Unveiling the Impact of Dynamic Contrast-Enhanced and Diffusion-Weighted MRI in Endometrial and Cervical Carcinoma Management

Original Article

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ABSTRACT

Background: Cervical and endometrial carcinomas, prevalent among gynecological cancers, often present with symptoms such as irregular vaginal bleeding and are typically diagnosed around the age of 50. The preoperative assessment plays a pivotal role in patient prognosis and survival.

Objective: This study aims to assess the effectiveness of diffusion-weighted imaging (DWI) and dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) in preoperative staging and evaluation of endometrial and cervical carcinoma.

Methods: In this prospective study, 40 cases of uterine malignancy (20 endometrial carcinomas, 20 cervical carcinomas) were staged using T2WIs, DCE-MRI, and DWI after initial biopsy confirmation. Patients aged 32-76 presented with abnormal vaginal bleeding. The overall staging was correlated with surgical results using the revised FIGO system.

Results: In a study of 120 patients with uterine malignancies—60 with endometrial carcinoma and 60 with cervical carcinoma—distinct imaging characteristics were observed. Results indicated an overall accuracy of 75% for T2WIs, 85% for DCE-MRI, and 92.5% for DW-MRI in aligning with surgical staging and FIGO clinical staging.

Conclusion: The utilization of dynamic contrast-enhanced MRI (DCE-MRI) and diffusion-weighted imaging (DWI) enhances the precision of diagnosing and staging cervical and endometrial cancers. This integration improves pre-surgical mapping, treatment response assessment, and outcome prediction.

Key Words: Cervical tumors, dynamic contrast enhanced MRI, diffusion-weighted MRI, endometrial tumors.

Received: 7 October 2024, **Accepted:** 24 October 2024.

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ISSN: 2735-3540, vol. 75, No. 4, December 2024.

INTRODUCTION

Endometrial and cervical carcinomas represent prominent gynecological malignancies, typically characterized by irregular vaginal bleeding, with a peak incidence around the age of 50[1, 2]. The accurate assessment of these cancers preoperatively plays a pivotal role in determining patient survival and prognosis, as treatment strategies are contingent upon precise tumor staging[3].

Magnetic resonance imaging (MRI) emerges as a valuable non-invasive modality for evaluating the female pelvis, offering exceptional soft tissue contrast resolution and versatile multi-planar imaging capabilities[3]. Notably, MRI can reveal critical prognostic indicators such as cervical stromal involvement, pre-operative pelvic lymph node encroachment, and depth of endometrial invasion in endometrial carcinomas. Moreover, in cervical carcinomas, MRI aids in therapeutic decision-making by delineating tumor extension into the para-cervical, para-metrial, and lower uterine regions[4].

The integration of dynamic contrast-enhanced MRI (DCE-MRI) with conventional MRI enhances the accuracy of T2-weighted imaging in uterine cancer staging, particularly in distinguishing between cervical and endometrial origins. Cervical carcinoma often exhibits

DOI: 10.21608/ASMJ.2024.326282.1324

rapid enhancement during the initial dynamic phase, contrasting with the more gradual enhancement observed in endometrial carcinoma. Hence, DCE-MRI plays a pivotal role in discriminating between cervical and endometrial uterine cancers, especially when involving the cervix and lower uterine segments[5].

In situations where intravenous contrast medium is contraindicated, diffusion-weighted imaging (DWI) emerges as a valuable functional imaging technique. Unlike contrast-enhanced methods, DWI relies on the inherent motion of water molecules within tissues to generate contrast. DWI serves as a non-invasive tool for assessing disease recurrence, monitoring treatment response, staging malignant lesions, and distinguishing between benign and malignant lesions[6].

Therefore, we aimed to evaluate the efficacy of diffusion-weighted imaging (DWI) and dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) for preoperative staging and assessment of endometrial and cervical carcinoma after initial biopsy confirmation.

METHODS

Study Design and Patient Selection:

This prospective cross-sectional study enrolled 120 patients diagnosed with uterine malignancies (60 with endometrial carcinoma and 60 with cervical carcinoma) following initial biopsy confirmation for staging before treatment initiation. Patients, aged between 32 and 76 years with a mean age of 51.9 years, presented with abnormal vaginal bleeding. They were referred from the gynecology department to the radiology department for imaging assessment.

Patient Evaluation:

Before imaging, a detailed patient history was obtained, focusing on relevant factors such as age, parity, menarche age, menopausal duration, hormonal therapy, gynecological history, systemic diseases, and medication history. Laboratory investigations included complete blood counts, blood sugar levels, and liver and kidney function tests. Pelvic ultrasounds were conducted using transvaginal approaches.

MRI Imaging and Equipment:

MRI scans were performed at Ain Shams University Hospital using a 1.5-Tesla MR scanner (Gyroscan Entra and Achieva) from Philips Medical Systems.

Magnetic resonance imaging (MRI) examinations were conducted utilizing a 1.5 T Achieva scanner from Philips Medical Systems, employing a pelvic phased-array Torso coil while patients were positioned supine. To mitigate potential renal complications stemming from contrast agent administration, all subjects underwent creatinine level assessments before imaging sessions.

The MRI protocol comprised non-contrast sequences, including axial T1-weighted (TR/TE, 500/10 ms) and axial T2-weighted (TR/TE, 3300/100 ms) acquisitions with a slice thickness of 6 mm, 1 mm gap, and field of view (FOV) ranging from 32 to 42 cm, employing a matrix size of 256 × 256. Coronal and sagittal T2-weighted images were obtained with slice thicknesses of 8-10 mm, 1 mm gap, and FOV ranging from 40 to 50 cm, also utilizing a matrix size of 256 × 256.

Diffusion-weighted imaging (DWI) sequences were acquired in the axial plane prior to contrast medium administration using a single-shot echo-planar imaging sequence with b values of 0, 300, and 600. Parameters for the DWI sequence included TR/TE of 5000/70, a slice thickness of 6 mm, 1 mm gap, FOV of 36 cm, and a matrix size of 128 × 128.

Dynamic contrast-enhanced MRI (DCE-MR) studies involved post-contrast T1 fat-saturated THRIVE sequences acquired immediately following the administration of 0.1 mmol/kg gadolinium (up to 20 mL) via manual injection, followed by a 20 mL saline flush. Sequential imaging was performed at 0, 30, 60, 90, and 120-second intervals post-contrast injection to capture the dynamic enhancement patterns within the examined tissues.

Image Analysis

Diffusion-weighted imaging involved axial oblique DWI with different b factors, ADC value calculations, and fusion imaging to combine functional and anatomical information. Image analysis focused on tumor

characteristics, size, ADC measurements, myometrial invasion depth, lymph node involvement, and metastatic disease presence.

Staging based on FIGO classification

Following the established criteria, stage I disease is confined to the uterine corpus and ovary. Subdivisions within stage I include Ia, characterized by endometrial confinement or a non-aggressive histological subtype with limited myometrial invasion (≤ 50%) and absence or focal presence of lymphovascular space invasion (LVSI).

Stage Ib encompasses non-aggressive histological types with invasion extending beyond half of the myometrium (≥ 50%) and no or focal LVSI. Stage Ic denotes aggressive histological types confined to the endometrium or within a polyp.

Progressing to stage II, involvement of the cervical stroma without extrauterine dissemination or with extensive LVSI is observed. Subcategories within stage II include IIa, entailing cervical stromal engagement with non-aggressive histological features, and IIb, characterized by extensive LVSI alongside non-aggressive histological characteristics. Stage IIc comprises aggressive histological types with myometrial infiltration of any depth.

Stage III signifies local or regional tumor spread, with IIIa indicating serosal invasion of the uterine body or adnexa, IIIb denoting vaginal or parametrial involvement, and IIIc representing pelvic or para-aortic lymphadenopathy.

Ultimately, stage IV denotes the most advanced disease stage, encompassing intestinal/bowel and bladder mucosal involvement (IVa), extrapelvic peritoneal dissemination (IVb), and distant metastases (IVc).

Statistical Analysis

Data analysis was conducted using SPSS software, with results presented as mean ± standard deviation or percentages. Standard diagnostic indices such as sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic efficacy were calculated to evaluate the imaging modalities' performance in staging uterine malignancies.

