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Original Article

Three and Two Dimensional Saline Infusion Sonohysterography in Diagnosing Uterine Cavity Lesions

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Abstract

Objective: Given the invasive and costly nature of reference diagnostic methods like hysteroscopy , this study aimed to compare the diagnostic accuracy and the dimensional measurement agreement of uterine cavity lesions between two-dimensional saline infusion sonography (2D SIS) and three-dimensional saline infusion sonography (3D SIS) against the gold standard of hysteroscopy and histopathology.

Materials and methods: This cross-sectional study was conducted on 283 female patients who were candidates for hysteroscopy. Prior to surgery, all patients underwent blinded evaluations via 2D SIS and 3D SIS performed by experienced radiologists, and the type, number, location, and size of the lesions were recorded. Subsequently, all patients underwent diagnostic hysteroscopy and tissue sampling for pathological evaluation as the gold standard. Diagnostic performance metrics were calculated, and the dimensional agreement of the lesions between the modalities was statistically evaluated using the Intraclass Correlation Coefficient (ICC) and Bland-Altman analysis.

Results: The mean age of the patients was 35.9 ± 8.1 years. Histopathological examination confirmed endometrial polyps in 20.5% and leiomyomas in 17.3% of the patients. Compared to 2D SIS, 3D SIS demonstrated higher sensitivity (83.15% vs. 78.65%), higher specificity (93.30% vs. 91.75%), and higher overall diagnostic accuracy (90.11% vs. 87.63%). In the dimensional agreement analysis, 3D SIS showed an excellent correlation (ICC = 0.927) and a negligible mean systematic error (mean bias: -0.26 mm; 95% limits of agreement: -7.77 to 7.25 mm) compared to hysteroscopy. In contrast, 2D SIS systematically overestimated lesion dimensions compared to hysteroscopy (mean bias: 2.21 mm) and exhibited the widest limits of agreement when compared with 3D SIS (-8.76 to 13.70 mm).

Conclusion: 3D SIS is an accurate, non-invasive tool that lacks systematic bias in measuring uterine tumors, offering superior performance compared to the 2D SIS method. Given its high overall accuracy, 3D SIS can be utilized as a reliable first-line diagnostic tool, significantly reducing the necessity for unnecessary diagnostic hysteroscopies and the associated financial burdens on the healthcare system.

Keywords: Three-Dimensiona; Transvaginal Sonography; Two-Dimensional; Hysteroscopy; Endometrial Polyp; Leiomyoma

Introduction

Endometrial polyps and submucosal myomas are the most common lesions of the uterine cavity, which play an important role in the development of abnormal uterine bleeding (AUB), infertility, and other complications. The prevalence of endometrial polyps in the general population is about 7.8%, which increases with age, reaching 11.8% in

