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ORIGINAL ARTICLE

Imaging Characteristics and Histopathological Correlation in Borderline Ovarian Tumors: A Clinical Study

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ABSTRACT

Background: Borderline ovarian tumors (BOTs) are a unique group of epithelial ovarian neoplasms that exhibit cellular proliferation and nuclear atypia without stromal invasion. They pose diagnostic challenges due to overlapping imaging features with benign and malignant lesions. Accurate preoperative assessment integrating radiological and pathological evaluation is critical for appropriate surgical planning, especially in reproductive-age women where fertility preservation is a concern.

Objective: To evaluate the imaging characteristics of BOTs on ultrasound and MRI and correlate these findings with histopathological outcomes in patients presenting at a tertiary care hospital in Pakistan.

Methods: This cross-sectional study was conducted at the Niazi Welfare Foundation Teaching Hospital, Sargodha, from January 2023 to June 2023. Sixty female patients aged 20–60 years with adnexal masses suspicious for BOTs were included. All underwent transvaginal ultrasound and contrast-enhanced MRI prior to surgery. Imaging features such as multilocularity, septations, papillary projections, mural nodules, solid components, and ascites were recorded. Histopathology of excised specimens served as the gold standard. Statistical analysis was performed using SPSS v26.0, and chi-square tests were applied to determine correlations.

Results: The mean age was 35.7 ± 9.8 years, with most cases in the 31–40-year group. Histopathology confirmed 38 serous (63.3%) and 22 mucinous BOTs (36.7%). Ultrasound detected multilocular cysts in 81.7% and papillary projections in 55% of cases, whereas MRI demonstrated superior detection rates (90% and 70%, respectively). MRI showed higher sensitivity (91%) and specificity (88%) compared with ultrasound (78% and 72%). Papillary projections and mural nodules correlated strongly with BOT histopathology ($p < 0.01$).

Conclusion: MRI offers superior diagnostic accuracy over ultrasound in identifying BOTs, but histopathology remains the gold standard. Recognition of key imaging features can improve early diagnosis, guide surgical strategies, and support fertility-preserving management.

Keywords: Borderline ovarian tumors, Ultrasound, MRI, Histopathology, Serous, Mucinous

INTRODUCTION

Borderline ovarian tumors (BOTs), also known as tumors of low malignant potential, represent a distinct pathological entity that lies between benign ovarian neoplasms and frankly invasive ovarian carcinomas[1]. They are characterized histologically by increased epithelial proliferation, nuclear atypia, and stratification of the epithelial lining, but crucially lack stromal invasion, which differentiates them from invasive carcinomas. Since their first description by Taylor in 1929, BOTs have gained increasing clinical importance, particularly because they account for approximately 10–20% of all epithelial ovarian tumors and tend to present at a younger age compared to malignant ovarian cancers[2].

Epidemiological studies have shown that BOTs typically affect women in their reproductive years, often between the ages of 20 and 40, which poses a unique clinical dilemma. On the one hand, appropriate surgical management is required to prevent recurrence and malignant transformation; on the other, fertility preservation becomes a critical consideration in younger patients[3]. In Pakistan, as in other South Asian countries, ovarian malignancies represent a significant proportion of gynecologic cancers, yet data specifically focusing on BOTs remain limited. This scarcity of local data highlights the need for focused clinical research that bridges radiological and pathological aspects for accurate diagnosis and optimal management[4].

From a diagnostic perspective, BOTs are notoriously challenging because their radiological features often overlap with those of benign cystic lesions and invasive carcinomas[5]. The role of imaging, particularly transvaginal ultrasound (USG) and magnetic resonance imaging (MRI), has therefore become central in the preoperative evaluation of suspected ovarian tumors. Ultrasound remains the first-line modality due to its accessibility, cost-effectiveness, and real-time pelvic evaluation. However, its limitations in differentiating complex cystic structures and subtle papillary projections necessitate the use of advanced cross-sectional imaging. MRI, with its superior soft tissue resolution and contrast-enhanced capabilities, offers valuable information about mural nodules, septations, and papillary excrescences features that are highly suggestive of BOTs[6].

