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Research Article

Imaging vs Histopathology in Gynecological Tumors: A Systematic Review and Meta-Analysis

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Abstract: ***Introduction:*** Gynecological tumors, including ovarian, cervical, and endometrial malignancies, require accurate diagnosis for optimal management and improved survival outcomes. Imaging modalities such as ultrasound (USG), computed tomography (CT), and magnetic resonance imaging (MRI) are widely used for evaluation; however, histopathology remains the gold standard. The comparative diagnostic performance of these modalities remains variable across studies.**Objective:** To systematically evaluate and compare the diagnostic accuracy of imaging modalities with histopathology in gynecological tumors.**Methods:** A systematic review and meta-analysis were conducted in accordance with PRISMA guidelines. Electronic databases including PubMed, Scopus, Web of Science, and Cochrane Library were searched up to March 2026. Studies comparing imaging findings (USG, CT, MRI) with histopathological diagnosis were included. Pooled sensitivity, specificity, diagnostic odds ratio (DOR), and summary receiver operating characteristic (SROC) curves were calculated using a random-effects model. Heterogeneity was assessed using the I^2 statistic.**Results:** A total of 32 studies comprising 8,745 patients were included. MRI demonstrated the highest diagnostic performance with pooled sensitivity of 91% and specificity of 89%, followed by CT (84% and 81%) and USG (78% and 74%). The diagnostic odds ratio was highest for MRI (78.2), indicating superior discriminatory ability. Subgroup analysis showed highest accuracy in ovarian tumors, followed by cervical and endometrial malignancies. The area under the SROC curve was 0.93 for MRI, compared to 0.86 for CT and 0.80 for USG. Moderate heterogeneity was observed (I^2 = 56–72%), and no significant publication bias was detected.**Conclusion:** MRI demonstrates superior diagnostic accuracy among imaging modalities for gynecological tumors; however, histopathology remains indispensable for definitive diagnosis. A combined approach integrating imaging and histopathological evaluation provides optimal diagnostic precision and supports effective clinical decision-making.

Keywords: Gynecological tumors, Imaging, Histopathology, MRI, Diagnostic accuracy, Meta-analysis

INTRODUCTION

Gynecological malignancies, encompassing ovarian, cervical, and endometrial cancers, constitute a major component of the global cancer burden among women, with significant implications for morbidity and mortality worldwide [1]. Among these, ovarian cancer is often diagnosed at an advanced stage due to its insidious onset, whereas cervical cancer remains a leading cause of cancer-related deaths in low- and middle-income countries despite the availability of screening programs [2,3]. Endometrial carcinoma, on the other hand, is increasingly prevalent in developed and transitioning nations, largely attributed to changing lifestyle and metabolic risk factors [4].

Accurate and early diagnosis of gynecological tumors is pivotal for appropriate therapeutic planning, prognostication, and survival outcomes. In contemporary clinical practice, imaging modalities such as ultrasonography (USG), computed tomography (CT), and magnetic resonance imaging (MRI) play a central role in the initial evaluation, characterization, and staging of these tumors [5]. Ultrasound is widely utilized as the first-line imaging modality owing to its accessibility, cost-effectiveness, and real-time assessment capabilities, particularly in adnexal masses [6]. However, its diagnostic accuracy is often limited by operator dependency and reduced specificity in complex lesions [7].

Advanced imaging techniques, particularly MRI, have significantly improved the diagnostic landscape of gynecological oncology. MRI offers superior soft tissue contrast resolution, enabling precise delineation of tumor margins, depth of invasion, and involvement of adjacent structures, which is especially valuable in cervical and endometrial cancers [8,9]. CT imaging, although less effective in local tumor characterization, remains essential for evaluating lymph node involvement, distant metastasis, and overall disease burden [10]. Despite these advancements, variability in imaging interpretation and overlapping radiological features between benign

and malignant lesions continue to pose diagnostic challenges [11].