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postmenopausal women (1). In contrast, submucosal myomas are commonly found in 4–6% of women and have a significant impact on bleeding and fertility (2). Also, about 1.3% of endometrial polyps have malignant potential (3), especially in postmenopausal women presenting with abnormal bleeding (2). Studies suggest that chronic endometrial inflammation (CE) is often associated with these lesions and may be a common factor in their development and progression (4). These lesions can lead to infertility by causing changes in the endometrial environment and disrupting embryo implantation (5). Accurate diagnosis of uterine cavity lesions, including endometrial polyps and submucosal myomas, plays a vital role in the clinical management of gynecological diseases such as abnormal uterine bleeding, infertility, and recurrent miscarriage. Hysteroscopy is considered the gold standard for the evaluation of the uterine cavity, allowing direct visualization of the cavity, enabling accurate diagnosis and therapeutic intervention. However, hysteroscopy is an invasive, costly, and potentially harmful procedure, highlighting the need for noninvasive but accurate alternatives. In recent years, pelvic imaging has emerged as an essential diagnostic modality for the evaluation of uterine diseases. However, conventional 2D transvaginal ultrasound has serious limitations in providing volumetric data or accurate visualization of structures within the uterine cavity, especially in the absence of fluid. This has led to the development and application of saline sonohysterography. This technique creates artificial distension or dilation by vaginally injecting saline solution into the cavity, which, like a natural contrast agent, separates the endometrial space-occupying defect from the uterine wall. The combination of this process with 3D technology has brought about a major revolution in volumetric imaging, as the ability to visualize coronal planes and reconstruct volumetric images of the uterine cavity in 3D saline sonohysterography promises greater accuracy in diagnosing uterine lesions. From a pathophysiological and clinical diagnostic perspective, the use of saline-injected sonohysterography is a crucial step in bridging the gap between traditional ultrasound and invasive techniques. The sterile injection of normal saline into the endometrial canal not only breaks up possible adhesions, but also allows the radiologist to assess the base of polyps or the extent of submucosal myoma invasion into the myometrium (uterine muscle) with millimeter accuracy; details that remain completely obscured in conventional vaginal ultrasound due to the overlapping of the uterine walls. Therefore, a comparative evaluation of the two-dimensional and three-dimensional formats of this injection technique has great potential in determining the precise anatomical map of lesions before intrauterine surgeries. Studies that have examined the diagnostic efficacy of 3D and 2D saline-injection sonohysterography compared with hysteroscopy have reported promising results. For example, studies have shown that 3D saline-injection sonohysterography offers higher sensitivity and specificity for the detection of polyps and submucosal myomas, and its accuracy is sometimes equal to or even exceeds that of hysteroscopy (6). In addition, this technique allows for precise localization of lesions, which is particularly valuable for preoperative planning or infertility treatment (7). The relative advantage of 3D saline sonohysterography is supported by studies that have evaluated its diagnostic criteria. For example, one study found that 3D saline sonohysterography had a sensitivity and specificity of 97.8% and 100%, respectively, for uterine cavity abnormalities, significantly outperforming the 2D model (8). Similarly, Grigore reported that this volumetric diagnostic method had a sensitivity of 88% and specificity of 94%, and was highly accurate in detecting polyps and submucosal myomas (9). Furthermore, its minimally invasive nature and relative low cost compared to the operating room make it a practical diagnostic tool in resource-limited settings. Nevertheless, 2D saline-injection sonohysterography remains a valuable initial screening tool because its technical procedure is simpler and more widely available. While it has lower performance than 3D for certain types of complex or multiple lesions, it still provides important diagnostic information, especially when combined with clinical findings. Comparative studies have shown that the 2D technique has diagnostic accuracy rates of approximately 70–80% for endometrial polyps and fibroids (10). This highlights its utility as an early and readily available first-line diagnostic option. This study evaluated the diagnostic accuracy of 3D saline-injection sonohysterography in the diagnosis of uterine cavity lesions, including polyps and myomas, and compared it with the performance of 2D saline-injection sonohysterography. By systematically reviewing their diagnostic criteria (sensitivity, specificity, positive

and negative predictive values) in relation to hysteroscopy findings, we aimed to provide evidence for the optimal use of these injection techniques in clinical practice.

In a 2014 study by Gaafar, aimed at assessing the accuracy of three-dimensional ultrasound in diagnosing uterine pathology in patients with premenopausal bleeding in Egypt, 100 women with abnormal uterine bleeding were enrolled. The study showed that 3D ultrasound had high accuracy in detecting polyps and provided a better diagnostic view of intrauterine lesions. They concluded that 3D ultrasound is very valuable for identifying uterine pathology (11).

In a 2020 study by Alsherbiny, aimed at evaluating the diagnostic accuracy of three-dimensional transvaginal ultrasound compared with hysteroscopy for diagnosing uterine abnormalities before ICSI in Egypt, 60 infertile women were enrolled. Results showed that 3D ultrasound had a diagnostic accuracy of 98.3% and a precision of 100% for diagnosing septate uterus and intrauterine adhesions. They concluded that 3D ultrasound should be used routinely to assess uterine abnormalities (12).