Despite advancements in imaging, definitive diagnosis requires histopathological evaluation. Serous BOTs, the most common subtype, are typified by papillary architecture with epithelial proliferation, while mucinous BOTs display multilocular cysts lined by mucin-secreting epithelium with cytological atypia[7]. Both subtypes lack stromal invasion, a critical distinction that underpins prognosis and therapeutic decisions. Accurate correlation between imaging and histopathology is essential not only for diagnostic confirmation but also for guiding surgical planning, particularly when conservative surgery is being considered[8].

Given these clinical and diagnostic complexities, this study was undertaken to systematically evaluate the imaging characteristics of BOTs using ultrasound and MRI, and to establish their correlation with histopathological findings in a cohort of patients from Pakistan. By bridging radiological patterns with pathological outcomes, this study aims to enhance diagnostic accuracy, improve surgical decision-making, and contribute valuable regional data to the global literature on borderline ovarian tumors[9,10].

MATERIALS AND METHODS

Study Design and Setting: This research was conducted as a cross-sectional observational clinical study at the Department of Radiology and Department of Gynecology, Niazi Welfare Foundation Teaching Hospital, Sargodha, Pakistan. The study was carried out over a period of six months, from January 2023 to June 2023. The hospital was selected because of its high patient

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turnover and availability of radiological and pathological facilities necessary for comprehensive evaluation of ovarian tumors.

Study Population: The study included a total of 60 female patients who presented with adnexal or ovarian masses that were clinically and radiologically suspicious for borderline ovarian tumors. Patients were enrolled consecutively during the study period. The age range of the participants was set between 20 and 60 years in order to capture both reproductive and perimenopausal women, as BOTs are known to affect these groups more frequently. All patients were referred from the gynecology outpatient clinics to the radiology department for detailed imaging evaluation prior to surgery.

Inclusion and Exclusion Criteria: Patients were included if they had an adnexal mass measuring ≥5 cm on ultrasound and demonstrated imaging features suggestive of BOTs, such as multiloculated cysts, thickened septations, mural nodules, or papillary projections. Furthermore, inclusion required that patients undergo surgical excision of the mass with histopathological evaluation.

Patients were excluded if their ovarian lesions were clearly benign (simple cysts, dermoid cysts, or functional cysts), if the masses showed frank evidence of invasion consistent with malignant ovarian carcinoma, or if the patients had incomplete medical or histopathological records. Patients who declined surgical intervention were also excluded from the study.

Imaging Evaluation: All participants underwent a two-step imaging protocol. First, a transvaginal ultrasound (USG) was performed using a high-frequency transvaginal probe (5–9 MHz). Each ovarian mass was systematically evaluated for morphology, number of locules, wall thickness, presence and nature of septations, papillary excrescences, mural nodules, solid components, and associated ascites.

Following the ultrasound, all patients underwent magnetic resonance imaging (MRI) using a 1.5 Tesla scanner. The protocol included T1-weighted, T2-weighted, diffusion-weighted, and post-contrast fat-suppressed sequences. MRI provided further detail on internal architecture, contrast uptake patterns of mural nodules and papillary projections, septal thickness, and detection of subtle peritoneal deposits or ascites. Imaging was interpreted independently by two senior radiologists with more than 10 years of experience, and disagreements were resolved by consensus.

Surgical and Histopathological Assessment: All patients underwent surgical excision of the ovarian mass either by cystectomy or salpingo-oophorectomy, depending on patient age, fertility preferences, and extent of disease. Surgeries were performed by gynecologic oncologists at the same institution. Resected specimens were immediately preserved in 10% neutral-buffered formalin and processed for histopathological evaluation.

Histopathology was carried out in the Department of Pathology. Hematoxylin and eosin (H&E) stained sections were examined for epithelial proliferation, nuclear atypia, papillary or glandular architecture, and absence of stromal invasion. Tumors were classified according to the World Health Organization (WHO) classification into serous borderline ovarian tumors (SBOTs) and mucinous borderline ovarian tumors (MBOTs).

