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Role of Diffusion Weighted MRI in Diagnosis of Cervical Cancer

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ABSTRACT

Background: Diffusion weighted magnetic resonance imaging (DW-MRI) is a functional, non-invasive imaging technique which generates tissue contrast from differences in mobility of water molecules that occurs during an MR pulse sequence. Information regarding the integrity of cellular membranes and tissue cellularity can be obtained, so that DW-MRI can now be included in routine patient assessment. **Aim of the Work:** The aim of this study is to evaluate the role of DW-MRI in the diagnosis of cervical carcinoma, with pathological diagnosis was taken as the reference. **Patients and Methods:** This is a retrospective study that included 20 patients in whom cervical cancer had been suspected clinically or by transvaginal ultrasound (U/S) and the control group consisted of 20 patients in whom cervical cancer had not been suspected and MRI was performed because of other Pelvic diseases. The study was conducted in El-Demerdash Hospital. The patients were referred from the Gynecology Department to the Radiology Department (Women's imaging unit) for further MRI assessment with diffusion weighted images (DWIs). **Results:** Lesions in all cases show restricted diffusion, however on apparent diffusion coefficient (ADC) map, only one case showed high signal proved to be chronic cervicitis on histopathology. Also, the mean ADC values for malignant lesions were (0.82 x10-^{3} mm^{2}/sec), while the mean ADC value in the control group was (1.58x10–^{3} mm^{2}/sec). Therefore ADC value of (1.04 x10-^{3} mm^{2}/sec) is a cut off between normal cervical tissue and malignant cervical lesion by sensitivity 95% and specificity 95 %. DWIs had elicited the same accuracy to Dynamic contrast-enhanced (DCE) sequences (95%) when added to the non-contrast MRI in the estimation of cancer cervix.

Conclusion: Our results proved that (DW–MRI) was significantly beneficial in terms of diagnostic performance that increases the radiologist's confidence in image interpretation. So it implies a non-invasive technique which can be used especially if contrast intake is avoided as in pregnancy. Thus, we suggest that DWI should be included in the routine pelvic MRI protocol. The ADC value in case of cervical carcinoma was significantly lower than in the normal cervical tissue. The ADC threshold of (1.04 x10^{-3} mm^{2}/sec) was a cut off value, which was detected when differentiating between cancer-affected and non-affected cervical tissues

Keywords: MRI, DW-MRI, cervical cancer.

INTRODUCTION

Cervical cancer is the third most common cancer in women worldwide and is diagnosed in over 12,000 women in the United States each year [(1)]. Most women with cervical cancer are diagnosed before the age of fifty. However; older women remain at risk. Cervical cancer is both preventable and, if identified early, treatable [(2)].

Cervical cancer is usually staged and managed on the basis of criteria proposed by the International Federation of Gynecology and Obstetrics (FIGO) which is based on clinical examination, rather than surgical findings. Early diagnosis and accurate staging of the disease is crucial in planning the optimal treatment strategy [(3)].

MRI is an ideal non-invasive technique and superior to other imaging modalities in the evaluation of pelvic abnormalities. The anatomical relation of the visceral organs, the differential zonal anatomy of the corpus uteri, and the cyclical endometrial changes during the menstrual cycle are well depicted with MRI [(4)].

Diffusion-weighted imaging (DWI) is one of the evolving imaging technologies. It carries the potential to improve tissue characterization when findings are interpreted together with conventional MR imaging sequences [(5)].

DW-MRI is a functional, non-invasive imaging technique which generates tissue contrast from differences in mobility of water molecules that occurs during an MR pulse sequence. Information regarding the integrity of cellular membranes and tissue cellularity can be obtained, so that DW-MRI can now be included in routine patient assessment [(6)]. DW-MRI enables the radiologist to move from morphological to functional assessment of diseases of the female pelvis [(7)], adding the possibility of discriminating between benign and malignant lesions. Cervical cancer has shown to have significantly lower ADC values as compared to normal cervical tissue [(8)].