RESULTS

The study cohort comprised 120 patients diagnosed with uterine malignancies, evenly split between endometrial carcinoma (60 cases) and cervical carcinoma (60 cases). For endometrial carcinoma, the patients' ages ranged from 45 to 76 years (mean 57), with 48 cases presenting with post-menopausal bleeding and 12 cases with meno-metrorrhagia. In the group with cervical carcinoma, patients aged between 32 to 63 years (mean 47), with 36 cases displaying meno-metrorrhagia and 24 cases showing post-menopausal bleeding.

In all instances of endometrial carcinoma, lesions exhibited inferior enhancement compared to normal myometrial tissue post intravenous contrast medium administration. Semi-quantitative analysis involving post-processing of dynamic contrast-enhanced MRI (DCE-MR) images was conducted for the endometrial cases, with time signal/intensity curves plotted to evaluate enhancement patterns.

All endometrial carcinoma cases demonstrated restricted diffusion relative to surrounding tissue, characterized by high signal intensity on diffusion-weighted MR images and low signal intensity on apparent diffusion coefficient (ADC) maps. Some cases with extra-uterine extensions also displayed restricted diffusion. Post-processing of DW images allowed for the generation of ADC maps, showing restricted diffusion in all endometrial cases, with a mean ADC value of $0.614x10^3$ mm^2/sec.

Conversely, in cervical carcinoma cases, lesions exhibited earlier enhancement compared to normal cervical stroma post-contrast administration. Semi-quantitative analysis involving DCE-MR images was performed for the cervical cases, with time signal/intensity curves plotted for evaluation. Similar to endometrial carcinoma, all cervical carcinoma cases displayed restricted diffusion on DW images, with a mean ADC value of $0.678x10^3$ mm^2/sec.

The study highlighted that more than half of the endometrial carcinoma cases (n=42) presented early and were diagnosed with Stage I endometrial carcinoma, with 12 cases classified as stage IA and 30 as stage IB. Detailed staging information, including individual assessments using pre-contrast T2-weighted imaging, DCE-MRI, and DW-MRI (comprising DWIs, ADC mapping, and fused T2/DW images), was provided in the respective tables. The statistical analysis of each imaging sequence in correlation

to the final operative staging was outlined, emphasizing the staging performance of T2-weighted imaging, DCE-MRI, and DW-MRI in the study cohort.

In this study, the comparison of staging methods—T2-weighted imaging (T2WIs), dynamic contrast-enhanced MRI (DCE-MRI) staging, and diffusion-weighted imaging (DWIs) staging—against post-operative staging in both endometrial and cervical carcinoma revealed consistent classification across all stages (Table 1 and Table 2). Notably, each method demonstrated perfect precision, correctly identifying all cases within their respective stages.

Table 1: Correlation between MRI (T2WIs, DCE- MRI & DW-MRI) and post-operative staging of 60 cases of endometrial carcinoma.

FIGO	T2Wis Staging	DCE-MRI staging	DWIs staging	Post-operative staging
Stage IA	6	9	15	12
Stage IB	36	33	27	30
Stage III	12	12	12	12
Stage IV	6	6	6	6
Total	60	60	60	60

Table 2: Correlation between MRI (T2WIs, DCE- MRI & DW-MRI) and pathology/FIGO clinical staging in staging 60 cases of cervical carcinoma.

FIGO	T2Wis Staging	DCE-MRI staging	DWIs staging	Post-operative staging
Stage I	6	9	9	12
Stage II	6	6	9	6
Stage III	24	18	15	15
Stage IVA	24	24	24	24
Stage IVB	0	3	3	3
Total	60	60	60	60

As shown in table 3, the current study found that in comparison to DCE-MRI, which had a sensitivity of 66.7%, conventional T2WIs and DWI were more sensitive than DCE-MRI in assessing lymph node metastasis, reaching 71.4% and 80%, respectively. T2WIs, DCE-MRI, and DWI were estimated to have specificities of 85.2%, 82.33%, and 85.7 percent, in that order. T2WIs, DCE-MRIs, and DWIs had estimated net present value (NPV) of 93.5%, 93.3 %, and 96.7%, respectively. T2WIs, DCE-MRIs, and DWIs were estimated to have 85%, 80%, and 85% of accuracy, respectively.

In the comprehensive evaluation of staging accuracy for both endometrial and cervical carcinomas within a cohort of 120 cases, comprising 60 cases each, the study observed notable performance metrics for T2-weighted imaging (T2WIs), dynamic contrast-enhanced MRI (DCE-MRI), and diffusion-weighted MRI (DW-MRI). Results indicated an overall accuracy of 75% for T2WIs, 85% for DCE-MRI, and 92.5% for DW-MRI in aligning with surgical staging and FIGO clinical staging.

Table 3: Diagnostic indices (sensitivity, specificity, PPV, and NPV) of T2W, DCE-MRI, and DWIs to assess cervical stromal invasion, parametrial infiltration, advanced extra-uterine extension, and metastatic lymph nodes in the studied group.

	Sensitivity	Specificity	PPV	NPV
Cervical stromal invasion				
T2Wis Staging	100%	94%	80%	95%
DCE-MRI staging	100%	94%	80%	95%
DWIs staging	100%	94%	80%	95%
Parametrial infiltration				
T2Wis Staging	100%	83.3%	80%	100%
DCE-MRI staging	100%	87.5%	84.2%	100%
DWIs staging	100%	92%	89%	100%
Advanced extra-uterine extension				
T2Wis Staging	90%	97%	90%	97%
DCE-MRI staging	70%	100%	100%	91%
DWIs staging	100%	100%	100%	100%
Metastatic lymph nodes				
T2Wis Staging	71.4%	85.2%	55.5%	93.5%
DCE-MRI staging	66.7%	82.3%	40%	93.3%
DWIs staging	80%	85.7%	44.4%	96.7%

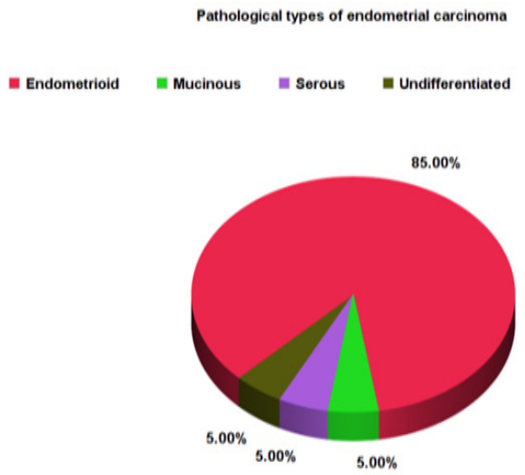


Fig. 1: Pathological types of endometrial carcinoma in the studied.

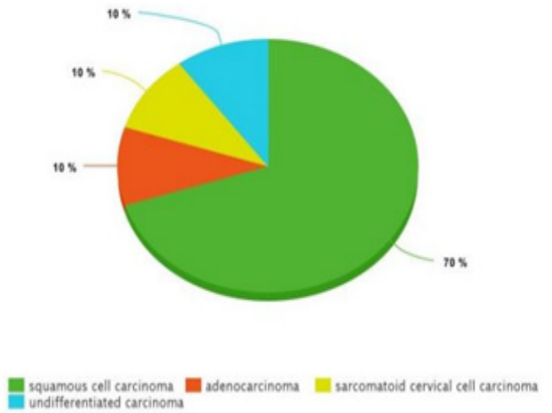


Fig. 2: Pathological types of cervical carcinoma in the studied group.

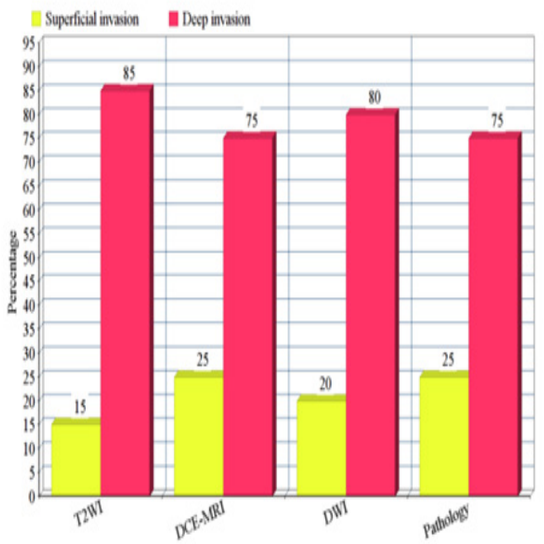


Fig. 3: Assessment of myometrial invasion by T2WIs, DCE-MRI, DWI and surgical pathology in the studied group.

