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Role of Diffusion and T2-Weighted Magnetic Resonance Imaging in Preoperative Assessment of Myometrial Invasion and Staging of Endometrial Carcinoma

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Abstract

Background: Assessment of myometrial invasion in patients with endometrial carcinoma could be done by magnetic resonance imaging (MRI) study. Several studies have demonstrated that combining DWI with T2 weighted MRI plays an important role in the detection the depth of myometrial invasion and staging of endometrial carcinoma.

Aim of Study: The aim of this study is to evaluate the role of the combined T2WI and DWI in assessment of the depth of myometrial invasion and staging of endometrial carcinoma at the preoperative staging.

Patients and Methods: Thirty eight cases were included; patients referred to Radiology Department of Mansoura University Hospital. There were postmenopausal female patients with age ranged from 53 to 76 years. All patients were subjected to proper history taking and DWI and T2 MRI. This study was using a 1.5 T Philips Ingenia MRI scanner.

Results: There is statistically significant difference between myometrial invasion in pateients with endometrial carcinoma by T2 MRI, Dynamic contrast enhanced (DCE) MRI, DWI MRI regarding the pathology results. Combination of T2 and DWI MRI in assessment of myometrial invasion in patients with endometrial carcinoma has accuracy, sensitivity, specificity, PPV and NPV of 94.7%, 86.7%, 100%, 100% and 92% respectively.

Conclusion: DWI is important complementary, and supplementary tools to T2 MRI, not replacing, and thus; It should be done as routine image modality side by side to conventional imaging for assessment of myometrial invasion in cases of endometrial carcinoma.

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Key Words: *T2 – Dynamic contrast enhancement – Diffusion weighted imaging – MRI – Myometrial invasion – Endometrial carcinoma.*

Introduction

ENDOMETRIAL carcinoma is the fourth most common malignancy among females worldwide **[1].** Obesity, unopposed estrogen intake, nulliparity, diabetes mellitus, Stein–Leventhal syndrome, Lynch syndrome, and tamoxifen therapy are the known risk factors for the development of endometrial carcinoma. Patients present with abnormal uterine bleeding in more than 80% of cases. It is more common during the 6^{th} and 7^{th} decades of life, with the mean age of patients being 65 years **[2].**

Prognosis depends on various factors such as tumor stage, depth of myometrial invasion, cervical stromal invasion, lymphovascular invasion, histological grade, and lymphatic nodal status. Depth of myometrial invasion is the most important morphologic prognostic factor **[3].**

Accurate assessment of the myometrial invasion depth and endometrial cancer staging prior to surgery is very important for patients and definitely affect treatment planning and subsequent prognosis **[4].**

MRI is the best tool for preoperatively assessing myometrial invasion depth which correlate with tumor grade and overall survival **[5].**

T2-weighted imaging (T2WI) is the mainstay of pelvic MRI. Morphologic evaluation with T2WI provided a high degree of anatomical detail to assess the uterus. T2-weighted imaging can be used to

identify the depth of myometrial invasion. The anatomical detail provided by T2WI is important for the assessment of lymph node metastases **[6]**.

Recently diffusion-weighted imaging (DWI) has been shown to increase accuracy of assessing depth of myometrial invasion **[7]**. DWI is a functional imaging technique that provides information about water mobility, tissue cellularity, and the integrity of cellular membranes. On DWI, endometrial cancer demonstrates restricted diffusion in comparison with that of normal myometrial tissue, resulting in high signal intensity at high *b*-values (500–1000s/mm^2) and low apparent diffusion coefficient (ADC) values **[8]**.

The combination of DWI and T2WI demonstrated superior diagnostic accuracy in the assessment of the depth of myometrial invasion when compared with that of DCE-MRI and T2WI, indicating that DWI+T2WI is a potential replacement for DCE MRI in the preoperative staging of endometrial cancer, especially for patients who have contraindications for contrast agent **[8]**.

The aim of the current study is to evaluate the role of the combined T2WI and DWI in assessment of the depth of myometrial invasion and staging of endometrial carcinoma at the preoperative staging.

Patients and Methods

A total of 38 cases were included; patients referred from Obstetric and Gynecology Department and Oncology Centre Mansoura University (OCMU) with clinical or radiological proven to have endometrial carcinoma during the period from July 2022 to December 2023.