DWI and ADC map help in differentiation of benign from malignant zones of cervix without exogenous contrast [(9)]. The measurement of ADC value in patient with cervical cancer is an

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important factor for assessing response to chemoradiotherapy, which may occur before conventional morphologic alterations [10].

AIM OF THE WORK

To evaluate the role of diffusion weighted magnetic resonance imaging (DW-MRI) in the diagnosis of cervical carcinoma, with pathological diagnosis was taken as the reference.

PATIENTS AND METHODS

Patients

This is a retrospective study that included 20 patients in whom cervical cancer had been suspected either clinically or by transvaginal U/S and confirmed by biopsy and 20 patients in whom cervical cancer had been not suspected and MRI was done because of other pelvic diseases as a control group.

The study was conducted in El-Demerdash Hospital. The patients were referred to the Radiology Department (Women's Imaging Unit) from the Gynecology Department for further MRI evaluation with DWIs. **The study was approved by the Ethics Board of Ain Shams University.**

Inclusion Criteria

Female patients ranging in age between 30 and 75 years, with clinical picture of pre-menopausal abnormal vaginal bleeding, vaginal discharge and post-menopausal bleeding and/or vaginal discharge, with histopathological diagnosis of cervical cancer.

Exclusion Criteria

- Patient with absolute contraindication to MR examination such as cardiac pacemaker, defibrillator, aneurysmal clipping, claustrophobia.
- Early pregnant patients.
- Patients who cannot receive contrast medium, as in cases of renal impairment or allergy to contrast medium.

Before MRI examination, all cases were subjected to:

1) Full history taking with a special emphasis on:
   - Age.
   - Parity.
   - Age of menarche.
   - Duration of menopause.
   - History of contraceptive therapy or replacement hormonal therapy
   - Previous gynecological problem or pervious curettage.
   - History of systemic disease or anticoagulant therapy.
2) Routine laboratory investigation for all patients including complete blood count, random blood sugar, renal functions test.

METHODS

Patient preparation

- Intravenous administration of an antispasmodic drug (Butylscopolamine) was given immediately before MR examination:
  - To reduce motion artifacts caused by peristalsis.
  - To attenuate uterine contractions.
- All patients were requested to fast for 6 hours before the examination.
- Moderate bladder filling would straighten an ante flexed uterus. Too much bladder filling may lead to restlessness during the course of the examination.
- No special bowel preparation was required.

Protocol of MR Imaging

MRI studies were performed on 1.5 T MRI (Achieva, Philips medical system), using body coil (phased array coil). All the patients were imaged in the supine position with head pointing to the magnet (HFS). The standard sequences included:

1. Conventional MRI

- Axial T1-weighted turbo spin-echo (TR/TE = 550/24 ms, slice thickness = 3 mm, intersection gap = 3 mm, FOV = 340×406 mm, matrix size = 284×266).
- Axial T2-weighted turbo spin-echo (TR/TE = 10055/115 ms, slice thickness = 3 mm, intersection gap = 0.3 mm, FOV = 340×406 mm, matrix size = 332×299).
- Sagittal T2-weighted turbo spin-echo (TR/TE = 3500/80 ms, slice thickness = 4.5 mm, intersection gap = 4.5 mm, FOV = 350×328 mm, matrix size = 320×162).
- Coronal T2-weighted turbo spin-echo (TR/TE = 8630/115 ms, slice thickness = 3 mm, intersection gap = 0.3 mm, FOV = 220×220 mm, matrix size = 216×150).

2. DW-MRI

DW-MRI was acquired in the axial plane immediately after the axial T2-weighted imaging and prior to administration of contrast medium by using a single shot echo-planar imaging sequence by using the following parameters: TR/TE = 1688/64 ms, slice thickness = 3 mm, intersection gap = 1.5 mm, FOV= 340×340 mm, matrix size = 112×100.

We acquired b values (0,400 and 800 s/mm^2) in the axial plane covering 20 slices to include the entire cervical cancer, using motion-probing gradients in three orthogonal axes.