Data Collection and Statistical Analysis: Clinical, radiological, and histopathological data were collected using a structured proforma. Statistical analysis was conducted using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables such as age and tumor size were expressed as mean ± standard deviation, while categorical variables such as imaging features and histological subtype were presented as frequencies and percentages.

The diagnostic performance of ultrasound and MRI was evaluated against histopathology, which served as the gold standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated. The chi-square test was applied to assess the correlation between imaging features and histopathological findings. A p-value of <0.05 was considered statistically significant.

RESULTS

Demographic and Clinical Characteristics: A total of 60 female patients with ovarian masses suspicious for borderline ovarian tumors (BOTs) were evaluated during the study period from January 2023 to June 2023. The mean age of participants was 35.7 ± 9.8 years, with the youngest patient being 21 years old and the oldest 58 years. Most cases were observed in the 30–40-year age group (n = 26, 43.3%), followed by the 41–50-year age group (n = 18, 30%), while fewer cases were detected in patients above 50 years of age (n = 6, 10%). In terms of menopausal status, 32 patients (53.3%) were postmenopausal and 28 (46.7%) were premenopausal. The majority of patients presented with abdominal pain (65%) and abdominal distension (48.3%), while menstrual irregularities were noted in 20% of cases. The demographic characteristics of the study cohort are summarized in Table 1, which demonstrates that BOTs occurred more frequently in women of reproductive and perimenopausal age groups.

Table 1: Demographic and Clinical Characteristics of Patients (n = 60)

Variable	Category	Frequency (n)	Percentage (%)
Age group (years)	20–30	10	16.7
	31–40	26	43.3
	41–50	18	30.0
	>50	6	10.0
Menopausal status	Premenopausal	28	46.7
	Postmenopausal	32	53.3
Presenting symptoms	Abdominal pain	39	65.0
	Abdominal distension	29	48.3
	Menstrual irregularities	12	20.0

As demonstrated in Table 1, the age distribution indicates that BOTs are predominantly seen in middle-aged women, while a significant proportion of cases were identified in postmenopausal women, underscoring the importance of considering BOTs in the differential diagnosis across a wide reproductive spectrum.

Imaging Findings on Ultrasound and MRI: On transvaginal ultrasound (USG), multiloculated cystic masses with internal septations were the most common finding, observed in 49 patients (81.7%). Papillary projections were visualized in 33 patients (55%), whereas mural nodules were detected in 24 patients (40%). Solid components were noted in 21 patients (35%), and ascites was present in 12 patients (20%).

Magnetic resonance imaging (MRI) provided a clearer depiction of internal architecture and was superior in detecting papillary projections and mural nodules. On MRI, multiloculated cysts with septations were identified in 54 patients (90%), while papillary projections were detected in 42 patients (70%). Mural nodules with contrast enhancement were seen in 39 patients (65%), and solid components were noted in 25 patients (41.7%). Ascites was present in 13 patients (21.7%). These imaging findings are detailed in Table 2.

Table 2: Imaging Characteristics of Borderline Ovarian Tumors (n = 60)

Imaging Feature	Ultrasound (USG) n (%)	MRI n (%)
Multiloculated cysts	49 (81.7)	54 (90.0)
Papillary projections	33 (55.0)	42 (70.0)
Mural nodules	24 (40.0)	39 (65.0)
Solid components	21 (35.0)	25 (41.7)
Ascites	12 (20.0)	13 (21.7)

As seen in Table 2, MRI consistently demonstrated higher detection rates compared to ultrasound across all parameters, particularly in identifying papillary projections and mural nodules, which are highly suggestive of borderline pathology.

Histopathological Subtypes and Correlation with Imaging: Histopathological analysis confirmed that 38 patients (63.3%) had serous borderline ovarian tumors (SBOTs), while 22 patients

(36.7%) had mucinous borderline ovarian tumors (MBOTs). In SBOTs, the predominant imaging feature was the presence of papillary projections and multilocular cystic architecture. In contrast, MBOTs were more frequently associated with thick septations and multilocular cysts filled with mucinous content.

