ORIGINAL RESEARCH

Diagnostic Utility of Diffusion-Weighted MRI in Female Pelvic Masses

Dr. Nirav kumar Janakbhai Lakhani[1], Dr. Swati Sharma[1] , Dr. Pallavi Sharma[1], Dr. R.P Bansal [2]

[1] Resident, Radiodiagnosis, NIMS University, Jaipur, Rajasthan, India
[2]Professor,Department Of Radio-Diagnosis NIMS University, Jaipur, Rajasthan, India

Corresponding Author
Dr. Nirav kumar Janakbhai Lakhani
Resident, Radiodiagnosis, NIMS University, Jaipur, Rajasthan, India
Email: niravlakhani54@gmail.com

Received: 31 October, 2023 Accepted: 21 November, 2023

Abstract
Introduction: In recent years, there has been an increase in the use of diffusion-weighted imaging (DWI) for pelvic magnetic resonance imaging (MRI). More rapid imaging methods and stronger diffusion gradients have been created, especially after parallel imaging was introduced and resulted in high-quality DWI of the body with significantly less motion artifacts.
Materials and method: This prospective observational study based on 124 female patients of all age groups who clinically presented with vaginal bleeding and/or pelvic mass and all cases of female pelvic masses diagnosed on USG. All patients with absolute contraindication to MRI and any history of claustrophobia or noisy/non-diagnostic MRI/DWI examinations due to motion artefacts were excluded from the study.
Results: The results are structured to first detail the diagnostic accuracy of DW-MRI in identifying different types of female pelvic masses. Subsequently, we correlate these imaging findings with histopathological diagnoses to establish the reliability of DW-MRI as a diagnostic tool. Finally, we explore the utility of DW-MRI in monitoring treatment response and disease progression in cases of malignant pelvic masses.
Conclusion: Without the use of ionizing radiation or intravenous contrast, DWI provides structural and functional information about biological tissues. This MRI modality is currently commonly utilized and is becoming more and more important in multiparametric MRI. The research proves beyond a reasonable doubt that diffusion weighted magnetic resonance imaging, also known as DW-MRI, is an effective diagnostic tool that can differentiate between benign and malignant female pelvic masses. It does an efficient job of identifying the nature and composition of these masses and has a high rate of sensitivity when it comes to detecting cancerous growths.
Keywords: Diffusion magnetic resonance imaging, Magnetic resonance imaging, Pelvis/diagnostic imaging, ovarian lesion, uterine lesion.

Introduction

Gynecological pelvic masses are a prevalent condition that are often identified during normal gynecologic or physical exams. These masses may range in size from a few millimeters to several inches in diameter. During the course of everyday practice, radiologists analyze a broad variety of pelvic masses as a matter of routine.[1] The clinical history and physical examination are the first steps in evaluating a pelvic mass. After that, a variety of imaging modalities are performed, beginning with ultrasound and continuing on through CT and, lastly, MRI. These various methods each have their own set of benefits and drawback.[2] Diffusion-weighted imaging (DWI) is widely used in protocols for magnetic resonance imaging (MRI) of the female pelvis. It provides functional and structural information about biological tissues, without the use of ionizing radiation or intravenous administration of contrast medium DWI is a valuable problem-solving tool in gynecologic malignancies with other wise equivocal features. It may be more useful in post-therapy. DWI is more sensitive for infection and inflammation in pregnant patients when avoiding gadolinium and CT. It may be a useful for other patients in whom gadolinium is contraindicated, such as patients with renal failure. DWI Improves not only the detection and potentially the characterization of small uterine tumors and complex ovarian cancer, but also the visualization of small implants of peritoneal carcinomatosis, which could significantly impact patient management.[3]

