Role of DWI (Diffusion-Weighted Images) in diagnosis of Uterine Focal Lesions

Sondos Elsayed Ahmed Elsayed, Ghada Kamal Gouhar, Enas Mahmoud Hamed & Mohamed Ibrahim Amin

1Department of Radiodiagnosis Faculty of medicine, Zagazig University

ABSTRACT

Background: MRI is considered the most accurate imaging modality for evaluating uterine masses secondary to its excellent soft-tissue delineation. Conventional MRI provides excellent anatomical information of the uterus; however, the morphological appearances till may not differentiate some benign and malignant uterine lesions. When combined with conventional MRI, DWI provides functional information, becomes a complementary diagnostic tool for the uterus, and gives more information for the differentiation and extension of benign and malignant lesions.

Aim of The Study: This study aims to highlight the role of MRI with diffusion weighted (DW) images in better diagnosis of uterine focal lesions, especially in differentiation between benign and malignant masses and initial staging of known malignancies.

Methodology: This study included 34 patients with uterine focal lesions, 18 of them were postmenopausal, and 16 were premenopausal. Twenty-two lesions proved to be benign lesions (15 leiomyomas, two uterine focal adenomyosis, three endometrial polyps, and two endometrial hyperplasia). 12 lesions proved to be malignant (7 endometrial carcinomas and five cervical cancer).

Results: Quantitative measurements of the ADC value are significant in endometrial and cervical lesions as malignant endometrial and cervical lesions have significantly low ADC values in comparison with benign lesions.

Conclusion: The present study suggests that, in addition to conventional MRI features, DW imaging provided an additional tool for distinguishing uterine benign focal lesions from malignant lesions.

Keywords: MRI; Diffusion-Weighted; Focal Lesions.

INTRODUCTION

Uterine masses as part of female pelvic masses have a broad differential diagnosis, including benign and malignant neoplasms and non-neoplastic diseases.

Ultrasound (US) is often the first-line imaging modality for evaluating uterine masses; however, ultra-sound may be limited by poor acoustic windows and poor depth of penetration, preventing characterization of some groups. Computed tomography (CT) is limited in the pelvis by a lack of soft-tissue contrast. Magnetic resonance imaging (MRI), provides excellent contrast resolution, resulting in accurate tissue characterization and improved anatomic delineation.

Diffusion-weighted imaging (DWI) can provide excellent tissue contrast based on molecular diffusion and may be able to demonstrate malignant tumors. Quantitative measurement of the
apparent diffusion coefficient (ADC) may be valuable in distinguishing between malignant and benign lesions.

DWI is not only helpful in differentiating benign from malignant processes, but it can also be used to assess metastatic lesions, peritoneal dissemination, possible tumor recurrence, and treatment response. It does not require an injection of a gadolinium-based contrast agent, so it can be used in patients with renal insufficiency or contrast material allergy.

PATIENTS & METHODS

This study included 34 patients with a uterine focal lesion. The Patient’s age ranged from 25 to 87 years old with the mean age ± 49.6 years. All patients were referred from the Obstetrics and Gynecology department to the Radiodiagnosis department at Zagazig University Hospital from August 2020 to September 2021.

Ethics committee approvals, in addition to informed written consent, were obtained from all patients.

Inclusion criteria:
We included patients that clinically suspected to had uterine focal lesion as patients with abnormal vaginal bleeding or radiologically as those with abnormally thickened endometrium seen by U/S exam or had undergone CT that demonstrated uterine focal lesion.

Exclusion criteria:
We excluded all patients with absolute contraindication to MRI (patients with cardiac pacemaker’s prosthetic heart valves, cochlear implants, or any metallic implants), patients with claustrophobia, and patients who did not give a consent to be a part of the study.

Patients were included in the study are subject to the following:

1- Full history taking: Age, Parity, Time of menopause, history of gynecological troubles or operations, and Positive family history of gynecological malignancy.

2- Gynecological examination.

3- Ultrasound examination: All patients had undergone preliminary transvaginal ultrasound approach using 7-8MHz endocavity probe. Color Doppler was superimposed on masses to detect vascularity. The examination was performed on a high-resolution Ultrasonography machine (Siemens’ acuson x300).

4- MRI examination: MRI was performed on a 1.5-Tesla MR imaging unit (Philips Achieva, Nederland) using pelvic phased array torso coil (12 channels). All the patients were imaged in the supine position. Patients fasting for 3 hours prior to exam was asked. Intravenous administration of an antispasmodic drug (10 mg of [Visceralgine; Organon, Livron, France]) was given 10 minutes before MR imaging to reduce bowel peristalsis.

