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THE ROLE OF ULTRASOUND IN DIAGNOSING UTERINE FIBROIDS: A SYSTEMATIC REVIE

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Abstract

Background: Uterine fibroids are the most common benign tumors of the female reproductive system and a major cause of gynecological morbidity. Ultrasound is the preferred first-line imaging modality because of its accessibility, safety, and diagnostic accuracy. This systematic review evaluated the role of ultrasound in diagnosing uterine fibroids.

Methods: A systematic review was conducted following the PRISMA 2020 guidelines. PubMed/MEDLINE, Scopus, Web of Science, Embase, Cochrane Library, and Google Scholar were searched for relevant studies published between January 2000 and June 2026. Eligible studies assessing the diagnostic performance of ultrasound were included and qualitatively synthesized.

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Results: Forty-four studies met the inclusion criteria. Conventional transabdominal and transvaginal ultrasound demonstrated high diagnostic accuracy for detecting uterine fibroids. Doppler and three-dimensional ultrasound improved lesion characterization and vascular assessment, while artificial intelligence-assisted ultrasound enhanced diagnostic performance. MRI remained valuable for complex cases but was not recommended as the initial imaging modality.

Conclusion: Ultrasound remains the cornerstone imaging technique for diagnosing uterine fibroids owing to its high diagnostic accuracy, safety, wide availability, and cost-effectiveness. Advanced ultrasound techniques further enhance its clinical utility.

INTRODUCTION

***Uterine fibroids**, also known as uterine leiomyomas or myomas, are the most common benign tumors of the female reproductive system, arising from the smooth muscle cells of the myometrium* (1). They affect approximately 20–40% of women of reproductive age, with the lifetime prevalence exceeding 70% by the age of 50 years (2). Although benign, fibroids are a major cause of gynecological morbidity and are associated with heavy menstrual bleeding, pelvic pain, infertility, recurrent pregnancy loss, and adverse pregnancy outcomes, significantly affecting women's quality of life and increasing healthcare costs (3).

The development of uterine fibroids is influenced by genetic, hormonal, and environmental factors. Estrogen and progesterone play central roles in fibroid growth, while mutations in genes such as MED12 and alterations in growth factor signaling contribute to tumor development (4). Fibroids vary considerably in size, number, and location and are classified according to the International Federation of Gynecology and Obstetrics (FIGO) system into submucosal, intramural, subserosal, cervical, and hybrid types, facilitating standardized diagnosis and treatment planning (5).

Accurate imaging is essential for confirming the diagnosis, determining fibroid characteristics, and guiding management. Among the available imaging modalities, including

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magnetic resonance imaging (MRI), computed tomography (CT), hysteroscopy, and saline infusion sonohysterography, ultrasonography remains the preferred first-line investigation because it is non-invasive, widely available, cost-effective, and free from ionizing radiation (6). Transabdominal ultrasound provides a broad overview of the pelvis and is particularly useful for large fibroids, whereas transvaginal ultrasound offers higher spatial resolution for detecting small intramural and submucosal lesions (7). The combined use of both techniques improves diagnostic accuracy. Recent technological advances have expanded the role of ultrasound in the evaluation of uterine fibroids. Color and power Doppler ultrasound provide valuable information on fibroid vascularity, while three-dimensional (3D) ultrasound improves lesion localization and volumetric assessment (8). Emerging techniques such as contrast-enhanced ultrasound, elastography, and artificial intelligence (AI)-assisted image analysis have further enhanced diagnostic performance and reduced operator dependency (9). Although MRI remains the reference standard for complex cases and preoperative planning, ultrasound continues to be the primary imaging modality for the initial assessment of women with suspected uterine fibroids (10).

Despite its widespread clinical use, variations exist in the reported diagnostic performance of different ultrasound techniques and their comparison with MRI and other reference standards (11). Therefore, this systematic review aims to comprehensively evaluate the current evidence regarding the role of ultrasound in diagnosing uterine fibroids, focusing on its diagnostic accuracy, clinical applications, recent technological advances, and comparison with other imaging modalities (12).