There were 38 postmenopausal female patients with age ranged from 53 to 76 years. All patients were subjected to proper history taking and DWI MRI.

Inclusion criteria:

- Patients have endometrial carcinoma that is confirmed by biopsy after surgery.
- Patients haven't received any other surgical or non surgical treatment.
- Completion of MRI examination before surgery including conventional MRI and DWI.

Exclusion criteria:

General contra-indication for MRI scan, for example:

- Patients who have a cardiac pacemaker.
- Patients who have a metallic foreign body in their eye.
- Bad general condition.
- Claustrophobic patients.

Methodology:

Magnetic Resonance Imaging:

All cases in this study were processed using the Philips Ingenia 1.5 T MRI scanner located in the Radiology Department of Mansoura University Hospital (with the same scanning parameters).

I- Patient preparation:

Patients were instructed to avoid movement during the acquisition time. Before entering the examination room, the patient was instructed to remove all metallic objects and all clothes containing metal. Irritable patients were reassured and informed about the examination. The patients were informed of the examination time as well as the importance of remaining motionless during the examination.

II- Technique:

The patient lied supine, head first on the MRI table and phase-array surface coil was used. Scanning was performed from the lung bases to the iliac crest.

The following sequences are obtained:

- Axial T1WI fast spin-echo. (TR=630 ms, TE=11 ms, FOV=200×200 mm, matrix=256×320).
- Axial T2WI fast spin-echo. (TR=4,000 ms, TE=101 ms, FOV=200×200 mm, matrix 256×320).
- Saggital T2WI fast spin-echo. (TR=4,000 ms, TE =92 ms, FOV=200×200 mm, matrix=256×320).
- Axial DWI data will obtained through a single-shot, echo-planar technique, with TR=5,000 ms, TE =81 ms, matrix=128×128, and FOV=200×200 mm; the diffusion sensitive factor *b*-value is 1,000 s/mm^2.
- Dynamic Multiphase Contrast-Enhanced Imaging (DCE-MRI): Dynamic contrast-enhanced MR images are obtained with a three-dimensional gradient echo T1W fat-saturated sequence after the administration of 0.1mmol/kg of gadolinium at a rate of 2mL/s. Images are acquired prior to contrast medium injection and then during multiple phases of enhancement in sagittal planes at 25s and 1 and 2min after injection; a delayed sequence may be added and acquired on axial oblique 4min after injection.

Image analysis:

At first, the conventional and post contrast MRI sequences were evaluated then DWI and ADC maps were correlated with them.

A- *Qualitative analysis:*

It refers to visual assessment of the SI of the lesions. The lesions SI were classified to low, inter-

mediate and high signals compared to that of myometrium.

B- *Quantitative analysis:*

ADC maps were automatically generated by the software on the basis of the images obtained. Mean ADC values (multiplied by 10-3mm^2/s) were calculated by drawing elliptical regions of interest (ROI) in one representative region as large as possible, however; care was taken to exclude necrotic and cystic areas on the basis findings on T2 WIs.

Ethical consent:

This study was ethically approved by the Institutional Review Board of the Faculty of Medicine, Mansoura University. Written informed consent was taken from all participants. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis:

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA). The Kolmogorov-Smirnov test was used to determine whether the data were normal. The Unpaired Student *t*-test was used to compare normally distributed continuous data, which are reported as mean (SD). Number-based nominal data were analyzed using the Chi-square test (percentage). When necessary, data are presented graphically. *p*-value <0.05 was considered significant.

Results

The current study included 38 cases with Endometrial Carcinoma. The mean age of the cases was 64.61±6.27 years with range between 53 and 76 years. The highest percentage of the cases was in the seventh decade.

Regarding the pathological types of our cases, endometrioid adenocarcinoma was themost common type in 35 cases, serous papillary carcinoma in 2 cases and carcinosarcoma in 1 case. The pathological grading of our cases with Grade I, grade II and grade III endometrioid adenocarcinoma were detected in 13.2%, 63.2% and 15.8%.