Correlation analysis demonstrated that the presence of papillary projections and mural nodules on imaging showed a strong association with histopathological confirmation of BOTs ($p < 0.01$). The sensitivity and specificity of USG in detecting BOTs were 78% and 72%, respectively, whereas MRI demonstrated significantly higher values with 91% sensitivity and 88% specificity. The detailed correlation between imaging modalities and histopathological diagnosis is presented in Table 3.

Table 3: Correlation of Imaging Findings with Histopathology (n = 60)

Imaging Feature	Histopathology Positive n (%)	p-value
Papillary projections	42 (70.0)	<0.01
Mural nodules	39 (65.0)	<0.01
Thick septations	47 (78.3)	0.03
Solid areas	25 (41.7)	0.07
Ascites	13 (21.7)	0.18

As demonstrated in Table 3, papillary projections and mural nodules were the most reliable imaging predictors of BOTs. While thick septations were also significantly associated, the presence of ascites and solid areas alone were not statistically significant indicators of borderline pathology.

Diagnostic Performance of Ultrasound and MRI: When compared against histopathology as the gold standard, ultrasound demonstrated a diagnostic accuracy of 77%, with a sensitivity of 78% and specificity of 72%. MRI, however, showed superior diagnostic performance, with an accuracy of 90%, sensitivity of 91%, and specificity of 88%. These results underscore the clinical value of MRI in preoperative evaluation of BOTs, particularly in cases where fertility preservation and conservative surgical approaches are being considered. The comparative diagnostic performance of both modalities is summarized in Table 4.

Table 4: Diagnostic Performance of Ultrasound and MRI Compared with Histopathology

Modality	Sensitivity (%)	Specificity (%)	Accuracy (%)
Ultrasound	78	72	77
MRI	91	88	90

As shown in Table 4, MRI consistently outperformed ultrasound across all diagnostic parameters. This highlights the importance of incorporating MRI into the diagnostic work-up of ovarian tumors suspicious for borderline pathology.

In summary, BOTs were more common among women in the reproductive and perimenopausal age groups, with serous BOTs representing the majority of cases. Imaging revealed that multilocular cysts, papillary projections, and mural nodules were the hallmark features strongly associated with BOTs. MRI outperformed ultrasound in diagnostic accuracy and provided more reliable detection of internal tumor architecture, enabling better surgical planning. Histopathology confirmed the borderline nature of these tumors, demonstrating the absence of stromal invasion despite significant epithelial proliferation and atypia.

DISCUSSION

The present clinical study sought to evaluate the imaging characteristics of borderline ovarian tumors (BOTs) and to correlate them with histopathological findings in a Pakistani population at the Niazi Welfare Foundation Teaching Hospital. Our findings confirm that BOTs predominantly occur in women of reproductive and perimenopausal age groups, with a mean age of 35.7 years, consistent with earlier reports suggesting that BOTs typically present in younger women compared to invasive epithelial ovarian cancers. This age distribution is clinically important, as fertility preservation is often a major concern in management, and accurate preoperative diagnosis becomes critical for guiding surgical decisions[11,12].

One of the most significant findings of this study was the superiority of MRI over ultrasound in detecting characteristic imaging features of BOTs. Ultrasound remains the first-line modality due to its cost-effectiveness, accessibility, and utility as a screening tool, particularly in low- and middle-income countries such as Pakistan[13]. However, our results demonstrated that MRI offered higher sensitivity (91%) and specificity (88%) than ultrasound (78% and 72%, respectively) in detecting features such as papillary projections, mural nodules, and complex septations. These results align with international studies. For example, Choi et al. (2020) highlighted the value of MRI in identifying papillary excrescences and enhancing mural nodules as strong predictors of borderline pathology, while Fischerova and colleagues (2020) also emphasized that ultrasound alone may misclassify complex cystic lesions without MRI confirmation[14,15].

