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A comparative study of ultrasonography and mri in the detection, characterization and evaluation of female adnexal lesions

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Abstract
Introduction: Adnexal masses represent a diverse group of gynaecological conditions with origins in the ovary, fallopian tube, and surrounding structures and are a frequent clinical presentation among women, ranging from benign cysts to malignant tumours. Early imaging-based characterization is crucial for management.
Aim: To compare the diagnostic efficacy of ultrasonography (USG) and magnetic resonance imaging (MRI) in evaluating and differentiating benign and malignant female adnexal masses.
Materials and Methods: A prospective study was conducted over 18 months on 100 patients with suspected adnexal masses. All underwent USG followed by MRI. Imaging findings were evaluated and compared with histopathological results. Data analysis was performed using SPSS; chi-square tests were applied with $p<0.05$ considered statistically significant.
Results: MRI demonstrated higher sensitivity (94.1%) and specificity (98.7%) compared to USG (88.2% and 96.3% respectively) in identifying and characterizing adnexal pathology especially for correctly identifying benign and malignant lesions by MRI as compared to USG. MRI outperformed USG in lesion characterization and staging, particularly in complex and malignant masses. The mean age of patients was 41.42 ± 7.6 years, with majority in the 31–40 age group. In cases where USG findings were indeterminate, MRI provided definitive characterization of lesions.
Conclusion: USG remains the first-line modality due to accessibility and cost-efficiency. However, MRI offers superior accuracy, especially in indeterminate cases, making it indispensable in complex or unclear adnexal lesions. MRI's multiplanar capability and tissue characterization provide critical information for preoperative planning and may prevent unnecessary surgery in benign lesions.

Keywords: Adnexal mass, ultrasonography, mri, pelvic imaging, ovarian tumours, indeterminate lesions, histopathology correlation

Introduction

Adnexal mass is a lump arising from structures closely related to uterus such as fallopian tube, ovaries and surrounding connective tissue. Adnexal mass can be benign or malignant.

Although benign lesions are more common, the risk of malignancy necessitates accurate evaluation. Imaging plays a pivotal role in this assessment. USG is the standard initial modality, offering real-time evaluation and Doppler capability. However, its diagnostic accuracy can be limited by operator dependency and lesion complexity. MRI, with its multiplanar capability and superior tissue contrast, serves as a robust complementary modality. This study aims to compare USG and MRI in the detection and characterization of adnexal masses, using histopathology as the reference standard.

Materials and methods

Study Design: Prospective cross-sectional study. Study Site: Department of Radiodiagnosis, Guru Gobind Singh Hospital, Jamnagar. Sample Size: 100 patients. Study Duration: 18 months.

Inclusion Criteria

- Female patients presenting with clinically or sonologically suspected adnexal masses
- Age above 18 years
- Patients who provided informed consent

Exclusion Criteria

- Simple adnexal cyst <3cm
- Ectopic pregnancies
- MRI contraindications (e.g., pacemakers, metallic implants)
- Patients who did not provide informed consent

Imaging Protocol:

- USG was performed using transabdominal and/or transvaginal approach with Doppler evaluation
- MRI performed on a 1.5T scanner with standard pelvic protocol including T1, T2, STIR, DWI, and contrast-enhanced sequences

All imaging findings were documented and correlated with histopathological examination (HPE) post-surgery or biopsy.

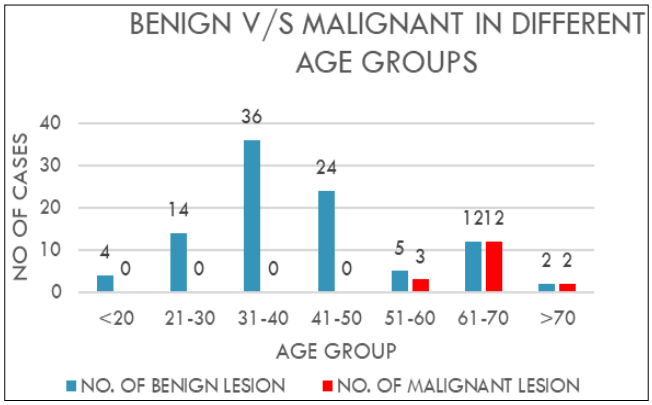
Statistical Analysis: Data were entered in a master chart and analysed using SPSS version 25. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for USG and MRI.