This table shows the accuracy, sensitivity, specificity, PPV and NPV by T2, DCE, DWI MRI in evaluation of myometrial invasion regarding to pathology results in our 38 cases with endometrial carcinoma. They are 81.6%, 70.5%, 90.5%, 85.7% and 79.2% respectively by T2 MRI, 81.6%, 72.2%, 90%, 86.7% and 78.3% respectively by DCE MRI, and 92.1%, 86.7%, 95.7%, 92.9% and 91.7% respectively by DWI MRI. Combination of T2 and DWI MRI has diagnostic accuracy of 94.7%, 86.7%, 100%, 100% and 92% respectively (Table 1).

In our study, there is statistically significant difference in detection of myometrial invasion by T2 MRI, DCE MRI, DWI MRI regarding the pathology results (p<0.001). By T2 MRI, there is overestimation of 3 cases and under estimation of 4 cases. By DCE MRI, there is overestimation of 4 cases and under estimation of 3 cases. By DWI MRI, there is overestimation of 1 case and under estimation of 2 cases.

Correlation of ADC values with the different histological grades, the mean ADC values were 0.946±0.036 for grade I, 0.841±0.079 for grade II, 0.788±0.098 for grade III, showing significant difference between grade I, II and between grade I and III. (p<0.05) (Table 2).

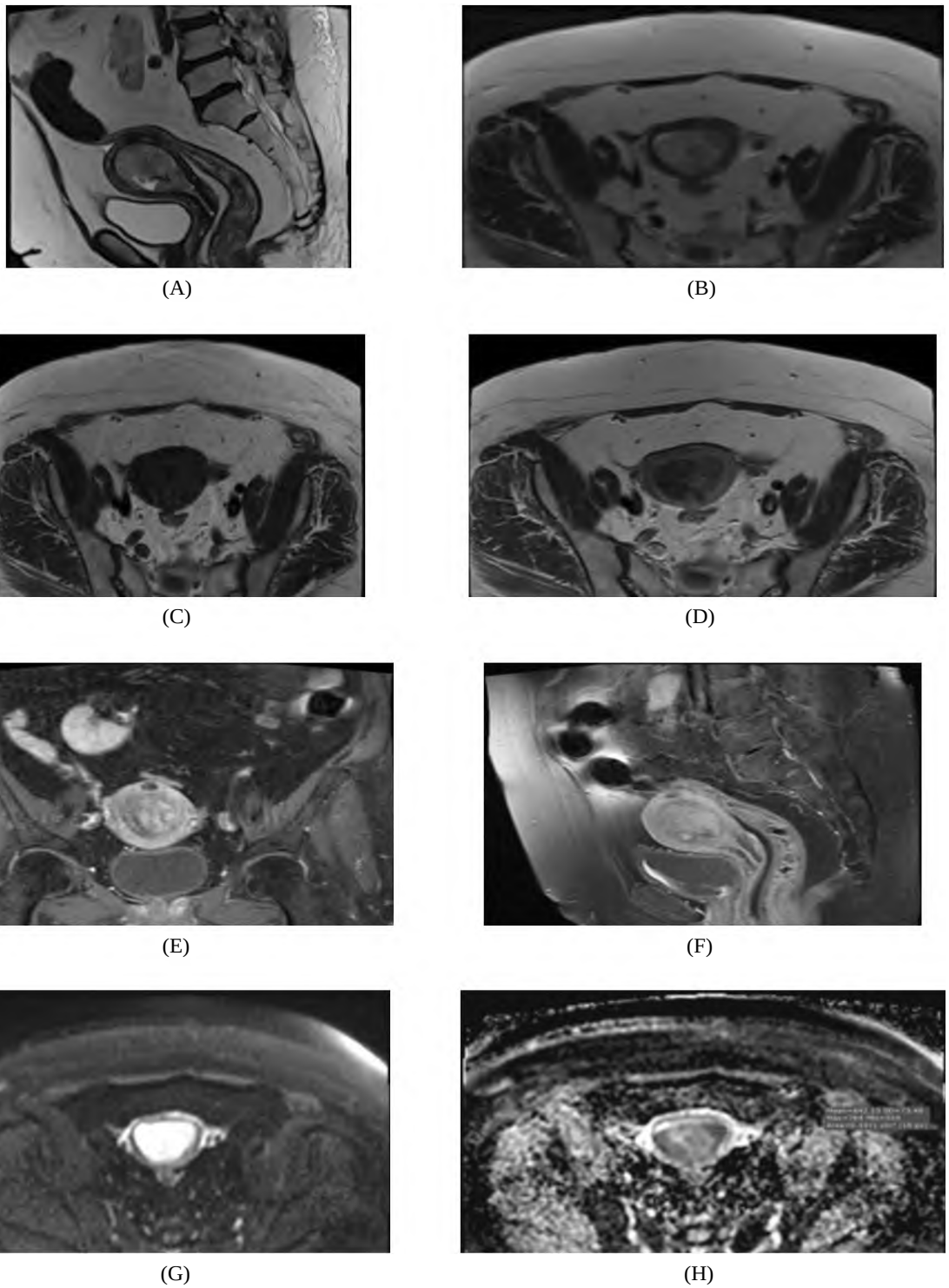
Table (1): Diagnostic accuracy in detection of myometrial invasion regarding to pathology in our study.

