RESEARCH PAPER

COMPARATIVE DIAGNOSTIC ACCURACY OF PREOPERATIVE RADIOLOGICAL IMAGING AND INTRAOPERATIVE FROZEN SECTION AGAINST FINAL HISTOPATHOLOGY IN OVARIAN LESIONS: A CROSS-SECTIONAL STUDY

Dr. P. Kamalanandan[1], Dr. N. R. Rajesh Kanna[2], Dr. Vindu Srivastava[3*], Dr. P. Blessy Annika[4]

[1]Postgraduate Student, Department of Pathology, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam - 603103, Tamil Nadu, India. Email: redquill7@yahoo.com, ORCID: 0009-0006-7846-4587

[2]Professor, Department of Pathology, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam - 603103, Tamil Nadu, India. Email: rajeshthuva@gmail.com, ORCID: 0000-0001-5354-670X

[3*]Professor and Head of Department, Department of Pathology, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam - 603103, Tamil Nadu, India. Email: vinsripath1@gmail.com (Corresponding Author), ORCID: 0000-0003-0402-3261

[4]Postgraduate Student, Department of Pathology, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam - 603103, Tamil Nadu, India. Email: blessy3795@gmail.com, ORCID: 0009-0007-3011-4112

ABSTRACT

Background: Ovarian lesions comprise a heterogeneous spectrum of benign, borderline, and malignant tumours, and accurate preoperative and intraoperative diagnosis is essential for appropriate surgical management and prognostication.

Objective: To compare the diagnostic accuracy of preoperative radiological imaging and intraoperative consultation against final histopathological examination for ovarian lesions.

Methods: This single-centre analytical cross-sectional study was conducted at Chettinad Hospital and Research Institute, Chennai, between October 2025 and January 2026 among 33 ovarian lesion cases with available preoperative imaging, intraoperative frozen section, and final histopathology on permanent sections.

Results: Among 33 ovarian lesions, 24 (72.7%) were benign, 2 (6.1%) borderline, and 7 (21.2%) malignant. Borderline/malignant tumours occurred in older patients (52.7 ± 9.4 vs 39.2 ± 11.8 years; p=0.003), were larger (12.7 ± 3.7 vs 7.3 ± 2.7 cm; p=0.002), showed higher CA-125 levels (163.9 vs 26.2 U/mL; p<0.001), and were more often bilateral (55.6% vs 4.2%; p=0.003). Benign epithelial cysts predominated (51.5%), while low-grade serous carcinoma was the commonest malignant subtype (9.1%). Preoperative imaging showed 81.8% agreement with final histopathology (weighted κ=0.731), whereas frozen section showed better concordance at 90.9% (weighted κ=0.933). For malignancy alone, frozen section achieved 100% sensitivity, specificity, and accuracy, outperforming imaging (85.7%, 96.2%, and 93.9%). Discordant imaging cases were mainly due to complex cyst morphology, while frozen section errors reflected sampling limitations and tumour heterogeneity.

Conclusion: Intraoperative frozen section demonstrated higher diagnostic accuracy and agreement with final histopathology than preoperative imaging, supporting its value as a reliable intraoperative tool for guiding surgical management of ovarian lesions.

Keywords: Ovarian lesions, Frozen section, Histopathology, Diagnostic accuracy, Preoperative imaging, Concordance

How to cite this article: Kamalanandan P, Rajesh Kanna NR, Srivastava V, Blessy Annika P. Comparative Diagnostic Accuracy of Preoperative Radiological Imaging and Intraoperative Frozen Section Against Final Histopathology in Ovarian Lesions: A Cross-Sectional Study. Int J Drug Deliv Technol. 2026;16(5): 1411-1419. DOI: 10.25258/ijddt.16.5.132

Source of support: Nil.