ADC values were measured from DW images that were previously evaluated. In the patient group, measurements of ADC were automatically calculated by drawing the largest possible region of interest (ROI) with focus on solid component of the cervical cancer.

Equal-sized ROIs (each 5 mm^2) that excluded

- Macroscopic necrotic areas (fluid signal on T2).
- Large vessels and areas with susceptibility artifact caused by air-water interface.

The largest dimension of the tumor was measured. ROIs were set up 3 times and the average of them was used for each ADC value calculation in the malignant tumor and detected pelvic lymph nodes (L.Ns) (longitudinal diameter >10 mm). ADC value was usually expressed in ($\times 10^{-3}$) square millimeters per second.

3. Dynamic study

Dynamic study was performed immediately after manually injected Gd-DTPA at a dose of 0.1 mmol/kg of body weight (maximum 20 ml) at a rate of 2 ml/s, flushed with 20 ml of 0.9% saline solution in the antecubital vein. Images were acquired sequentially at 0,30,60,90 and 120 sec.

- Axial T1-weighted turbo-field-echo contrast-enhanced acquisition (TR/TE = 1632/7 ms, slice thickness = 3 mm, intersection gap = 3 mm, FOV = 340×403 mm, matrix size = 300×301).
- Sagittal T1-weighted turbo-field-echo contrast-enhanced acquisition (TR/TE = 906 / 7 ms, slice thickness = 3.5 mm, intersection gap = 3.5 mm, FOV = 250×329 mm, matrix size = 228×240).
- Coronal T1-weighted turbo-field-echo contrast-enhanced acquisition (TR/TE = 1523/ 7 ms, slice thickness = 3 mm, intersection gap = 3 mm, FOV = 220×220 mm, matrix size = 200×160).

Table (1): The sequences of MRI used in the study

Sequence	TR (msec.)	TE (msec.)	FOV (mm)	Matrix	Slice thickness (mm)	Slice gap (mm)
T1 axial	550	24	340x406	284x266	3	3
T2 axial	10055	115	340x406	332x299	3	0.3
T2 sagittal	3500	80	350x328	320x162	4.5	4.5
T2 coronal	8630	115	220x220	216x150	3	0.3
DWI *(b: 0, 400, 800) axial*	1688	64	340x340	112x100	3	1.5
T1 axial post contrast	1632	7	340x403	300x301	3	3
T1 sagittal post contrast	906	7	250x329	228x240	3.5	3.5
T1 coronal post contrast	1523	7	220x220	200x160	3	3

MRI Imaging analysis

MR images were analyzed for the following:

MRI appearance of the tumor

- Lesion size.
- Tumor signal intensity.
- Tumor enhancement.
- Involvement of other pelvic organs.
- Presence of infiltrated pelvic or para aortic lymph nodes.
- Presence of peritoneal deposits or omental deposits or ascites or hydronephrosis.

Staging Analysis

A combination of T2-weighted MR imaging sequence and dynamic post contrast MR imaging was used in staging of cervical carcinoma. The MRI staging followed the FIGO staging analysis.

Interpretation of DWI of cervical cancer:

Qualitative analysis

Regarding the signal intensity: benign mass demonstrates area of hypointensity on diffusion images with high signal in the corresponding ADC maps (facilitated), while malignant mass typically shows diffusion restriction, which is appeared as an area of hyperintensity on diffusion-weighted images and an area of low signal intensity on apparent diffusion coefficient (ADC) maps, avoiding reduced signal intensity areas which could indicate necrotic areas.

Quantitative analysis

Regarding the quantitative analysis of DWI, we generated the ADC map, and then we selected the ROI manually, which was then automatically calculated on the work station to get a mean ADC value providing a measurement in square millimeters per second (mm^2/sec) **(11).**

Pathological examination was performed for all patients to compare between cases diagnosed as malignant tumor by MRI-DWIs and pathological diagnosis.