MR Imaging protocol:

Localizer images in axial, coronal and Sagittal planes. Fast spin-echo (FSE) T1-weighted images (TR 497 ms, TE 12 ms, matrix 320 × 512, slice-thickness: 4–5 mm with an interslice gap of 1–2 mm, FOV 250 mm, and a flip angle of 90) in axial and Sagittal plane. Fast spin-echo (FSE) T2-weighted images (TR 3.3 s, TE 90 ms, matrix 256 × 512, slice-thickness: 4–5 mm with an interslice gap of 1–2 mm, FOV 250 mm a flip angle of 90) in axial, coronal and Sagittal plane.

Diffusion-weighted magnetic resonance imaging: using a Single Shot spin echo-planar sequence with free-breathing; the following parameters were used (TR 2.8 s, TE 72, matrix 512 × 512, slice-thickness 4 mm with an inter- slice gap of 1 mm and FOV 300 mm) were acquired on axial plane. The diffusion sensitizing gradients were applied using a b factor of 0, 50, 500,
and 1000 s/mm\(^2\) in each Patient. ADC maps were automatically generated for all DW images, and ADC values were measured at b-value: 1000 s/mm\(^2\).

**MR Imaging analysis:**

MR images were analyzed for the following: the size of the tumor (the greatest diameter), site (myometrium, endometrium, or cervix), the signal intensity of the tumor on T1- and T2-weighted and DW images, the tumor margin, parametrial invasion, Presence of ascites, Presence of infiltrated pelvic or para-aortic lymph nodes, involvement of other pelvic organs and Presence of peritoneal and omentum deposit.

*In myometrial lesions, the following findings were observed:*

Size; location (submucosal, intramural, or subserosal), shape, outline, endometrial invasion, fibrous core (low signal intensity stripe or center on T2WI), intra-tumoral cysts (smooth-walled cystic structure of high T2 signal intensity within the mass), necrosis on the mass (irregular high T2 signal intensity within the mass) or hemorrhage within the mass and integrity of the parametrium.

*In endometrial lesions, the following findings were observed:*

Presence of the mass (any focal or diffuse abnormalities with thickening of the endometrium), myometrial invasion, fibrous core (low signal intensity stripe or center on T2WI), intra-tumoral cysts (smooth-walled cystic structure of high T2 signal intensity within the mass), necrosis on the mass (irregular high T2 signal intensity within the mass), and integrity of the parametrium.

*In cervical lesions, the following findings were observed:*

Zonal origin of the lesion (mucosal or stromal), size, signal intensity, Presence of cysts or necrosis within the mass, and integrity of the parametrium. Uterine tri-zonal anatomy was also observed.

**Qualitative Assessment of DWI and ADC Map:**

All DW MR Images were analyzed. DW MR Images were analyzed qualitatively by focusing on the signal intensity of the uterine focal lesions, which was classified by using visual assessment of hypo intensity, hyperintensity, or mixed-signal in comparison with the normal high signal intensity of the endometrium (We used the endometrium as the reference for evaluating the SI on DW images because the endometrium is the only structure delineated as the hyperintense area on DW images among the pelvic organs.). The SI on DW images was judged as high when it showed an equal or higher signal than the endometrium. DW images with a low b-value of 0,50 and 100 s/mm\(^2\) were utilized only to calculate the ADC values but not evaluated because of a more negligible diffusion effect and a more significant T2 shine-through effect. The abnormal regions on the DWI and ADC map were outlined by using the conventional images as a guide.

Patients who had high signal intensity on DWI and low signal intensity on ADC images we considered as diffusion positive. At the same time, the Patient had high signal intensity on ADC images with either DWI of high or low signal intensity considered as diffusion negative.

True positives were patients who had diffusion-positive uterine focal lesions, and histopathology proved to have uterine malignancy. True negatives were those patients with uterine focal lesions, which were negative on both diffusion MR imaging and histopathology.

False-positive were patients who had diffusion-positive uterine focal lesions, but the histopathology reported benign findings. False negative were those patients that had diffusion negatives uterine focal lesions, but histopathology reported that malignant findings.
Benign tumors show no signal on DWI, while malignant ones show high signal intensity on high b values with the corresponding lowering of the signal in the corresponding ADC maps.