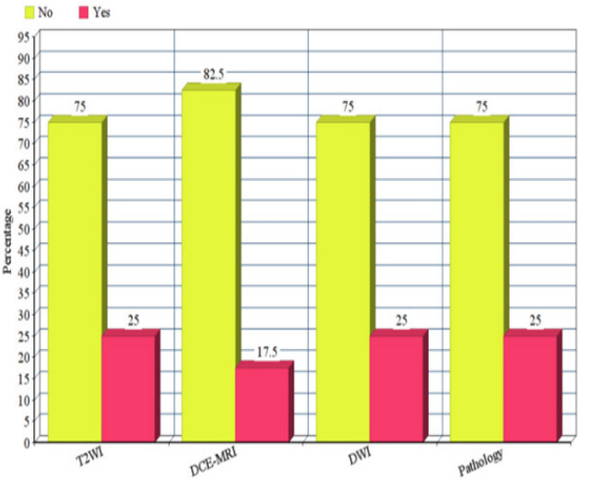


Fig. 4: Assessment of cervical stromal invasion by T2WIs, DCE-MRI, DWI and surgical pathology in the studied group.

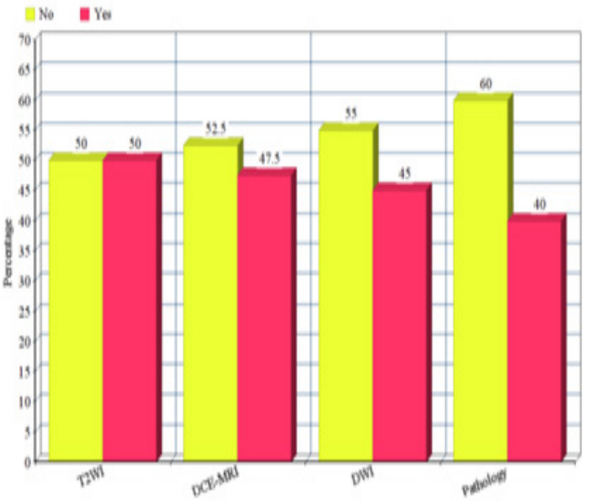


Fig. 5: Assessment of parametrial infiltration by T2WIs, DCE-MRI, DWI and pathology in the studied group.

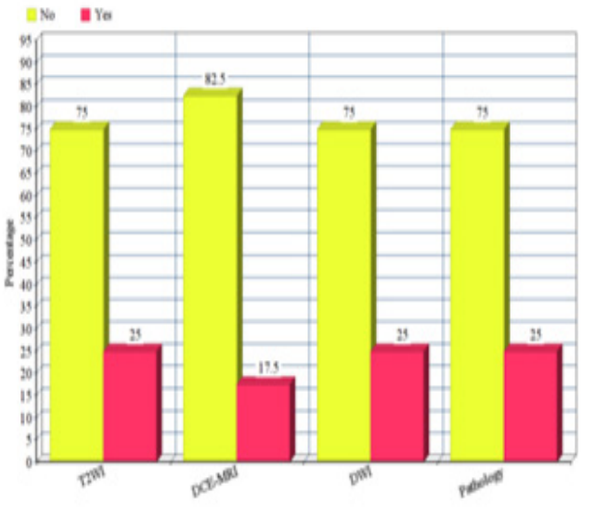


Fig. 6: Assessment of locally advanced and advanced stages by T2WIs, DWI, DCE-MRI and pathology/FIGO clinical staging in the studied group.

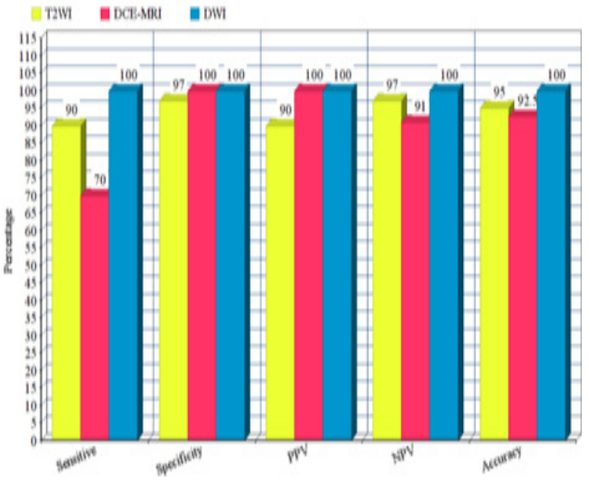


Fig. 7: Diagnostic indices (sensitivity, specificity, PPV, NPV and efficacy) of the ability of T2WIs, DCE-MRI & DWI to assess locally advanced and advanced stages in the studied group.

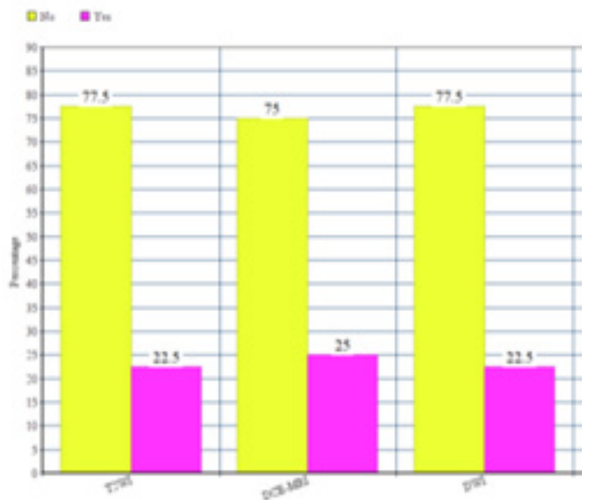


Fig. 8: Assessment of lymph nodes by T2WIs, DCE-MRI, DWI and pathology in the studied group.

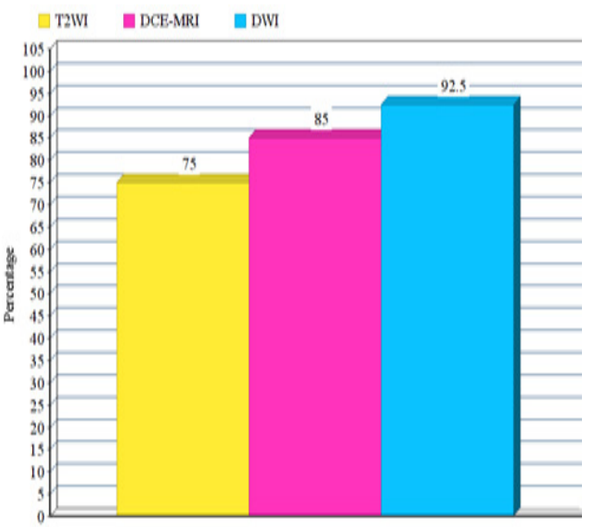


Fig. 9: Overall staging accuracy of T2WIs, DCE-MR & DWI in staging of uterine carcinoma.