Conflict of interest: None

Introduction

Ovarian neoplasms comprise a broad spectrum of lesions ranging from functional and benign cysts to borderline tumours and frankly invasive malignancies, and this heterogeneity makes preoperative characterization clinically important because the extent of surgery, need for staging, fertility preservation, and referral to gynaecologic oncology all depend on the estimated malignant

potential of the adnexal mass. Ovarian cancer also remains a major global health problem: GLOBOCAN 2022 estimated 324,398 new ovarian cancer cases and 206,956 deaths worldwide, ranking ovary among the leading causes of cancer-related mortality in women because many cases still present at an advanced stage.(1) In routine practice, ultrasonography is the first-line imaging modality for adnexal masses because it is accessible, non-invasive, and highly effective in recognizing classic benign lesions; when typical benign sonographic features are present, the risk of malignancy approaches 0%. However, a substantial proportion of ovarian masses remain indeterminate on ultrasound, especially when they show septations, mural nodules, papillary projections, or mixed solid-cystic morphology.(2) To improve standardization, the International Ovarian Tumor Analysis (IOTA) group developed structured descriptors and predictive models, including the ADNEX model, which was the first multiclass model designed to distinguish benign tumours, borderline tumours, stage I ovarian cancer, stage II–IV ovarian cancer, and metastatic ovarian tumours. In an external validation study by He et al., the ADNEX model achieved an AUC of 0.97 for differentiating benign from malignant adnexal masses, with 87.1% sensitivity and 97.7% specificity at the optimal cut-off, although discrimination between borderline tumours and some malignant subtypes remained more difficult.(3)

For lesions that remain indeterminate after ultrasound, MRI has an established complementary role because it improves tissue characterization and risk stratification. The ACR O-RADS MRI system was developed to provide a reproducible malignancy-risk framework based on lesion composition, signal characteristics, and enhancement of solid tissue. In the prospective multicentre study underpinning the system, the O-RADS MRI score showed 92% overall accuracy, 93% sensitivity, 91% specificity, and 98% negative predictive value, supporting its use in triaging women with sonographically indeterminate adnexal lesions and in reducing unnecessary extensive surgery for benign disease.(4) Serum biomarkers, particularly CA-125, also continue to be integrated with imaging because they can strengthen preoperative suspicion of epithelial malignancy, although marker elevation is not entirely specific and may occur in selected benign conditions. Despite improvements in imaging-based risk stratification, definitive categorization still depends on histopathology, and intraoperative frozen section remains a valuable bridge between preoperative suspicion and final tissue diagnosis because it can guide the extent of surgery during the same operative session. Goel et al. reported 90.0% overall accuracy, 89.4% sensitivity, and 100% specificity for malignant tumours,(5) while Pujani et al. reported 94% accuracy, 90% sensitivity, and 97% specificity.(6) At the same time, both studies emphasized that borderline tumours and heterogeneous mucinous lesions remain the principal sources of discrepancy, underscoring the need to compare preoperative radiologic impression, frozen section diagnosis, and final histopathology in individual institutional settings. Against this background, the objective of the present study was to compare the diagnostic accuracy of preoperative radiological imaging and intraoperative frozen section consultation against final histopathological examination for ovarian lesions, quantify concordance/discordance between these modalities with identification of scenarios contributing to diagnostic uncertainty, and estimate the sensitivity of each diagnostic approach.

Materials and Methods

This was a single-centre, hospital-based, analytical cross-sectional study conducted in the Chettinad Hospital and Research Institute, Chennai, Tamil Nadu, India over a period of four months between October 2025 and January 2026. The study was approved by the Institutional Human Ethics Committee (IHEC) with reference number IHEC-I/020/10/2025 dated 24/10/2025. Participants were included if they had undergone preoperative radiological imaging (ultrasound and/or MRI and/or PET), received intraoperative frozen section consultation, and had complete final histopathological reports available. Cases were excluded if the final histopathological diagnosis was inconclusive, frozen section evaluation was not performed, or diagnostic data were missing for any of the modalities.