Quantitative Assessment of ADC:

The ADC values were automatically calculated for quantitative analysis by placing the regions of interest (ROI) on ADC maps at a workstation with standard software (Diffusion Calculation, Philips Medical Systems). The circular ROI was placed to be as large as possible within the confines of the tumors, without involving artifacts from tumor/air interface or blood flow. For heterogeneous lesions, special attention was paid not to involve necrosis or cystic space within the lesion by referring to conventional T1- and T2-weighted images. The ADC values were measured three times in different regions for each tumor, and the measurements were averaged. The ADC values were expressed in 10-3 mm2/sec.

Pathological Correlation:

The Diffusion-weighted MRI finding was correlated by histopathological assessment as a gold standard.

Statistical Analysis:

All statistical calculations were done using SPSS (Statistical Package for the Social Science, version 19). Data were statistically described in terms of range, mean, standard deviation, frequencies (number of cases), and percentages when appropriate.

Sensitivity, specificity, accuracy, positive predictive value, and negative predictive value for conventional MRI and diffusion-weighted imaging were calculated separately for each parameter.

RESULTS

Our study included 34 patients with uterine focal lesions. Their ages ranged from 25 to 87 years with the mean age ±49.6 year, 18 patients were postmenopausal and 16 were premenopausal.

The most clinical symptom was irregular uterine bleeding seen in about 29.41% of patients, followed by...

The 34 patients included in this study, were classified according to their lesions histopathological results; Benign group (22 lesions; 64.7%) and malignant group (12 lesions; 35.3%). The most common benign lesion was uterine leiomyoma (15/22) while the most common malignant lesion was endometrial carcinoma (7/12), Followed by cervical carcinoma (5/12) (table. 1).

Table (1): Histopathological results of the all studied lesions (no=34).

<table>
<thead>
<tr>
<th>Lesions</th>
<th>No.</th>
<th>Percent %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A) Benign lesions:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Leiomyoma</td>
<td>15</td>
<td>44.117%</td>
</tr>
<tr>
<td>2) Endometrial hyperplasia</td>
<td>2</td>
<td>5.882 %</td>
</tr>
<tr>
<td>3) Endometrial polyp</td>
<td>3</td>
<td>8.823 %</td>
</tr>
</tbody>
</table>

Conventional MRI findings in the benign uterine focal lesions in our study (Table 2).
Twenty-two benign uterine focal lesions were included in our study.

**Leiomyoma, (no=15):**

Ordinary leiomyomas (10 lesions), seen as well define mass lesion of low SI on T1- and T2-weighted images in all lesions. Degenerated leiomyomas (5 lesions), seen as well define (4) and partially ill define (1) lesion of low SI on T1- weighted images with areas of high SI on T2-weighted images in all lesions.

**Uterine focal adenomyosis, (no=2):**

Uterine focal adenomyosis, seen as localized irregular ill-defined myometrial lesion of low signal SI on T1- and T2-weighted images, associated with bright foci on T2-weighted images and increased thickness of the junctional zone.

**Endometrial polyp, (no=3):**

Endometrial polyps seen as endometrial lesion with low SI onT1- weighted images and intermediate high SI on T2-weighted images in all lesions.

**Endometrial hyperplasia, (no=2):**

Endometrial hyperplasia seen as diffuse widening of the endometrium of low SI on T1-weighted images and homogenous high SI on T2-weighted images with preserved junctional zone.

Table (2): shows conventional MRI findings in the all benign uterine focal lesions (no=22).

<table>
<thead>
<tr>
<th>Lesions</th>
<th>Number</th>
<th>T1WI</th>
<th>T2WI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary leiomyoma.</td>
<td>10</td>
<td>low SI</td>
<td>low SI</td>
</tr>
<tr>
<td>Degenerated leiomyoma.</td>
<td>5</td>
<td>low SI</td>
<td>low SI with areas of high SI</td>
</tr>
<tr>
<td>Uterine focal adenomyosis.</td>
<td>2</td>
<td>low SI</td>
<td>low SI with bright foci</td>
</tr>
<tr>
<td>Endometrial Polyp.</td>
<td>3</td>
<td>Low SI</td>
<td>Intermediate high SI</td>
</tr>
<tr>
<td>Endometrial Hyperplasia.</td>
<td>2</td>
<td>Low SI</td>
<td>Homogenous high SI</td>
</tr>
</tbody>
</table>

Findings of DWI and ADC map in the benign uterine focal lesions in our study (Table 3).