	T2	DCE	DWI	T2+DWI
Accuracy	81.6%	81.6%	92.1%	94.7%
Sensitivity	70.5%	72.2%	86.7%	86.7%
Specificity	90.5%	90%	95.7%	100%
PPV	85.7%	86.7%	92.9%	100%
NPV	79.2%	78.3%	91.7%	92%

Table (2): Comparison of the ADC value according to pathological grading in our study.

Variables	Grade 1 [N= 5]	Grade II [N=24]	Grade III [N=9]
ADC (x 10^{-3} mm^2/sec)	0.946± 0.036	0.841± 0.079	0.788± 0.098

Cases Presentation



(A) (B)

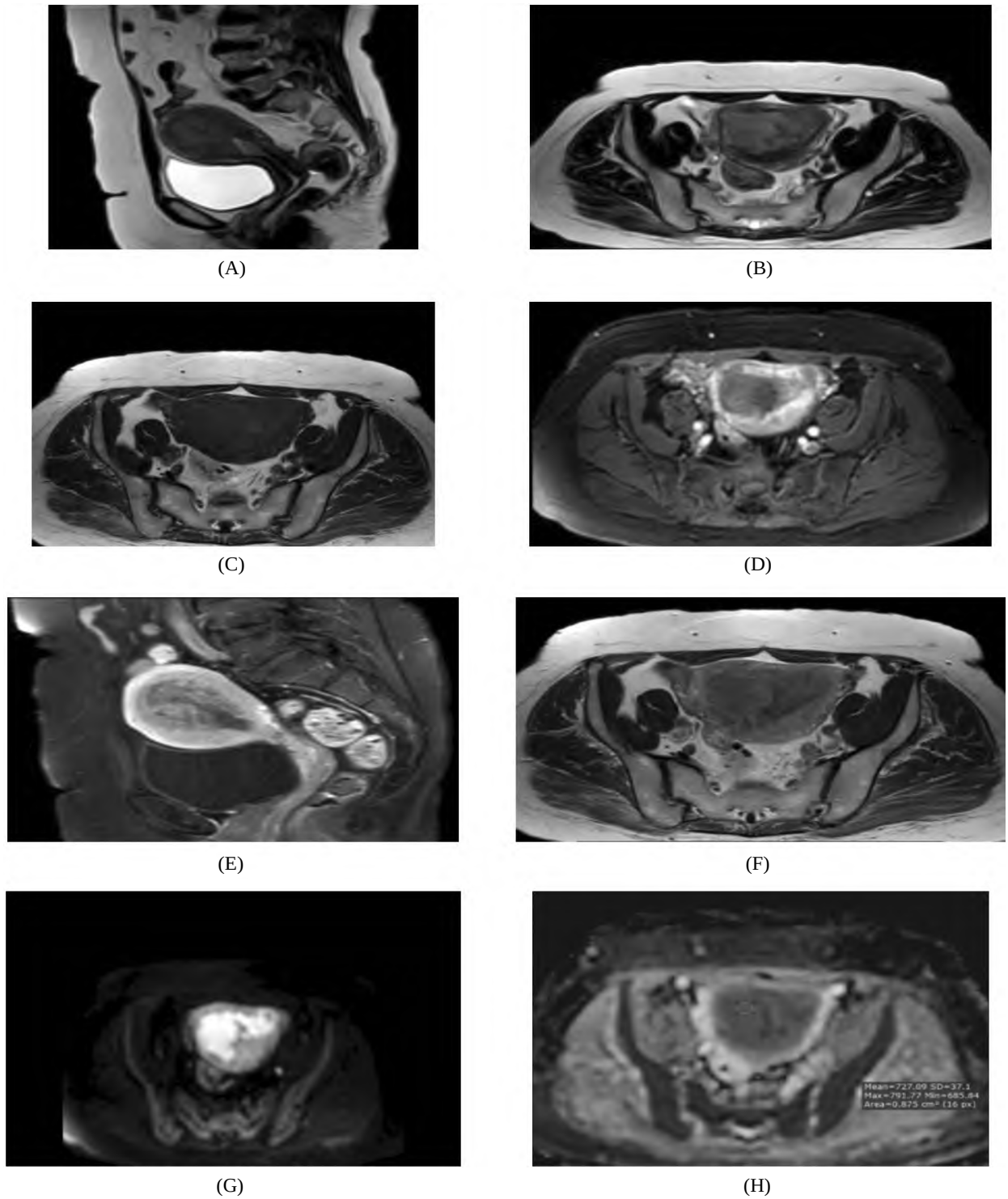
(C) (D)