The sample size was estimated using the single-proportion formula for sensitivity: $n = Z^2 \times p \times (1-p) / d^2$, where $Z = 1.96$ for 95% confidence, p is the expected sensitivity, and d is the absolute precision. Taking sensitivity of 90% ($p = 0.90$) for intraoperative frozen section in differentiating malignant/borderline from benign ovarian tumours from Asp et al. (2022),(7) and fixing the desired precision at 10% ($d = 0.10$), the minimum required sample size was 33 participants; enrolled using nonprobability sampling technique – convenient/purposive sampling. All cases underwent a detailed preoperative clinical assessment, including history, examination, and review of relevant serum tumour markers for adnexal masses (including CA-125, and—when clinically indicated—CEA, CA19-9, AFP, β-hCG and LDH), along with preoperative radiological evaluation using ultrasonography and/or cross-sectional imaging (MRI and/or PET/CT) to characterise the ovarian lesion and assess the likelihood of malignancy. Specimen was received

from the OT, and it was examined grossly and sectioned, prioritising viable solid areas, papillary projections, septations, mural nodules, and any grossly suspicious foci, while avoiding necrotic or haemorrhagic tissue; large multiloculated mucinous tumours were sampled from multiple areas to reduce under-sampling errors. It was embedded in optimal cutting medium, rapidly frozen, and sectioned on a cryostat maintained at approximately −27 °C. Multiple sections were cut at 4 µm thickness, stained using rapid haematoxylin and eosin (H&E), and examined by the reporting pathologist, who issued an intraoperative interpretation that was communicated to the surgical team to guide real-time operative management. After completion of frozen section assessment, the entire specimen was fixed in 10% neutral buffered formalin, followed by routine grossing with additional sampling of suspicious or heterogeneous areas; tissue was processed by dehydration, clearing, and paraffin embedding, and sections were cut at 3 µm and stained with routine H&E for final histopathological diagnosis. The diagnoses from preoperative imaging, frozen section, and final histopathology were independently recorded in a structured proforma and categorised as benign, borderline, or malignant (based on final histology as the reference standard), and all discordant cases were reviewed.

Statistical analysis: Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality (Shapiro–Wilk) and summarized as mean ± SD or median (IQR), and categorical variables as n (%). Benign versus borderline/malignant groups were compared using the independent t-test/Mann–Whitney U test for continuous variables and χ^2/Fisher's exact test for categorical variables. Diagnostic performance of preoperative imaging and intraoperative frozen section was evaluated against final histopathology (reference standard) using 3×3 cross-tabulations and dichotomized analyses (malignant positive and borderline/malignant positive) to compute sensitivity, specificity, PPV, NPV, and accuracy with 95% CI. Agreement between modalities was assessed using overall percent agreement and weighted Cohen's kappa (quadratic weights). All tests were two-tailed, with $p < 0.05$ considered statistically significant.

Results

The study included 33 patients, of whom 24 had benign lesions and 9 had borderline/malignant lesions. Patients with borderline/malignant tumours were significantly older than those with benign lesions (52.7 ± 9.4 vs 39.2 ± 11.8 years; p=0.003) and had significantly larger tumours (12.7 ± 3.7 vs 7.3 ± 2.7 cm; p=0.002). Median CA-125 was markedly higher in the borderline/malignant group than in the benign group (163.9 [127.8–220.8] vs 26.2 [18.9–34.7] U/mL; p<0.001), and CA-125 elevation >35 U/mL was seen in all borderline/malignant cases compared with 25.0% of benign cases. Bilaterality was also more frequent in borderline/malignant lesions (55.6% vs 4.2%; p=0.003). Abdominal or pelvic pain was the most common presenting symptom overall (81.8%), followed by abdominal distension (39.4%). CEA was tested in 30.3% and LDH in 12.1% of cases as seen in table 1. Surgical management differed significantly between groups (p<0.001), with cystectomy performed only in benign lesions, whereas staging procedures were restricted to borderline/malignant tumours.