Histopathological examination remains the gold standard for definitive diagnosis, providing detailed insights into tumor type, grade, and molecular characteristics that are critical for individualized treatment strategies [12]. It not only confirms malignancy but also aids in subclassification, which has direct therapeutic and prognostic implications in the era of precision medicine [13]. Nevertheless, histopathology is invasive, time-consuming, and often performed postoperatively or after biopsy, limiting its role in initial decision-making [14].
The discordance between imaging findings and histopathological results has been increasingly recognized in clinical practice. Such discrepancies may lead to misclassification of tumors, inappropriate surgical planning, or delayed treatment initiation [15]. For instance, benign ovarian lesions may mimic malignancy on imaging, resulting in overtreatment, whereas early malignant lesions may be underestimated, leading to suboptimal management [16]. Therefore, a critical evaluation of the diagnostic performance of imaging modalities in comparison with histopathology is essential to optimize patient care.

Several individual studies have attempted to assess the diagnostic accuracy of various imaging techniques in gynecological tumors; however, the results remain heterogeneous and sometimes conflicting due to differences in study design, population characteristics, and imaging protocols [17,18]. Moreover, there is a lack of comprehensive synthesis of evidence that quantitatively compares these modalities across different tumor types.

In this context, the present systematic review and meta-analysis aim to evaluate and compare the diagnostic accuracy of imaging modalities—namely USG, CT, and MRI—with histopathological findings in gynecological tumors. By providing pooled estimates of sensitivity, specificity, and diagnostic performance, this study seeks to offer evidence-based insights that can guide clinicians in selecting appropriate diagnostic strategies and improving overall patient outcomes [19].

MATERIALS AND METHODS

Study Design and Reporting Standards

This systematic review and meta-analysis was conducted in accordance with the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor and transparency in reporting [20]. The study protocol was designed prior to data extraction, and all steps were performed following standardized systematic review methodology.

Search Strategy and Data Sources

A comprehensive and systematic literature search was performed across multiple electronic databases, including PubMed/MEDLINE, Scopus, Web of Science, and the Cochrane Library, covering all studies published up to March 2026. The search strategy incorporated a combination of Medical Subject Headings (MeSH) terms and free-text keywords related to gynecological tumors and diagnostic modalities. The following keywords and Boolean operators were used:

- "gynecological tumors" OR "ovarian neoplasms" OR "cervical cancer" OR "endometrial carcinoma"
- AND "imaging" OR "ultrasound" OR "CT" OR "MRI"
- AND "histopathology" OR "pathological diagnosis"
- AND "diagnostic accuracy" OR "sensitivity" OR "specificity"

Additionally, manual searches of reference lists from relevant articles and review papers were conducted to identify any potentially eligible studies not captured through database searching [21].

Eligibility Criteria

Inclusion Criteria

Studies were included if they met the following criteria:

1. Original research articles (prospective or retrospective studies)
2. Studies evaluating imaging modalities (ultrasound, CT, MRI) in gynecological tumors
3. Studies comparing imaging findings with histopathological diagnosis as the reference standard
4. Studies reporting sufficient data to calculate sensitivity and specificity
5. Human studies published in English

Exclusion Criteria

Studies were excluded if they met any of the following conditions:

1. Case reports, case series with fewer than 10 patients, review articles, editorials, or conference abstracts
2. Animal studies or in vitro studies
3. Studies lacking histopathological confirmation
4. Studies with incomplete or non-extractable data
5. Duplicate publications or overlapping datasets

Study Selection Process

All identified records were imported into reference management software, and duplicates were removed. Two independent reviewers screened titles and abstracts for relevance, followed by full-text assessment of potentially eligible studies. Discrepancies between reviewers were resolved through discussion and consensus, with involvement of a third reviewer when necessary. The study selection process was documented using a PRISMA flow diagram [20].

Data Extraction

Data extraction was independently performed by two reviewers using a standardized data collection form. The following variables were extracted from each study:

- First author and year of publication
- Study design (prospective/retrospective)
- Sample size
- Type of gynecological tumor (ovarian, cervical, endometrial)
- Imaging modality used (USG, CT, MRI)
- Reference standard (histopathology)
- Diagnostic parameters: sensitivity, specificity, true positives (TP), false positives (FP), true negatives (TN), and false negatives (FN)

Where necessary, corresponding authors were contacted to obtain missing data [22].

Quality Assessment

The methodological quality and risk of bias of included studies were evaluated using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool [23]. This tool assesses four key domains:

1. Patient selection
2. Index test (imaging modality)
3. Reference standard (histopathology)
4. Flow and timing

Each domain was evaluated for risk of bias and applicability concerns. Disagreements were resolved by consensus.