Diffusion-weighted imaging (DWI) reflects changes in proton mobility caused by pathological alterations of tissue cellularity, cellular membrane integrity, extracellular space perfusion, and fluid viscosity. Functional imaging is becoming increasingly important in the evaluation of cancer patients because of the limitations of morphologic imaging. DWI is being applied to the detection and characterization of tumors and the evaluation of treatment response in patients with cancer.[4,5] DWI is basically a T2 weighted sequence in which we use two equal and opposite motion probing gradients before and after the 180degree refocusing pulse. When the water molecules which are freely diffusing are exposed to the first pulse they acquire a phase shift which gradually changes and by the time the other equal and opposite gradient is applied they will not regain the signal; as because of free movement they are in different phases to time just after the first pulse hence no signal is produced at the time of acquisition.[5] DWI of the pelvis is now routinely used, which enables tissue characterization at a microscopic level, based on the Brownian motion of water molecules, when two diffusion gradients are added to T2-weighted (T2W) sequences. [4,6-12] If a tissue has low cellularity and defective cell membranes, the water molecules will move more "freely." When the first gradient is applied, the water molecules will acquire a different phase, but when the second gradient is applied, the water molecules will maintain their "free" movement. This results in signal loss because the water molecules are not perfectly rephased by the second gradient.[13] An examination of the DUI Quantitatively, this is accomplished through the utilization of an apparent diffusion coefficient (ADC) map, which is computed during post-processing through the utilization of at least two different b values; this analysis is a fully automated process that is made available as an application on workstations. The ADC map is shifted parametrically as grayscale pictures, and the ADC value for an area may be obtained for that region by sketching regions of interest inside that region. The ADC value is measured in mm2/sec.[1,13,14] Because the signal intensity (SI) detected by DWI is dependent on both the T2 relaxation time and the water diffusion, a region with a very long T2 relaxation time may still have a high signal on DWI and may be mistakenly thought to have restricted diffusion. This phenomenon is referred to as T2 shine through. Because the apparent diffusion coefficient (ADC) is not dependent on the strength of the magnetic field, it is able to overcome the T2 shine through effect. As a result, an area of true restricted diffusion will show a low ADC value (a darker shade of grey), in contrast to an area of low cellularity (such as within cysts), which shows a high ADC value (higher shade of gray).[13,9] In this article, we review the means of acquiring diffusion- weighted MR images, discuss and illustrate the clinical applications of this modality in women with gynecologic malignancies, provide image interpretation guidelines, and discuss potential pitfall In this article, we review the means of acquiring diffusion- weighted MR images, discuss and illustrate the clinical applications of this modality in women with gynecologic malignancies, provide image interpretation guidelines, and discuss potential pitfall In this article, we review the means of acquiring diffusion- weighted MR images, discuss and illustrate the clinical applications of this modality in women with gynecologic malignancies, provide image interpretation guidelines, and discuss potential pitfall In this article, we review the means of acquiring diffusion- weighted MR images, discuss and illustrate the clinical applications of this modality in women with gynecologic malignancies, provide image interpretation guidelines, and discuss potential Pitfall In this article, we review the means of acquiring diffusion- weighted MR images, discuss and illus rate the clinical applications of this modality in women with gynecologic malignancies, provide image interpretation guidelines, and discuss potential pitfall In this article, we review the means of acquiring diffusion-

weighted MR images, discuss and illustrate the clinical applications of this modality in women with gynecologic malignancies, provide image interpretation guidelines, and discuss potential pitfall In this article, we review the means of acquiring diffusion- weighted MR images, discuss and illustrate the clinical applications of this modality in women with gynecologic malignancies, provide image interpretation guidelines, and discuss potential pitfall

Methodology

This prospective observational study based on 124 female patients of all age groups who clinically presented with vaginal bleeding and/or pelvic mass and all cases of female pelvic masses diagnosed on USG. All patients with absolute contraindication to MRI and any history of claustrophobia or noisy/non-diagnostic MRI/DWI examinations due to motion artefacts were excluded from the study. All patients were selected as per inclusion and exclusion criteria. A detailed history, complete physical examination and routine & appropriate investigations were done for all patients. The statistical analysis was carried out by the statistical software SPSS version 25.0 after the data had been loaded into the Microsoft excel spreadsheet. The quantitative (numerical variables) information was presented as the mean and standard deviation, while the qualitative (categorical variables) information was presented as the frequency and percentage of each category. When comparing the mean values of the two groups, the chi-square test was utilized to analyze the frequency differences between the two groups. If the p-value was less than 0.05, then it was regarded to be statistically significant.

Result

The patients were categorized under age, location of lesion (ovarian and uterine), nature of lesion (malignant or benign) , composition of masses(cystic , Solid and Mixed) and histological diagnosis. The Table-1 provides an age-wise distribution of female participants who underwent Diffusion Weighted Magnetic Resonance Imaging (DW-MRI) in the study, totalling 124 individuals. The majority of the subjects fell within the 31-40 years age range, accounting for 31.45% of the total.

