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Diagnostic Accuracy of Diffusion Weighted Imaging in Diagnosing Malignant Ovarian Lesions Keeping Histopathology as the Gold Standard

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ABSTRACT

Objective: To determine the accuracy of diffusion weighted imaging (DWI) and apparent diffusion coefficient (ADC) value in diagnosing malignant ovarian lesions.

Study Design: Cross-sectional study.

Place and Duration of Study: Department of Radiology, Combined Military Hospital, Multan Pakistan, from Jun 2024 to May 2025.

Methodology: A total of 58 patients were enrolled in this study. They were first subjected to DWI, and ADC values were calculated to categorize ovarian masses as benign/malignant. Later, all patients underwent excision of the mass, followed by histopathological categorization of the mass as benign or malignant. The diagnostic accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of DWI in diagnosing malignant ovarian lesions were determined.

Results: Mean age was 50.03±6.68 years, while mean BMI was 26.44±2.40 kg/m2. ADC values of malignant tumors showed a mean of 1.08 × 10-3 mm2/s±0.014, with a *p*-value <0.001 (highly statistically significant). Sensitivity 83.33%, specificity 80.00%, PPV 95.24%, NPV 50%, and overall diagnostic accuracy 82.76% of DWI MRI in differentiating benign and malignant ovarian masses.

Conclusion: DWI with ADC value has good sensitivity and specificity in differentiating benign from malignant ovarian lesions.

Keywords: Apparent diffusion coefficient (ADC), Diagnostic accuracy, Diffusion weighted imaging, Ovarian mass, Sensitivity, Specificity.

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INTRODUCTION

Ovarian carcinoma accounts for significant morbidity and mortality worldwide. About 5% of female cancer patients die from ovarian cancer, which accounts for 2.5% of all gynaecological cancers.[1] The precise prevalence of ovarian cancer in Pakistan is unclear. The incidence in Asian countries is 2–6.5 new cases per 100,000 women annually.[2] The three types of primary ovarian cancers are germ cell tumours, sex cord-stromal tumours, and epithelial-stromal tumours, which account for 90% of cases.[3] The endometrium, pancreas, gastrointestinal system, and breast are the most common sites of origin for secondary ovarian tumours. The majority of them exhibit the same histological and clinical characteristics as the main tumours.[4]

Intravenous (IV) contrast combined with pelvic and abdominal CT is the preferred test for determining the extent of disease before surgery. Additionally, it can forecast if surgical cytoreduction will be successful.[5] However, in CT patients typically receive far larger doses of ionising radiation.[6] By carefully choosing pulse sequences, MRI can be utilised to visualise anatomy and evaluate physiological parameters and metabolic activity.[7] The diffusivity of endogenous water molecules in a tissue is determined using MRI. ADC maps of water molecules can be created using DWI.[8] With a higher sensitivity of diffusion than traditional MRI, the optimal cutoff value of ADC to distinguish between benign and malignant lesions is estimated to be 1.2 x 10-3 mm2/s.[9] The only chance of a good cure rate for ovarian cancer is early and timely diagnosis. Regretfully, even though several biomarkers have emerged, there isn't a successful early diagnosis method.[10]

This study's primary goal is to evaluate the diagnostic accuracy of DWI in identifying malignant ovarian tumours using the quantitative ADC value

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metric. Patients with ovarian cancer who have a relative or absolute contraindication to contrast material will benefit from early diagnosis and timely treatment.

METHODOLOGY

This cross-sectional (validation) study was carried out in Department of Radiology, Combined Military Hospital, Multan, Pakistan, from Jun 2024 to May 2025, after receiving Institutional Ethical Committee approval (EC 101/2024 dated 13 May 2024). Using the OpenEpi sample size calculator, version 3, a sample size of 55 was determined with a 95% confidence level, a 5% margin of error, and a 3.7% prevalence of ovarian cancer.[11] The chosen sample size was fifty-eight. Non-probability convenient sampling technique was employed.

Inclusion Criteria: This study included women aged 20 to 70 who were sent to the radiology department for MRIs of the abdomen and pelvis with DWI. After undergoing surgery at CMH Multan, these patients were able to acquire postoperative histopathology diagnostic results. These patients never had an adnexal mass biopsy or surgery before.

Exclusion Criteria: This study excluded pregnant women, patients who had previously undergone adnexal surgery or biopsy/histopathology, patients who were younger than 20 or older than 70, patients who were contraindicated for MRI, had no indication for surgery, or had already received radiation, chemotherapy, or any other treatment before an MRI test.

Following an informed written agreement, 58 women who met the inclusion criteria were enrolled. Age, BMI, parity, monthly menstruation irregularities, menopause status, and abdominal/pelvic discomfort were among the questions asked of each patient. The MRI equipment, Vantage Atlas 1.5 Tesla, Toshiba Japan, performed MRI with DWI on all patients in accordance with hospital procedure. For optimal image quality, patients were kept nil per os for at least three hours before MRI. Every patient had a full bladder and was resting supine. A consultant radiologist with at least five years of post-fellowship experience reported all of the MRIs. The ADC value of the solid component was assessed. If their ADC values on DWI were less than 1.17 × 10-3 mm2/s, they were considered malignant.[9] When bilateral ovarian masses were discovered, the mass with the most intricate shape was examined.