Table 1: Baseline clinicopathological characteristics of the study cohort, stratified by final histopathology (benign vs borderline/malignant)

		Overall (N=33)	**Benign (n=24)**	**Borderline/Malignant (n=9)**	**p-value**
Age (years), Mean ± SD		42.8 ± 12.6	39.2 ± 11.8	52.7 ± 9.4	0.003*
Tumor size (cm), Mean ± SD		8.8 ± 3.8	7.3 ± 2.7	12.7 ± 3.7	0.002*
CA-125 (U/mL), Median (IQR)		30.5 (22.2–73.4)	26.2 (18.9–34.7)	163.9 (127.8–220.8)	<0.001*
CA-125 elevated (>35 U/mL), n (%)		15 (45.5)	6 (25.0)	9 (100.0)	<0.001*
Laterality, n (%)	Right	13 (39.4)	10 (41.7)	3 (33.3)	0.003*
	Left	14 (42.4)	13 (54.2)	1 (11.1)	
	Bilateral	6 (18.2)	1 (4.2)	5 (55.6)	
Presenting symptoms (non	Abdominal/pelvic pain	27 (81.8)	18 (75.0)	9 (100.0)	0.597
	Abdominal distension	13 (39.4)	8 (33.3)	5 (55.6)	

- mutually exclusive), n (%)	Palpable/subjective mass	7 (21.2)	3 (12.5)	4 (44.4)	
	Menstrual irregularity	7 (21.2)	5 (20.8)	2 (22.2)	
	GI symptoms	3 (9.1)	2 (8.3)	1 (11.1)	
	Incidental detection	5 (15.2)	3 (12.5)	2 (22.2)	
Other tumor markers (performed as clinically indicated)	CEA tested, n (%)	10 (30.3)	9 (37.5)	1 (11.1)	
	CEA elevated (>5 ng/mL) among tested, n/N (%)	1/10 (10.0)	0/9 (0.0)	1/1 (100.0)	
	LDH tested, n (%)	4 (12.1)	4 (16.7)	0 (0.0)	
	LDH elevated (>250 U/L) among tested, n/N (%)	3/4 (75.0)	3/4 (75.0)	–	
Type of surgery performed, n (%)	Cystectomy	11 (33.3)	11 (45.8)	0 (0.0)	<0.001*
	Oophorectomy	3 (9.1)	3 (12.5)	0 (0.0)	
	Unilateral salpingo-oophorectomy	12 (36.4)	10 (41.7)	2 (22.2)	
	Unilateral salpingo-oophorectomy with staging	3 (9.1)	0 (0.0)	3 (33.3)	
	TAH+BSO with staging	4 (12.1)	0 (0.0)	4 (44.4)	
	Staging surgery (any), n (%)	7 (21.2)	0 (0.0)	7 (77.8)	
*Statistically significant at p<0.05					

On final histopathological examination, most ovarian lesions were benign (24/33, 72.7%), while 2 cases (6.1%) were borderline and 7 cases (21.2%) were malignant. Benign epithelial cysts accounted for 17 cases (51.5%), followed by mature cystic teratoma in 4 cases (12.1%) and endometriotic cyst in 3 cases (9.1%). Among malignant lesions, low-grade serous carcinoma was the most frequent subtype (3/33, 9.1%). In concordance analysis, preoperative imaging showed an overall agreement of 81.8% with final histopathology, with a weighted kappa of 0.731, indicating substantial agreement. Intraoperative frozen section performed better, with 90.9% overall agreement and a weighted kappa of 0.933, indicating almost perfect agreement. Agreement between imaging and frozen section was 72.7%, with a weighted kappa of 0.663 as seen in table 2 and 3. Overall, frozen section showed closer concordance with final histopathology than preoperative imaging.