(E) (F)

(G) (H)

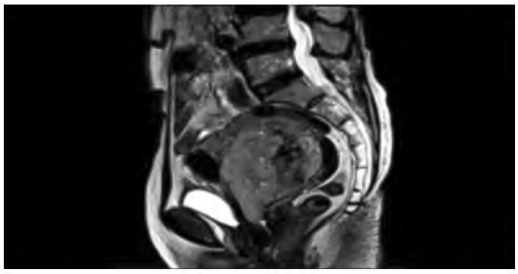
Case (1): Female patient aged 58 years old presented with postmenopausal bleeding. (A) Sagittal and (B) Axial T2 WI showing bulky uterus with soft tissue mass distending the endometrial cavity displaying heterogeneous SI with focal disruption of junctional zone posteriorly denoting superficial myometrial invasion with abutting the upper cervix without cervical stromal invasion. (C) Axial precontrast T1 WI showing low SI of the previously described mass. (D, E, F) Dynamic post contrast WIs. (D) Axial image at early acquisition phase (E) Coronal fat suppressed image at equilibrium phase. (F) Sagittal delayed image: Showing heterogeneous enhancement of the previously described mass. Axial DWI (at high *b*-value of 1000 mm/s^2) showing the mass displaying high SI corresponding to low SI in (G) Axial ADC map denoting restricted diffusion pattern. The mean ADC value is 64 $x10^{-3}$ mm^2/s.

- Pathological diagnosis: Serous papillary carcinoma FIGO stage IIC.

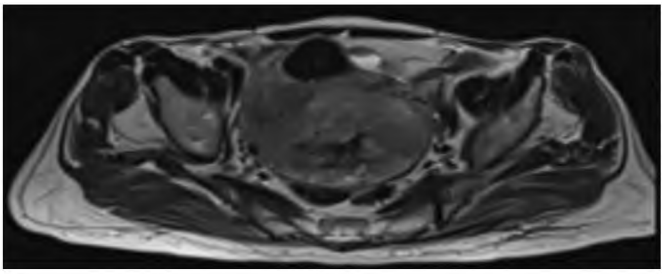


Case (2): Female patient aged 63 years old, presented with postmenopausal bleeding. (A,B) Sagittal and axial T2 WI showing bulky uterus with ill defined large mass distending the endometrial cavity displaying intermediate SI with complete disruption of the junctional zone and infiltration of more than 50% of the myometrium more anterolaterally. (C) Axial precontrast T1 WI showing low SI of the previously described mass. (D, E, F) Dynamic post contrast WIs (D) Axial fat suppressed image at early acquisition phase, (E) Sagittal fat suppressed at equilibrium phase, (F) Axial delayed image: Showing heterogeneous enhancement of the previously described mass. (G) Axial DWI (at high *b*-value of 1000 s/mm^2) showing the mass displaying high SI corresponding to low SI in (H) axial ADC map denoting restricted diffusion pattern. The mean ADC value is 71 x10^{-3} mm^2/s.