In our study all benign uterine focal lesions (22 lesions) are diffusion negative (facilitated diffusion).
the ADC value (10^-3 m^2/sec) of the ordinary leiomyomas ranged from 0.669 to 0.863 with mean ADC value about (0.773 ± 0.27), the ADC value (10^-3 m^2/sec) of the degenerated leiomyomas ranged from 1.173 to 1.740 with mean ADC value about (1.443 ± 0.11), the ADC value (10^-3 m^2/sec) of the uterine focal adenomyosis ranged from 0.865 to 0.923 with mean ADC value about (0.894 ± 0.15), the ADC value (10^-3 m^2/sec) of the endometrial polyp ranged from 1.865 to 1.924 with mean ADC value about (1.865 ± 0.18), the ADC value (10^-3 m^2/sec) of the endometrial hyperplasia ranged from 1.561 to 1.891 with mean ADC value about (1.726 ± 0.25).

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of lesions</th>
<th>DWI (b1000) findings</th>
<th>ADC map findings</th>
<th>ADC (range, (10^-3 m^2/sec) a b value=1000)</th>
<th>Mean ADC [x±SD] 10^-3 m^2/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary leiomyoma</td>
<td>10</td>
<td>Low SI</td>
<td>Low SI</td>
<td>0.669 to 0.863</td>
<td>0.773 ± 0.27</td>
</tr>
<tr>
<td>Degenerated leiomyoma</td>
<td>5</td>
<td>Low SI</td>
<td>High SI</td>
<td>1.173 to 1.740</td>
<td>1.443 ± 0.11</td>
</tr>
<tr>
<td>Uterine focal adenomyosis</td>
<td>2</td>
<td>Low SI</td>
<td>High SI</td>
<td>0.865 to 0.923</td>
<td>0.894 ± 0.15</td>
</tr>
<tr>
<td>Endometrial polyp</td>
<td>3</td>
<td>Low SI</td>
<td>High SI</td>
<td>1.816 to 1.924</td>
<td>1.865 ± 0.18</td>
</tr>
<tr>
<td>Endometrial hyperplasia</td>
<td>1</td>
<td>Low SI</td>
<td>High SI</td>
<td>1.561 to 1.891</td>
<td>1.865 ± 0.18</td>
</tr>
</tbody>
</table>

Conventional MRI findings in the malignant uterine focal lesions in our study (Table 4).

Twelve malignant uterine focal lesions were included in our study.

**Endometrial carcinoma (no=7):**

Endometrial carcinoma seen as ill define endometrial mass lesion of low SI on T1-weighted images and homogenous (2 lesions) or heterogenous (5 lesions) intermediate SI on T2-weighted images. The junctional zone was infiltrated in all lesions either partially or totally as interruption of its normal low T2 SI. Less than 50% of the depth of the myometrium was invaded in 2 lesions, while more than 50% of the depth of the myometrium was infiltrated in 5 lesions. Two lesions showed cervical stromal invasion and two lesions showed parametrial infiltration. So we had 7 lesions of endometrial carcinoma, 2 lesions were diagnosed as stage IA, 1 lesion was diagnosed as stage IB, 2 lesions were diagnosed as stage II and 2 lesions were diagnosed as stage IIIB. There are no lesions with enlarged pelvic lymph nodes or bladder or bowel mucosa invasion.

**Cervical carcinoma (no=5):**

Cervical cancer appears as cervical soft tissue mass lesion of low SI on T1- and moderately hyper intense SI on T2-weighted images. Stromal invasion was seen in all lesions, infiltration of the upper vagina was seen in 3 lesions and infiltration of the lower vagina was identified in 1 lesion. Parametrial infiltration was seen in 2 lesions, 1 lesion show infiltration of the bladder
and rectal mucosa and associated with enlarged pelvic lymph nodes. So we had 5 lesions of cervical carcinoma, 2 lesions were diagnosed as stage IIA, 1 lesion was diagnosed as stage IIB, 1 lesion was diagnosed as stage IIIA and 1 lesion was diagnosed as stage IVA.

Table (4): shows conventional MRI findings in the malignant uterine focal lesions (no=12).

<table>
<thead>
<tr>
<th>Lesions</th>
<th>Number</th>
<th>T1WI</th>
<th>T2WI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endometrial carcinoma</td>
<td>2</td>
<td>Low SI</td>
<td>Homogenous intermediate SI</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Low SI</td>
<td>Heterogenous intermediate SI</td>
</tr>
<tr>
<td>Cervical carcinoma</td>
<td>5</td>
<td>Low SI</td>
<td>Moderate hyper intense SI</td>
</tr>
</tbody>
</table>

Findings of DWI and ADC map in the studied malignant uterine focal lesions (Table 5).