Table 2: Spectrum and distribution of ovarian lesions on final histopathological examination (reference standard) (N=33)

	n	**%**
Benign	24	72.7
Benign epithelial cyst (serous/mucinous/simple)	17	51.5
Endometriotic cyst	3	9.1
Mature cystic teratoma	4	12.1
Borderline	2	6.1
Borderline mucinous tumor	2	6.1
Malignant	7	21.2
Clear cell carcinoma	1	3.0
Dysgerminoma	1	3.0
High-grade serous carcinoma	1	3.0
Low-grade serous carcinoma	3	9.1
Metastatic tumor to ovary (possible)	1	3.0

Table 3: Concordance of preoperative imaging and intraoperative frozen section diagnoses with final histopathology and inter-modality agreement

		Histopathology		
		Benign	**Borderline**	**Malignant**
Imaging	Benign	20	1	1
	Borderline	3	1	0
	Malignant	1	0	6
	Benign	22	1	0

Frozen section	Borderline	2	1	0
	Malignant	0	0	7
Imaging vs final histopathology: Overall agreement, 81.8%; Weighted kappa (quadratic), 0.731 Frozen section vs final histopathology: Overall agreement, 90.9%; Weighted kappa (quadratic), 0.933 Imaging vs frozen section: Overall agreement, 72.7%; Weighted kappa (quadratic), 0.663				

Using final histopathology as the reference standard, intraoperative frozen section showed better diagnostic performance than preoperative imaging overall. When malignancy alone was considered positive, imaging demonstrated a sensitivity of 85.7%, specificity of 96.2%, and accuracy of 93.9%, whereas frozen section achieved 100% sensitivity, 100% specificity, and 100% accuracy. When borderline and malignant lesions were combined as positive, the performance of both modalities decreased slightly, but frozen section still outperformed imaging, with sensitivity, specificity, and accuracy of 88.9%, 91.7%, and 90.9%, respectively, compared with 77.8%, 83.3%, and 81.8% for imaging. Analysis of discordant cases showed that imaging errors were most commonly due to complex cyst morphology with septations or internal debris causing overcalling (3 cases, 50.0%), while other causes included calcified/solid components, overlap of borderline morphology with benign complex cysts, and subtle early malignant features. In contrast, frozen section discordance was mainly related to sampling limitation and interpretive difficulty, especially focal epithelial proliferation (2 cases, 66.7%) and tumour heterogeneity in a large mucinous borderline lesion (1 case, 33.3%).

Table 4: Diagnostic performance of preoperative imaging and intraoperative frozen section using final histopathology as the reference standard (malignant positive and borderline/malignant positive)

	Imaging				**Frozen section**			
	Malignant		**Borderline/malignant**		**Malignant**		**Borderline/malignant**	
Metric	**Estimate**	**95% CI (Wilson)**	**Estimate**	**95% CI (Wilson)**	**Estimate**	**95% CI (Wilson)**	**Estimate**	**95% CI (Wilson)**
Sensitivity (%)	85.7	48.7–97.4	77.8	45.3–93.7	100.0	64.6–100.0	88.9	56.5–98.0
Specificity (%)	96.2	81.1–99.3	83.3	64.1–93.3	100.0	87.1–100.0	91.7	74.2–97.7
PPV (%)	85.7	48.7–97.4	63.6	35.4–84.8	100.0	64.6–100.0	80.0	49.0–94.3
NPV (%)	96.2	81.1–99.3	90.9	72.2–97.5	100.0	87.1–100.0	95.7	79.0–99.2
Accuracy (%)	93.9	80.4–98.3	81.8	65.6–91.4	100.0	89.6–100.0	90.9	76.4–96.9

