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ADDED VALUE OF QUANTITATIVE ANALYSIS OF DWI/ADC IN OVARIAN ADNEXAL REPORTING AND DATA SYSTEM MRI

Original Research

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ABSTRACT

Background: Adnexal masses are among the most frequent gynecological findings, with ultrasound being the primary imaging tool for their initial evaluation. Although ultrasonography reliably classifies many adnexal lesions, up to 31% remain indeterminate, posing diagnostic and management challenges. Magnetic Resonance Imaging (MRI) with the Ovarian-Adnexal Reporting and Data System (O-RADS) has been introduced as a standardized approach to improve lesion characterization, reduce unnecessary interventions, and enhance patient outcomes.

Objective: This study aimed to evaluate the diagnostic accuracy of MRI using the O-RADS classification system in characterizing adnexal masses indeterminate on ultrasonography, with histopathology serving as the gold standard.

Methods: A prospective, observational study was conducted at the Armed Forces Institute of Radiology and Imaging (AFIRI), Rawalpindi, over six months. A total of 150 female patients aged 18–65 years with indeterminate adnexal masses based on IOTA Simple Rules or similar ultrasound scoring systems were enrolled using consecutive sampling. All patients underwent pelvic MRI with contrast, and lesions were categorized using the O-RADS MRI scoring system. Surgical excision followed by histopathological examination provided the definitive diagnosis. Statistical analysis was performed using SPSS version 21. Sensitivity, specificity, predictive values, and overall diagnostic accuracy were calculated, and Receiver Operating Characteristic (ROC) curve analysis was used to evaluate performance.

Results: The mean age of participants was 42.6 ± 10.8 years, with 87 (58.0%) premenopausal and 63 (42.0%) postmenopausal. Pelvic pain was the most common presenting symptom, reported in 87 patients (58.0%). MRI categorized lesions as O-RADS 2 in 26 patients (17.3%), O-RADS 3 in 47 (31.3%), O-RADS 4 in 38 (25.3%), and O-RADS 5 in 39 (26.0%). Histopathology confirmed 42 malignant cases (28.0%) and 108 benign cases (72.0%). Using O-RADS ≥4 as the threshold for malignancy, MRI demonstrated a sensitivity of 88.1%, specificity of 63.0%, positive predictive value of 48.1%, negative predictive value of 93.2%, and an overall diagnostic accuracy of 71.3%. ROC analysis showed an area under the curve (AUC) of 0.86 (95% CI: 0.80–0.92).

Conclusion: MRI with O-RADS scoring provided high sensitivity and reliability in excluding malignancy among sonographically indeterminate adnexal masses. Its application improved diagnostic confidence, minimized unnecessary surgical procedures, and guided more accurate clinical decision-making, making it a valuable adjunct to ultrasound in routine practice.

Keywords: Adnexal Masses, Diagnostic Imaging, Magnetic Resonance Imaging, Malignancy Detection, O-RADS, Ovarian Tumors, Ultrasonography Indeterminate.

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INTRODUCTION

Adnexal masses represent one of the most frequent findings in gynecological practice and are associated with a substantial clinical workload for diagnostic imaging, surgery, and pathology. While the majority of adnexal lesions are benign, a small but clinically important proportion harbor malignant potential, necessitating careful evaluation to optimize patient outcomes (1). Ultrasound remains the first-line imaging modality owing to its accessibility, repeatability, and non-invasiveness, and it can reliably classify most masses as benign or malignant. However, despite the use of validated ultrasound scoring systems such as the "simple rules," between 18% and 31% of adnexal lesions remain indeterminate, leaving diagnostic uncertainty and influencing management decisions (2,3). Magnetic resonance imaging (MRI) has emerged as a valuable adjunct in such scenarios, overcoming many of the inherent limitations of ultrasound. MRI enables precise characterization of adnexal masses by differentiating ovarian from non-ovarian origins and by evaluating the internal architecture of lesions regardless of their size or location (4). Importantly, it has been shown to be superior to ultrasonography in clarifying the nature of sonographically indeterminate lesions, particularly in ruling out malignancy (5). In line with the increasing demand for standardization and improved diagnostic accuracy, the Ovarian-Adnexal Reporting and Data System (O-RADS) for MRI was proposed in 2013 and has since undergone extensive validation. This five-point scoring system integrates morphological assessment with tissue characterization, offering a structured and reproducible framework for adnexal lesion evaluation (6,7).