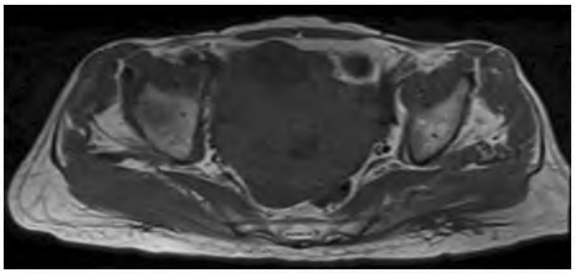
- Pathological diagnosis: Grade II Endometrial adenocarcinoma. FIGO stage IB.



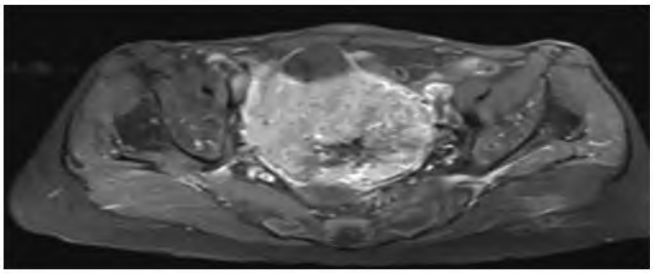
(A)



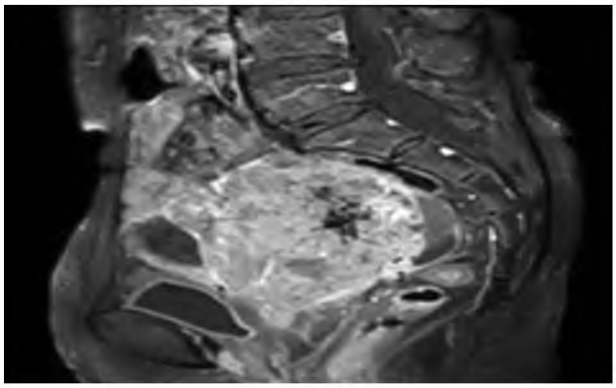
(B)



(C)



(D)



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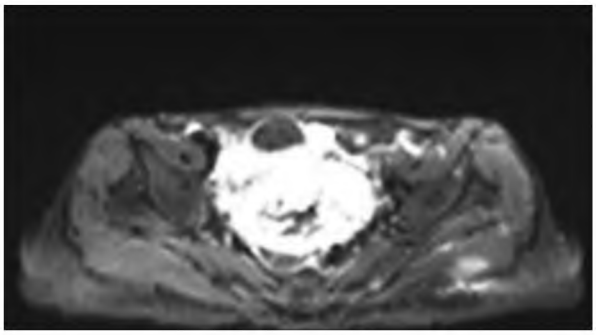
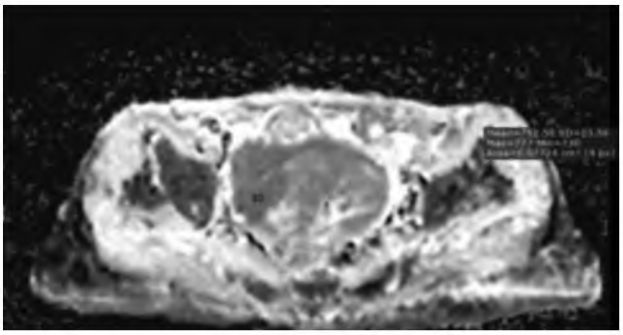


(F)



(G)

Case (3): Female patient aged 75 years old, presented with postmenopausal bleeding. (A,B) Sagittal and axial T2 WI showing enlarged uterus with large soft tissue mass distending the endometrial cavity displaying heterogenous SI, it shows deep myometrial invasion and extending into the endocervical canal with cervical stromal invasion. There is interruption of of fat planes posteriorly and the mass abutting the rectum without infiltrate it. The mass shows extrauterine extension with extension to pelvic side walls and loss of fat planes between it and right iliac vessels. (C) Axial precontrast T1 WI showing heterogenous SI of the previously described mass. (D, E) Dynamic post contrast WIs. (D) Axial fat suppressed image at early acquisition phase, (E) Sagittal fat suppressed at equilibrium phase showing heterogenous enhancement of the previously described mass. (F) Axial DWI (at high *b*-value of 1000 mm/s^{2}) showing the mass displaying high SI corresponding to low SI in (G) axial ADC map denoting restricted diffusion pattern. The mean ADC value is 79 $x10^{-3}$ mm^{2}/s.