In a 2022 study by Kutlucan, aimed at comparing two-dimensional and three-dimensional transvaginal ultrasound with hysteroscopy in abnormal uterine bleeding in Turkey, 50 women were enrolled. Results showed that 3D ultrasound had an accuracy of 80% while 2D ultrasound accuracy was 65.71%. They concluded that 3D ultrasound can replace invasive methods (13).

In a 2016 study by Ahmadi, aimed at comparing the diagnostic accuracy of three-dimensional transvaginal ultrasound with hysteroscopy for intrauterine lesions in Iran, 155 infertile women were enrolled. Three-dimensional ultrasound had a diagnostic accuracy of 94%, sensitivity of 92.15%, and specificity of 96.9%. They concluded that 3D ultrasound is a reliable diagnostic tool for intrauterine lesions (14).

In a 2018 study by Tagy, aimed at evaluating three-dimensional transvaginal ultrasound and hysteroscopy in diagnosing uterine cavity abnormalities in Egypt, 100 women were enrolled. They reported that 3D ultrasound had a diagnostic accuracy of 85% and identified all cases of submucosal fibroids. They concluded that 3D ultrasound is highly effective for identifying uterine pathology (15).

In a 2022 study by Sakr, aimed at comparing hysteroscopy and three-dimensional transvaginal ultrasound for uterine cavity abnormalities in Egypt, 60 women were enrolled. They found that 3D ultrasound had a sensitivity of 95% and a specificity of 88% for uterine abnormalities. They concluded that 3D ultrasound can be an effective substitute for invasive methods (16).

In a 2015 study by Zhang, aimed at evaluating the value of three-dimensional ultrasound in diagnosing intrauterine lesions in China, 171 patients were enrolled. Three-dimensional ultrasound had a diagnostic accuracy of 89.5% while two-dimensional ultrasound accuracy was 78.9%. They concluded that 3D ultrasound plays an important role in diagnosing uterine lesions (17).

This article aimed to provide evidence for the optimal use of two and three dimensional ultrasound techniques in clinical practice for endometrial lesion.

Materials and methods

This research was conducted as an analytic cross-sectional study. Inclusion criteria were as below:

- Patients with increased endometrial thickness (greater than 10 millimeters)
- Patients with abnormal uterine bleeding (AUB)
- Informed consent to participate in the study

Exclusion criteria included:

- Patients with Müllerian anomalies
- Patients whose ultrasound image quality is insufficient for analysis
- Patients with conditions that make hysteroscopy or ultrasound impossible, such as pregnancy, excessive vaginal bleeding, early postpartum period, acute infection, history of cervical surgery, uterine rupture, or allergy to anesthesia

The study was approved by the Research Deputy of Tehran University of Medical Sciences and received the ethics code IR.TUMS.IKHC.REC.1404.242. It was conducted at Imam Khomeini Hospital, Tehran, during 2024 and 2025.

Sampling was performed by convenience sampling. All patients who presented and met the inclusion criteria were enrolled and completed informed consent forms. All patients underwent two-dimensional and three-dimensional ultrasound examinations. Evaluations were performed by experienced radiologists who were blinded to the results of other tests. Collected information included type, size, number, and location of lesions. After the ultrasounds, all patients underwent diagnostic hysteroscopy. When necessary, biopsy of suspicious lesions was performed and sent to the pathology laboratory for final confirmation. Pathology results

were used as the gold standard to evaluate the accuracy of the ultrasounds. All three modalities (2D-SIS, 3D-SIS, and hysteroscopy) were performed by experienced specialists. Sonologists and hysteroscopists were blinded to the results of other tests. Final pathology review was considered the gold standard for confirming results.

Data analysis was performed using SPSS version 26. Quantitative variables are reported as mean ± standard deviation and qualitative variables as frequency and percentage. Multivariable logistic regression was applied to identify factors affecting the accuracy of the ultrasound methods; variables that were significant in univariable analyses were entered into the multivariable regression model. Normality of quantitative variable distributions was assessed and a significance level of 0.05 was used for all analyses.