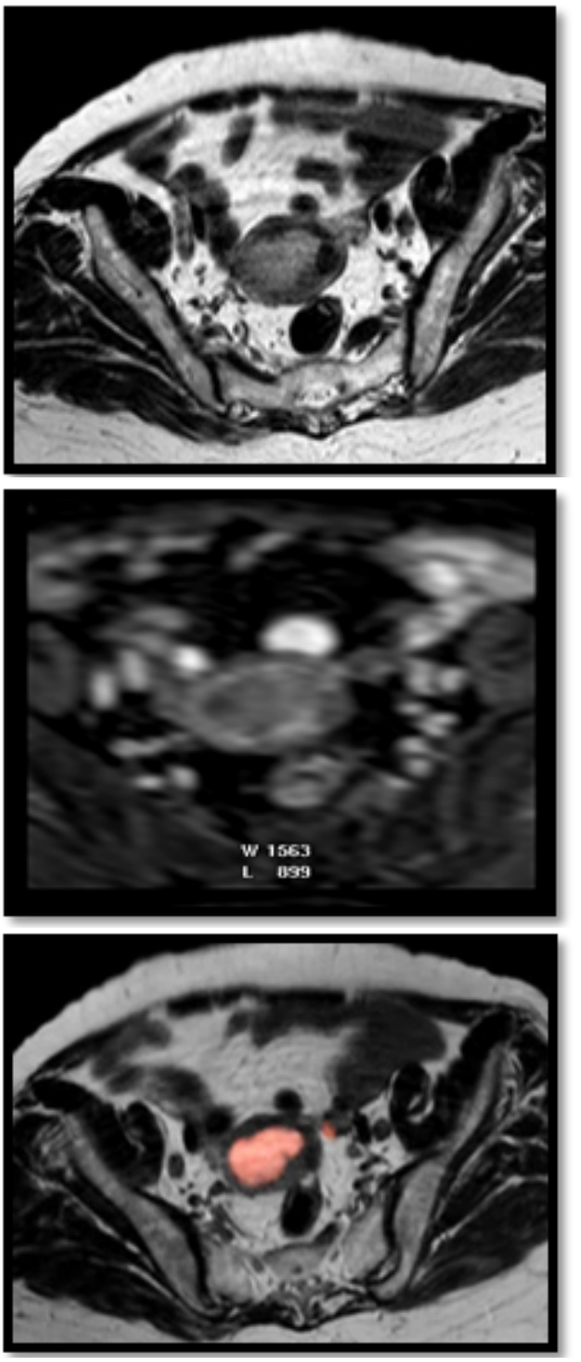
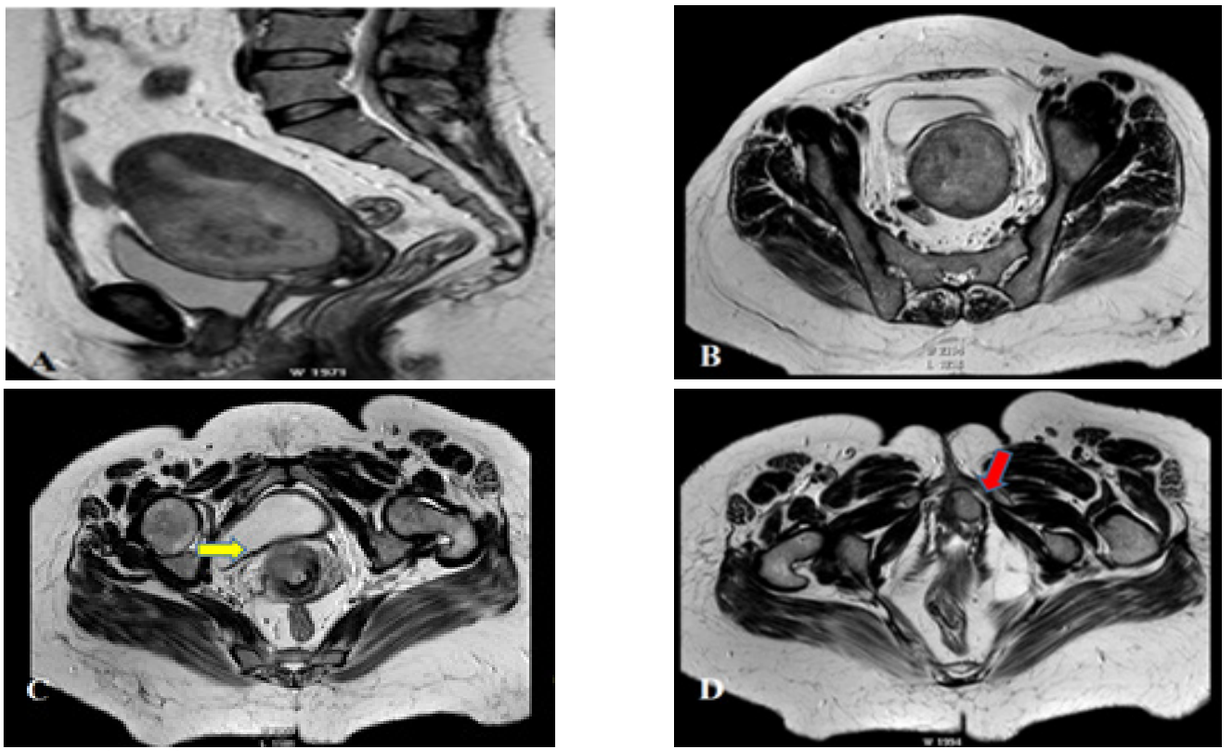


Fig. 10: A 68-year old female patient with endometrioid adenocarcinoma. Conventional MRI findings (T2WIs): A large endometrial mass of intermediate signal intensity is seen. Indistinct junctional zone is noted on the axial images with suggested deep endometrial invasion, consequently the pre-operative staging by T2WIs was stage IB. DCE-MRI findings: The subendometrial zone shows preserved enhancing band suggesting absence of myometrial invasion, consequently the pre-operative staging by DCE-MRI was stageIAT3/ DW fused images suggest deep myometrial invasion (>50 %), i.e. Stage IB. the estimated ADC value is $0.724x10^{3-}$ mm²/sec. Consequently the pre-operative staging by DWI was similar to that of T2WIs as stageIB.



Post-operative staging:
Superficial myometrial invasion was confirmed by surgery compatible with the result of DCE-MRI.

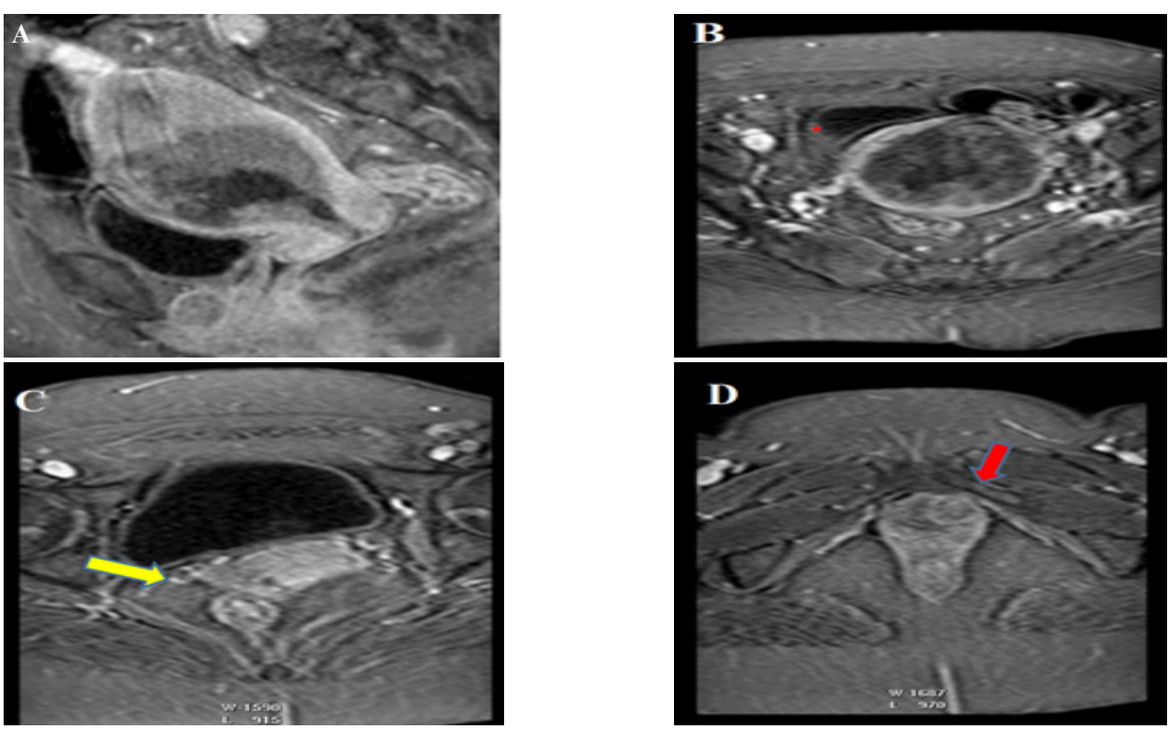
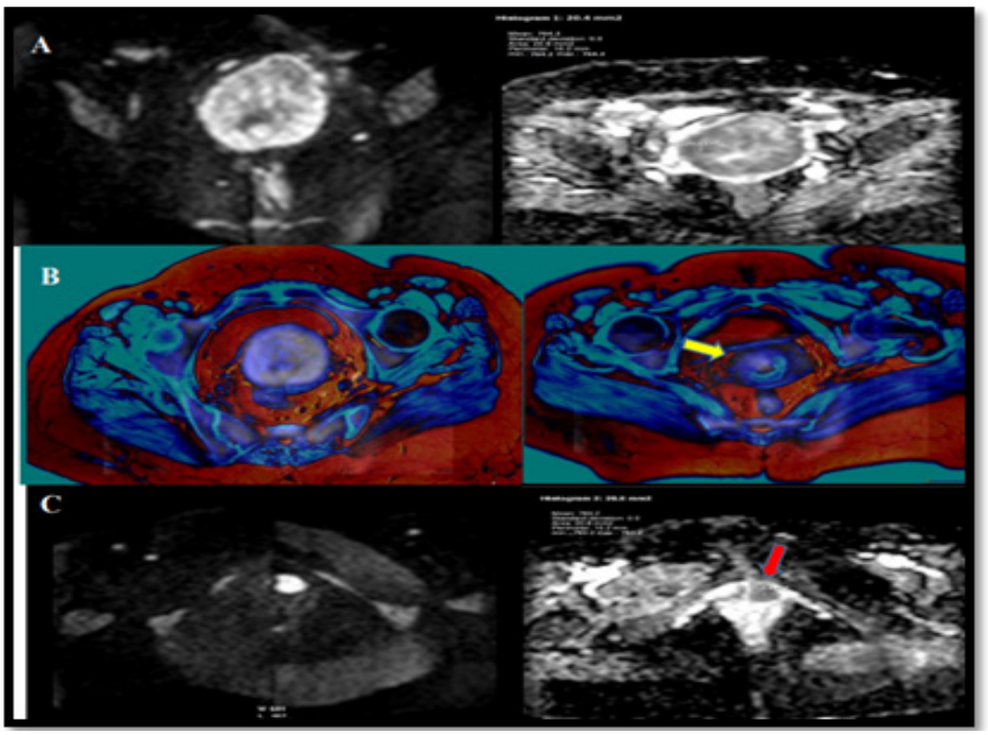


