagnostic efficacy of DWI and DCE-MRI for cervical invasion (%).

Methods	Accuracy	Sensitivity	Specificity	Positive predictive value	Negative predictive value
DWI	89.06 (114/128)	87.50 (35/40)	89.77 (79/88)	79.55 (35/44)	94.05 (79/84)
DCE-MRI	61.27 (79/128)	50.00 (20/40)	67.05 (59/88)	40.82 (20/49)	74.68 (59/79)
χ^2 value	25.792	13.091	13.425	14.390	11.756
p value	<0.001	<0.001	<0.001	<0.001	0.001

DWI: Diffusion Weighted Imaging; DCE-MRI: Dynamic Contrast Enhancement-Magnetic Resonance Imaging.

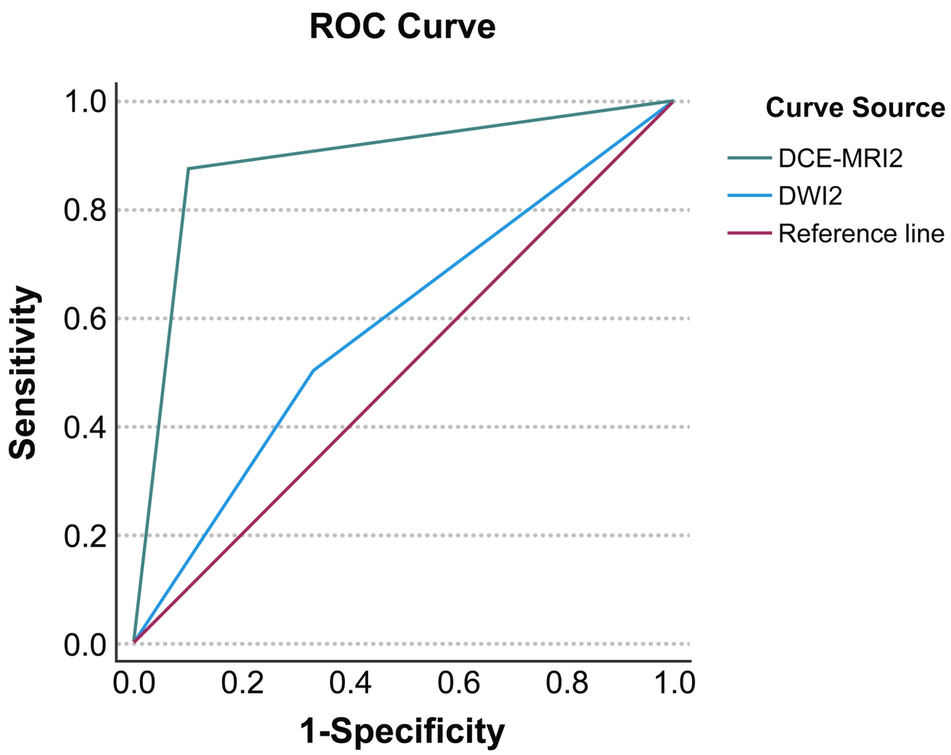

FIGURE 2. ROC curve of DWI and DCE-MRI for cervical invasion. ROC: Receiver Operating Characteristic Curve; DCE-MRI: Dynamic Contrast Enhancement-Magnetic Resonance Imaging; DWI: Diffusion Weighted Imaging.

TABLE 8. Comparison of area under ROC curve between DWI and DCE-MRI for cervical invasion.

Test Result Variables	Area under the curve	Standard error	Asymptotic significance	Asymptotic 95% confidence interval	
				Lower limit	Upper limit
DWI	0.886	0.031	<0.001	0.825	0.947
DCE-MRI	0.585	0.047	0.072	0.493	0.678

DWI: Diffusion Weighted Imaging; DCE-MRI: Dynamic Contrast Enhancement-Magnetic Resonance Imaging.

TABLE 9. Comparison on area differences of paired samples under the ROC curve between DWI and DCE-MRI.

Test results	z	Asymptotic		Standard Error of Difference	Asymptotic 95% confidence interval	
		Sig. (2-tailed)	AUC difference		Sig. (2-tailed)	AUC difference
DWI—DCE-MRI	6.722	<0.001	0.301	0.278	0.213	0.389

DWI: Diffusion Weighted Imaging; DCE-MRI: Dynamic Contrast Enhancement-Magnetic Resonance Imaging; AUC: Area Under Curve.

TABLE 10. Comparison of pathological findings (FIGO staging) by DWI (n).

Method	Pathological findings	IA (n = 84)	IB (n = 17)	II (n = 14)	IIIA (n = 6)	IIIB (n = 5)	IIIC (n = 2)	Total (n = 128)
DWI								
	IA	80	4	1	0	0	0	85
	IB	4	13	5	0	1	0	23
	II	0	0	8	1	0	1	10
	IIIA	0	0	0	5	0	0	5
	IIIB	0	0	0	0	4	0	4
	IIIC	0	0	0	0	0	1	1
Total		84	17	14	6	5	2	128

DWI: Diffusion Weighted Imaging.