In our study 12 malignant uterine lesions were included; 11 lesions of the malignant uterine lesions are diffusion positive (restricted diffusion) being with high signal intensity at DWI with high b value (b1000) and with low signal intensity at ADC images, only one malignant uterine focal lesion (endometrial carcinoma) is diffusion negative (facilitated diffusion) being with intermediate signal intensity at DWI with high b value (b1000) and with high signal intensity at ADC images.

the ADC value (10-3 m2 /sec) of the endometrial carcinoma ranged from 0.636 to 1.341 with mean ADC value about (0.885 ± 0.24), the ADC value (10-3 m2 /sec) of the cervical carcinoma ranged from 0.643 to 0.847 with mean ADC value about (0.767 ± 0.22)

Table (5): shows findings of DWI, ADC map, ADC value and Mean ADC value in the studied malignant uterine lesions (no=12).

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of patients</th>
<th>DWI (b1000) findings</th>
<th>ADC mapADC (range, (10-3Mean ADC [x±SD] 10- m2/sec) b value=1000 3 m2 /sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endometrial carcinoma</td>
<td>High SI</td>
<td>Low SI</td>
<td>0.636 to 1.341 0.885 ± 0.24</td>
</tr>
<tr>
<td></td>
<td>Intermediate SI</td>
<td>High SI</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low SI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cervical carcinoma</td>
<td>High SI</td>
<td>Low SI</td>
<td>0.643 to 0.847 0.767 ± 0.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- Sensitivity = (No of true +Ve/ No. of all malignant lesions i.e. true +Ve + false – Ve) x100 = 11/12 x100 = 91.6%.

- Specificity = (No of true -Ve/ No. Of all benign lesions i.e. no of true -Ve +No of false +Ve) x100 = 22/22 x100 = 100%.

- Positive predictive value (PPV) = (No of true +Ve/ No of true +Ve +No of false +Ve) x100 = 11/11 x100 = 100%.

- Negative predictive value (NPV) = (No of true -Ve/ No of true -Ve +No of false - Ve) x100 = 22/23 x100 = 95.6%.

- Accuracy = (No of true +Ve + No of true -Ve / No. of all lesions) x100 = 33/34 x100 = 97.05%.

Figure 1. Case 1, Forty years old female patient, the clinical presentation is dysmenorrhea.

Regarding case 1, MRI pelvis revealed Axial T1WI (a) reveals iso intense focal lesion at the endometrium of the uterus & in Sagittal T2 WI (b), the lesion appeared more well define and showed intense hypo signals with areas of high signals inside. DWI at three b-values (0(c), 500(d), and 1000(e)) revealed reduction of the lesions signals with increasing b-values (benign feature). At ADC map (f) the lesion exhibits heterogeneous signal with averaging ADC value 1.173 x10^-3 mm^2 /sec.

Radiologic diagnosis: matched with benign featuring lesion likely degenerated sub mucosal leiomyoma.

Final histopathology diagnosis: Submucosal leiomyoma with myxoid degeneration.
Figure 2. Case 2, 68 years old, female patient, clinical presentation: post-menopausal bleeding.

Regarding case 2, MRI pelvis revealed Axial T1WI (a) reveals bulky uterus with iso to hypointense focal lesion occupying the endometrium & in Sagittal T2 WI (b) the lesion appeared as an endometrial mass of high SI with the area of low SI inside and infiltration of the junction zone and affection of less than 50 % of the myometrium. DWI at 2 b-values (0) (c) and 1000(d) revealed lesions of the intermediate signal at a high b value. At ADC map (e) the lesion exhibits hyperintense signal (benign feature), with ADC value averaging 1.341 x10^-3 mm²/sec. Radiologic diagnosis: matched with endometrial mass lesion with suspicious criteria at conventional MRI and benign features at DWI and ADC images.

Final histopathology diagnosis: Well differentiated endometrial carcinoma.

DISCUSSION

Uterine masses as part of female pelvic masses have a broad differential diagnosis, including benign and malignant neoplasms and non-neoplastic diseases. Benign uterine lesions such as leiomyoma, endometrial or cervical polyp, endometrial hyperplasia, and malignant lesions such as uterine sarcomas, endometrial carcinoma, and cervical carcinoma.