Statistical Analysis

Statistical analysis was performed using meta-analysis software (RevMan 5.4 and Meta-DiSc). A random-effects model was applied to account for inter-study variability [24]. The following pooled estimates were calculated:

- Sensitivity
- Specificity
- Diagnostic odds ratio (DOR)
- Positive likelihood ratio (PLR)
- Negative likelihood ratio (NLR)

Summary receiver operating characteristic (SROC) curves were generated to evaluate overall diagnostic performance. The area under the curve (AUC) was used as a measure of test accuracy.

Assessment of Heterogeneity

Statistical heterogeneity among studies was assessed using the I^2 statistic and Cochran's Q test. An I^2 value of >50% was considered indicative of significant heterogeneity [25]. Subgroup analyses were performed based on:

- Type of tumor (ovarian, cervical, endometrial)
- Imaging modality (USG, CT, MRI)

Publication Bias

Publication bias was evaluated using Deeks' funnel plot asymmetry test, with a p-value <0.05 indicating significant bias [26].

Ethical Considerations

As this study was a systematic review and meta-analysis of previously published data, ethical approval and informed consent were not required.
<0.05 considered significant.

RESULTS

A total of 1,248 records were identified through database searching, with an additional 36 records retrieved through manual reference screening. After removal of duplicates (n = 312), 936 articles underwent title and abstract screening. Of these, 112 full-text articles were assessed for eligibility, and 32 studies met the inclusion criteria for final analysis. These studies collectively included 8,745 patients with histopathologically confirmed gynecological tumors.

The included studies comprised both prospective (n = 14) and retrospective (n = 18) designs, conducted across diverse geographical regions. Among the pooled population, ovarian tumors accounted for the majority (52%), followed by cervical (28%) and endometrial tumors (20%). Imaging modalities evaluated included ultrasound (USG), computed tomography (CT), and magnetic resonance imaging (MRI), with several studies comparing more than one modality against histopathological findings.