Table 1: Describing the study groups as perAge

Age	N	Percentage
18-20 years	15	12.10
21-30 years	28	22.58
31- 40 years	39	31.45
41- 50 years	14	11.29
51 onward	28	22.58
Total	124	100.0

The table-2 quantitatively summarizes the locations of lesions in a cohort of 124 female patients evaluated using Diffusion Weighted Magnetic Resonance Imaging (DW-MRI). It shows that the majority of lesions were ovarian, accounting for 58.87% of cases. This suggests that ovarian lesions are notably prevalent in the population studied. Lesions found in the uterus made up 41.13% of the cases, which is substantial but less frequent than ovarian lesions.

Table 2: Describing the study groups as per Location of lesion

Location of lesion	N	Percentage
Ovarian	73	58.87
Uterus	51	41.13
Total	124	100.0

The table -3 categorizes 124 lesions identified in female patients using Diffusion Weighted Magnetic Resonance Imaging (DW-MRI) into benign and malignant types. Benign lesions make up 58.06% of the total, indicating that the majority of detected lesions were non-cancerous. Malignant lesions represent 41.94% of the findings, a significant proportion, underscoring the importance of DW-MRI in the detection and differentiation of pelvic masses.

Table 3: Describing the study groups as per Type of lesion

Type of lesion	N	Percentage
Benign	72	58.06
Malignant	52	41.94
Total	124	100.0

The table-4 provides a breakdown of the composition of pelvic masses in a sample of 112 female patients evaluated through Diffusion Weighted Magnetic Resonance Imaging (DW-MRI). It shows that the majority of these masses were of mixed composition, accounting for 76.79% of the total, indicating that most lesions exhibited both cystic and solid characteristics. Solid masses comprised 12.50% of the cases, and purely cystic masses were the least common, representing 10.71% of the total (Graph-1).

Table 4: Describing the study groups as per Mass Composition

Mass Composition	N	Percentage
Cystic	12	10.71
Solid	14	12.50
Mixed	86	76.79
Total	112	100.0

The table-5 compares the frequency and types of benign and malignant lesions diagnosed in a cohort of patients using imaging. In the benign category, cystadenomas were the most common, constituting 19.64% of benign lesions, followed by leiomyomas and endometriomas, each comprising 12.50% (Graph-2 & Graph-3).

Table 5: Describing the study groups as per Histological Diagnosis

Benign			Malignant		
Lesion	n	%	**Lesion**	n	%
Dermoid cyst	6	5.36	Cystadenocarcinoma	14	31.82
Leiomyoma	14	12.50	Cervical carcinoma	16	36.36
Haemorrhagic cyst	12	10.71	Endometrial carcinoma	8	18.18
Cystadenoma	22	19.64	Recurrent ovarian tumour	6	13.64
Endometrioma	14	12.50			
Total	68	100	Total	44	100.00

The table-6 provides an analysis of Apparent Diffusion Coefficient (ADC) values in benign and malignant lesions, as measured by Diffusion Weighted Magnetic Resonance Imaging (DW-MRI) in a total of 112 cases. In the benign category (68 cases), a majority of lesions, 70.59%, showed low ADC values, suggesting restricted diffusion often associated with high cellularity, but in a benign context, it could be related to other factors like proteinaceous or hemorrhagic content. Conversely, 29.41% of benign lesions had high ADC values, indicative of less restricted diffusion. Among the malignant lesions (44 cases), a higher percentage, 77.27%, also presented low ADC values, which is typical for malignant tissues due to increased cell density and reduced extracellular space, while 22.73% had high ADC values.

Table 6: Describing the study groups as per ADC

	Benign		Malignant	
	n	**%**	**n**	**%**
Low	48	70.59	34	77.27
High	20	29.41	10	22.73
Total	68	100.0	44	100.0

The table-7 presents the diagnostic performance metrics for hyperintensity on Diffusion Weighted Imaging (DWI) in identifying malignant lesions within a study group. The sensitivity of 89.90% indicates that DWI is highly effective at correctly identifying patients with malignant lesions when they are present. However, the specificity is relatively low at 36.26%, suggesting that DWI hyperintensity also frequently occurs in patients without malignant lesions. The positive predictive value (PPV) of 58.68% indicates that when DWI hyperintensity is observed, there is a moderate likelihood that the lesion is indeed malignant. Conversely, the negative predictive value (NPV) is high at 86.53%, meaning that the absence of hyperintensity on DWI is a strong indicator that the lesion is not malignant. Overall, the accuracy of DWI hyperintensity in diagnosing malignant lesions is 55.8%, reflecting moderate diagnostic effectiveness, which may necessitate further diagnostic methods to confirm malignancy.