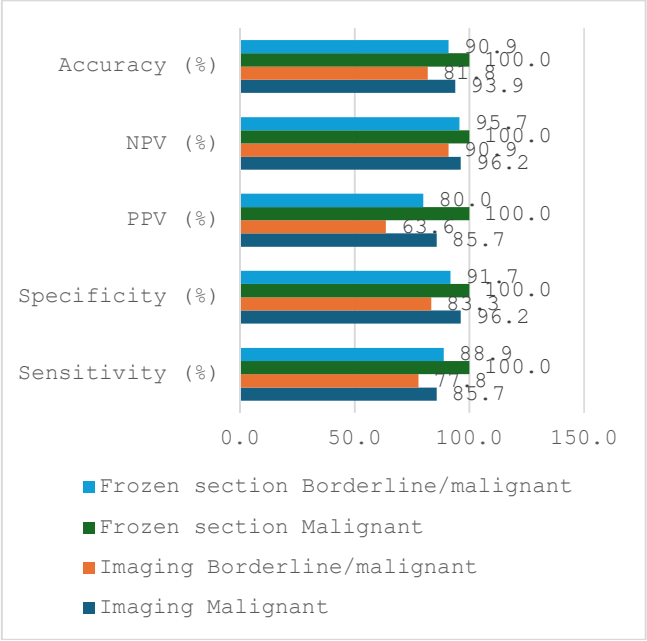

Figure 1: Diagnostic performance of preoperative imaging and intraoperative frozen section using final histopathology as the reference standard (malignant positive and borderline/malignant positive)

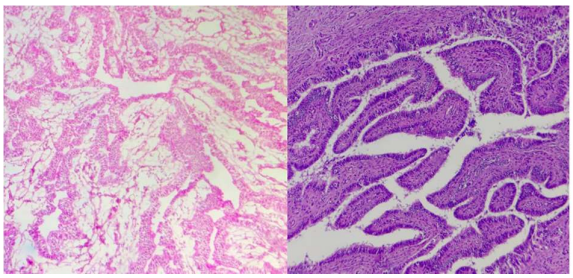

Figure 2: left image shows frozen section and right image histopathology sections of the same case diagnosed as benign Cystadenofibroma of the ovary

Table 5: Causes of diagnostic discordance – frequency distribution of stated reasons for misclassification on imaging and frozen section (discordant cases only)

	n	% of imaging discordant
Imaging reason		
Complex cyst morphology (septations/debris) led to overcall on imaging	3	50.0
Solid/calcified components raised suspicion on imaging (interpretive limitation)	1	16.7
Borderline morphology overlaps with benign complex cyst; limited imaging specificity for borderline lesions	1	16.7
Subtle solid components/early-stage appearance resulted in undercall on imaging	1	16.7
Frozen section reason		
Limited intraoperative sampling with focal epithelial proliferation; inadequate technical quality of frozen section; interpretive limitation	2	66.7
Sampling limitation and tumour heterogeneity in a large mucinous tumour; borderline features focal	1	33.3

Discussion

In the present study, benign ovarian lesions predominated on final histopathology, accounting for 72.7% of cases, whereas borderline and malignant lesions together constituted 27.3%. This distribution is consistent with routine surgical pathology, where benign adnexal masses far outnumber malignant neoplasms, and with the broad pathologic heterogeneity of ovarian tumours described in Kroeger & Drapkin (2017) and Meinhold-Heerlein & Hauptmann (2014).(8, 9) The dominance of benign epithelial cysts in our cohort is also biologically plausible because surface epithelial tumours form the largest category of ovarian neoplasms overall, while germ cell and other uncommon malignant subtypes are relatively infrequent; in corroboration with Hashmi et al. (2016) and Huang et al. (2018).(10, 11) Similar to the present study, Fischerova et al. (2012) noted that borderline ovarian tumours themselves represent a smaller intermediate category, estimated at roughly 15%–20% of epithelial ovarian malignancies.(12)

A clinically important finding in the present study as seen in table 1 was that patients with borderline/malignant tumours were significantly older than those with benign lesions and also had significantly larger tumours. This pattern aligns with established epidemiology showing that the probability of malignancy in an adnexal mass rise with age, particularly after the reproductive years, and with Park et al. (2019) and Shetty et al. (2019) adding that malignant or potentially malignant ovarian masses tend to have larger size, more solid components, and more complex internal architecture than straightforward benign cysts.(13, 14) The observation that the borderline/malignant group in our study had a mean tumour size of 12.7 cm compared with 7.3 cm in the benign group is also in concordance with Shao et al. (2024), because increasing tumour size—especially in mucinous neoplasms—has been linked to diagnostic under-sampling and lower intraoperative accuracy.(15)