Fig. 11: A 45-year old female patient with endometrioid carcinoma. Conventional MRI findings:
(A) A large endometrial mass of intermediate signal intensity is seen invading the whole myometrial thickness with no evidence of serosal invasion. (B) Axial images showing suspected cervical stromal invasion. (C) The lower axial cuts show a small well defined left paraurethral solid mass of intermediate signal. Consequently, pre-operative staging by T2WIs was stage IV B. DCE-MRI findings: (A) Shows the contrast between the mass and intensely enhancing myometrium confirming full thickness myometrial invasion with preserved enhancing serosa. (B) Axial DCE-MRI at the level of the cervix showing suspected cervical stromal invasion in the delayed image (4 min) by a poorly enhancing area within the enhancing stroma (arrow). (C) Axial DCE-MRI at the level of the paraurethral lesion which shows heterogeneous enhancement (arrow). Consequently the pre-operative staging by DCE-MRI was compatible with T2WIs (stage IV B).

DWIs: (A)T2/DW fused images of the endometrial mass lesion show restricted diffusion of the endometrial carcinoma with full thickness myometrial invasion and (B)suspected cervical stromal invasion (arrow), the estimated ADC value of the mass is $0.764x10^{3-}$ mm²/sec. (C) ADC map at the level of the left para-urethral nodule (arrow) showing restricted diffusion of the nodule with estimated ADC value of $0.783x10^{3-}$ mm²/sec suggesting metastatic deposit. Consequently the pre-operative staging by DWI was compatible with both T2WIs & DCE-MRI as stage IV B.



Post-operative staging: Although the overall post-operative staging was IV B compatible with that estimated by T2WIs, DW-MRI and DCE-MRI due to presence of the left paraurethral metastatic nodule, the cervical stromal invasion that was suggested by the A ` B C three sequences was excluded by the surgical pathology. On re-viewing the images, we suggested that such false impression could be attributed to the inaccurate scanning of the axial oblique plane. Though correct staging was achieved by the 3 sequence, yet we have to admit that DWI was superior to the other two sequences in its ability to detect the paraurethral soft tissue mass lesion owing to its distinct bright signal against the suppressed background signal together with its low ADC value suggesting its metastatic nature.

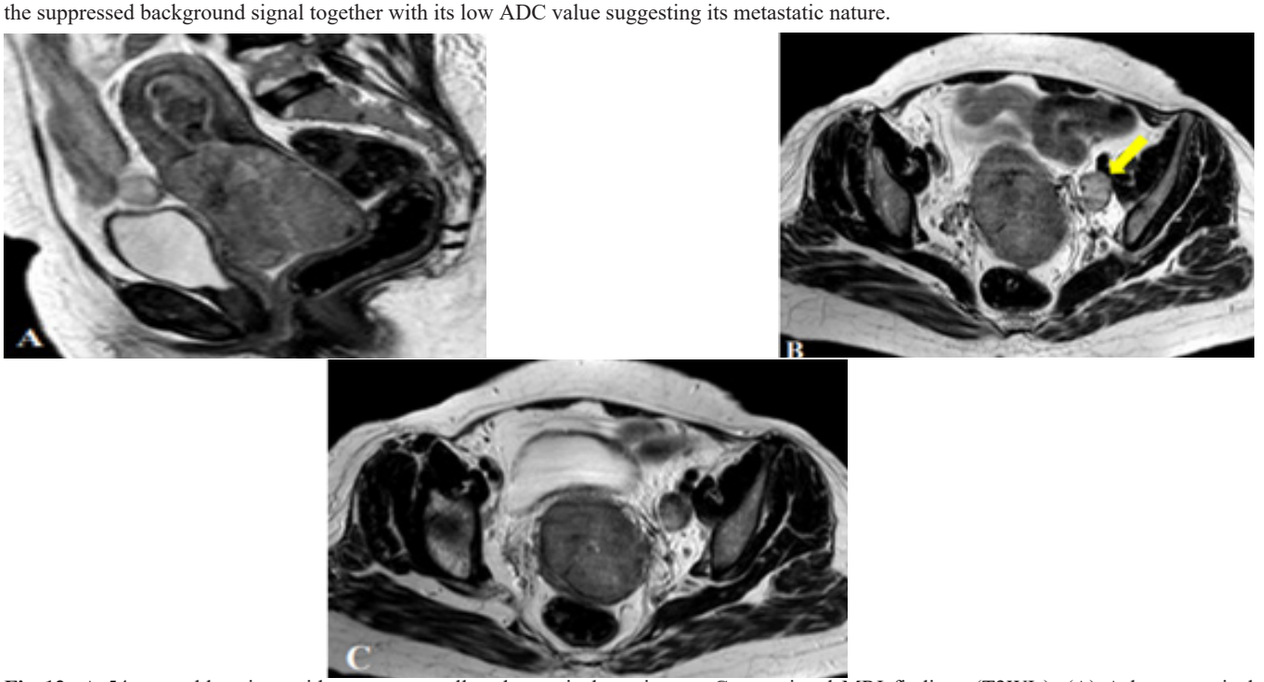
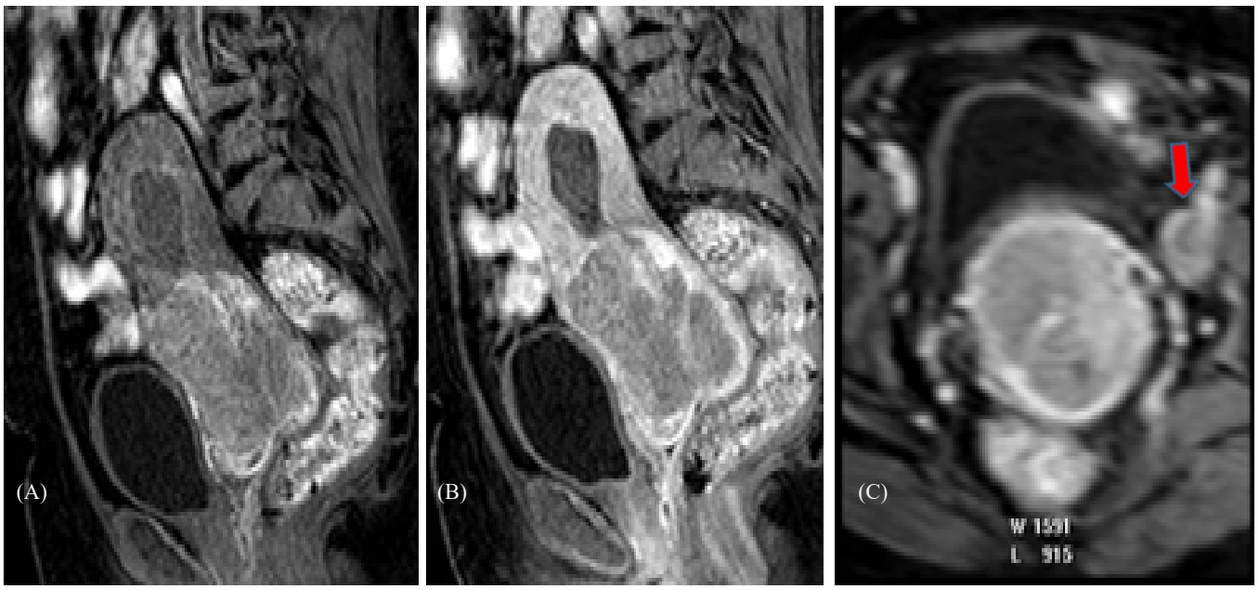
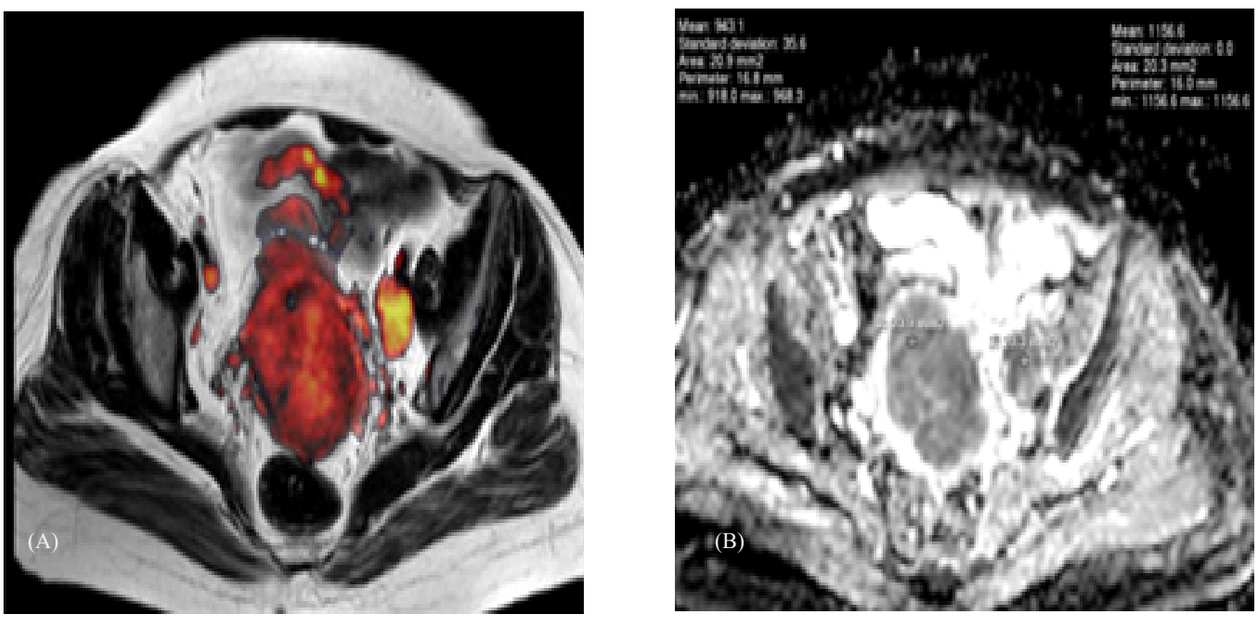