- Pathological diagnosis: Grade III Endometrial adenocarcinoma. FIGO stage IIIB1.

Discussion

Magnetic Resonance Imaging has been found to be the most accurate modality that assesses myometrial, cervical, and nodal involvements in patients with endometrial carcinoma. Because its distinctive features of non-invasiveness, high soft tissue resolution, and multiple imaging parameters, MRI provides anatomical and functional information about the endometrial carcinoma and is playing an important role for clinical decisions regarding endometrial carcinoma *[9]*.

Depth of the myometrial invasion is a crucial step in the preoperative MRI assessment and can help patient management strategy. T2-weighted images and dynamic post contrast T1-weighted images are the routinely used sequences *[10]*.

DWI is a functional imaging technique that provides information about water mobility, tissue cellularity, and the integrity of cellular membranes. With DWI, increased cellularity and fewer mesenchymal structures between the glands in endometrial carcinomas may restrict water diffusion when compared with a normal endometrium. On DWI, endometrial cancer demonstrates restricted diffusion in comparison with that of normal myometrial tissue, resulting in high signal intensity at high *b*-values (500-1000s/mm^2) and low apparent diffusion coefficient (ADC) values *[11,12,13]*.

We studied the diagnostic role of T2 and DWI in preoperative assessment of myometrial invasion in postmenopausal females with endometrial carcinoma, their ages ranged from 53 to 76 years old, presented with abnormal vaginal bleeding. On T2 MRI, 19 out of 24 patients with endometrial carcinoma were diagnosed as superficial myometrial invasion and confirmed by pathological findings and 12 out of 14 patients with endometrial carcinoma were diagnosed as deep myometrial invasion and confirmed by pathological findings On DCE MRI, 18 out of 24 patients with endometrial carcinoma were diagnosed as superficial myometrial invasion and confirmed by pathological findings and 13 out of 14 patients with endometrial carcinoma were diagnosed as deep myometrial invasion and confirmed by pathological findings. On DWI MRI, 22 out of 24 patients with endometrial carcinoma were diagnosed as superficial myometrial invasion and confirmed by pathological findings and 13 out of 14 patients with endometrial carcinoma were diagnosed as deep myometrial invasion and confirmed by pathological findings. By combination of T2 and DWI MRI, 23 out of 24 patients with endometrial carcinoma were diagnosed as superficial myometrial invasion and confirmed by pathological findings and 13 out of 14 patients with endometrial carcinoma were diagnosed as deep myometrial invasion and confirmed by pathological findings.

According to Gil et al., study confirmed the high diagnostic accuracy of MRI in the preoperative assessment of endometrial carcinoma. The combination of DWI and T2WI demonstrated superior diagnostic accuracy in the assessment of the depth of myometrial invasion when compared with that of DCE-MRI and T2WI, indicating that DWI+T2WI is a potential replacement for DCE MRI in the preoperative staging of endometrial cancer, especially for patients who have contraindications for contrast agent. DWI+T2WI having a diagnostic accuracy of 95% compared with only 86% for DCE-MRI+T-2WI *[11]*.

Arian et al., reported that The simultaneous consideration of T2 and DWI technique may signify a noninvasive, rapid, safe, and accurate approach for assessing myometrial invasion and EC staging. Elimination of intravenous contrast material result in prevention of contrast related side effects beside significant cost reduction for health care systems and patients with a comparable result to contrast enhanced MRI *[14]*.

Shady et al., confirmed that DW-MRI has a high diagnostic accuracy compared to post contrast study, making it to be a good alternative method in preoperative assessment of depth of myometrial invasion in patients with endometrial carcinoma. DW-MRI should to be apart of the routine pre-operative MRI in these patients *[15]*.