Statistical analysis

Data were analyzed using Statistical Program for Social Science (SPSS) version 20.0. Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done

- Independent-samples t-test of significance was used when comparing between two means.
- Chi-square (X^2) test of significance was used in order to compare proportions between two qualitative parameters.
- Receiver operating characteristic (ROC curve) analysis was used to find out the overall predictivity of parameter in and to find out the best cut-off value with detection of sensitivity and specificity at this cut-off value.
  - Sensitivity = (true +ve)/ [(true +ve) + (false –ve)].
  - Specificity = (true –ve) / [(true –ve) + (false +ve)].
  - PPV = (true +ve) / [(true +ve) + (false +ve)].
  - NPV = (true –ve)/ [(true –ve) + (false –ve)].

- The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:
- Probability (P-value)
  - P-value <0.05 was considered significant.
  - P-value <0.001 was considered as highly significant.
  - P-value >0.05 was considered insignificant.

RESULTS

1. Patients characteristics

The included 20 patients ages ranged between 39-74 years (mean age: 55.5±11.4), 50% of patients were ≤55 years and 50% of them were >55 years.

Table (2): Age (years) distribution of the study group.

Age (years)	No.	%
≤55 years	10	50
>55 years	10	50
Total	20	100
Range	39-74	
Mean±SD	55.5±11.4	

Table (3): Presentation distribution of the study group.

Presentation	No.	%
Irregular vaginal bleeding	8	40.0%
Postmenopausal bleeding	9	45.0%
Vaginal discharge	3	15.0%
Total	20	100.0%

This table shows that the irregular vaginal bleeding (40%), postmenopausal bleeding (45%) and vaginal discharge (15%) were the presentation of the study group.

2. Lesions characteristics:

a. Size of tumor:

The cervical mass size was less than 6 cm in (20%) between (6-8 cm) in (65%) cases and more than 8 cm in (15%) cases.

Table (4): Size (cm) distribution of the study group.

Size (cm)	No.	%
<6cm	4	20.0%
6-8cm	13	65.0%
>8cm	3	15.0%
Total	20	100.0%

b. Signal intensity of tumor

On T1 weighted images, heterogeneous signal intensity was found in 2 cases (10%), isointense signal intensity was found in 5 cases (25%) and hypo signal intensity was found in 13 cases (65%).

Table (5): T1 distribution of the study group.

T1	No.	%
Heterogeneous	2	10.0%
Hypo	13	65.0%
Iso	5	25.0%
Total	20	100.0%

On T2 weighted images, heterogeneous signal intensity was found in 3 cases (15%), hyper signal intensity was found in 5 cases (25%), isointense signal intensity was found in 11 cases (55%) and hypo signal intensity was found in 1 case (5%).

Table (6): T2 distribution of the study group.

T2	No.	%
Heterogeneous	3	15.0%
Hyper	5	25.0%
Hypo	1	5.0%
Iso	11	55.0%
Total	20	100.0%

On T1 post contrast enhancement, heterogeneous enhancement was found in 17 cases (85%), homogenous enhancement was found in 3 cases (15%).

Table (7): T1 post contrast (DCE) distribution of the study group.

T1 post contrast(DCE)	No.	%
Heterogeneous enhancement	17	85.0%
Homogeneous enhancement	3	15.0%
Total	20	100.0%

Lesions in all cases were seen restricted on DWI, and ADC seen high on only one case (5%) proved to be chronic cervicitis on histopathology, however ADC was found to be low on the rest 19 cases proved to be cervical cancer on histopathology (95%).

Table (8): DWI distribution of the study group.

DWI	No.	%
Restricted	20	100.0%

Table (9): ADC distribution of the study group.

ADC	No.	%
High	1	5.0%
Low	19	95.0%
Total	20	100.0%

A total 19 cervical cancer lesions, 2 lesions were stage IB2 (%10), 1 lesions were stage IIA (%5), 11 lesions were stage IIB (55%), 1 lesions were stage IIIA (5%), 1 lesion was stage IIIB (5%), and 3 lesions were stage IVA (15%) of FIGO staging.