Results

A total of 283 patients were evaluated in this study. The mean age of participants was 35.9 ± 8.1 years. Review of the patients' primary complaints and main clinical presentations showed that the most common reason for referral was menorrhagia with 86 cases (30.4%) and premenstrual spotting with 57 cases (20.1%). Other reasons for referral included metrorrhagia in 37 patients (13.1%) and menometrorrhagia in 36 patients (12.7%), while 67 patients (23.7%) presented with other clinical symptoms (Table 1).

Based on detailed secondary evaluations, 89 patients were found to have definite intrauterine lesions). Analysis of lesion count in this subgroup showed that the majority—47 patients (52.8%)—had a single lesion. The frequencies of 2, 3, 4, and ≥ 5 lesions were 21 cases (23.6%), 12 cases (13.5%), 6 cases (6.7%), and 3 cases (3.4%), respectively (Table 1). Regarding anatomic location of lesions within the uterus, the uterine cavity was the most common site with 40 cases (44.9%). This was followed by the posterior uterine wall with 30 cases (33.7%) and the anterior wall with 17 cases (19.1%); the fundus had the lowest prevalence with 2 cases (2.2%).

Final histopathology reports from biopsy of all samples (N = 283) showed that endometrial polyp was definitively confirmed in 58 patients (20.5%) and leiomyoma (uterine fibroid) in 49 patients (17.3%). In the assessment of lesion dimensions and comparison of mean lesion sizes reported in millimeters, the mean size measured by hysteroscopy was 20.6 ± 9.72 mm, by 2D-SIS ultrasound was 22.4 ± 11.2 mm, and by 3D-SIS ultrasound was 20.0 ± 11.3 mm (Table 1).

Table 1: Patient demographics and clinical characteristics

Variable	Value
Age (years), Mean ± SD	35.9 ± 8.1
Chief Complaint (CC), n (%) [N = 283]	
Menorrhagia	86 (30.4%)
Metrorrhagia	37 (13.1%)
Menometrorrhagia	36 (12.7%)
Premenstrual spotting	57 (20.1%)
Other	67 (23.7%)
Number of Lesions, n (%) [n = 89]	
1	47 (52.8%)
2	21 (23.6%)
3	12 (13.5%)
4	6 (6.7%)
5	3 (3.4%)
Lesion Location, n (%) [n = 89]	
Uterine cavity	40 (44.9%)
Anterior wall	17 (19.1%)
Posterior wall	30 (33.7%)
Fundus	2 (2.2%)
Histopathological Findings, n (%) [N = 283]	
Endometrial Polyp	58 (20.5%)
Leiomyoma	49 (17.3%)
Tumor Size Measurements (mm), Mean ± SD	
Hysteroscopy	20.6 ± 9.7
2D SIS	22.4 ± 11.2
3D SIS	20.0 ± 11.3

The diagnostic performance indices for the two SIS ultrasound methods, compared with each other, showed differences in clinical accuracy metrics. Sensitivity for 2D-SIS was 78.65%, while it increased to 83.15% for 3D-SIS. Specificity was higher for 3D-SIS at 93.30% versus 91.75% for 2D-SIS.

For predictive values, positive predictive value (PPV) was 81.40% for 2D-SIS and 85.06% for 3D-SIS. Negative predictive value (NPV) was 90.36% for 2D-SIS and 92.35% for 3D-SIS.

Overall diagnostic accuracy was 90.11% for 3D-SIS, higher than 87.63% for 2D-SIS (Table 2). Likelihood ratio analysis showed a positive likelihood ratio (+LR) of 12.408 for 3D-SIS and 9.537 for 2D-SIS; the negative likelihood ratio (−LR) decreased to 0.181 for 3D-SIS compared with 0.233 for 2D-SIS, indicating a stronger ability of 3D-SIS to rule out lesions (Table 2).