Results

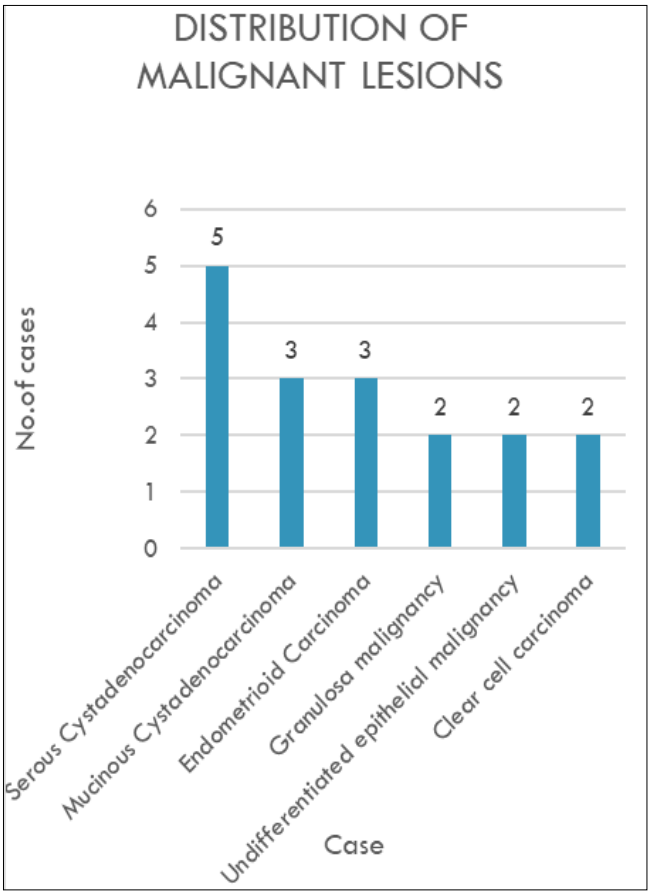
- **Mean age of patients:** 41.42 ± 7.6 years; most common age group: 31–40 years (36%)
- **Total benign lesions:** 83; Total malignant lesions: 17
- Most benign lesions occurred in 31–40 age group; most malignant lesions in >50 years, particularly 61–70 (12 of 17 malignant cases)