Fig 12: A 54-year old patient with squamous cell endo-cervical carcinoma. Conventional MRI findings (T2WIs): (A) A large cervical mass obstructed the uterine cavity with retained blood; the mass is seen expanding the vagina superiorly yet with no mural or parametrial involvement. (B)Associated suspicious left obturator lymph node (arrow). Consequently the pre-operative staging by T2WIs was stage IV B.



DCE-MRI findings:
(A)The mass shows earlier enhancement than the myometrium and less enhancement than the surrounding residual cervical stroma, (B) with intact overlying serosa at delayed images (4 min) excluding parametrial infiltration. (C)The enlarged pelvic lymph node is noted with mild heterogeneous enhancement (arrow). Consequently the pre-operative staging by DCE-MRI was compatible with that of T2WIs as stage IV B.

DWIs: (A)T2/DW fused image show diffusion restriction of the cervical tumor and associated left obturator lymph node. (B)The estimated ADC measurement of the mass lesion is $0.94x10^{3}$-mm^2/sec. The estimated ADC measurement of the lymph node is $1.15x10^{3}$-mm^2/sec excluding its metastatic nature. Consequently the pre-operative staging by DWI was lowered to stage IB2.



Post-operative staging: It was compatible with the result of DWI as stage IB2. In that case by considering the ADC value, DW-MRI was able to truly exclude metastatic lymph node. Such way of proper assessment wasn't possible by conventional or DCE-MRI.

DISCUSSION

Among the most prevalent gynecological cancers are endometrial and cervical carcinomas. Usually, they exhibit unusual uterine bleeding. Around the age of fifty is when most cases are diagnosed[1, 2]. Pre-operative assessment is closely related to patient survival and prognosis because treatment planning is dependent on the tumor's stage[3]. In 2009, the International Federation of Gynecology and Obstetrics (FIGO) staging committee recommended using MRI for patient evaluation and treatment planning[7]. The shortcomings of morphologic imaging, particularly when it comes to traps like losing the definition of the junctional zone, leiomyomas, overestimating parametrial infiltration, and invasion of the bladder and rectal area, have made it necessary to alter the conventional imaging protocol. Consequently, functional MRI (fMRI) using DWI and DCE-MRI is starting to be included in standard imaging protocols for staging. Pre-surgical mapping, predicting treatment outcome, assessing treatment response, and differentiating tumor from non-tumor tissue in cervical and endometrial cancer are among the difficult problems that fMRI may be used for. Less patient morbidity and therefore improved overall survival are possible in order to achieve all these benefits[5]. This study focused on the role of fMRI in preoperative staging with an aim to evaluate the performance of each of the conventional images, specifically the T2WI for each patient, the DCE-MRI, and the DWI focused on highlighting its significance in choosing the right patient care strategy in order to improve overall patient survival while reducing anticipated morbidity from needless procedures.

According to ***Manfredi et al.,*** DCE-MRI and T2W images together provide the most effective "one-stop" examination for endometrial cancer staging[8]. They also emphasized the significance of multiphase dynamic MR imaging in the evaluation of reported cases with endometrial carcinoma. This research included sixty female patients who had pathologically been diagnosed with endometrial cancer. Eighty percent of the cases began with postmenopausal bleeding, with endometrioid adenocarcinomas accounting for the majority at eighty percent. According to ***Lin et al.*** (2016), endometrial tumors showed less enhancement than normal myometrium[9].

We concur with their findings. In the present investigation, that pattern of enhancement was present in every case of endometrial carcinoma. A similarly sized ROI was also drawn around the area of the piriformis muscle to provide an internal reference with calculation of the SImax/SI (piriformis) ratio[10].

According to ***Fukunaga et al.*** (2015), type II carcinomas exhibit strong contrast enhancement, but there is some overlap in the enhancement characteristics between the two groups. All enhancement parameters, with the exception of SImax and area under curve, were higher in type II than in type I carcinomas. With a sensitivity of 93%, specificity of 60%, and accuracy of 66%, this study also demonstrated that the cutoff values of SIrel 58.8 and WIR 37.0 for identifying the presence of type II carcinomas offered an ideal diagnostic performance. A 67 percent sensitivity, 79 percent specificity, and 67 percent accuracy were linked to a threshold value of SImax/SI (piriformis) ratio of 1.55 for the differentiation of the two groups. According to a study[10], a cutoff value of SImax 708 was linked to sensitivity of 43%, specificity of 90%, and accuracy of 81%.

The current study yielded mean values of 496, 111 percent, 31/sec, and 1 point 43 for SImax, SIrel, WIR, and SImax/SI (piriformis) ratio, respectively. All forms of endometrial carcinoma were included, however type I represented 85% of cases. Cervical carcinoma has an average SIrel that is higher than endometrial carcinoma, according to ***Lin et al.*** (2016). A cutoff value of 122.2 percent for SIrel and 521.4 percent for SImax was taken into consideration to distinguish between endometrial and cervical carcinoma[9].