TABLE 11. Comparison of pathological findings (FIGO staging) by DCE-MRI (n).

Method	Pathological findings	IA (n = 84)	IB (n = 17)	II (n = 14)	IIIA (n = 6)	IIIB (n = 5)	IIIC (n = 2)	Total (n = 128)
DCE-MRI								
	IA	63	5	4	0	1	0	73
	IB	19	12	6	1	1	1	40
	II	2	0	4	4	0	0	10
	IIIA	0	0	0	1	0	0	1
	IIIB	0	0	0	0	3	0	3
	IIIC	0	0	0	0	0	1	1
Total		84	17	14	6	5	2	128

DCE-MRI: Dynamic Contrast Enhancement-Magnetic Resonance Imaging.

indicators of the two methods were compared, and ROC curve was adopted to compare the advantages and disadvantages of the two methods.

This study displayed that the accuracy, sensitivity, positive predictive value and negative predictive value of DWI were higher than that of DCE-MRI in the diagnosis of depth of myometrial invasion and cervical invasion with differences showing statistical significance ($p < 0.05$). The ROC curve analysis results manifested that the diagnostic effect of DWI was superior to that of DCE-MRI in the diagnosis of depth of myometrial invasion and cervical invasion, and the differences in the area under the curve between the two diagnostic methods were statistically significant ($p < 0.05$). In terms of FIGO staging diagnosis, the accuracy of DWI was 86.72%, which was higher than 65.63% of DCE-MRI (χ^2 = 15.689, $p <$ 0.001).

The diagnostic accuracy of FIGO staging in this study was slightly lower than that in previous domestic and foreign studies, and the reason was that only early cases were included in previous studies, while there were few studies on advanced cases. The pathological FIGO stages included in this study were comprehensive. The diagnostic accuracy for FIGO stages was somewhat compromised because the assessment of uterine adnexa and lymph node metastasis was difficult [11, 12]. After in-depth study, we discovered that the basic principle of DCE-MRI technique is to image the hemodynamic changes of patients through contrast medium. Therefore, this method has a significant diagnostic effect on local diseases with abundant vascular system in patients. The richer the vascular system, the clearer the imaging effect. For some postmenopausal patients, the endometrium will present with irregular hyperplasia to varying degrees [13]. When patients use DCE-MRI technique during imaging examination, it is easy to have the problem of unclear display, which in turn affects the interpretation of results by clinical imaging physicians, resulting in decreased diagnostic efficacy [14]. When DWI technique is utilized, the principle is to distinguish cancerous cells through the diffusion rate of water molecules. Therefore, it will not be affected by irregular hyperplasia, weak blood flow signal intensity and other problems with better diagnostic efficacy. It enables accurate identification of cases missed by routine magnetic resonance examinations [15, 16].

Clinical experience suggests [17, 18] that scientific treatment regimens for tumors should be based on targeted clinical staging. The identification of clinical stages has important clinical significance for the treatment of all tumors including endometrial cancer. Most patients with early (stage I and II) endometrial cancer are given active surgical treatment as the first choice. However, after relevant patients receive surgical treatment, the selection of subsequent treatment therapy should be targeted in combination with individual differences in patients. For endometrial cancer patients without myometrial invasion or local invasion, surgical treatment should also be the best choice. For patients with some high risk factors, preoperative adjuvant chemoradiotherapy should be selected in combination with specific circumstances. Whether the cervix is involved in patients with EC remains as one of the important factors affecting their surgical approaches. For patients with cervical involvement, the risk of lymph node metastasis will increase, which predicts poor prognosis. Therefore, radical surgery should be conducted for such patients, and it is necessary to strengthen the supplementary intensive treatment like postoperative chemoradiotherapy.

This study is limited by the number and source of cases, and this study also has some limitations. For example, in terms of pathological type, the diagnostic efficacy study for the two methods was not carried out. Meanwhile, due to the patient's personal privacy issues, the personal images of the patients were not presented. Hence, in the future study, the scope of the study subjects and connotation are further expanded to draw a more comprehensive and objective study conclusion, thereby providing a reference for the clinical imaging diagnosis of endometrial cancer.

5. Conclusions

In summary, for patients with EC, preoperative depth of myometrial invasion, cervical invasion and FIGO staging have important guiding significance for clinical diagnosis and treatment of patients. Compared with DCE-MRI, the use of DWI technology has better diagnostic efficacy for depth of myometrial invasion, cervical invasion and FIGO staging, which is worthy of clinical application.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

CZ—designed the study and carried them out; CZ, GW and CC—supervised the data collection, analyzed the data, interpreted the data, prepare the manuscript for publication and reviewed the draft of the manuscript. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Ethics Committee of The First Affiliated Hospital of Jinzhou Medical University (Approval no. 202359). Written informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Cheng Zhou, Gang Wang, Cheng Che. Comparison of the diagnostic efficacy of DWI and DCE-MRI in depth of myometrial invasion, cervical invasion and FIGO staging in patients with endometrial cancer. European Journal of Gynaecological Oncology. 2024; 45(1): 124-131. doi: 10.22514/ejgo.2024.017.