All of the patients had lesions surgically removed from the Obstetrics & Gynaecology department either by laparotomy or laparoscopy, and the specimens (ovarian mass, peritoneum, and lymph nodes) were transported to the histopathology department. A consultant histopathologist with at least ten years of post-fellowship experience evaluated each biopsy specimen and classified them as benign or malignant. For microscopic analysis, three to five biopsy specimen sections were stained using standard Haematoxylin and Eosin stain under both low and high fields. Cellularity, stromal invasion, pleomorphism, and the number of mitoses per ten high-power fields were all assessed in the sections. Cellular pleomorphism and stromal invasion were indicators of malignant lesions. The histopathologist was unaware that ovarian lesions might be classified by MRI. To evaluate the diagnostic accuracy of DWI in identifying malignant ovarian lesions, a histopathology report was obtained from the histopathology department and compared with an MRI DWI report.

Data was analyzed for age, BMI, and parity, and the mean and standard deviation. Monthly irregularities (oligomenorrhea/amenorrhea), menopause status, and pelvic/abdominal discomfort were measured for frequency and percentage. The purpose of the 2x2 contingency table was to ascertain DWI's precision in identifying cancerous ovarian lesions. To evaluate the diagnostic performance of the measured ADC value in identifying malignant ovarian lesions, a receiver operating characteristic (ROC) curve was created. AUC, or area under the curve, was computed. AUC >0.8 was regarded as good, while AUC > 0.9 as exceptional.[12] Associations between categorical variables (pain, oligomenorrhea, postmenopausal status) and histopathological diagnosis (benign vs malignant) were assessed using the Chi-square test. Fisher's Exact test was applied when the expected frequency in any cell was <5%. A statistically significant result was defined as a p-value < 0.05.

RESULTS

The final analysis included 58 female patients. Most patients had BMIs between 25 and 30 kg/m^2, with the mean age being 50.03±6.68 years and the mean BMI being 26.44±2.40 kg/m^2. The median of parity value was determined to be 2.

During study, all patients were asked about their history of oligomenorrhea, abdominal/pelvic pain,

and menopausal status. It was observed that 12.1% of patients had oligomenorrhea, a history of pain was present in 19% patients, and 63.8% patients were postmenopausal (Table-II).

Table-I: Summary of participants' demographics (n=58)

Variable	Value
Age in years (Mean± SD)	50.03±6.68
BMI in Kg/m2 (Mean± SD)	26.44±2.40

BMI = Body Mass Index

Table-II: Distribution based on the clinical parameters (n=58)

Variable		Histopathology		*p*-value
		Benign (n=10)	Malignant (n=48)	
Oligomenorrhea (n=7)	Yes	2(20%)	5(10.4%)	0.592
	No	8(80%)	43(89.6%)	
Pain (n=11)	Yes	2(20%)	9(18.8%)	1.000
	No	8(80%)	39(81.2%)	
Menopause (n=37)	Yes	2(20%)	35(72.9%)	0.002
	No	8(80%)	13(27.1%)	

The mean ADC value of malignant tumours was 1.08 × 10-3 mm2/s ±0.014, with a minimum value of 0.85 × 10-3 mm2/s and a maximum value of 1.35 × 10-3 mm/s. The benign masses' ADC values ranged from 1.06 × 10-3 mm2/s to 2.12 × 10-3 mm2/s, with a mean of 1.62 × 10-3 mm2/s ±0.112. It is clear from Table III that the mean ADC value for benign tumours was higher than that of malignant ones. ADC measurements were used to build an ROC curve, and Figure-1 shows that the area under the curve was 0.14.

Table-III: Comparison of mean ADC values in benign and malignant ovarian lesions

Parameter		Mean± SD	*p*-value
ADC Value	Benign	1.62 × 10-3 mm2/s ±0.112	<0.001
	Malignant	1.08 × 10-3 mm2/s ±0.014	

ADC - Apparent diffusion coefficient

In 42 cases, DWI confirmed the cancer diagnosis. In 48 cases, histopathology results verified cancer. Of the 42 patients with a DWI suspicion of cancer, 40 were true positives and 2 were false positives. Out of sixteen DWI-negative patients, eight patients had actual negative results, while eight patients had misleading negative results. In order to distinguish between benign and malignant ovarian masses using histopathology results as the gold standard, a 2x2 contingency table was created to estimate the sensitivity of 83.33%, specificity of 80.00%, PPV of 95.24%, NPV of 50%, and diagnostic accuracy of 82.76% of DWI MRI with ADC values. (Table-IV).