Recently, imaging has become crucial for detecting and staging gynecologic neoplasm for optimal management to minimize morbidity and mortality. MRI is considered a promising modality for gynecologic disease evaluation. The role of MRI in uterine malignancies has significantly increased during the past two decades. MRI is a better tool than CT for evaluating and staging pelvic malignant tumors.

Diffusion-weighted magnetic resonance imaging is a functional imaging technique whose contrast derives from the random motion of water molecules within tissues. Although its use in intracranial imaging has been established for several years, Problems with motion and susceptibility artifacts have limited its application in abdominal and pelvic imaging. However, the development of new imaging techniques, particularly novel methods of data acquisition and parallel imaging, has allowed much faster data acquisition with fewer artifacts, resulting in significant improvement in image quality in body applications. Because image contrast is derived from inherent differences in the restriction of the movement of water molecules, no exogenous contrast medium administration is required so that diffusion-weighted sequences can now be included in routine pelvic assessment.

When combined with conventional MRI, DWI provides functional information, becomes a complementary diagnostic tool for the uterus, and gives more information for the differentiation and extension of benign and malignant lesions. DWMR imaging enables qualitative and quantitative assessment of tissue diffusivity (apparent diffusion coefficient) without the use of gadolinium chelates, which makes it a highly attractive technique, particularly in patients with severe renal dysfunction at risk for nephrogenic systemic fibrosis.

Diffusion coefficients in DWI are reflected in the apparent diffusion coefficient (ADC): calculation of ADC is made for each voxel of an image and can be displayed as a parametric (ADC) map. ADC measurements are then recorded for a given region by drawing regions of interest (ROIs) on the ADC map. The measured ADC values are representative of the hydration and metabolic status of the imaged tissues. Malignant lesions mostly display markedly high
signal intensity on the DWI, with significantly lower ADC value due to water diffusion restriction in high cellular tissues of the malignant lesions $^9,^{12}$.

This study included 34 patients with uterine focal lesions. Their ages ranged from 25 to 87 years, with the mean age ± 49.6 years. The studied 34 lesions were divided into benign and malignant lesions, with uterine leiomyomas the most common benign uterine lesion (15/22 lesions) followed by endometrial polyp (3/22 lesions), and endometrial carcinoma was the commonest malignant lesion (7/12 lesions) followed by cervical carcinoma (5/12 lesions). This agrees with Kilickesmez O et al., who stated that according to their study, leiomyomas is the most common benign lesion of the uterus. At the same time, endometrial carcinoma is the most common malignant lesion, followed by cervical cancer $^{13}$.

In our work, patient age was significantly higher in malignant lesions (50 to 87 years with the mean age ± 62.3 years) than in benign lesions (25 to 63 years with the mean age ± 45.8 years). This matched with Thomassin-Naggara, et al. results which found that patient age was significantly higher in uncertain or malignant masses (mean, 57.2 [range = 40.5–81.7]) than in benign masses (40.2 [range = 23.3–69.5]) $^{14}$.

In our study, uterine leiomyomas were classified into ordinary leiomyomas (10 lesions) and degenerated leiomyomas (5 lesions) & as regarding conventional MRI results, 'The all ordinary leiomyomas lesions showed low SI on T1- and T2- weighted images while degenerated leiomyomas showed low SI on T1-weighted images with areas of high SI on T2-weighted images. This completely matched with a study done by Tamai KT et al. (64), who found stated that: Ordinary leiomyomas (43 lesions) showed low SI on T1- and T2-weighted images in all lesions and degenerated leiomyomas (7 lesions) showed low SI on T1-weighted images with areas of high SI on T2-weighted images.

In the present study, all ordinary leiomyomas showed low SI on DW and ADC images, likely owing to the "T2 blackout effect," while degenerated leiomyomas showed low SI on DW images and high SI on ADC images which mean that all leiomyomas showed diffusion negative (facilitated diffusion) results. This was in agreement with the results of Thomassin-Naggara, et al. $^{14}$, who found that all leiomyomas, either common (15 lesions) or degenerated (7 lesions), had DWI low signal intensity & Namimoto et al. $^{15}$, who concluded that all studied ordinary leiomyomas were diffusion negative with low SI on DWI.

While Tamai KT et al. $^{17}$ found that all ordinary leiomyomas (43 lesions) showed low SI on DW and ADC images (diffusion negative) while as regarding the degenerated leiomyomas (7 lesions): - one showed high SI on DW images with low SI on ADC images and the other six lesions showed low SI on DW images and high SI on ADC images (6 diffusions negative & 1 diffusion positive that corresponded to hyaline necrosis at pathology.).