We concurred with ***Lin et al.,*** 2016 because it was shown that the SIrel and SImax for endometrial cases were lower than those for cervical cases[9]. Regarding the relatively low WIR & SImax/SI, we also concurred with the findings of ***Fukunaga et al.***, 2015 regarding the relatively low WIR & SImax/SI (piriformis) ratio as most of our endometrial cases were type I endometrial carcinoma[10].

According to DWI and ADC maps, which offer a quantitative assessment of water diffusion, endometrial cancer shows restricted diffusion in comparison to surrounding tissue, showing high signal intensity and low signal intensity, respectively[11]. Restrictions in diffusion can arise in areas of retained mucus, such as an obstructed endometrial cavity, and diffusion-weighted MR images should always be compared with their corresponding ADC maps and other anatomic images to avoid pitfalls like T2 shine-through. In addition, because DW-MRI has comparatively low resolution for precise anatomical correlation. All cases of endometrial cancer in this study, including the lesion itself and any extra-uterine lesions, showed restricted diffusion on functional imaging with DW-MRI. This was especially observed at high b-values (b>500 s mm−2) and low signal intensity on ADC

appearance. This concurs with Takeuchi and colleagues. 2009 as well as Shen and colleagues, 2008[11,12]. Sub-mucosal leiomyomas and endometrial polyps, for example, have much higher ADC values than malignant tumors[13]. It is imperative to exercise caution as tumor necrosis in lesions with poor differentiation may also exhibit low ADC values[11]. Given that our study's endometrial cases had an average ADC value of 0.614x10ž³ mm²/sec.

In comparison to our study, DCE-MR imaging, Beddy and colleagues (2012) found that DW MR imaging was significantly more accurate for endometrial cancer staging overall with the new FIGO system. They reported that 81 percent of DW MR imaging and 62 percent of DCE-MR imaging had diagnostic accuracy[14]. The current results were comparable to those of ***Beddy et al.*** when examining the accuracy of overall staging in cases of endometrial carcinoma, with DW-MRI showing higher overall staging accuracy (90%) than T2WIs (80%) and DCE-MRI (85%).

Regarding the assessment of myometrial invasion, precise measurement of its depth enables the selection of patients for pelvic or para-aortic lymph node sampling, sparing patients with low risk disease from surgery[15]. DWI was a more accurate method of assessing the depth of myometrial invasion in the study conducted by ***Beddy et al.***[14]. ***Rechichi et al.*** conducted a prospective study that was published in European Radiology in 2010 discovered that, with sensitivity, specificity, positive and negative predictive values of 84.6%, 70.66 %, 52.4%, and 92.3%, DWI was very accurate in determining myometrial invasion. The corresponding percentages for T2W imaging and dynamic gadolinium-enhanced imaging were 69.2%, 61.8%, 40.9%, 84.0%, and 92.3 percent, 76.5%, 60.0%, and 96.3%, respectively, with a noteworthy inter-observer agreement with DWI. In addition to standard T2WI, they proposed that DWI might eventually take the place of dynamic imaging for the preoperative assessment of endometrial cancer[16].

Additionally, ***Lin et al.*** claimed that combining T2WI and DWI sequences could enhance the evaluation of myometrial invasion. They discovered that pathological correlation was greatly enhanced by the addition of fused T2/DWI sequences to standard T2WI and DCE-MRI, and that T2WI plus fused T2WI/DWI imaging was significantly more accurate than T2WI plus DCE-MRI[17]. Shen and others, evaluated the depth of myometrial invasion using DWI and DCE-MRI in comparison, and discovered that the diagnostic accuracy for DWI was 62% while that of DCE-MRI was 71%. They came to the conclusion that, despite DWI's superior ability to depict the extent of tumor infiltration in the myometrium over DCE-MRI, its relatively low resolution and one-plane acquisition—two planes are required for an accurate assessment—made it less than ideal for detecting superficial myometrial invasion[11].

The current study found that DWI performed better in detecting deep myometrial invasion than both conventional T2WIs and DCE-MRI, with a diagnostic accuracy of 95% compared to 90% for both procedures. The DWI's stated sensitivity, specificity, positive and negative predictive values (PPV and NPV) were 100%, 80%, 93.88%, and 100%, respectively. Investigations have shown that specificity can reach 100% (ranging from 87% to 100%), accuracy can reach 98 percent (from 46 to 98%), and sensitivity can reach 100% (from 33 to 100%)[18]. PPV, NPV, diagnostic accuracy, sensitivity, specificity, and overall MRI sensitivity in the evaluation of cervical infiltration were 64 percent, 66 percent, 65 percent, 91 percent, and 25 percent, respectively, in a 2011 study conducted by ***Helal et al.***[19].

The value of DWI in identifying cervical stromal invasion in endometrial cancer is not well documented in the literature. Four patients with stage II disease were included in the patient cohort of the ***Beddy et al.*** (2012) study. Cervical stromal invasion was more frequently correctly identified by both readers on the DWI than the DCE-MRI; however, the sample size is too small to draw any firm conclusions[14]. In the current study, T2WIs, DCE-MRI, and DWIs revealed a diagnostic accuracy, sensitivity, specificity, PPV, and NPV of 95%, 100%, 94%, 80%, and 100% by the three modalities, respectively, they all function similarly.

Additionally, MRI helps evaluate lymph node metastases and other key prognostic factors like tumor size, parametrial and pelvic side wall invasion, and adjacent organ invasion[20]. According to ***Lin et al.*** (2016), cervical carcinoma lesions were showing significantly higher early enhancement in comparison to normal cervical stroma, a finding supported by this study[9]. In the current study, that pattern of enhancement was present in every cervical case. We also concurred with ***Lin et al.,*** 2016 that cases of cervical carcinoma had higher SIrel and SImax than cases of endometrial carcinoma[9]. In this study, there was a difference of 111 percent for endometrial carcinoma cases and 726 percent for cervical cases in terms of SImax, while the percentage of cases with Sirel was higher in the former category. Cervical cancer lesions showed restricted diffusion with hyper-intensity on DWI & low intensity on ADC maps, with a mean ADC value of 1.110x10€³ mm²/sec, according to a study by ***Chen et al.*** (2010). For the purpose of distinguishing cervical carcinoma from the normal, they reported a cutoff value of 1.359x10ž³ mm²/sec for differentiating cervical carcinoma from the normal tissue[21].

The outcomes were in line with ***Chen et al.*** (2010). The mean ADC estimated value for all cervical cases was 0.678x10ž³ mm²/sec, and all lesions displayed restricted diffusion. This was observed in particular at high b-values (b>500 s mm−2) and low signal intensity on ADC appearance that were associated with them. That's in line with ***Shen et al.*** 2008 in addition to ***Takeuchi et al.*** 2009 saw 12 cases classified as stage IB, 6 as stage IIA, 15 as stage IIIB, 24 as stage IVA, and 3 as stage IVB[11,12]. Studies contrasting the efficacy of DWI and DCE-MRI in the overall staging and parametrial infiltration detection of cervical cancer, however, remain flawed. A retrospective analysis was conducted on 72 patients who had cervical carcinoma in a 2007 study by ***Li et al.*** They found that while conventional MRI was 86% accurate in locating the tumor, it was only 64% accurate in clinical staging[22].

With an overall accuracy of 95% by DWI compared to 85% and 70% by DCE-MRI and T2WIs, respectively, DWI outperformed T2WIs and DCE-MRI in the current study. The same three cases with T2WI that were understaged after the DCE-MRI analysis was performed were caused by the inability to identify an early cancerous cervical ulcer. The false impression of parametrial infiltration was the primary cause of the overstaging. Three DWI cases were overstaged as a result of a false detection of parametrial infiltration. Our findings are not the same as ***Sala et al.***'s. who stated that the use of contrast medium is not required for the staging of cervical cancer and that, while it might boost the reader's confidence in the identification of tumors, stromal, and parametrial invasion, staging accuracy is not improved in comparison to T2WI alone[23]. In this study, DCE-MRI significantly contributed to appropriate staging by ruling out bowel infiltration, parametrial invasion, and lower third vaginal infiltration when T2WIs suggested the opposite.

With an estimated PPV of 89%, DWI demonstrated greater specificity than T2WIs and DCE-MRI, with up to 92 %. With a high negative predictive value of up to 100%, the three sequences exhibit high sensitivity. The usefulness of DWI compared to DCE-MRI in the assessment of locally advanced and advanced staging in both endometrial and cervical carcinoma has not been sufficiently covered by prior scientific work when examining the detection of locally advanced and advanced stages. We saw it as a standard parameter for staging cervical and endometrial cancer.