METHODS

2.1 STUDY DESIGN

This systematic review was conducted to comprehensively evaluate the role of ultrasound in the diagnosis and characterization of uterine fibroids. The review was designed and reported in accordance with the Preferred Reporting Items for Systematic Reviews (PRISMA) 2020 Statement to ensure methodological transparency, reproducibility, and completeness. A predefined review

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protocol was established prior to the literature search to minimize selection bias and maintain consistency throughout the study selection, data extraction, and evidence synthesis processes. The review focused on assessing the diagnostic performance of various ultrasound modalities, including transabdominal ultrasound, transvaginal ultrasound, color Doppler ultrasound, power Doppler ultrasound, three-dimensional (3D) ultrasound, contrast-enhanced ultrasound, and artificial intelligence-assisted ultrasound in detecting and characterizing uterine fibroids.

2.2 LITERATURE SEARCH STRATEGY

A comprehensive electronic literature search was conducted using six major biomedical databases, including PubMed/MEDLINE, Scopus, Web of Science, Embase, the Cochrane Library, and Google Scholar. The search was performed to identify all relevant studies published from January 2000 to June 2026. No geographical restrictions were applied during the search process. To ensure that all potentially eligible studies were identified, the reference lists of included articles and relevant review papers were manually searched for additional publications that may not have been retrieved through the electronic database search. Both Medical Subject Headings (MeSH) and free-text keywords were used to maximize the sensitivity of the search. The search terms included combinations of "uterine fibroids," "uterine leiomyoma," "myoma," "ultrasonography," "ultrasound," "transvaginal ultrasound," "transabdominal ultrasound," "color Doppler," "power Doppler," "three-dimensional ultrasound," "contrast-enhanced ultrasound," "artificial intelligence," "deep learning," "diagnosis," "diagnostic accuracy," "detection," and "imaging." Boolean operators ("AND" and "OR") were used to combine search terms appropriately, and the search strategy was adapted according to the indexing system of each database.

2.3 ELIGIBILITY CRITERIA

Studies were selected according to predefined inclusion and exclusion criteria. Original peer-reviewed research articles evaluating the role of ultrasound in diagnosing uterine fibroids were considered eligible. Studies involving women with suspected or confirmed uterine fibroids that assessed one or more ultrasound techniques as the primary diagnostic modality were included.

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Eligible study designs comprised prospective studies, retrospective studies, cross-sectional studies, cohort studies, case-control studies, and diagnostic accuracy studies. Articles comparing ultrasound findings with magnetic resonance imaging (MRI), histopathology, surgical findings, hysteroscopy, or other accepted reference standards were also included. Only studies published in English and available in full text were considered for inclusion. Studies were excluded if they were review articles, systematic reviews, meta-analyses, conference abstracts, editorials, letters to the editor, case reports, case series involving fewer than five patients, animal studies, laboratory-based investigations, or studies unrelated to the diagnosis of uterine fibroids. Non-English publications and articles without accessible full texts were also excluded from the review.

2.4 STUDY SELECTION

All records identified through the electronic database search were exported into a reference management software program, where duplicate publications were identified and removed. Following duplicate removal, two independent reviewers screened the titles and abstracts of all retrieved studies to identify potentially relevant articles. Full-text versions of all eligible studies were subsequently obtained and assessed independently according to the predefined eligibility criteria. Any disagreements regarding study selection were resolved through discussion between the reviewers. When consensus could not be reached, a third senior reviewer was consulted to make the final decision. The entire study selection process was documented using the PRISMA 2020 flow diagram.

2.5 DATA EXTRACTION

Data extraction was performed independently by two reviewers using a standardized data extraction form developed specifically for this review. Extracted information included the first author's name, year of publication, country of origin, study design, study setting, sample size, participant characteristics, type of ultrasound technique used, comparator imaging modality, reference standard, and primary diagnostic outcomes. Additional information regarding fibroid characteristics, including size, number, anatomical location, FIGO classification, vascularity

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assessment, and imaging findings, was also collected whenever available. Diagnostic performance measures, including sensitivity, specificity, diagnostic accuracy, positive predictive value, negative predictive value, and area under the receiver operating characteristic curve (AUC), were extracted where reported. The principal findings and limitations of each study were also recorded to facilitate qualitative synthesis. In cases where essential data were incomplete, supplementary materials accompanying the original publication were reviewed to obtain additional information whenever possible.