Table (10): Staging distribution of the study group

Staging	No.	%
IB2	2	10.0%
IIA	1	5.0%
IIB	11	55.0%
IIIA	1	5.0%
IIIB	1	5.0%
IVA	3	15.0%

On histopathological diagnosis, adenocarcinoma was diagnosed in 4 cases (20%), Squamous cell carcinoma was diagnosed in 15 cases (75%) and 1 (5%) case was diagnosed as chronic cervicitis in histopathology.

Table (11): Histopathological diagnosis distribution of the study group.

Histopathological diagnosis	No.	%
Adenocarcinoma	4	20.0%
Chronic cervicitis	1	5.0%
Squamous cell carcinoma	15	75.0%
Total	20	100.0%

By Dynamic Contrast Enhanced-MRI (DCE-MRI), 20 cases were diagnosed as malignant cervical lesions, the DWI-MRI also had the same results while pathological examination revealed 19 cases were diagnosed as malignant cervical lesions & 1 case was diagnosed as benign lesion.

Table (12): Correlation between the numbers of cases diagnosed as benign or malignant by the DCE-MR imaging, DWI and pathological diagnosis.

	Malignant	Benign	Total
DCE-MRI	20	0	20
DWI-MRI	20	0	20
Histopathological	19	1	20

Table (13): Comparison between patients and control according to ADC values.

ADC value ($x10^{-3}$)	Patients	Control	p-value
Mean±SD	0.82±0.18	1.58±0.21	<0.001
Range	0.6-1.45	1.24-2.05	

This table shows highly statistically significant difference between the groups according to ADC value. The mean ADC values for malignant lesions were ($0.82x10^{-3}$ mm^2/sec), while the mean ADC value in the control group is ($1.58x10^{-3}$ mm^2/sec).

The different ADC values elicited from the corresponding ADC maps were calculated and statistically significant difference was found between the malignant and benign tumors with p-value <0.001.

Table (14): Mean ADC value of different histopathological types.

Histopathological diagnosis	Range	Mean±SD
Adenocarcinoma	0.6-0.87	0.76±0.12
Squamous cell carcinoma	0.6-0.93	0.81±0.10

We reported no significant difference in ADC value between different histological subtypes of cervical cancer.

Table (15): Diagnostic Performance of ADC-value $x\ 10^{-3}$ in discrimination of patients and control.

Cut-off	Sensitivity	Specificity	PPV	NPV	Accuracy
1.04	95%	95%	95%	95%	96.4%

Receiver operating characteristics (ROC) curve was used to define the best cut off value of ADC-value *x* 10^{-3} which was 1.04, with sensitivity of 95%, specificity of 95%, positive predictive value (PPV) of 95%, negative predictive value (NPV) of 95%, and with diagnostic accuracy of 96.4%.

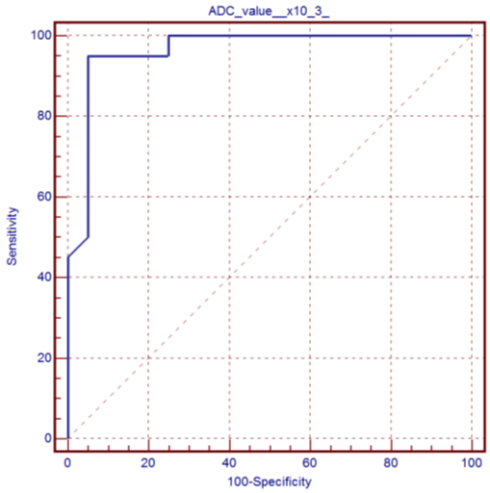

Figure (1): Receiver-operating characteristic (ROC) curve for prediction of malignant using the ADC value.

Table (16): Correlation between the accuracy of MRI-DWI, DCE-MRI and pathology staging results in cervical carcinoma.

Cervical Carcinoma		Accuracy
DWI [TP]	19	95%
DCE [TP]	19	95%
Histopathology [TP]	20	100%

Each of the DWI and DCE-MRI sequences when added to the non-contrast MRI sequences in the estimation of cancer cervix had elicited the same accuracy.