The significance of accurate preoperative characterization extends beyond diagnosis; it plays a pivotal role in reducing unnecessary surgical interventions, preserving fertility in women of childbearing age, and ensuring timely referral to gynecologic oncologists when malignancy is suspected (8,9). Histopathological confirmation through intraoperative frozen section analysis is often uncertain, further emphasizing the importance of precise imaging before surgery (10). Given that ovarian tumors remain the sixth leading cause of cancer-related mortality in women worldwide, with a lifetime risk of 1 in 75 for developing ovarian cancer and 1 in 100 for dying from it, the stakes of early and accurate diagnosis are high (11). Alarmingly, more than 75% of patients with ovarian cancer are diagnosed at advanced stages due to vague and nonspecific symptoms, contributing to its ranking as one of the deadliest gynecological malignancies (12). Ultimately, the goal of imaging in adnexal pathology is to triage patients effectively: to avoid unnecessary interventions for benign conditions, minimize patient anxiety, reduce healthcare costs, and accurately identify high-risk lesions that warrant specialized oncologic care (13,14). Against this background, the current study seeks to evaluate the role of MRI, particularly O-RADS MRI, in improving diagnostic certainty for adnexal lesions that remain indeterminate on ultrasound. The objective is to determine whether standardized MRI-based risk stratification can enhance diagnostic accuracy, reduce unnecessary surgical procedures, and optimize patient outcomes.

METHODS

This prospective observational study was conducted at the Armed Forces Institute of Radiology and Imaging (AFIRI), Rawalpindi, with the aim of evaluating the diagnostic accuracy of magnetic resonance imaging (MRI) using the Ovarian-Adnexal Reporting and Data System (O-RADS) in characterizing adnexal masses that remained indeterminate on ultrasound. The study was carried out over a period of six months following approval from the Institutional Review Board (IRB) and written informed consent was obtained from all participants prior to enrollment in accordance with ethical standards for clinical research. A total of 150 female patients, aged between 18 and 65 years, were included through non-probability consecutive sampling. Eligible participants were those with adnexal masses classified as indeterminate on ultrasound based on the International Ovarian Tumor Analysis (IOTA) Simple Rules or other validated ultrasound scoring systems. Exclusion criteria comprised pregnant women, patients with a known history of ovarian malignancy confirmed on previous biopsy, those with prior pelvic malignancy or history of pelvic radiotherapy, individuals with contraindications to MRI such as pacemakers or metallic implants, and patients with incomplete imaging or loss to follow-up (3-5).

The diagnostic workup for each participant included an initial pelvic ultrasonography, performed using transvaginal and/or transabdominal probes, during which adnexal masses were assessed and scored according to IOTA Simple Rules or similar validated classification systems. Subsequently, all patients underwent pelvic MRI with contrast, which was interpreted by radiologists experienced in female pelvic imaging. MRI assessments included analysis of lesion morphology (solid, cystic, septations), contrast enhancement

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patterns, and assignment of O-RADS MRI scores ranging from 1 to 5. Surgical excision of the adnexal mass was performed, and histopathological analysis of the specimen served as the gold standard for diagnosis. Demographic data such as patient age, menopausal status, and clinical symptoms, along with ultrasound findings, MRI features, and histopathological outcomes, were systematically recorded in a predesigned proforma. Data analysis was conducted using SPSS version 26. Quantitative variables, including patient age, were expressed as mean ± standard deviation, while qualitative variables, such as O-RADS MRI categories and the presence of malignancy, were presented as frequencies and percentages. The diagnostic performance of MRI was evaluated against histopathology by calculating sensitivity, specificity, positive predictive value, and negative predictive value. Chi-square test or Fisher's exact test, where applicable, was used to assess associations between categorical variables. Receiver Operating Characteristic (ROC) curve analysis was employed to determine the overall diagnostic performance of MRI, expressed as the area under the curve (AUC). A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 150 female patients with sonographically indeterminate adnexal masses were enrolled, with a mean age of 42.6 ± 10.8 years. Among them, 67 patients (44.7%) were younger than 40 years, while 83 (55.3%) were aged 40 years or above. Regarding menopausal status, 87 (58.0%) were premenopausal and 63 (42.0%) were postmenopausal. Pelvic pain was the most common presenting symptom, reported in 87 patients (58.0%), followed by abdominal mass in 41 (27.3%) and menstrual irregularities in 22 (14.7%). MRI assessment using the O-RADS classification demonstrated that 26 patients (17.3%) were scored as category 2 (almost certainly benign), 47 (31.3%) as category 3 (low risk of malignancy), 38 (25.3%) as category 4 (intermediate risk), and 39 (26.0%) as category 5 (high risk). Histopathological analysis confirmed malignancy in 42 patients (28.0%), while 108 cases (72.0%) were benign. When O-RADS scores of 4 and 5 were used as the threshold for malignancy, 37 malignant cases and 40 benign cases were included in this group, while 5 malignant and 68 benign cases were classified within O-RADS 2–3. This yielded a sensitivity of 88.1%, specificity of 63.0%, positive predictive value of 48.1%, and negative predictive value of 93.2% for MRI in diagnosing adnexal malignancy. The overall diagnostic accuracy was 71.3%. Receiver Operating Characteristic (ROC) curve analysis showed an area under the curve (AUC) of 0.86 with a 95% confidence interval of 0.80–0.92, indicating good diagnostic performance.