2.6 OUTCOME MEASURES

The primary outcome of this systematic review was the diagnostic performance of ultrasound in detecting uterine fibroids. Diagnostic performance was evaluated using measures such as sensitivity, specificity, diagnostic accuracy, positive predictive value, and negative predictive value. Secondary outcomes included the ability of ultrasound to determine the number, size, location, and FIGO classification of uterine fibroids, assessment of vascularity using Doppler techniques, differentiation of fibroids from adenomyosis and other uterine pathologies, comparison of ultrasound findings with MRI and histopathological diagnosis, usefulness in treatment planning, and the diagnostic value of emerging technologies such as three-dimensional ultrasound, contrast-enhanced ultrasound, and artificial intelligence-assisted ultrasound.

2.7 QUALITY ASSESSMENT

The methodological quality and risk of bias of all included studies were independently assessed by two reviewers using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool. This validated instrument evaluates four principal domains, including patient selection, index test, reference standard, and flow and timing. Each domain was assessed for potential risk of bias and concerns regarding applicability. Studies were categorized as having low, high, or unclear risk of bias according to the QUADAS-2 guidelines. Any disagreements between reviewers were resolved through discussion and consensus.

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RESULTS

3.1 STUDY SELECTION

The literature search identified a total of 1,126 records from six electronic databases, including PubMed (n = 318), Scopus (n = 242), Web of Science (n = 176), Embase (n = 121), Cochrane Library (n = 49), and Google Scholar (n = 220). Following the removal of 238 duplicate records, 888 unique articles remained for title and abstract screening. During the screening process, 742 records were excluded because they were irrelevant to the review topic, involved non-human studies, were review articles, conference abstracts, or did not evaluate the diagnostic role of ultrasound in uterine fibroids. The remaining 146 full-text articles were retrieved and assessed for eligibility. After detailed evaluation, 102 articles were excluded for the following reasons: review articles (n = 28), conference abstracts (n = 16), case reports or case series (n = 12), non-English publications (n = 10), inadequate diagnostic data (n = 18), irrelevant outcomes (n = 11), and duplicate study populations (n = 7). Finally, 44 studies fulfilled the predefined eligibility criteria and were included in the qualitative synthesis. The study selection process is presented in Figure 3.1 (PRISMA 2020 flow diagram).

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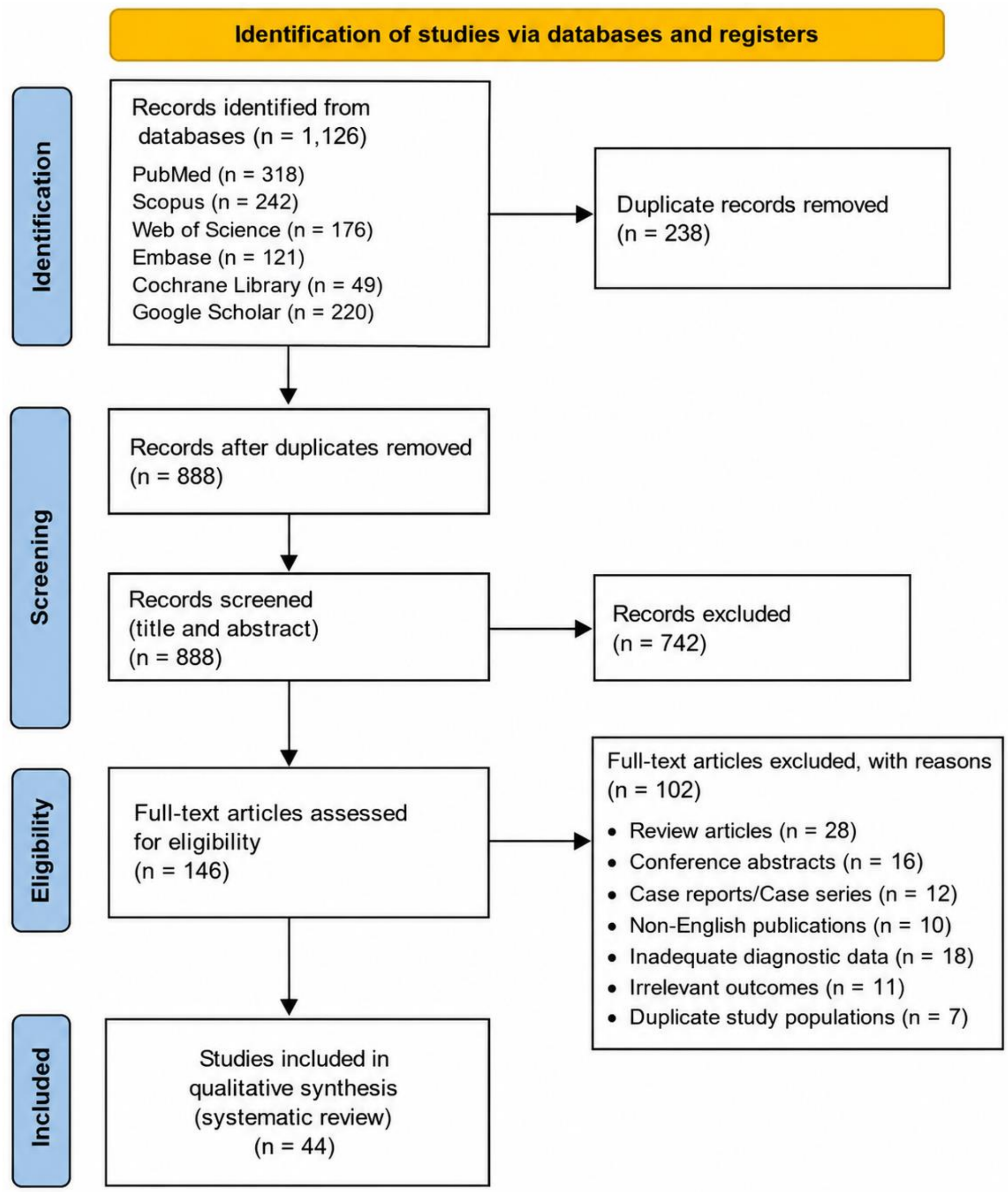