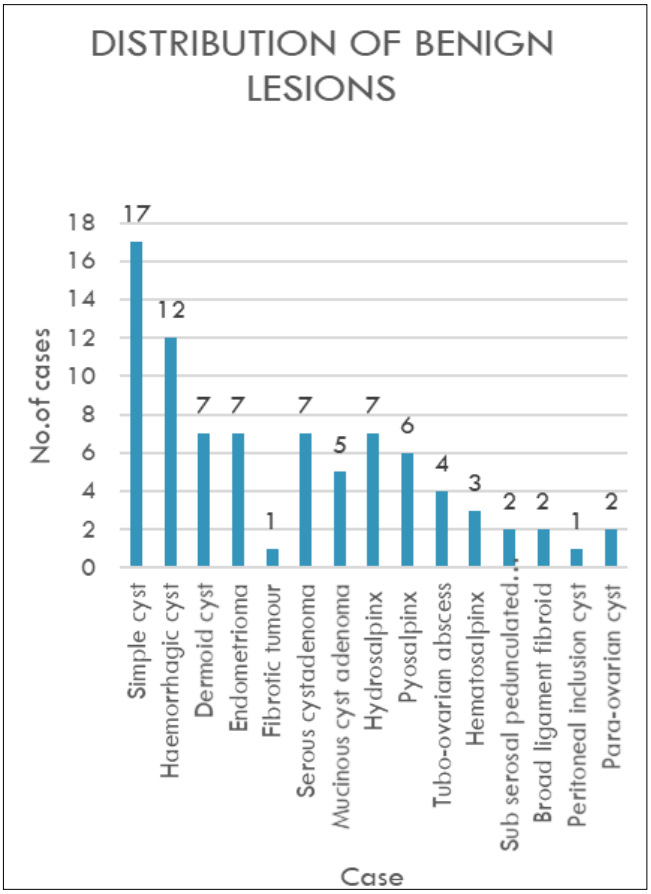
- **Unilateral lesions:** 90; Bilateral lesions: 10. Bilaterality more common in malignant lesions
- **Most common presenting complaint:** abdominal pain. Malignancy-related symptoms (distension, weight loss, anorexia, fatigue) more common in malignant group
- **Common benign lesions:** functional cysts (n=29), PID spectrum (hydrosalpinx, pyosalpinx, TOA), endometrioma, serous cystadenoma, parovarian cyst, inclusion cyst, fibroma-thecoma, broad ligament fibroid
- Association between histopathology and presence of true diffusion restriction within the lesion is significant as per our study. Among the 17 malignant lesions, 16 of them showed evidence of diffusion restriction
- Diameter less than 4 cm, entirely cystic components, wall thickness less than 3 mm, lack of internal solid component and absence of ascites are markers of benignancy.
- Presence of solid component, papillary projections, irregular margins, ascites, peritoneal deposits increases the likelihood of patient having malignancy.
- **Malignant lesions (n=17):** 15 epithelial tumours (5 serous cystadenocarcinoma, 3 mucinous, others endometrioid, clear cell, undifferentiated), 2 granulosa cell tumours
- 2 cases, one each of mucinous and serous cystadenocarcinoma were wrongly diagnosed by USG as benign of which one is identified as malignant in MRI and 1 was also wrongly diagnosed by MRI as benign and 3 benign cases are wrongly diagnosed as malignant by USG. One case of mucinous adenoma and 2 cases of serous cystadenoma were wrongly diagnosed as malignant by USG.
- The present study established 88.2% sensitivity, 96.3% specificity, 83.3% positive predictive value and 97.5% negative predictive value in identifying and characterizing malignant and benign lesions of adnexa on USG.
- Also established 94.1% sensitivity, 98.7% specificity, 94.1% positive predictive value and 98.7% negative predictive value in identifying and characterizing malignant and benign lesions of adnexa on MRI.