Table 1: Baseline Characteristics of Patients (n = 150)

Characteristic	Value
Age (mean ± SD)	42.6 ± 10.8 years
Age Group	<40 years: 67 (44.7%)
	≥40 years: 83 (55.3%)
Menopausal Status	Premenopausal: 87 (58.0%)
	Postmenopausal: 63 (42.0%)
Presenting Complaint	Pelvic Pain: 87 (58.0%)
	Abdominal Mass: 41 (27.3%)
	Menstrual Irregularities: 22 (14.7%)

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Table 2: O-RADS MRI Score Distribution (n = 150)

O-RADS MRI Score	Description	Frequency (%)
2	Almost certainly benign	26 (17.3%)
3	Low risk of malignancy	47 (31.3%)
4	Intermediate risk of malignancy	38 (25.3%)
5	High risk of malignancy	39 (26.0%)

Table 3: Comparison of MRI O-RADS Score with Histopathology

O-RADS Score	Malignant (n = 42)	Benign (n = 108)	Total	PPV (%)	NPV (%)
2–3	5	68	73	6.8	93.2
4–5	37	40	77	48.1	87.0

Table 4: Diagnostic Accuracy of MRI Using O-RADS System

Diagnostic Parameter	Value
Sensitivity	88.1%
Specificity	63.0%
Positive Predictive Value (PPV)	48.1%
Negative Predictive Value (NPV)	93.2%
Accuracy	71.3%
AUC (95% CI)	0.86 (0.80–0.92)