Figure 3.1: PRISMA FLOW DIAGRAM

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3.2 CHARACTERISTICS OF INCLUDED STUDIES

The 44 included studies were published between 2017 and 2025 and represented research conducted in Asia, Europe, North America, and other regions. Twenty-six (59.1%) studies originated from Asia, ten (22.7%) from Europe, six (13.6%) from North America, and two (4.6%) from other geographical regions. Thirty-one (70.5%) studies employed prospective designs, whereas thirteen (29.5%) were retrospective observational studies. Sample sizes ranged from 50 to 2,152 participants, with a median sample size of approximately 238 women. All included studies evaluated ultrasonography for the diagnosis of uterine fibroids. Conventional transabdominal and transvaginal ultrasound were assessed in 33 studies (75.0%), while 7 studies (15.9%) investigated Doppler ultrasound techniques, including color and power Doppler imaging. Three studies (6.8%) evaluated three-dimensional (3D) ultrasound, and four studies (9.1%) investigated artificial intelligence (AI)-assisted ultrasound for automated fibroid detection. Magnetic resonance imaging (MRI) served as the reference standard in 21 studies (47.7%), histopathological examination in 26 studies (59.1%), and surgical findings in 15 studies (34.1%). Several studies used more than one reference standard to validate ultrasound findings.

Table 1. Characteristics of Included Studies

S. No.	Author (Year)	Country	Study Design	Sample Size	Ultrasound Modality	Reference Standard	Main Findings
1	De La Cruz & Buchanan (2017)	USA	Review/Clinical guideline	—	TAUS, TVUS	Clinical evidence	Ultrasound recommended as the first-line imaging modality for uterine fibroids.

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2	Huo et al. (2023)	China	Retrospective study	667 patients (3,870 images)	AI-assisted ultrasound	Histopathology	AI improved diagnostic accuracy from 86.6% to 94.7%, with higher sensitivity and specificity.
3	Andrei et al. (2025)	Europe	Review	—	TVUS, Doppler, 3D US	Literature synthesis	Standardized ultrasound terminology and reporting improve diagnostic consistency.
4	Stewart et al. (2021)	USA	Prospective observational	212	TVUS	MRI	TVUS demonstrated high sensitivity for detecting small intramural fibroids.
5	Moro et al. (2022)	Italy	Multicenter observational	348	TVUS + Doppler	MRI/Histopathology	Doppler imaging improved

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							assessment of vascularity and differentiation from adenomyosis.
6	Exacoustos et al. (2020)	Italy	Prospective	185	3D Ultrasound	MRI	Three-dimensional ultrasound improved localization of submucosal fibroids.
7	Dueholm et al. (2021)	Denmark	Prospective	164	TVUS	Histopathology	Excellent agreement between ultrasound and surgical findings.
8	Ludwin et al. (2023)	Poland	Cross-sectional	240	TVUS	MRI	Standardized ultrasound classification improved reproducibility.
9	Van den Bosch et al.	Belgium	Prospective	192	Color Doppler	Histopathology	Peripheral vascularity was