Bar diagram showing age distribution of benign and malignant lesions

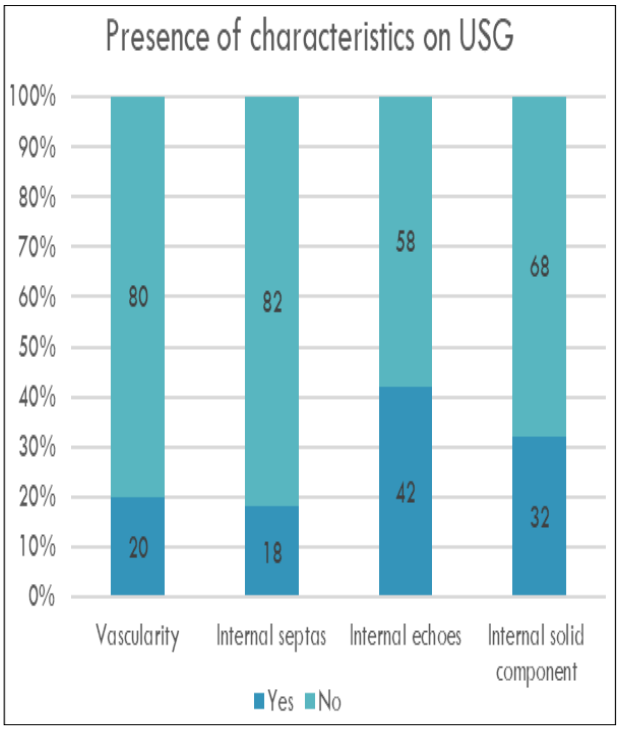


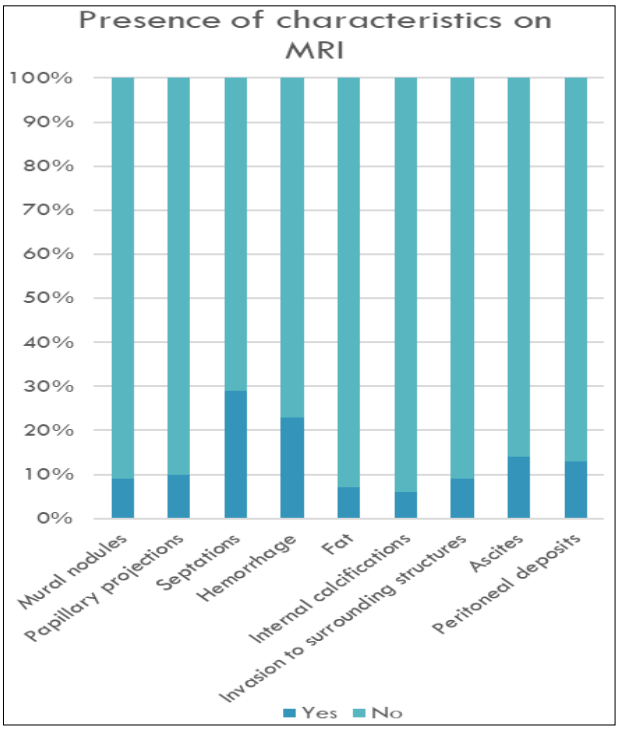
Distribution of Benign and Malignant Lesions

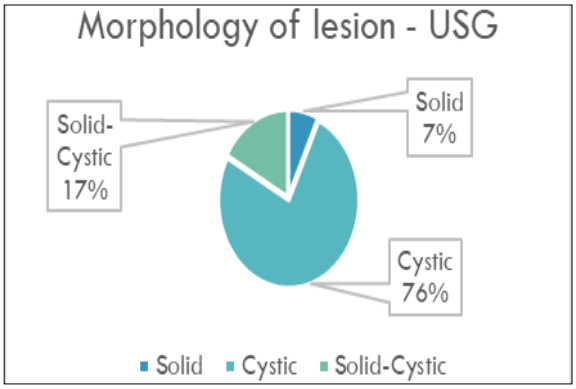


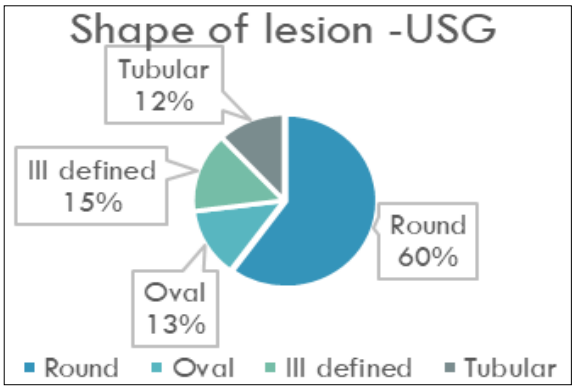


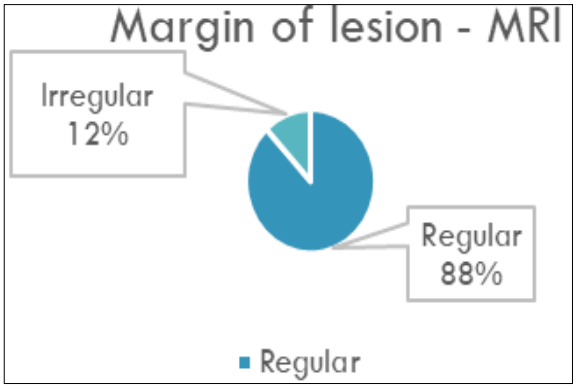
Characteristics of Pelvic Lesions as Seen on Ultrasound and Mri