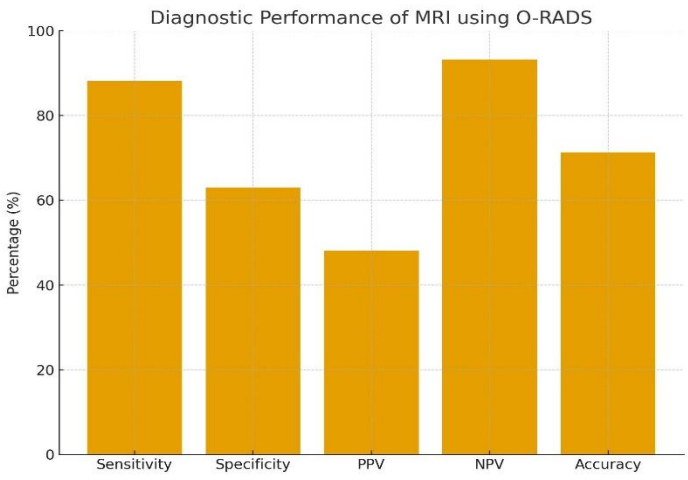


Figure 2 Diagnostic Performance of MRI using O-RADS

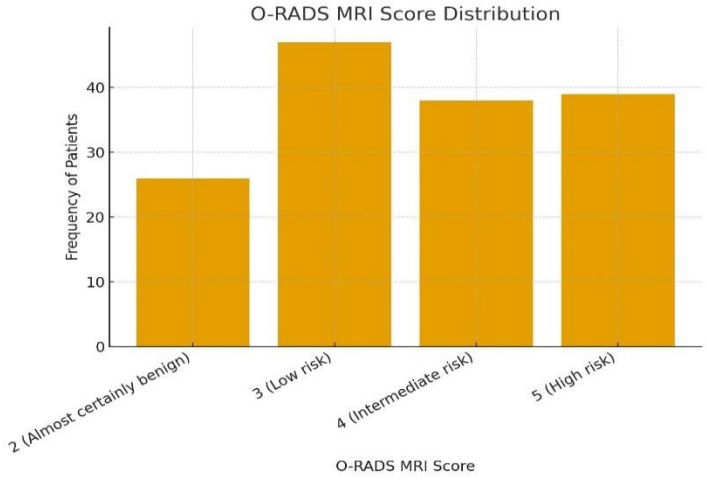


Figure 2 O-RADS MRI Score Distribution

DISCUSSION

The findings of this study demonstrated that MRI using the O-RADS classification system provided high sensitivity and negative predictive value in characterizing adnexal masses that were indeterminate on ultrasound. This indicates that MRI is a reliable modality

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for excluding malignancy and offers significant clinical value in guiding patient management. The results are consistent with earlier research, where the incorporation of advanced MRI techniques enhanced diagnostic performance and improved clinical confidence in differentiating benign from malignant lesions (15,16). Histopathology confirmed malignancy in 28% of the cases, with the remaining 72% diagnosed as benign. The accuracy of MRI in risk stratification underscores its role in avoiding unnecessary surgeries while ensuring timely intervention in high-risk cases. These findings align with prior studies that highlighted the importance of integrating diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC) values into the O-RADS framework, further refining its predictive accuracy and standardization in clinical practice (17,18). The evidence suggests that quantitative imaging biomarkers can complement morphological features, thereby improving radiological reproducibility and diagnostic precision. More recently, additional research has confirmed the prognostic potential of quantitative DWI in enhancing the diagnostic performance of multiparametric MRI across all O-RADS score groups (19). The clinical implications of these findings are substantial. By improving diagnostic confidence, MRI can help reduce unnecessary gynecological surgeries, preserve fertility in premenopausal women, and ensure referral to specialized oncology care when required. This is particularly important as indeterminate adnexal lesions often present a diagnostic dilemma, and the consequences of misclassification may significantly affect patient outcomes. The present findings also align with evidence showing that O-RADS MRI contributes to improved treatment planning and patient prognostication through higher sensitivity, specificity, and overall diagnostic accuracy (20,21).

The strengths of this study include its prospective design, the use of histopathology as the gold standard, and the standardized application of O-RADS scoring in a well-defined cohort of patients. Furthermore, the inclusion of a relatively large sample size of 150 patients increases the reliability of the findings and reflects real-world clinical practice. Nonetheless, certain limitations must be acknowledged. The study relied on non-probability consecutive sampling, which may introduce selection bias and limit the generalizability of the results. Moreover, all patients underwent surgical excision for histopathological confirmation, which may not reflect routine practice where some indeterminate lesions are followed conservatively. The absence of subgroup analysis based on menopausal status also represents a missed opportunity, as postmenopausal women typically carry a higher baseline risk of malignancy compared with premenopausal women. Additionally, interobserver variability in MRI interpretation was not assessed, which could influence diagnostic performance in broader clinical settings. Future research should focus on integrating advanced imaging biomarkers such as ADC thresholds into the O-RADS framework to further enhance risk stratification (21). Multicenter studies with larger and more diverse populations are warranted to validate these findings and ensure external applicability. Furthermore, future studies should evaluate cost-effectiveness and patient-centered outcomes, including the psychological and fertility-related implications of reduced surgical interventions. In summary, this study reinforced the diagnostic value of MRI with O-RADS scoring in managing adnexal masses that remain inconclusive on ultrasound. The high sensitivity and negative predictive value highlighted its role as a dependable tool for excluding malignancy, improving clinical decision-making, and minimizing unnecessary interventions, while underscoring the need for continued refinement and validation in broader clinical contexts.

CONCLUSION

This study concluded that MRI using the O-RADS classification system is a dependable tool for evaluating adnexal masses that remain indeterminate on ultrasound. Its use strengthened diagnostic confidence, minimized the risk of unnecessary surgical interventions, and guided more accurate clinical decision-making. By complementing ultrasound in complex or ambiguous cases, MRI contributes meaningfully to improving patient outcomes and ensuring that management strategies are both timely and appropriate.

AUTHOR CONTRIBUTION

Author	Contribution
Rabia Haq*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Faiza Haq	Substantial Contribution to study design, acquisition and interpretation of Data

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Author	Contribution
	Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Sarah Nathaniel	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Rabia Khan	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Aden Khan	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Ayesha Khan	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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