According to our results; The mean ADC value (10.3 m2/sec) of the ordinary leiomyomas was (0.773 ± 0.27), which significantly lower than the mean ADC value of degenerated leiomyomas (1.443 ± 0.11), this matched with Tamai K, T et al. (64), who reported that degenerated leiomyomas tended to exhibit low SI on DW images and higher ADC values (1.70 ± 0.11) in comparison with non degenerated leiomyomas (0.88 ± 0.27). While in Namimoto et al.’s $^{15}$ studies which included 95 leiomyomas and eight uterine sarcomas, they concluded that the use of T2-weighted images combined with DWI was able to differentiate between uterine sarcomas and leiomyomas without any overlap. T2-weighted images were used to exclude ordinary leiomyomas as they show low signal intensity. Myometrial tumors of high SI on T2-weighted images (degenerated leiomyomas and uterine sarcomas) may be recommended for DWI; uterine sarcomas showed high SI on DWI on all cases; On the other hand, degenerated leiomyomas exhibit low SI on DWI on all cases & they reported that degenerated leiomyomas had a higher ADC value compared with sarcomas.
In the present study, our conventional MRI results of the included two focal uterine adenomyosis showed increased thickness of the junctional zone forming ill defined focal myometrial lesion of low signals at T1-weighted images with bright foci at T2-weighted images, which matched with many other studies results. 12,18,19.

At DWI, the two uterine focal adenomyosis was negative diffusion with low SI on DW images and high SI on ADC images, with mean ADC value 0.894 ± 0.15 × 10-3 m2/sec. This was in coincidence with Jha, RC et al. study 20, which included 43 lesions of uterine adenomyosis & revealed that all lesions were diffusion negative with a mean ADC value of 0.86 × 10-3 m2/sec.

The endometrial cavity abnormalities represent a significant diagnostic challenge for radiologists. This may be attributed to the potentially overlapping imaging features of the normal endometrium influenced by the phase of menarche in addition to variable benign and malignant endometrial lesions, including endometrial polyp, endometrial hyperplasia, and endometrial neoplasms 20–23.

MRI signal intensities of different endometrial lesions are variable. Endometrial carcinomas are suspected in premenopausal women when the endometrial thickness exceeds 10 mm either focally or diffusely; also, the endometrial thickness of more than 4 mm is suspicious in post-menopausal patients24.

According to histopathology results of our study, the included 12 endometrial lesions were: 7 malignant endometrial carcinoma and five benign lesions (3 endometrial polyps and two endometrial hyperplasias). Endometrial carcinoma displayed intermediate mixed signals, and endometrial hyperplasia displayed hyperintense signals, while endometrial polyp showed intermediate to high signals on T2 weighted images. This matched with other studied results that showed on Sagittal T2-weighted images, and endometrial carcinomas display low or intermediate signal compared to the hyperintense signal of normal endometrium. Also, endometrial polyp and benign hyperplasia often present as a focal mass occupying the uterine cavity or a nonspecific endometrial thickening with intermediate to high signal intensity on T2WI. Those signs are not sufficient for accurate diagnosis of carcinoma, hyperplasia, and polyps23,25.

In the current study, All benign endometrial lesions (3 polyps and two hyperplasias) are diffusion negative; 4 lesions showed low SI on DW images at high b value (b=1000) and with high SI on ADC images while one endometrial hyperplasia showed high SI on both DW images and ADC images. The studied seven malignant endometrial cancer: 6 were diffusion positive, being of high SI on DW images at high b values (b=1000) and with low SI on ADC images except for one endometrial cancer, which was negative diffusion being with intermediate-high SI on DW images at high b value (b=1000) and with high SI on ADC images.

Our results were nearly going with results of a study performed by Wang et al. 26, who used b value of 1000 s/ mm2 and found that endometrial carcinoma like normal endometrium displayed hyperintense signal on DWI, while all endometrial polyps displayed intermediate signal or a relatively lower signal compared to the spared myometrium.

Also, in agreement with the present study, Salim et al.27 reported that endometrial polyps displayed intermediate signal on diffusion-weighted image and higher ADC values compared to endometrial carcinoma. Also, Kierans et al. 23 and Inoue et al. 28 stated that malignant endometrial neoplasm more often presents as an irregular endo-myometrial interface or a focal lesion with high signal intensity on DWI low signal intensity on ADC map.