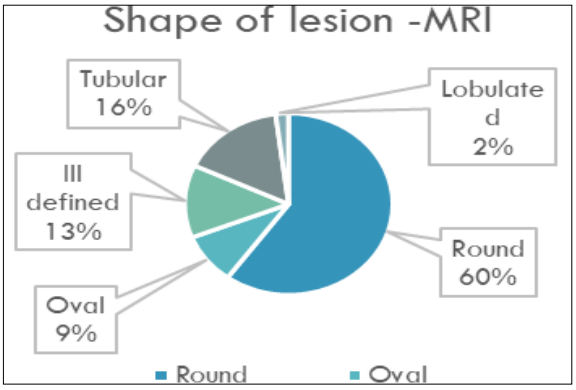

Presence of characteristics on USG
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
80
20
82
18
58
42
68
32
Vascularity
Internal septas
Internal echoes
Internal solid component
Yes
No


Presence of characteristics on MRI
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Mural nodules
Papillary projections
Septations
Hemorrhage
Fat
Internal calcifications
Invasion to surrounding structures
Ascites
Peritoneal deposits
Yes
No


Morphology of lesion - USG
Solid-Cystic 17%
Solid 7%
Cystic 76%
Solid
Cystic
Solid-Cystic


Shape of lesion -USG
Tubular 12%
Ill defined 15%
Round 60%
Oval 13%
Round
Oval
Ill defined
Tubular


Margin of lesion - MRI
Irregular 12%
Regular 88%
Regular


Shape of lesion -MRI
Tubular 16%
Lobulated 2%
Ill defined 13%
Round 60%
Oval 9%
Round
Oval

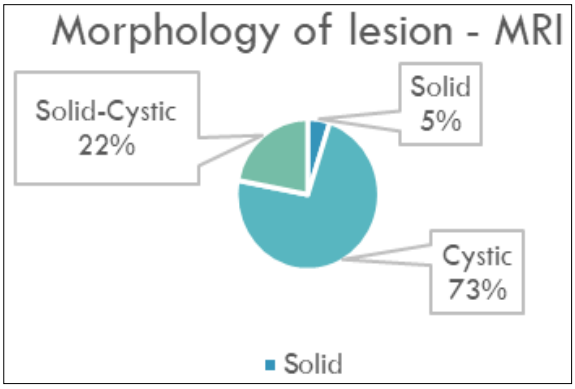

Morphology of lesion - MRI
Solid-Cystic 22%
Solid 5%
Cystic 73%
Solid

Table 1: Comparison of USG findings with clinical and histopathological diagnosis data

	Clinical and histopathological diagnosis (malignant)	Clinical and histopathological diagnosis (benign)
Usg (malignant)	15	3
Usg (benign)	2	80
	17	83

2 cases, one each of mucinous and serous cystadenocarcinoma were wrongly diagnosed by USG as benign of which one is identified as malignant in MRI and 1 was also wrongly diagnosed by MRI as benign and 3 benign cases are wrongly diagnosed as malignant by USG. One case of mucinous adenoma and 2 cases of serous cystadenoma were wrongly diagnosed as malignant by USG.

Table 2: Comparison of MRI findings with clinical and histopathological diagnosis data

	Clinical and histopathological diagnosis (malignant)	Clinical and histopathological diagnosis (benign)
MRI (MALIGNANT)	16	1
MRI (BENIGN)	1	82
	17	83

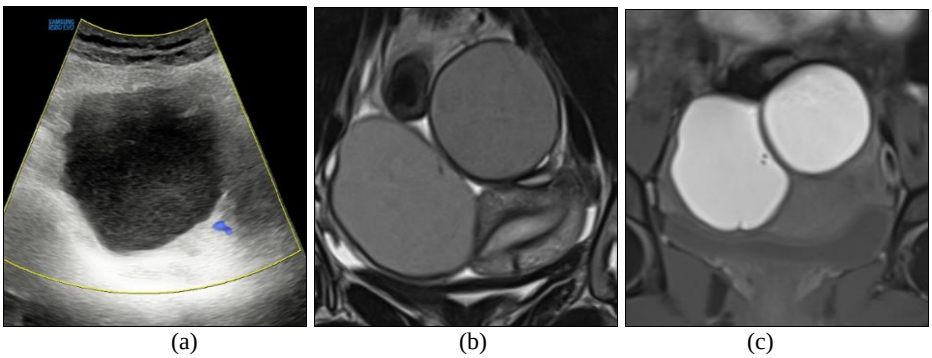
1 case of mucinous cystadenocarcinoma was wrongly diagnosed by MRI as benign mucinous adenoma and another case of benign serous cystadenoma was wrongly diagnosed as malignant by USG and MRI.