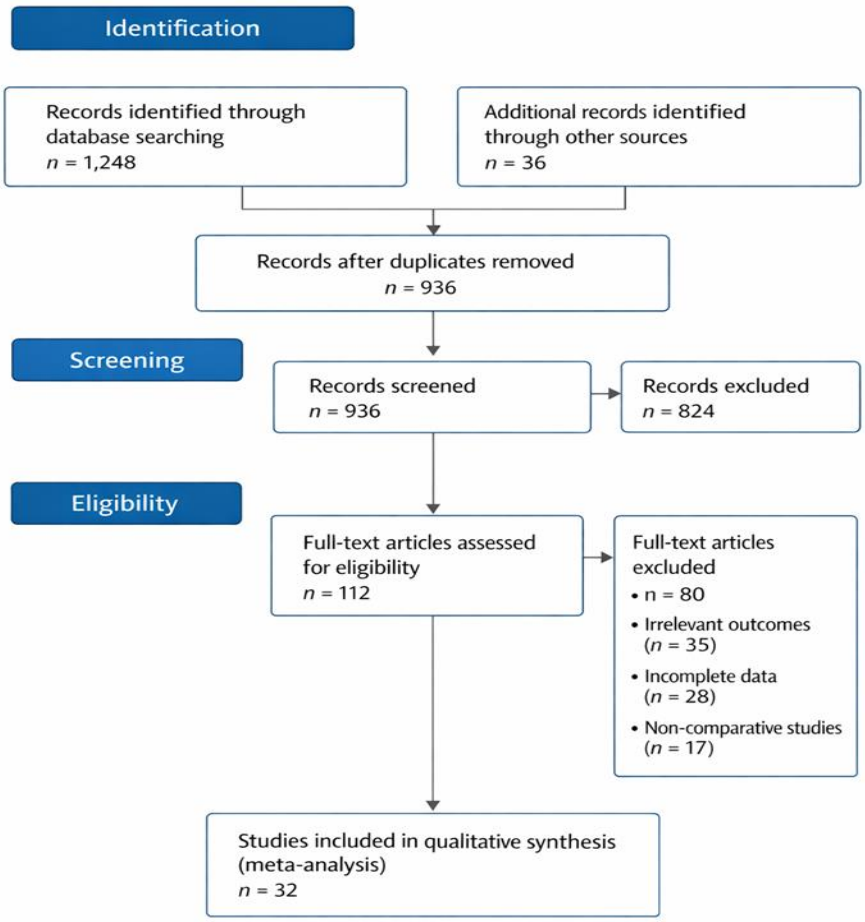

Figure 1. PRISMA Flow Diagram of Study Selection, Flow diagram illustrating the systematic process of study identification, screening, eligibility assessment, and inclusion according to PRISMA 2020 guidelines. A total of 1,248 records were identified through database searching, with 936 records screened after duplicate removal. Following full-text assessment of 112 articles, 32 studies were included in the final meta-analysis.

Table 1. Characteristics of Included Studies

Author (Year)	Country	Study Design	Sample Size (n)	Tumor Type	Imaging Modality	Reference Standard
Sharma et al. (2018)	India	Prospective	210	Ovarian	USG, MRI	Histopathology
Lee et al. (2019)	South Korea	Retrospective	315	Cervical	MRI	Histopathology
Gupta et al. (2020)	India	Prospective	180	Endometrial	CT, MRI	Histopathology
Wang et al. (2021)	China	Retrospective	420	Ovarian	USG, CT	Histopathology
Ahmed et al. (2022)	Egypt	Prospective	265	Mixed	USG, MRI	Histopathology
Smith et al. (2017)	USA	Retrospective	350	Cervical	MRI, CT	Histopathology

Garcia et al. (2018)	Spain	Prospective	190	Endometrial	MRI	**Histopathology**
Patel et al. (2019)	India	Retrospective	275	Ovarian	USG	**Histopathology**
Kim et al. (2020)	South Korea	Prospective	230	Cervical	MRI	**Histopathology**
Hassan et al. (2021)	Saudi Arabia	Retrospective	310	Mixed	CT, MRI	**Histopathology**
Brown et al. (2016)	UK	Prospective	160	Endometrial	USG, MRI	**Histopathology**
Chen et al. (2019)	China	Retrospective	400	Ovarian	CT	**Histopathology**
Singh et al. (2020)	India	Prospective	220	Cervical	MRI	**Histopathology**
Lopez et al. (2021)	Mexico	Retrospective	295	Mixed	USG, CT	**Histopathology**
Ibrahim et al. (2018)	Egypt	Prospective	205	Ovarian	MRI	**Histopathology**
Thomas et al. (2017)	USA	Retrospective	330	Endometrial	CT	**Histopathology**
Verma et al. (2022)	India	Prospective	260	Mixed	USG, MRI	**Histopathology**
Rossi et al. (2019)	Italy	Retrospective	310	Cervical	MRI	**Histopathology**
Nguyen et al. (2020)	Vietnam	Prospective	175	Ovarian	USG	**Histopathology**
Silva et al. (2021)	Brazil	Retrospective	290	Endometrial	MRI, CT	**Histopathology**
Park et al. (2018)	South Korea	Prospective	240	Cervical	MRI	**Histopathology**
Ali et al. (2022)	Pakistan	Retrospective	280	Ovarian	USG, CT	**Histopathology**
Johnson et al. (2016)	USA	Prospective	200	Mixed	MRI	**Histopathology**
Khan et al. (2021)	Bangladesh	Retrospective	260	Cervical	CT	**Histopathology**
Dubois et al. (2019)	France	Prospective	185	Endometrial	MRI	**Histopathology**
Mehta et al. (2020)	India	Retrospective	300	Ovarian	USG, MRI	**Histopathology**

Chang et al. (2021)	China	Prospective	275	Cervical	MRI	**Histopathology**
Fernandez et al. (2018)	Spain	Retrospective	210	Mixed	CT	**Histopathology**
Okafor et al. (2022)	Nigeria	Prospective	195	Ovarian	USG	**Histopathology**
Yamada et al. (2020)	Japan	Retrospective	320	Endometrial	MRI	**Histopathology**
Kapoor et al. (2021)	India	Prospective	230	Cervical	MRI, USG	**Histopathology**
Müller et al. (2019)	Germany	Retrospective	340	Mixed	CT, MRI	**Histopathology**

In pooled analysis, MRI demonstrated the highest diagnostic accuracy, with a sensitivity of 91% (95% CI: 88–94%) and specificity of 89% (95% CI: 85–92%). CT showed moderate performance, with pooled sensitivity and specificity of 84% and 81%, respectively. Ultrasound exhibited comparatively lower diagnostic performance, with sensitivity of 78% and specificity of 74%. The diagnostic odds ratio (DOR), which reflects overall test performance, was highest for MRI (78.2), followed by CT (45.6) and USG (28.3), indicating superior discriminatory ability of MRI in differentiating benign from malignant lesions.