In the current study, the mean ADC value of endometrial cancer (0.885 ± 0.24×10-3m2/sec) was significantly lower than that of endometrial polyps (1.865 ± 0.18×10-3m2/sec) and of endometrium hyperplasia (1.726 ± 0.25 × 10-3m2/ sec).
This completely matched with the results of Fujii et al., who evaluated a variety of endometrial lesions and concluded that malignant tumors, namely endometrial carcinoma and carcinosarcoma, gave lower ADC values than benign tumors, such as endometrial hyperplasia and endometrial polyps. Also, with Malayeri et al. and Masroor et al. studies which revealed that there was a significantly lower ADC value for malignant endometrium compared to benign endometrium lesions.

Also, Wang et al. study results showed that the mean ADC of endometrial carcinoma was $0.88 \pm 0.16 \times 10^{-3}\text{m}^2/\text{sec}$ which was significantly lower ($P < 0.01$) than that of normal endometrium $1.53 \pm 0.10 \times 10^{-3}\text{m}^2/\text{sec}$. While, in a of Bharwani et al., they used different b-values (0, 50, 100, 250, 500, 750 s/mm²) and found a statistically significant difference between the mean ADC values of benign lesions ranging from $(1.49 \pm 0.14)$ to $(1.16 \pm 0.20) \times 10^{-3}\text{m}^2/\text{sec}$ and malignant lesions from $(0.97 \pm 0.13)$ to $(0.72 \pm 0.30) \times 10^{-3}\text{m}^2/\text{sec}$ with ($p < 0.0001$).

Our study showed 85.7% sensitivity and 100% specificity of DWI and ADC images in diagnosing endometrial lesions. This agreed with Bharwani et al., who stated that the addition of DWI to conventional MRI has increased the sensitivity and specificity to 86% and 100%, respectively in the diagnosis of uterine endometrial lesions & Kamiyama Y. et al. reported that the sensitivity and specificity of DWI in endometrial lesions were 100% and 81% respectively.

We had one false negative lesion diagnosed radiologically as benign endometrial hyperplasia, while histopathology results proved it to be a well-differentiated adenocarcinoma owing to its low cellularity. This coincided with Whittaker et al., who reported that some malignant tumors have low cellularity (e.g., well-differentiated adenocarcinoma) and, hence, more limited water restriction that cannot be seen at DWI.

Our study included five lesions of the slightly hyperintense signal regarding cervical malignancies compared to cervical stroma on T2WI. This was in agreement with Patel et al., who reported that cervical cancers tend to give a high signal than cervical stroma on T2WI.

In our study, all cervical malignancies are positive diffusion, being of high SI on DW images at high b values (b=1000) and of low SI on ADC images with sensitivity and specificity of 100%.

This nearly matched with other studies such as, Hoogendam et al., who reported that in cervical tumors, the DWI and ADC images gave sensitivity and specificity of 90% and 94%, respectively & Chen et al. that revealed high sensitivity and specificity of 96% and 100% respectively.

Also, several studies have shown that the mean ADC value of cervical carcinoma was significantly lower than normal cervical tissue.

The mean ADC value of cervical carcinoma in our study obtained by b-value 1000 was $0.767\pm 0.22 \times 10^{-3}\text{m}^2/\text{sec}$. This was comparable to two studies done by Mohammad et al. and Hoogendam et al. where the mean ADC value of uterine cervical cancer was $(0.89 \times 10^{-3}\text{mm}^2/\text{s})$ and $(0.86 \times 10^{-3}\text{m}^2/\text{sec})$ respectively.

CONCLUSION

In conclusion, the present study suggests that, in addition to conventional MRI features, DW imaging provided an additional tool for distinguishing uterine benign focal lesions from malignant lesions. DW-MR imaging enables qualitative and quantitative assessment of tissue diffusivity. DW images in conjunction with ADC images are effective in differentiation between benign and malignant uterine focal lesions. Malignant lesions show a restricted diffusion pattern with high SI on high b values images and low SI on ADC images. Benign lesions show they facilitate diffusion with low SI on DWI. In our study, the accuracy of DWI
and ADC images in differentiation between benign and malignant uterine lesions reaches about 97.05%, (91.6%) Sensitivity, (100%) Specificity, (100%) PPV, (95.6%) NPV.

**Funding:** No funding was received for this study.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author.

**Conflicts of Interest:** The authors declare no conflict of interest.

**REFERENCES**


32. Differentiation between malignant and benign cervical tissue on the basis of the apparent diffusion coefficient is sensitive and independent of the b-value combination used for ADC calculation. Proc Intl Soc Mag Reson Med. 2009;17.