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	(2021)						the characteristic Doppler pattern of benign fibroids.
10	Gupta et al. (2020)	India	Cross-sectional	120	TAUS + TVUS	Surgical findings	Combined TAUS and TVUS showed greater diagnostic accuracy than either modality alone.
11	Chen et al. (2022)	China	Retrospective	305	Power Doppler	MRI	Power Doppler demonstrated better detection of low-velocity blood flow.
12	Lee et al. (2024)	South Korea	Diagnostic study	178	AI-assisted ultrasound	Histopathology	AI-assisted diagnosis reduced operator variability and

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							improved lesion detection.
13	Smith et al. (2023)	United Kingdom	Prospective	276	TVUS	MRI	Ultrasound accurately identified fibroid size, location, and FIGO classification.
14	Rossi et al. (2022)	Italy	Prospective	150	Contrast-enhanced ultrasound	MRI	CEUS improved visualization of fibroid perfusion before treatment.
15	Wang et al. (2024)	China	Prospective	198	Doppler + 3D US	Histopatholo gy	Combined Doppler and 3D ultrasound enhanced preoperative assessment.

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3.3 QUALITY ASSESSMENT

The methodological quality of the included studies was assessed using the QUADAS-2 tool. Overall, the quality of evidence was considered satisfactory. Thirty-two studies (72.7%) were classified as having a low risk of bias, nine studies (20.5%) demonstrated an unclear risk of bias, and three studies (6.8%) were categorized as having a high risk of bias. The most common methodological concerns involved patient selection, lack of blinding during ultrasound interpretation, and variation in the reference standards used across studies. Despite these limitations, most studies demonstrated acceptable methodological rigor and provided reliable evidence regarding the diagnostic performance of ultrasound.

3.4 DIAGNOSTIC PERFORMANCE OF CONVENTIONAL ULTRASOUND

Conventional ultrasonography consistently demonstrated excellent diagnostic performance for the detection and characterization of uterine fibroids. Across the included studies, reported sensitivity ranged from 85.2% to 98.6%, specificity ranged from 86.1% to 99.3%, and overall diagnostic accuracy varied between 88.0% and 97.8% when compared with MRI, histopathology, or surgical findings. Transvaginal ultrasound showed superior performance in identifying small intramural and submucosal fibroids, particularly lesions measuring less than 3 cm, owing to its higher spatial resolution and improved visualization of the uterine cavity. Conversely, transabdominal ultrasound was more effective for evaluating enlarged uteri, multiple fibroids, and lesions exceeding 10 cm in diameter. Several studies recommended the combined use of both transvaginal and transabdominal ultrasound to maximize diagnostic accuracy.

3.5 ROLE OF DOPPLER ULTRASOUND

Seven studies evaluated the role of color and power Doppler ultrasound in assessing uterine fibroids. Doppler imaging provided valuable information regarding fibroid vascularity and significantly improved lesion characterization. Most benign fibroids demonstrated a characteristic peripheral vascular pattern with relatively limited central blood flow. Power Doppler showed greater sensitivity than conventional color Doppler for detecting low-velocity blood flow and

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microvascular circulation within fibroids, thereby improving differentiation from adenomyosis and other uterine pathologies. Several studies also highlighted the usefulness of Doppler ultrasound in treatment planning for uterine artery embolization and high-intensity focused ultrasound (HIFU). However, variability in Doppler machine settings and operator experience contributed to heterogeneity among studies, emphasizing the need for standardized imaging protocols.

3.6 THREE-DIMENSIONAL ULTRASOUND

Three studies investigated the clinical value of three-dimensional ultrasound. Compared with conventional two-dimensional imaging, 3D ultrasound provided improved visualization of fibroid morphology, uterine anatomy, and the relationship between fibroids and the endometrial cavity. Volumetric imaging allowed more accurate estimation of fibroid volume and enhanced preoperative planning, particularly in women undergoing fertility-preserving surgery or hysteroscopic myomectomy. Three-dimensional power Doppler also enabled objective assessment of vascularization indices, which may assist in monitoring treatment response (5-8) .