So, DWI was true positive in 19 cases (diagnosed to be malignant and confirmed by histopathology), and was false positive in 1 case (diagnosed to be malignant and proven to be benign chronic cervicitis by histopathology). Subsequently, the diagnostic accuracy of diffusion-weighted MRI for detection of cervical cancer was 95%, compared to (DCE-MRI) displayed the same accuracy 95%.

However, when ADC value was added to interpretation all the 19 cervical cancer cases were diagnosed to be malignant depending on low ADC value (true positive), and the chronic cervicitis case was diagnosed to be benign depending on high ADC value (true negative), and this increased the diagnostic accuracy to 100%.

A 47 year old female patient complaining of irregular vaginal bleeding.

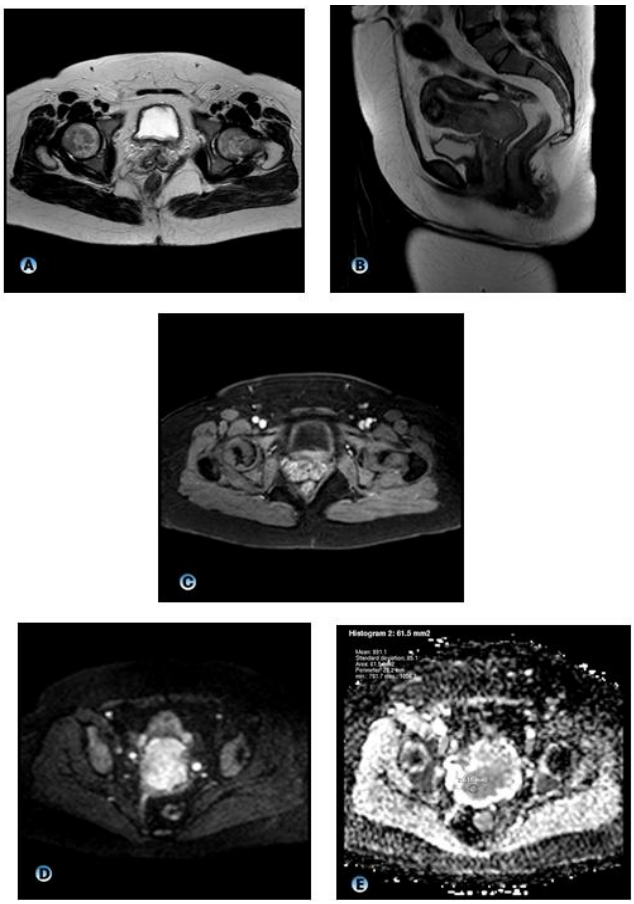

Figure (2): (a) axial T2 WI **(b)** sagittal T2 WI **(c)** axial post contrast T1 WI, A cervical mass is noted measuring 5.2 x 6.3 cm exhibiting iso to high intensity in T2 with heterogenous post contrast enhancement. It shows high signal on axial DWI **(d)** with low signal on the corresponding axial ADC maps **(e)**. ADC value of the tumor was 0.92 x 10 -3mm2/s.

Conventional MRI/DWI based diagnosis

A malignant looking large cervical mass stage IIIB.

Pathological diagnosis

Cervical squamous cell carcinoma.

DISCUSSION

Cervical cancer is the third most common cancer in women worldwide and is diagnosed in over 12,000 women in the United States each year [(1)].

Cervical cancer is usually staged and managed on the basis of criteria proposed by the International Federation of Gynecology and Obstetrics (FIGO) [(3)].

FIGO staging system is inadequate in the evaluation of prognostic factors such as tumor volume and nodal status. MRI is an excellent modality for depicting invasive cervical cancer for planning of the treatment; it can provide objective measurement of:

- Tumor size
- Depth of cervical invasion
- Extent of locoregional spread of cervical cancer [(12)].

In our study, the study group that included 20 patients in whom cervical cancer had been suspected either clinically or by transvaginal U/S and confirmed by biopsy and 20 patients in whom cervical cancer had been not suspected and MRI was done because of other pelvic diseases as a control group.