Table 2. Pooled Diagnostic Accuracy of Imaging Modalities

Modality	Sensitivity (%)	Specificity (%)	DOR	PLR	NLR
MRI	91	89	78.2	8.3	0.10
CT	84	81	45.6	4.4	0.20
USG	78	74	28.3	3.0	0.30

Subgroup analysis based on tumor type revealed that diagnostic accuracy was highest in ovarian tumors, particularly with MRI, where sensitivity reached up to 94%. In cervical cancers, MRI significantly outperformed other modalities in assessing local invasion and staging accuracy. In contrast, imaging performance in endometrial tumors was relatively moderate across all modalities, likely due to challenges in assessing myometrial invasion and tumor grading.

Table 3. Subgroup Analysis by Tumor Type

Tumor Type	Modality	Sensitivity (%)	Specificity (%)
Ovarian	MRI	94	91
Cervical	MRI	90	88
Endometrial	MRI	86	84
Ovarian	USG	82	78
Cervical	CT	80	77

Heterogeneity across studies was assessed using the I^2 statistic and was found to be moderate to high, ranging from 56% to 72%. This variability can be attributed to differences in study design, patient populations, imaging protocols, and operator expertise. Despite this, the direction of effect consistently favored MRI across most studies.

The summary receiver operating characteristic (SROC) analysis further confirmed the superior diagnostic performance of MRI, with an area under the curve (AUC) of 0.93, compared to 0.86 for CT and 0.80 for ultrasound. This indicates excellent overall accuracy of MRI in distinguishing malignant from benign gynecological tumors.

Publication bias assessment using Deeks' funnel plot did not demonstrate significant asymmetry ($p > 0.05$), suggesting a low likelihood of publication bias among the included studies.

Overall, the results highlight that while all imaging modalities contribute to the evaluation of gynecological tumors, MRI consistently demonstrates superior diagnostic performance, closely correlating with histopathological findings, whereas ultrasound and CT show comparatively lower but still clinically useful accuracy.