In Terms of Characterizing the Detected Lesions as Malignant Has Following Data

		Disease ⊕	Disease ⊖	Predictive Value	
Test	⊕	A True Positive (TP)	B False Positive (FP)	Positive Predictive Value (PPV) $\frac{TP}{TP+FP} = \frac{A}{A+B}$	Total Positive Results (A + B)
Test	⊖	C False Negative (FN)	D True Negative (TN)	Negative Predictive Value (NPV) $\frac{TN}{FN+TN} = \frac{D}{C+D}$	Total Negative Results (C + D)
Sensitivity & Specificity		Sensitivity $\frac{TP}{TP+FN} = \frac{A}{A+C}$	Specificity $\frac{TN}{FP+TN} = \frac{B}{B+D}$		
		All diseased patients (A + C)	All non-diseased patients (B + D)		

	MRI	USG
Sensitivity	16 / 16+1 x 100 = 94.1 %	15 / 15+2 x 100 = 88.2%
Specificity	82 / 82 + 1 x 100 =98.7%	80 / 80 + 3 x 100 =96.3%
Ppv	16 / 16+1 x 100 = 94.14 %	15 / 15+3 x 100 = 83.3%
Npv	82 / 82 + 1 x 100 =98.7%	80 / 80 + 2 x 100 =97.5%

Cases and images



(a) (b) (c)

Fig 1: endometrioma – chocolate cyst

Case 1: Endometriotic cyst. (a- 1st image): Unilocular cystic lesion with homogenous internal echoes involving right ovary, similar lesion also noted in left ovary also (not seen in image); (b- 2nd image on middle) Axial T2 weighted MR images showing two well-defined unilocular T2 hypointense cystic lesions (T2 shading sign) involving bilateral ovaries. (c- 3rd image on left) The lesions appear hyperintense on T1FS sequence without suppression owing to the presence of blood products.

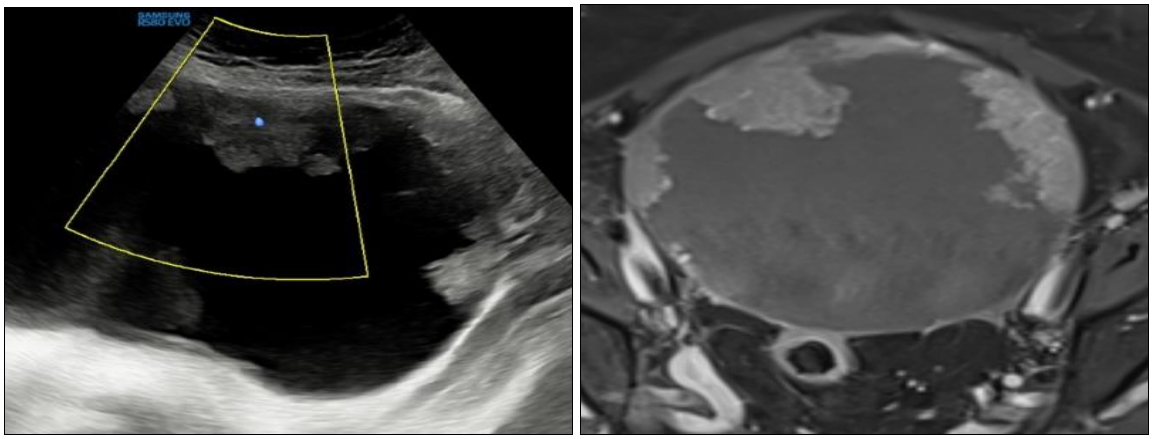


Fig 2: Serous Cystadenocarcinoma

Case 2: Serous cystadenocarcinoma: (a) Trans-abdominal ultrasound image showing large cystic lesion with internal solid component showing internal vascularity involving left adnexa. (b) Axial T1FS post contrast images through the pelvis show intense post contrast enhancement of the lesion.