The marked separation in CA-125 values between the benign and borderline/malignant groups in this study is also in keeping with prior evidence. CA-125 remains the most widely used serum marker in the evaluation of epithelial ovarian cancer, and values above 35 U/mL are conventionally regarded as abnormal.(16) Sharma & Vinocha (2020) reported that CA-125 is elevated in about 80% of epithelial ovarian cancers, with reported sensitivity ranging from 61% to 90% and specificity from 71% to 93% when used to distinguish benign from malignant adnexal disease.(17) At the same time, CA-125 is not cancer-specific and may also rise in endometriosis, pelvic inflammation, menstruation, and other benign conditions, which explains why one-quarter of benign lesions in our cohort also had elevated values.(18) The very high median CA-125 in the borderline/malignant group in our study therefore supports its value as a risk-stratification tool, but not as a stand-alone discriminator.

Our finding that bilateral involvement was significantly more common in borderline/malignant lesions than in benign lesions is similarly credible from a radiologic-pathologic standpoint. Bilateral ovarian masses on imaging are classically associated with serous carcinoma and metastatic tumours, although bilateral benign lesions do occur. Mukuda et al. (2018) reported that the most common bilateral ovarian tumours on MRI were serous carcinoma, mature teratoma, and metastases, supporting the

principle that bilaterality should increase suspicion and prompt careful assessment of morphology and clinical context.(19) The single possible metastatic tumour in our malignant group also fits Lee et al. (2009) that metastatic ovarian tumours often present bilaterally and can mimic primary ovarian neoplasia, adding to preoperative diagnostic complexity.(20)

With respect to symptoms, abdominal or pelvic pain was the most frequent presentation in our cohort, followed by abdominal distension. This is unsurprising because many benign cysts, endometriotic cysts, and large malignant masses alike may produce pain through stretching, torsion risk, haemorrhage, or associated adhesions, whereas distension more often reflects increasing tumour burden or ascites. Symptom-based distinction is therefore limited, and this helps explain why clinical presentation alone cannot reliably separate benign from malignant disease.(13) The selective use of ancillary markers such as CEA and LDH in our cohort was appropriate: CEA is most useful when a mucinous neoplasm or gastrointestinal origin is suspected, while LDH is particularly relevant in germ cell tumours such as dysgerminoma, which are rare but important differential diagnoses.(21)

Benign epithelial cysts were the most common diagnosis, followed by mature cystic teratoma and endometriotic cyst, whereas low-grade serous carcinoma was the most frequent malignant subtype in our sample. This pattern differs somewhat from high-volume ovarian cancer studies, where high-grade serous carcinoma usually predominates among invasive cancers, but such variation is expected in a small institutional cohort over a short study period.(10, 18) Importantly, the presence of both epithelial and non-epithelial lesions underscores why preoperative evaluation must remain multimodal: no single imaging sign or tumour marker can fully resolve the differential diagnosis across cystic epithelial lesions, germ cell tumours, endometriosis-associated lesions, and metastatic deposits. A major strength of the present results is the demonstration that intraoperative frozen section was more concordant with final histopathology than preoperative imaging. Imaging achieved an overall agreement of 81.8% with a weighted kappa of 0.731, which corresponds to substantial agreement, while frozen section achieved 90.9% agreement with a weighted kappa of 0.933, indicating almost perfect agreement. This hierarchy is consistent with the fact that imaging evaluates morphology indirectly, whereas frozen section evaluates tissue architecture and cytology directly in real time. Published ovarian frozen-section studies have reported overall accuracies in the 90%–97% range, with high sensitivity and specificity for clearly benign and clearly malignant lesions but lower performance for borderline tumours.(10, 22, 23) Suprasert et al. reported an overall accuracy of 93.8%,(23) while Hashmi et al. summarized earlier reports showing strong performance for benign and malignant categories but persistent difficulty in borderline, especially mucinous, tumours.(10)