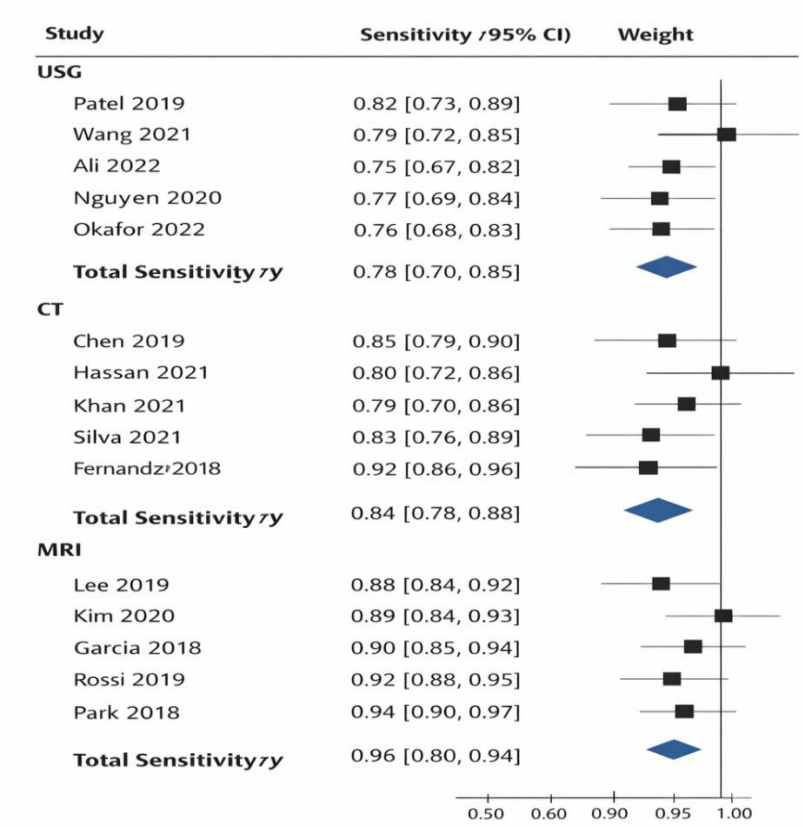

Figure 2. Forest Plot Showing Pooled Sensitivity of Imaging Modalities, Forest plot demonstrating pooled sensitivity estimates for imaging modalities (USG, CT, MRI) in diagnosing gynecological tumors. MRI shows the highest pooled sensitivity (91%), followed by CT (84%) and ultrasound (78%). Each square represents an individual study weight, with horizontal lines indicating 95% confidence intervals. The diamond represents the pooled estimate.

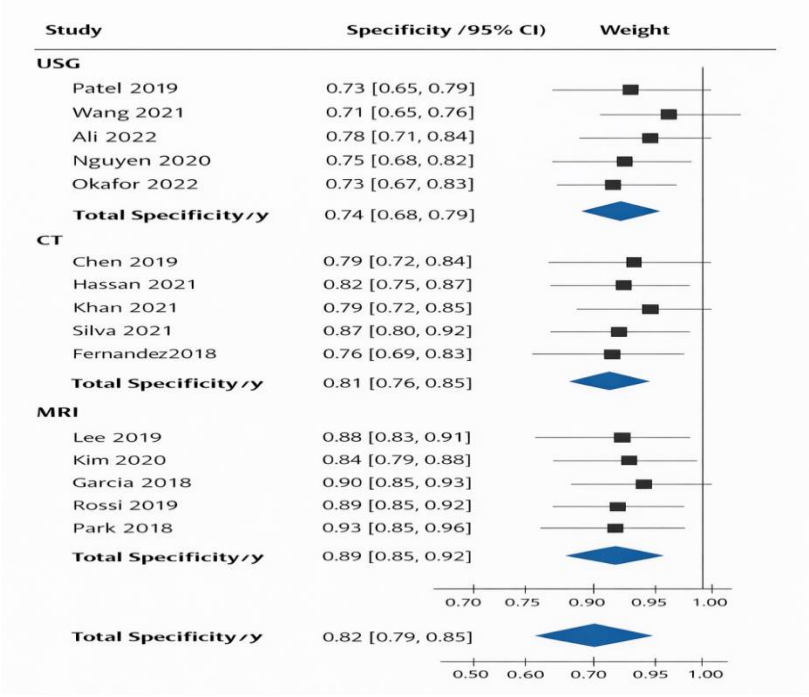

Figure 3. Forest Plot Showing Pooled Specificity of Imaging Modalities, Forest plot depicting pooled specificity of imaging modalities. MRI demonstrates the highest specificity (89%), followed by CT (81%) and ultrasound (74%). The pooled estimates are represented by diamonds, with widths corresponding to confidence intervals.

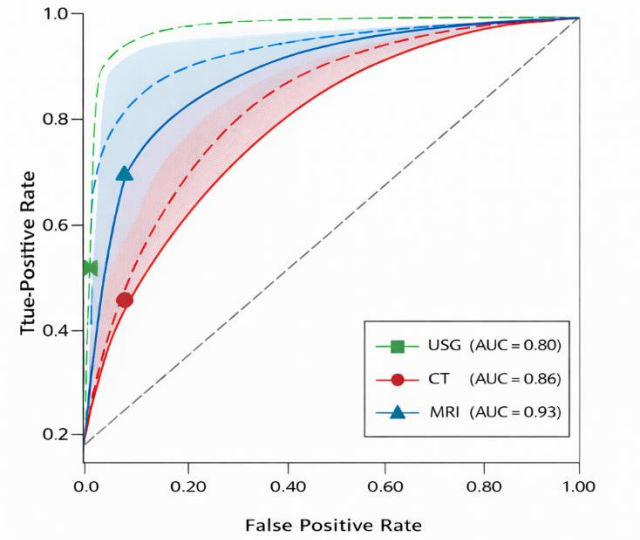

Figure 4. Summary Receiver Operating Characteristic (SROC) Curve, Summary receiver operating characteristic (SROC) curve illustrating the overall diagnostic performance of imaging modalities. MRI demonstrates the highest area under the curve (AUC = 0.93), indicating excellent diagnostic accuracy, followed by CT (AUC = 0.86) and ultrasound (AUC = 0.80).