Pelvic MR with DWI were done for all patients and DCE- MR was done for all patients.

The clinical presentations of women with cervical cancer are irregular vaginal bleeding, vaginal discomfort, vaginal discharge and dysuria [(13)].

In our study, the clinical presentations were irregular vaginal bleeding in 8 (40%), postmenopausal bleeding in 9 (45%) and vaginal discharge in 3 (15%).

Cervical carcinoma is hypo-isointense signal in T1 compared with pelvic muscles and hyperintense

in T2 relative to the low signal of the cervical stroma [14].

In our study, heterogeneous T1 signal intensity was seen in 2 (10%) cases, low T1 signal intensity in 13 (65%) cases, and isointense T1 signal intensity in 5 (25%) cases.

Heterogeneous T2 signal intensity was seen in 3 (15%) cases, low T2 signal intensity in 1 (5%) cases, isointense T2 signal intensity in 11 (55%) and high T2 signal intensity in 5 (25%) cases.

On contrast enhanced T1 WI, cervical cancer presents as a high signal relative to the low signal of the cervical stroma [15].

However, the use of gadolinium-based contrast media is limited in patients with:

- Kidney impairment (patients with glomerular filtration rates <30 ml/min, patients with acute kidney insufficiency and patients on dialysis).
- Cases of allergy requiring medical treatment,
- Pregnancy
- Patient refusal [16].

In our study, heterogeneous post contrast enhancement was seen in (17/20, 85%) and homogenous post contrast enhancement was seen in (3/20, 15%).

Each of the DWI and DCE-MRI sequences when added to the non-contrast MRI sequences in the evaluation of cervical carcinoma had resulted the same sensitivity value (100%), specificity (50%) and accuracy (97%).

Malignant cervical tissue demonstrates diffusion restriction and hence low ADC values when compared to normal tissue. DWI and ADC maps allow discrimination of benign from malignant zones of cervix with high sensitivity and specificity [9].

Our result agreed with a study conducted by Kuang et al. [17] to determine diagnostic accuracy of diffusion-weighted MRI for differentiation of cervical cancer and benign cervical lesions at 3.0T: Comparison with routine MRI and dynamic contrast-enhanced MRI. The study included 75 cervical carcinoma, 25 cervical leiomyoma, and 22 cervical polyps. In their results, DWI-routine MRI was significantly better than routine MRI and obtained high accuracy 95%; the diagnostic performance was not significantly different between DWI-MRI and DCE-MRI with same accuracy. In their results, DWI-MRI displayed accuracy of 95%; compared with that of DCE-MRI (96%). In our study, the accuracy of DWI-MRI was the same as the accuracy of DCE-MRI which is 95%.

In a study carried out by Kilickesmez et al. [18] for evaluation 87 patients (mean age 53 years) with benign and malignant uterine pathologies, the accuracy of DWI was 94.94% and this result agreed with the result of our study, which was 95%.

Regarding the DWI with apparent diffusion coefficient (ADC) measurement gives quantitative data, which reflects cellularity of the tissue, and may help to discriminate relatively hypercellular cervical cancer from benign cervical lesions and normal cervix, in which abundant cystic components and edematous tissue may increase the extracellular space and increase the ADC. The mean ADC value of cervical carcinoma in our study was ($0.82x10^{-3}$ mm^2/sec). This was compatible with Hoogendam et al. [9] where the mean ADC of uterine cervical cancer of 20 cases was ($0.86\ X10^{-3} mm^2$/sec).

In study carried out by **Demirbaş *et al*.** [19] for evaluating 25 patients who had cervical cancer proved histopathologically, and 20 patients with otherwise normal uterus, the mean ADC values of cervical cancer ($0.96\pm0.15\ x10^{-3}$ mm^2/sec) were statistically lower than that of the control group ($1.65\pm0.15x10^{-3}$ mm^2/sec). According to histopathologic subtypes there was no significant difference between mean ADC values of squamous cell cancer and adenocarcinoma, which was the same as our results in which the mean ADC values of cervical cancer ($0.82x10^{-3}$ mm^2/sec) were statistically lower than that of the control group ($1.58x10^{-3}$ mm^2/sec), with no significant difference between mean ADC values of different histological subtypes.