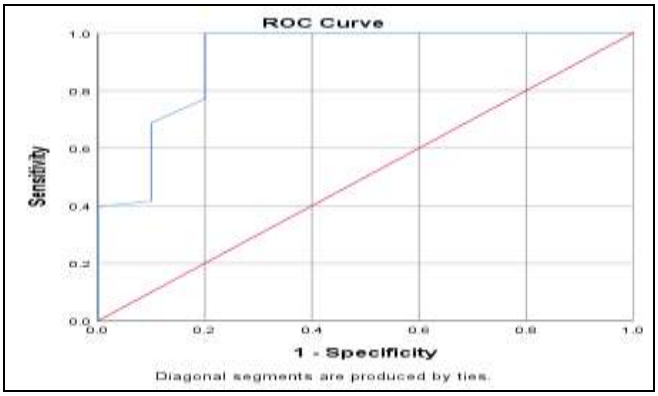

Figure: ROC Curve Using ADC Value (AUC=0.914)

Table-IV: Assessment of DWI MRI accuracy in diagnosing malignant ovarian lesions, keeping histopathology as gold standard (n=58)

DWI MRI	Histopathology	
	Benign (n=48)	Malignant (n=10)
Positive (n=42)	40 (83.3%)	2 (20%)
Negative (n=16)	8 (16.7%)	8 (80%)

DWI - Diffusion Weighted Imaging, MRI – Magnetic Resonance Imaging

DISCUSSION

The study was conducted as Ovarian Cancer is now a growing global health issue and is becoming more common, particularly in lower socioeconomic areas. Timely diagnosis can optimize treatment plan. The findings of 58 subjects of the study. The mean age of the patients in this study was 50.03±6.686 years, and the bulk of them (84.5%) were between the ages of 40 and 60, with just 8.6% being under 40. The analysis determined that DWI and ADC have good specificity, which enhances the accuracy of imaging diagnostics.

According to research by Grabowska *et al.*,[13] the mean age for primary mucinous ovarian cancer, as determined by DWI MRI, was 55.5 years. The average BMI of the participants in our study was 26.44±2.408 kg/m^2. Only 3.4% of patients had a BMI over 30 kg/m^2, whereas 72.5% had a BMI between 25 and 29.9 kg/m^2. In their study, Fischerova *et al.*,[14] reported a mean BMI of 26.5±5.5 kg/m^2. In this cross-sectional study of 58 patients, 12.1% and 19% had a history of oligomenorrhea and pain, respectively. Our results were like those reported by Marrium et al.,[15], who found that the most common presenting complaints among patients with adnexal tumors were irregular menstrual periods and nonspecific abdominal/pelvic pain.

The ADC value of malignant tumours in this study was lower than that of benign tumours. It was deemed highly statistically significant with a *p*-value of 0.000. The area under the curve of the ROC curve was determined to be 0.914. In their study, Ali *et al*.,[16] examined 51 adult females with complex adnexal lesions, with the mean ADC value for ovarian malignancy being 0.977× 10-3 mm2/s±0.32. A value below 1.17 × 10-3 mm^2/s indicated malignancy with 69.9% sensitivity and 75% specificity, while the area under the ROC curve was 0.756. A study by El Razeq et al.,[17] calculated that the mean ADC value of the benign ovarian masses 1.6 × 10−3 mm2/s ±0.27, whereas the value of malignant ovarian lesions was 1.01 × 10−3 mm2/s ±0.34. In our investigation, the DWI with ADC values' sensitivity, specificity, PPV, NPV, and diagnostic accuracy in identifying malignant ovarian tumours were 83.33%, 80.00%, 95.24%, 50%, and 82.76%, respectively. In order to determine the pooled sensitivity and specificity of DWI to distinguish between malignant and benign ovarian tumours, Yuan et al.,[18] carried out a meta-analysis that included 12 studies with 1142 individuals. The DWI specificity and sensitivity were 81% and 86%, respectively. 0.916 was the area under the curve. A study on the function of DWI MRI was carried out by Dawlat et al.,[19] confirmed that DWI's specificity was 78.6% and its sensitivity was 100%. According to Liu et al.,[20] research studies described that DWI MRI has an 81.2% diagnosis accuracy rate for ovarian cancer.

This exploration aims to investigate the important role of magnetic resonance imaging (MRI) in the diagnosis of ovarian cancer. The accuracy of diffusion weighted imaging (DWI) and apparent diffusion coefficient (ADC) value in diagnosing malignant ovarian lesions was determined.

LIMITATIONS OF STUDY

The small sample size of the single-centre investigation recommends that more randomised controlled trials with a comparatively higher sample size could establish trustworthy, valid, and reliable results in determining early diagnosis of Ovarian Cancer.

CONCLUSION

The study concluded that for accurate identification of malignant ovarian lesions, DWI and ADC values have good sensitivity, specificity, and accuracy. As a result, DWI with ADC value may develop into a potential method for ovarian cancer diagnosis, preoperative staging, and treatment, especially for patients with contraindications for contrast material.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

TR & HRI: Data acquisition, data analysis, critical review, approval of the final version to be published.

NS & TR: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

HT: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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