Histopathologically, serous BOTs represented the majority (63.3%) of cases in our cohort, while mucinous BOTs accounted for 36.7%. This predominance of serous subtype is consistent with Western and Asian data, although mucinous BOTs are often more frequently observed in South Asian populations due to underlying epidemiological and genetic differences[16]. Serous tumors were strongly associated with papillary projections on imaging, whereas mucinous tumors tended to display multilocular cystic morphology with thick septations. The statistically significant correlation between papillary projections and histopathology ($p < 0.01$) in our study underscores their diagnostic importance. These findings reinforce prior reports by Timmerman et al. (2020), who found that papillary structures on ultrasound were among the most predictive features of BOTs[17].

The study also demonstrated that imaging findings such as ascites and solid components were not significantly associated with borderline pathology. This observation is particularly relevant, as ascites is more strongly associated with invasive carcinoma rather than BOTs[18]. Our data support the notion that the absence of frank invasion on imaging should not be equated with benignity, as BOTs may still exhibit atypical epithelial proliferation without stromal infiltration. This highlights the essential role of histopathological confirmation in differentiating borderline tumors from both benign and malignant lesions[19].

In terms of clinical implications, the findings of this study are crucial for surgical planning. Because BOTs often affect younger women, conservative surgical approaches such as unilateral salpingo-oophorectomy or cystectomy are considered when fertility preservation is desired. Accurate imaging assessment, particularly with MRI, enables clinicians to tailor management strategies, avoid overtreatment, and preserve reproductive function without compromising oncological safety. Furthermore, this study contributes to the limited local literature on BOTs in Pakistan, emphasizing the need for radiological–pathological correlation in resource-limited healthcare systems[20,21].

When compared with international literature, our results mirror those of large multicenter studies in Europe and North America, which consistently highlight MRI's role in improving preoperative diagnostic accuracy. However, in low-resource settings like Pakistan, reliance on ultrasound remains high due to limited MRI availability. This reinforces the necessity of enhancing diagnostic capacity and training radiologists to recognize subtle ultrasound markers of BOTs while incorporating MRI selectively for complex or indeterminate cases[22,23].

Despite its strengths, this study has limitations. The sample size was relatively modest (n = 60) and limited to a single tertiary care hospital, which may restrict the generalizability of results. Additionally, we did not perform long-term follow-up of patients to assess recurrence patterns or fertility outcomes after conservative surgery[11,17]. Future studies should focus on multicenter recruitment with larger sample sizes, extended follow-up, and integration of advanced imaging modalities such as diffusion-weighted MRI and PET-MRI, which may further refine diagnostic accuracy. Molecular

profiling of BOTs in Pakistani women may also provide new insights into pathogenesis and potential targeted therapies[24].

Finally, the present study validates the importance of imaging in the preoperative assessment of BOTs, with MRI outperforming ultrasound in diagnostic accuracy. The integration of radiological features with histopathological confirmation offers a comprehensive approach to diagnosis and management, ensuring better surgical planning, fertility preservation, and patient outcomes[25].

CONCLUSION

Borderline ovarian tumors are an important diagnostic entity, occurring predominantly in women of reproductive and perimenopausal age. This study demonstrated that imaging, particularly MRI, plays a crucial role in identifying key features such as multilocular cysts, papillary projections, and mural nodules, which are strongly correlated with histopathological diagnosis. While ultrasound remains the first-line screening tool, MRI provides superior diagnostic accuracy and should be incorporated in the evaluation of complex adnexal masses. Definitive diagnosis, however, continues to rely on histopathology. Recognition of these characteristic imaging findings enables timely surgical planning, facilitates fertility-preserving approaches, and contributes to improved patient care in both local and global contexts.

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Authors' Contributions

SA: Conceptualization of the study, study design, supervision of data collection, and critical revision of the manuscript.

MZ: Patient recruitment, clinical evaluation, surgical planning, and drafting of the clinical methodology.

SAsh: Histopathological evaluation of specimens, data interpretation, and manuscript drafting for pathology-related sections.

DS: Radiological assessment, image interpretation, preparation of imaging results, and contribution to the discussion.

AS: Literature review, data entry, statistical analysis, and preparation of results with tables.

BF: Drafting of introduction, formatting of the manuscript, referencing, and final proof editing before submission.

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