Discussion

Accurate characterization of adnexal masses is vital for appropriate clinical management, given the wide spectrum ranging from benign cysts to invasive malignancies. Our findings are consistent with several prior studies demonstrating that MRI offers superior diagnostic performance compared to USG in evaluating complex adnexal lesions.

In this study, MRI correctly identified 16 of 17 malignant lesions (sensitivity 94.1%), whereas USG identified 15 (sensitivity 88.2%). This supports the results of Sohaib *et al*. [1], who noted MRI's higher sensitivity and specificity in detecting malignant ovarian tumors. Tanusri Debbarma *et al* [2]. and Kinkel *et al* [3]. also reported that MRI provides better lesion characterization, especially in masses with indeterminate features on USG.

MRI offers multiplanar imaging and excellent soft tissue contrast resolution, enabling visualization of features such as mural nodules, thickened septa, papillary projections, necrosis, and contrast enhancement patterns with greater confidence [1, 4]. These findings are often ambiguous on ultrasound, especially when the lesion is deep-seated or when bowel gas obscures adnexal structures. Studies by Valentini *et al* [4]. and Arora *et al* [5]. emphasize that complex adnexal masses are more reliably assessed with MRI due to these advantages.

Additionally, diffusion-weighted imaging (DWI) and dynamic contrast-enhanced sequences in MRI further aid in distinguishing benign from malignant lesions, as highlighted by Chen and Wang [6]. They found that restricted diffusion and early enhancement patterns correlate strongly with malignancy. Saini *et al* [7]. and Yamashita *et al* [8]. reported similar observations, showing that DWI enhances diagnostic confidence and reduces false-positive rates when used alongside conventional MRI sequences.

Our study also observed that MRI had greater concordance with histopathological diagnoses (95%) compared to USG (83.3%). This observation is reinforced by Adusumilli *et al* [9]., who found that MRI closely matched histopathological findings in the majority of ovarian tumor cases. Moreover, in our subset of patients where USG findings were indeterminate (n=15), MRI was able to confidently characterize 14 cases (93.3%), confirming its problem-solving role. This aligns with the findings of Thomassin-Naggara *et al* [10], who introduced the ORADS MRI scoring system, which significantly improved interobserver agreement and diagnostic uniformity.

The limitations of ultrasound, including operator dependency and limited field of view, are well-documented in studies by Sokalska *et al* [11]. and Guerra *et al* [12]. While transvaginal USG is effective for many simple cystic lesions, its reliability diminishes in cases involving complex, multilocular, or solid-cystic adnexal masses.

Recent studies such as those by Wengert *et al* [13]. have underscored the added value of advanced MRI techniques in oncologic imaging of female pelvis, citing MRI as particularly useful in preoperative staging and surgical planning. Haggerty *et al* [14]. further pointed out the importance of identifying peritoneal and omental deposits on MRI, which often go undetected in USG, thus improving staging accuracy in ovarian malignancies.

Collectively, the findings in our study corroborate this body of evidence, confirming that MRI is not only complementary to ultrasound but, in complex or indeterminate cases, often decisive. Its superior diagnostic accuracy aids in reducing unnecessary surgeries for benign lesions while ensuring early detection and appropriate referral for malignancies.

Conclusion

USG remains the frontline modality in adnexal mass evaluation. However, MRI provides enhanced lesion characterization, better correlation with HPE, and improved diagnostic confidence in complex or ambiguous cases. Particularly in sonologically indeterminate lesions, MRI proves to be a reliable problem-solving tool, significantly influencing patient management. The strong histopathological correlation observed with MRI further

underscores its pivotal role in accurate diagnosis and treatment planning. MRI's ability to delineate origin, composition, and spread of adnexal pathology makes it indispensable for preoperative planning and may reduce unnecessary biopsies or surgeries.

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