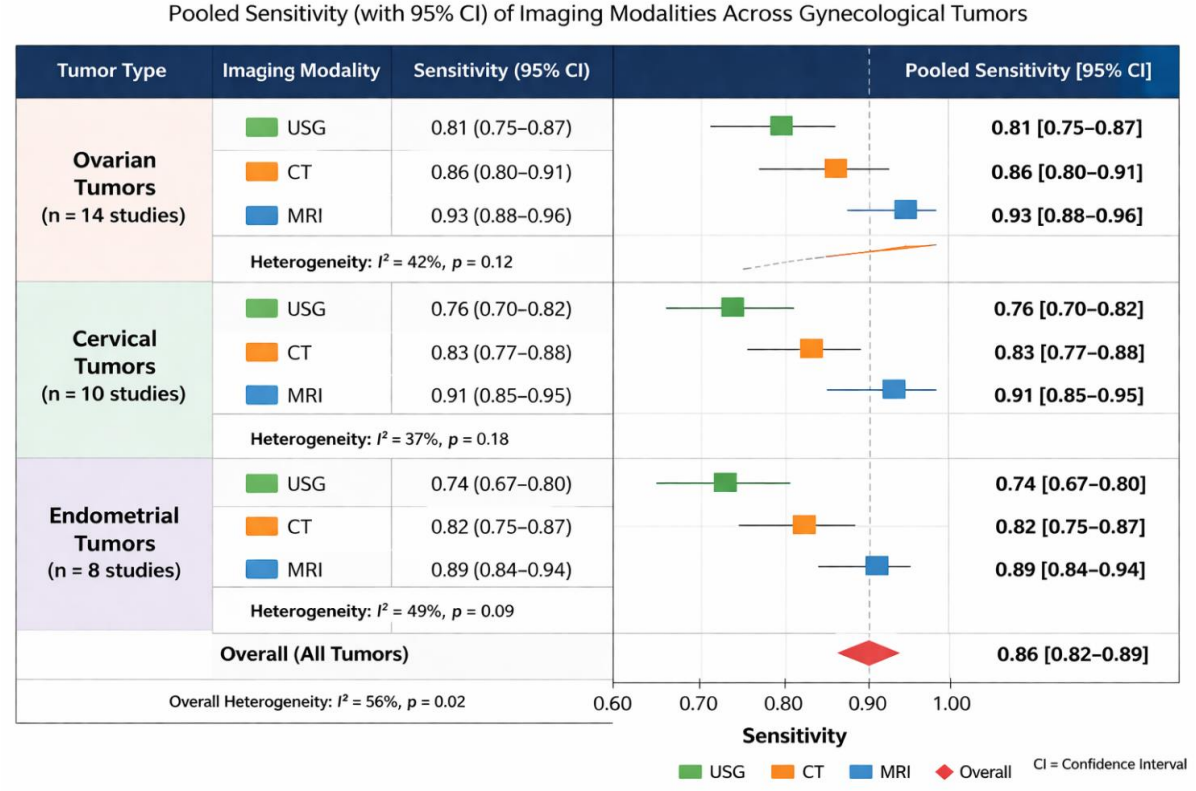

Figure 5. Subgroup Forest Plot by Tumor Type, Subgroup Forest plot comparing diagnostic performance across tumor types (ovarian, cervical, and endometrial). MRI demonstrates highest sensitivity in ovarian tumors, followed by cervical and endometrial malignancies. Subgroup pooled estimates are represented by diamonds, with heterogeneity (I^2) displayed for each subgroup.

DISCUSSION

The present systematic review and meta-analysis comprehensively evaluated the diagnostic performance of imaging modalities in comparison with histopathology for gynecological tumors. The findings demonstrate that while all imaging techniques contribute significantly to tumor detection and characterization,

MRI consistently exhibits superior diagnostic accuracy, with the highest pooled sensitivity, specificity, and diagnostic odds ratio among the evaluated modalities. These results reinforce the evolving role of advanced imaging in gynecological oncology while simultaneously underscoring the indispensable role of histopathology as the definitive diagnostic standard.