Li et al., reported that DWI and DCE-MRI are helpful in improving the accuracy of the staging and pathological grading of endometrial carcinoma with more accuracy by DCE-MRI over the DWI which not match with our results. This is may be due to inaccurate DWI measurements *[16]*.

Our study revealed that ,by correlation of ADC values with the different histological grades of endometrial carcinoma, there was significant difference between ADC value and grade I and II endometrial carcinoma, and between ADC value and grade I and III endometrial carcinoma and this is in agreement with Nakamura et al., who reported that there was a significant difference between mean ADC of grade I and grade III tumors. Inoue et al., reported that minimum ADC that reflects portions of highest cellularity within the tumor may be useful for predicting endometrial carcinoma grades. In contrast to Shady et al., who showed that there was no significant difference was found in the mean ADC values of the different grades of endometrial carcinoma. This study limitations were the small sample size and the relative large tumor size at time of diagnosis *[15,17,18]*.

In conclusion, DWI is important complementary, and supplementary tools to T2 MRI, not replacing, and thus; It should be done as routine image modality side by side to conventional imaging for

assessment of myometrial invasion in cases of endometrial carcinoma and further studies with a larger number of cases are recommended to give more reliable quantitative data.

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التقييم قبل الجراحى لاختراق جدار عضل الرحم فى T2 دور الرنين المغناطيسى باستخدام الانتشار والتصوير الموزون ودرجة انتشار سرطان بطانة الرحم

سرطان بطانة الرحم هو رابع أكثر الاورام الخبيثة شيوعا بين الاناث فى جميع أنحاء العالم.

فى اكثر من ٨٠٪ من الحالات يعانى المرضى من نزيف رحمى غير طبيعى بين الحيض او بعد انقطاع الطمث، وهو اكثر شيوعاً خلال العقدين السادس والسابع من العمر والعمر الرئيسى للمرضى ٦٥ عاماً.

يعتمد التشخيص على عوامل عديدة مثل مرحلة الورم، عمق غزو عضل الرحم، غزو انسجة عنق الرحم، غزو الاوعية الدموية الليمفاوية، الصف النسيجى، وحالة العقد الليمفاوية، يعتبر غزو عضل الرحم هو اهم عوامل النذير المورفولوجى.

يعتبر التصوير بالرنين المغناطيسى افضل وسيلة قبل التدخل الجراحى لتقييم عمق اختراق عضل الرحم والذي يرتبط بمرحلة الورم والنجاة بشكل عام. لخصائصه الفريدة من عدم التدخل الجراحى، والدقة العالية للانسجة الرخوة، ومعلمات التصوير المتعددة؛ يوفر التصوير بالرنين المغناطيسى معلومات تشريحية ووظيفية عن سرطان بطانة الرحم ويلعب دورا متزايدا فى القرارات السريرية المتعلقة بسرطان بطانة الرحم.

الهدف من الدراسة: تقييم دور الجمع بين التصوير الموزون T2 والتصوير الموزون بالانتشار فى تقييم عمق اختراق عضل الرحم ودرجة انتشار سرطان بطانة الرحم قبل التدخل الجراحى.

تم عمل هذه الدراسه فى الفتره ما بين يوليو ٢٠٢٢ وديسمبر ٢٠٢٣ وتم فحص ٣٨ مريضًا يعانون من سرطان الرحم وتم تأكيد التشخيص النهائى عن طريق العينات وتحليل الأنسجه.

نتائج البحث: اظهرت ان التصوير بالرنين المغناطيسى مع الجمع بين خاصية الانتشار والتصوير الموزون T2 اعطى اعلى نسبة صحيحة من التشخيص وتقييم درجة اختراق الورم السرطانى لعضلة بطانة الرحم مقارنة بنتائج الباثولوجى.

الإستنتاج: إن التصوير بالرنين المغناطيسى بخاصية الانتشار والتصوير الموزون T2 يمنح دقة أكبر فى معرفة درجة انتشار سرطان بطانة الرحم وهو أمر بالغ الأهمية للوصول لطريقة العلاج المناسبة للمريض.