The diagnostic performance reinforces this interpretation. For malignancy alone, imaging performed well, with sensitivity 85.7%, specificity 96.2%, and accuracy 93.9%, but frozen section performed even better. When borderline and malignant tumours were combined as the positive category, performance dropped for both modalities, but the reduction was greater for imaging than for frozen section. This is entirely in line with existing evidence that the borderline category is the main source of diagnostic uncertainty. Huang et al., in a meta-analysis of borderline ovarian tumour frozen section, showed that the major vulnerability of frozen section lies not in overt malignant lesions but in borderline tumours and in distinguishing borderline from invasive disease.(11) Similarly, De Decker et al. showed that among women given an intraoperative diagnosis of “at least borderline,” just over 40% were found to have carcinoma on final histology, illustrating the biological and morphologic continuum that complicates intraoperative categorization.(24)

The discordance profile in our study is particularly informative because it mirrors known mechanisms of error. Imaging discordance was most often caused by overcalling complex benign cysts with septations or internal debris. This is a well-recognized limitation of morphology-based assessment: haemorrhagic cysts, endometriotic cysts, teratomas with echogenic or calcified components, and complex epithelial cysts may mimic malignant features, especially outside ultrasound pathways. Although IOTA-based ultrasound systems can achieve sensitivities and specificities around 92% in experienced hands, inconclusive or complex masses still require expert pattern recognition and often remain diagnostically indeterminate until pathology is available.(13, 25) Frozen-section discordance in our cohort was less frequent and was chiefly attributable to sampling limitation, focal epithelial proliferation, and tumour heterogeneity in a large mucinous borderline lesion. This again closely parallels published evidence. Park et al. specifically identified sampling error as the most frequent cause of frozen-section misdiagnosis in mucinous ovarian tumours and suggested that increasing the number of sampled frozen blocks improves accuracy.(14) Shah et al. likewise observed that mucinous borderline tumours are more likely than serous borderline tumours to be upgraded on permanent sections because they tend to be larger and may contain benign, borderline, and invasive areas within the same tumour.(26) Thus, the residual discordance in our study does not undermine the value of frozen section; rather, it defines the precise scenarios in

which caution, broader sampling, and close communication between surgeon and pathologist remain essential.

The present study had several limitations. First, it was a single-centre study with a small sample size (N=33) conducted over a short duration, which limits the generalisability of the findings and results in wide confidence intervals for diagnostic performance estimates, particularly for borderline and malignant subgroups. Second, the relatively low number of borderline tumours restricted more detailed subgroup analysis of this diagnostically challenging category. Third, the study included patients who had undergone different preoperative imaging modalities (ultrasound, MRI, and/or PET), and the diagnostic performance of imaging was assessed collectively rather than separately for each modality, which may have introduced heterogeneity. Fourth, because the study was conducted in a tertiary care setting using convenient/purposive sampling, a degree of selection bias cannot be excluded. Fifth, although discordant cases were reviewed, factors such as interobserver variability among radiologists and pathologists were not formally analysed.

Conclusion

In conclusion, intraoperative frozen section showed higher diagnostic accuracy and closer agreement with final histopathology than preoperative radiological imaging in the evaluation of ovarian lesions. While both modalities performed well for identifying overt malignancy, frozen section was superior overall and remained more reliable when borderline and malignant tumours were analysed together, although this category continued to pose the greatest diagnostic challenge. Borderline/malignant lesions in the present study were associated with older age, larger tumour size, higher CA-125 levels, and more frequent bilaterality, supporting their value as important clinicopathological indicators of increased malignant potential. Most discordant cases arose from complex benign cyst morphology on imaging and sampling or heterogeneity-related issues on frozen section, particularly in borderline and mucinous tumours. These findings support the continued role of frozen section as a valuable intraoperative tool for guiding surgical decision-making in ovarian neoplasms, while also highlighting the need for cautious interpretation in morphologically heterogeneous lesions.

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