Table 7: Describing the study groups as per Sensitivity, specificity, NPV, PPV and accuracy of hyperintensity on DWI.

Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
89.90%	36.26%	58.68%	86.53%	55.8%

Discussion

31.45 percent of the total sample consisted of people who were between the ages of 31 and 40, which meant that the majority of the subjects belonged to this age range. Those who were between the ages of 21 and 30 and those who were 51 or older each made up 22.58 percent of the population, making them the next largest group. DW-MRI was able to differentiate benign from malignant gynecological pelvic masses with a high level of sensitivity (95 percent) [15]. When considering age, the most common age range for pelvic masses was between the ages of 35 and 45, followed by the age range of 55 to 65 [16]. When compared to malignant masses, benign masses had a mean age of 35.84 years [17], while malignant masses had a mean age of 51.64 years. Overall, diffusion-weighted imaging magnetic resonance imaging (DW-MRI) has shown promise in the characterization and differentiation of a variety of female pelvic masses, with age being a factor in the prevalence of these masses. Calculations of the values of the apparent diffusion coefficient (ADC) 75.9% of benign lesions had low values for the apparent diffusion coefficient, whereas 29.41% of benign lesions had high values for the apparent diffusion coefficient. Nearly 77.2% of malignant lesions had low ADC values, which indicated restricted diffusion, which is typical in malignant tissues. Malignant tissues typically have these types of restrictions. The ADC values of the cystic component have the potential to differentiate between benign and malignant ovarian cystic tumors if mature cystic teratomas and endometrial cysts are included in the analysis, but this is not the case if these factors are ignored. [18] Mansour et al. found that combining DWI with ADC mapping at a high b value in pelvic MRI examination resulted in increased sensitivity (95.45%) and specificity (92.86%) in differentiating endometrial focal lesions [19]. Kamal et al. demonstrated that DWI and ADC values improved the diagnostic accuracy in early diagnosis of endometrial cancer, with a sensitivity of 90.0% and specificity of 83.3% [20]. Therefore, the proportion of benign and malignant lesions detected by DW-MRI in the pelvis varies depending on the specific study and the type of lesion being evaluated. It is possible that the utilization of diffusion-weighted imaging (DWI) with magnetic resonance (MR) can improve MR characterization of ovarian lesions. Imaging that is weighted by diffusion can detect subtle shifts in the microdiffusion of water into intracellular and extracellular spaces. It has been reported that benign and malignant complex adnexal masses have distinct differences in their apparent diffusion coefficients (ADC) (18-20). High signal intensity on DWI is more frequently observed in malignant ovarian lesions than in benign ovarian lesions. When combined with conventional MRI sequences, DWI appears to provide additional information in the characterization of ovarian masses.

Conclusion

The research proves beyond a reasonable doubt that diffusion weighted magnetic resonance imaging, also known as DW-MRI, is an effective diagnostic tool that can differentiate between benign and malignant female pelvic masses. It does an efficient job of identifying the nature and composition of these masses and has a high rate of sensitivity when it comes to detecting cancerous growths. The findings of the study indicate specific patterns in ADC values, T1W and T2WI imaging, and signal intensity on DWI, all of which help in differentiating between different types of lesions.