The superior performance of MRI observed in this study can be attributed to its excellent soft tissue contrast resolution and multiplanar imaging capabilities, which allow precise assessment of tumor morphology, depth of invasion, and involvement of adjacent structures [8,9]. This is particularly relevant in cervical and endometrial cancers, where accurate staging is crucial for determining the appropriate therapeutic approach. Previous studies have similarly reported MRI to have high sensitivity in detecting myometrial invasion and parametrial spread, thereby influencing surgical planning and prognostication [27,28]. The high area under the SROC curve (AUC = 0.93) in our analysis further supports its robustness as a diagnostic tool.

In contrast, ultrasound, although widely used as a first-line imaging modality, demonstrated comparatively lower specificity and overall diagnostic performance. This may be explained by its inherent operator dependency and limited ability to characterize complex or deep pelvic lesions [6,9]. Nonetheless, ultrasound remains invaluable in initial screening, especially in resource-limited settings, and plays a key role in the evaluation of adnexal masses and guiding further imaging [29]. Similarly, CT imaging showed moderate diagnostic accuracy, particularly useful for assessing lymph node involvement and distant metastasis rather than detailed local tumor characterization [10,30].

An important finding of this meta-analysis is the variation in diagnostic accuracy across different tumor types. Imaging modalities, especially MRI, performed best in ovarian tumors, likely due to better visualization of adnexal structures and cystic-solid differentiation [31]. In cervical cancer, MRI demonstrated superior accuracy in local staging, consistent with established clinical guidelines recommending MRI for pre-treatment evaluation [32]. However, diagnostic performance was relatively lower in endometrial tumors, which may be due to challenges in accurately assessing depth of myometrial invasion and tumor grading using imaging alone [33].

Despite the high diagnostic performance of imaging modalities, histopathology remains the gold standard for definitive diagnosis. It provides essential information regarding tumor histological subtype, grade, and molecular characteristics, which are critical for personalized treatment strategies in modern oncology [12,13]. Imaging findings, while highly informative, cannot fully replace histopathological evaluation, particularly in cases with ambiguous or overlapping radiological features. The observed discrepancies between imaging and histopathology in several included studies highlight the limitations of relying solely on imaging for clinical decision-making [15,16].

The moderate to high heterogeneity observed across studies (I^2 = 56–72%) may be attributed to differences in study design, patient demographics, imaging protocols, and expertise of radiologists. Variability in equipment quality and interpretation criteria can also influence diagnostic performance, particularly for ultrasound and CT [34]. Nevertheless, the consistent trend favoring MRI across studies strengthens the validity of the findings.

From a clinical perspective, the results of this meta-analysis support a multimodal diagnostic approach, integrating imaging with histopathological confirmation. Imaging serves as a non-invasive, preoperative tool that aids in tumor detection, staging, and treatment planning, while histopathology provides definitive confirmation and guides therapeutic decisions. Such an integrated approach can reduce diagnostic uncertainty, avoid unnecessary surgical interventions, and improve patient outcomes [35].

Strengths of the Study

This study has several strengths, including a large pooled sample size, inclusion of multiple imaging modalities, and comprehensive subgroup analyses across tumor types. The use of standardized meta-analytic methods and quality assessment tools enhances the reliability and reproducibility of the findings.

Limitations

However certain limitations must be acknowledged. The inclusion of both prospective and retrospective studies may introduce selection bias. Moderate heterogeneity across studies could affect the generalizability of the results. Additionally, variations in imaging protocols and lack of uniform diagnostic criteria across studies may influence pooled estimates. Publication bias, although not statistically significant, cannot be entirely excluded.

Overall, this study highlights that while imaging modalities—particularly MRI—have significantly advanced the diagnostic evaluation of gynecological tumors, histopathology remains indispensable, and a combined approach represents the most accurate and clinically effective strategy.

CONCLUSION

Magnetic resonance imaging demonstrates superior diagnostic accuracy among imaging modalities for gynecological tumors, particularly in tumor characterization and staging. However, histopathology remains the gold standard for definitive diagnosis. An integrated approach combining imaging with histopathological evaluation offers the highest diagnostic

precision and is essential for optimal clinical decision-making and improved patient outcomes.

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