In a study conducted by **Kuang *et al*.** [6] to evaluate the potential value of apparent diffusion coefficient (ADC) measurement in the assessment of cervical cancer on 112 patients with cervical cancer and 67 control subjects underwent DWI in addition to routine MR imaging at 3.0-T MRI, the ADCs of cervical cancer were significantly lower than those of normal cervix ($P = 0.001$) this result agreed with our study.

In a study carried out by **McVeigh *et al.*** [20], diffusion-weighted MRI was performed in 47 patients with cervical carcinoma and 26 normal controls on a 1.5-T system with a b-value of 600 s/mm2, the mean ADC (mADC) of cervical carcinomas ($0.89\times10-3$ mm2/sec) was significantly lower than normal cervix ($1.6\times10-3$ mm2/sec) ($P<0.001$). This is compatible with our results; where the mean ADC for malignant lesions was (0.82x10-3 mm2/sec), mean ADC for normal cervical tissue was (1.58x10–3

mm2/sec). The difference between the malignant and normal tissues was statistically significant with p-value <0.001. Also another study conducted by Liu et al. (21) in which 42 patients with histopathologically proven uterine cervical cancer and 15 patients with uterine leiomyomas underwent MR examinations using a 1.5-T, demonstrated similar result to our result. They stated that the mean ADC value of cervical cancer (0.88±0.15 x 10-3 mm2/sec) was lower than in normal uterine tissue (1.5±0.15 x 10-3 mm2/sec). ADC value was statistically different (P = 0.001) between normal and cancerous tissue in the uterine cervix, with no significant difference in ADC between different histological subtypes.

In a prospective study carried out by Payne et al. [(22)] statistically significant difference was observed in ADC values of normal and malignant cervix (P <0.001) with diagnostic accuracy of DWI 99% which is compatible to our resulted diagnostic accuracy of DWI 95%.

Our study agreed with a study carried out by **Chen *et al.*** [(8)], where 33 patients with cervical carcinoma and 20 patients with other pelvic abnormalities underwent diffusion-weighted imaging (DWI) in addition to routine MR imaging. The mean ADC value of cervical carcinoma (0.93×10^{-3} mm^2/sec) was significantly lower than that of normal cervical tissue (1.44×10^{-3} mm^2/sec) (P<0.001).

Regarding to mean ADC cut-off values used to determine the level of ADC value for detecting cancer lesions, in our study the mean ADC cut-off value was (1.04×10^{-3} mm^2 /sec), which was compatible with Chen et al. [(23)]; in their study that included 26 patients, with untreated uterine cervical carcinoma, received preoperative conventional MR and DWI scans. DWI scans were also obtained in 30 healthy volunteers. Measurements of apparent diffusion coefficient (ADC) were made on scans of normal uterine cervix and uterine cervical carcinoma. Mean ADC value of uterine cervical carcinoma was significantly lower than that of normal uterine cervix (P = 0.001), with an ADC value of 1.28×10^{-3} mm^2/sec was used as the threshold and the accuracy is 98%.

CONCLUSION

Our results proved that (DW–MRI) was significantly beneficial in terms of diagnostic performance that increases the radiologist's confidence in image interpretation. So it implies a non-invasive technique which can be used especially if contrast intake is avoided as in pregnancy.

Thus, we suggest that DWI should be included in the routine pelvic MRI protocol.

- The ADC value in case of cervical carcinoma was significantly lower than in the normal cervical tissue.
- The ADC threshold of **(1.04×10^{-3} mm^2/sec)** is a cut off value was detected when differentiating between cancer-affected and non-affected cervical tissues.

RECOMMENDATIONS

- Further study with larger number of patients is recommended.

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