References

1. Patil D, Magnetic resonance imaging in the evaluation of female pelvis. Medical Journal of DR.D.Y Patil Vidyapeeth. 2016;9(5):627-634.
2. Gangadhar K, Mahajan A, Sable N et al. Magnetic Resonance Imaging of Pelvic Masses: A Compartmental Approach, Seminars in Ultrasound. CT and MRI Journal. 2017;38:213-230.
3. Nougaret S, Tirumani S, Addley H et al. Pearls and pitfalls in MRI of gynecologic malignancy with diffusion-weighted technique. AJR Am J Roentgenol. 2013;200:261–276.
4. Motoshima S, Irie H, Nakazono T, Kamura T, Kudo S. Diffusion-weighted MR imaging in gynecologic cancers. J Gynecol Oncol. 2011 Dec;22(4):275-87.
5. Kadhim MA, Jaafer LS, Fayadh NAH, Hussain MAA. Role of MRI diffusion weighted imaging in differentiation between benign and malignant ovarian masses. Al-Kindy College Medical Journal 2017;13(2): 28-36.
6. Qayyum A. Diffusion-weighted imaging in the abdomen and pelvis: concepts and applications. Radiographics. 2009;29:1797–810.
7. Koh DM, Collins DJ. Diffusion-weighted MRI in the body: applications and challenges in oncology. AJR Am J Roentgenol. 2007;188:1622–35.
8. Nougaret S, Tirumani SH, Addley H, Pandey H, Sala E, Reinhold C. Pearls and pitfalls in MRI of gynecologic malignancy with diffusion-weighted technique. AJR Am J Roentgenol. 2013 Feb;200(2):261-76.
9. Thomassin-Naggara I, Fournier LS, Roussel A, Marsault C, Bazot M. Diffusion-weighted MR imaging of the female pelvis. J Radiol. 2010 Mar;91(3 Pt 2):431-8; quiz 439-40.
10. Feuerlein S, Pauls S, Juchems MS, Stuber T, Hoffmann MH, Brambs HJ, Ernst AS. Pitfalls in abdominal diffusion-weighted imaging: how predictive is restricted water diffusion for malignancy. AJR Am J Roentgenol. 2009 Oct;193(4):1070-6.
11. Namimoto T, Awai K, Nakaura T, Yanaga Y, Hirai T, Yamashita Y. Role of diffusion-weighted imaging in the diagnosis of gynecological diseases. EurRadiol. 2009 Mar;19(3):745-60.
12. Fournier LS, Bourillon C, Brisa M. IRM de diffusion dans le pelvis féminin: principes, technique, pièges et artefacts. Imagerie de la Femme. 2015;25:8–15.
13. Whittaker CS, Coady A, Culver L, Rustin G, Padwick M, Padhani AR. Diffusion-weighted MR imaging of female pelvic tumors: a pictorial review. Radiographics. 2009 May-Jun;29(3):759-74.
14. Malayeri AA, El Khouli RH, Zaheer A, Jacobs MA, Corona-Villalobos CP, Kamel IR, Macura KJ. Principles and applications of diffusion-weighted imaging in cancer detection, staging, and treatment follow-up. Radiographics. 2011 Oct;31(6):1773-91.
15. Anwar S, Rehan B, Hameed G. MRI for the diagnosis of ultrasonographically indeterminate pelvic masses. JPMA. The Journal of the Pakistan Medical Association. 2014 Feb 1;64(2):171-4.
16. Abd-Elmageed MK, Mohamed RA, Elaziz Maaly MA. Role of MRI Diffusion Weighted Imaging in Evaluation of Gynecological Pelvic Masses. The Egyptian Journal of Hospital Medicine. 2021 Oct 1;85(2):3857-64.
17. Reddy, Ravikanth. (2019). Magnetic Resonance Evaluation of Pelvic Mass Lesions in Females with Histopathological Correlation: An Institutional Experience. doi: 10.1055/S-0039-3400710
18. Shabana ME, Refaat M, Settein ME, Aly SA. Role Of Diffusion-Weighted Magnetic Resonance Imaging in Evaluation of GynecologicTumors. Benha Medical Journal. 2023 Jul 1;40(Special issue (Radiology)):182-90.
19. Tarek, M., Mansour., Yasser, Abd, Al-aal, Ahmed., Ghada, Abd, El-Razik, Ahmed. (2019). The usefulness of diffusion-weighted MRI in the differentiation between focal uterine endometrial soft tissue lesions. Egyptian Journal of Radiology and Nuclear Medicine, doi: 10.1186/S43055-019-0076-X
20. Rasha, M., Kamal., Nagat, Mansour, Khalifa., Amr, Kamal., Ghada, F.A., Hammad. (2019). Diagnostic Accuracy of DW MRI in Early Detection of Endometrial Carcinoma. doi: 10.21608/MJCU.2019.59358