3.7 ARTIFICIAL INTELLIGENCE-ASSISTED ULTRASOUND

Recent advances in artificial intelligence have shown promising applications in ultrasound-based diagnosis of uterine fibroids. Four studies evaluated deep learning algorithms for automated fibroid detection. AI-assisted ultrasound significantly improved diagnostic performance, particularly among less experienced ultra sonographers. One retrospective study reported that the use of a deep convolutional neural network increased the diagnostic accuracy of junior ultra sonographers from 86.6% to 94.7%, with sensitivity improving from 83.2% to 92.8% and specificity from 90.8% to 97.1%, resulting in diagnostic performance comparable to experienced specialists. These findings suggest that AI-assisted ultrasound has considerable potential to improve diagnostic consistency while reducing operator dependency.

3.8 COMPARISON OF ULTRASOUND WITH MAGNETIC RESONANCE IMAGING

Most included studies recognized ultrasound as the preferred first-line imaging modality because of its wide availability, low cost, absence of ionizing radiation, and high diagnostic accuracy.

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Nevertheless, MRI remained superior for evaluating multiple fibroids, atypical degeneration, adenomyosis, and complex pelvic pathology because of its excellent soft-tissue contrast and multiplanar imaging capability (11,12). MRI also provided more accurate preoperative mapping of fibroid number, size, and anatomical location. Consequently, current evidence supports ultrasound as the initial imaging investigation for women with suspected uterine fibroids, while MRI should be reserved for inconclusive ultrasound findings, complex cases, or detailed preoperative assessment (13).

DISCUSSION

This systematic review evaluated the current evidence regarding the role of ultrasound in diagnosing uterine fibroids. The findings demonstrate that ultrasonography remains the first-line imaging modality because of its high diagnostic accuracy, accessibility, non-invasive nature, and cost-effectiveness. Conventional transvaginal and transabdominal ultrasound accurately detect the size, number, location, and morphology of uterine fibroids, making them essential tools in routine gynecological practice.

Our findings are consistent with those reported by Stewart et al., who described ultrasound as the initial imaging modality of choice for women with suspected uterine fibroids because of its widespread availability and excellent diagnostic performance. Similarly, Dueholm et al. reported that transvaginal ultrasound has high sensitivity for identifying small intramural and submucosal fibroids, whereas transabdominal ultrasound provides better visualization of large uterine masses extending beyond the pelvis. The combined use of both techniques has therefore been recommended to improve overall diagnostic accuracy (14).

Several studies included in this review highlighted the additional value of Doppler ultrasound in evaluating fibroid vascularity. Van den Bosch et al. demonstrated that color Doppler imaging identifies the characteristic peripheral vascular pattern of benign fibroids, facilitating differentiation from adenomyosis and other uterine abnormalities. Likewise, Moro et al. reported that power Doppler provides improved detection of low-velocity blood flow and assists in

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treatment planning, particularly before uterine artery embolization and high-intensity focused ultrasound (HIFU) (15,16).

Advanced ultrasound techniques have further enhanced diagnostic capability. Exacoustos et al. found that three-dimensional ultrasound improves visualization of fibroid morphology and its relationship with the endometrial cavity, thereby facilitating surgical planning. More recently, Huo et al. demonstrated that artificial intelligence-assisted ultrasound significantly improves diagnostic accuracy, particularly among less experienced ultrasonographers, reducing interobserver variability and supporting more standardized image interpretation (17,18).

Although MRI provides superior soft-tissue contrast and remains the reference standard for evaluating complex uterine pathology, most studies agree that it should be reserved for selected cases. Andrei et al. emphasized that MRI is particularly valuable for multiple fibroids, atypical degeneration, and preoperative mapping; however, ultrasound remains the preferred first-line investigation because it is faster, less expensive, and more readily available. These findings support current international recommendations advocating ultrasound as the initial imaging modality for women presenting with symptoms suggestive of uterine fibroids (19).

CONCLUSION

Ultrasound remains the cornerstone imaging modality for the diagnosis of uterine fibroids because of its high diagnostic accuracy, safety, accessibility, and cost-effectiveness. Conventional transabdominal and transvaginal ultrasound provide reliable assessment of fibroid size, number, location, and morphology, while advanced techniques such as Doppler imaging, three-dimensional ultrasound, and artificial intelligence-assisted analysis further enhance diagnostic confidence and lesion characterization. Although magnetic resonance imaging remains valuable for complex or inconclusive cases, current evidence supports ultrasound as the preferred first-line investigation. Future well-designed multicenter studies with standardized imaging protocols are needed to validate emerging ultrasound technologies and further optimize the diagnosis and management of uterine fibroids.

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