The DW-MRI yielded a 100% accuracy rate for locally advanced and advanced stage assessment, while T2WIs and DCE-MRI yielded 95% and 92.5% accuracy, respectively. Despite having the lowest negative predictive value (91%) and lowest sensitivity (70%) of all the imaging modalities, DCE-MRI proved to be highly helpful in ruling out bladder infiltration that had been detected on T2WIs and in ruling out suspected bowel infiltration. However, its capacity to identify peritoneal and bone deposits was restricted; nevertheless, we were able to detect them through the use of DCE-MRI in a retrograde manner. When it comes to identifying drop metastases in the cervix or metastatic foci outside the uterus, like the adnexa, peritoneum, and bone deposits, DW imaging is extremely helpful. In cases where metastatic foci exhibit diffusion restriction against a suppressed background, this is typically accomplished with a high b-value. As a result, there is mounting evidence that, in comparison to CT, DW MR imaging may be useful in providing a more accurate mapping of the extent of peritoneal disease[15].

In 2008, ***Fujii et al.*** conducted a study on 26 patients to assess the usefulness of DWI for the identification of peritoneal dissemination in gynecological malignancies. They found that DWI was very specific (95 percent) and sensitive (90 percent) for peritoneal dissemination evaluation[13]. Since systemic lymphadenectomy carries a significant risk of complications, it is imperative to accurately assess the involvement of lymph nodes in endometrial carcinoma, even though it is part of the FIGO staging system. Finding nodal metastases would help choose patients for lymphadenectomy more carefully and possibly prevent overly aggressive surgery[24]. Despite not being part of the FIGO clinical staging system, lymph node involvement is thought to be the most significant prognostic factor in cases of cervical carcinoma. Tumor size, stromal invasion depth, lympho-vascular invasion, and para-metrial disease all raise the risk of nodal metastasis[25].

Kim et al. discovered that, among patients undergoing lymph node dissection for cervical cancer, malignant nodes had significantly lower ADC values (0.7651×10Ć³mm²/s±0.1137 versus 1.0021×10(−3) mm2/s±0.1859, respectively; $P < 0.001$). When it came to distinguishing between metastatic and non-metastatic lymph nodes, the sensitivity and specificity of ADC were 87% and 80%, respectively[26]. Present findings resembled those of ***Nakai et al.*** At 1point 5 T, they assessed the nodal status. In this investigation, they discovered that DWI had a better capacity for identifying lymph nodes, but they were unable to differentiate reactive from malignant lymph nodes or benign from malignant nodes based on ADC values[27]. According to the current study, the true positive lymph nodes' ADC value ranged from 0.8 to 0.9 x 10³mm²/sec, while the false positive lymph nodes' ranged from 0.65 to 0.9 x 10ž³ mm²/sec. Therefore, we were unable to discover any correlation between the absolute ADC values and the existence of metastatic deposits. Though the enlarged pelvic lymph node was thought to be likely metastatic due to its large size, the ADC value was able to rule out lymph

node metastasis in 3 cases (1.2 x100³ mm²/sec). Lin and colleagues increased their sensitivity for the detection of metastatic lymph nodes from 25% to 83% by measuring the ADC of the primary tumor, the ADC of the lymph node, and the long and short axis diameter of the lymph node[28].

The current study found that, in comparison to DCE-MRI, which had a sensitivity of 66.7%, conventional T2WIs and DWI were more sensitive than DCE-MRI in assessing lymph node metastasis, reaching 71.4% and 80%, respectively. T2WIs, DCE-MRI, and DWI were estimated to have specificities of 85.2%, 82.33%, and 85.7 percent, in that order. T2WIs, DCE-MRIs, and DWIs had estimated net present value (NPV) of 93.5%, 93.3 %, and 96.7%, respectively. T2WIs, DCE-MRIs, and DWIs were estimated to have 85%, 80%, and 85% of accuracy, respectively. Because the T2W images have a high spatial resolution that both dynamic and DWI sequences lack, they are still essential for anatomical reference. When performing a routine preoperative evaluation for endometrial and cervical carcinomas, DWI should be used in addition to conventional MRI. When a patient cannot receive a contrast material injection due to an allergy or a higher risk of nephrogenic systemic fibrosis, DWI may be a good substitute for contrast-enhanced MRI. Although DCE-MRI slightly alters overall staging when compared to DWI, it is useful in determining the depth of myometrial invasion and increases reader confidence in ruling out cervical stromal, parametrial, and urinary bladder/rectal invasion[29].

CONCLUSIONS

The utilization of dynamic contrast-enhanced MRI (DCE-MRI) and diffusion-weighted imaging (DWI) enhances the precision of diagnosing and staging cervical and endometrial cancers. This integration improves pre-surgical mapping, treatment response assessment, and outcome prediction.

LIST OF ABBREVIATIONS

DCE MRI: Dynamic contrast enhanced Magnetic resonance imaging.

DWI: Diffusion weighted imaging.

ADC: Apparent diffusion coefficient.

ROI: Region of interest

THRIVE: High Resolution Isotropic Volume Examination.

SImax, Maximum absolute enhancement.

SIrel: Maximum relative enhancement.

FIGO: Fédération Internationale de Gynécologie et d'Obstétrique.

fMRI: functional Magnetic resonance imaging.

NPV: negative predictive value.

NPV: Negative predictive value.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by National hepatology, tropical medicine research institute (NHTMRI- IRB), Cairo, Egypt, approval number: 39-2023, date: 4/10/2023.

Written informed consent was signed by patients.

CONSENT FOR PUBLICATION

All patients included in this research gave written informed consent to publish the data contained within this study.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

FUNDING

Self-funding.

CONFLICT OF INTERESTS

There is no conflicts of interest.

AUTHORS' CONTRIBUTIONS

All authors have read and approved the manuscript. - Study concept: Z.M., R.SM. - Study design: Z.M., R.SM. - Data acquisition: Z.M. - Data analysis and interpretation: Z.M., R.SM. - Statistical analysis: Z.M., R.SM. - Manuscript preparation: Z.M. - Manuscript editing: R.SM. - Manuscript reviewing: R.SM.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of emergency departments' staff, for their contribution to patient data collection.

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اظهار تأثير دمج التصوير الديناميكى المعزز والتصوير المرجح الأنتشارى بالرنين المغناطيسى فى مرحلة ماقبل العملية الجراحية لسرطان بطانة و عنق الرحم

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الخلفية: أكثر أنواع السرطانات النسائية انتشاراً هي سرطانات بطانة وعنق الرحم. عادةً، يظهرون بنزيف غير منتظم في الرحم. حوالي سن الـ ٥٠ ، تُشخَّص غالبية الحالات. ويؤثر تقييم ما قبل العملية تأثيرا مباشرا على بقاء المريض على قيد الحياة وعلى التكهن بما أن التخطيط للعلاج يتوقف على مرحلة تكوين الورم.

تهدف هذه الدراسة إلى: تقييم فعالية التصوير المعزز للرنين المغناطيسي بالتباين الديناميكي والتصوير المرجح الانتشاري في التقييم السابق للعمليات الجراحية وتقسيم سرطانات بطانة وعنق الرحم، و تقسيم أفضل الخيارات العلاجية إلى طبقات.

النتائج: من بين الـ ١٢٠ مريضة مصابات بسرطان الرحم في الدراسة الحالية؛ ٦٠ مصابات بسرطان بطانة الرحم و ٦٠ مصابات بسرطان عنق الرحم. وقد أُحيلت هذه الحالات من قسم أمراض النساء إلى وحدة التصوير بالرنين المغناطيسي بين /يوليه ٢٠٢١ و/يوليه ٢٠٢٣ بعد أن تم تشخيصهم هستولوجياً.

الاستنتاجات: إن دمج استخدام التصوير المعزز للرنين المغناطيسي بالتباين الديناميكي والتصوير المرجح الانتشاري بالاقتران مع نظام التخطيط قبل العملية الجراحية، وتقييم الاستجابة للعلاج، والتنبؤ بنتائج العلاج من خلال تيسير التشخيص لسرطانات عنق الرحم وسرطانات بطانة الرحم. وبالإضافة إلى ذلك، فإنه يؤدي إلى الحد من التحقيقات التي لا داعي لها ، ويؤدي في المقابل إلى خفض معدلات اعتلال المرضى وزيادة بقائهم بشكل عام.