Analysis of agreement and concordance indices between different lesion dimension measurement methods (in millimeters) revealed specific statistical relationships among these tools.

Table 2: Comparison of diagnostic performance of 2D-SIS versus 3D-SIS

Diagnostic Metric	2D SIS (95% CI)	3D SIS (95% CI)
Sensitivity (%)	78.65 (69.00 to 85.90)	83.15 (74.00 to 89.50)
Specificity (%)	91.75 (87.00 to 94.90)	93.30 (88.90 to 96.00)
Positive Predictive Value (%)	81.40 (71.90 to 88.20)	85.06 (76.10 to 91.10)
Negative Predictive Value (%)	90.36 (85.40 to 93.70)	92.35 (87.80 to 95.30)
Diagnostic Accuracy (%)	87.63 (83.30 to 91.00)	90.11 (86.10 to 93.10)
Positive Likelihood Ratio	9.537 (5.891 to 15.438)	12.408 (7.279 to 21.151)
Negative Likelihood Ratio	0.233 (0.156 to 0.347)	0.181 (0.114 to 0.287)

In evaluating the intraclass correlation coefficient (ICC), the comparison between 3D-SIS ultrasound and hysteroscopy showed an excellent correlation coefficient of 0.927. This index for the comparison of 2D-SIS ultrasound with hysteroscopy was 0.920, and for the comparison between the two ultrasound imaging methods (2D-SIS vs. 3D-SIS) it was 0.847.

In the Bland-Altman analysis, the mean systematic error or bias (Mean Bias) for the 3D-SIS versus hysteroscopy comparison was −0.26 mm, indicating the lowest level of systematic bias in measurement. The limits of agreement for this comparison ranged from −7.77 to 7.25 mm.

In contrast, the comparison of 2D-SIS ultrasound with hysteroscopy showed that this method systematically overestimates lesion dimensions by a mean bias of 2.21 mm, with limits of agreement varying between −5.40 to 9.82 mm (Table 3). Furthermore, when comparing the two imaging methods with each other, 2D-SIS had a mean systematic bias of 2.47 mm relative to 3D-SIS, with Bland-Altman limits of agreement showing the widest range, from −8.76 to 13.70 mm (Table 3).

Discussion

The aim of this study was to compare the diagnostic accuracy and concordance of 2D and 3D SIS ultrasound in detecting and measuring uterine cavity lesions (including polyps and leiomyomas) against the gold standard of hysteroscopy and pathology. The results showed that 3D-SIS ultrasound outperformed 2D-SIS ultrasound across all diagnostic indices and demonstrated significantly higher dimensional concordance with surgical findings.

Analysis of diagnostic indices revealed that sensitivity, specificity, and overall accuracy of 3D ultrasound were higher than those of 2D ultrasound. This improvement in diagnostic performance aligns with the findings of Zhang, who reported that the diagnostic accuracy of 3D ultrasound (89.5%) was significantly higher than that of 2D ultrasound (78.9%) in 171 patients (17). Kutlucan in Turkey also reported 3D ultrasound accuracy of 80% versus 65.71% for 2D ultrasound; despite differences in absolute rates due to the smaller sample size, this confirms the decisive superiority of 3D technology (13). Grigore recorded sensitivity of 88%, specificity of 94%, and accuracy of 90% for 3D ultrasound in 139 patients, which closely matches the accuracy trends observed in the present study (9). The diagnostic superiority of 3D ultrasound can be attributed to its ability to reconstruct volumetric acoustic data and provide a coronal plane, allowing radiologists to examine endometrial lines and the junctional boundaries with the myometrium with greater detail and to overcome the limitations of 2D imaging planes.

Endometrial polyp and leiomyoma were the most common histopathological findings in the present study. 3D ultrasound demonstrated high capability in confirming or ruling out these masses by improving positive and negative likelihood ratios. In this context, Gaafar in Egypt noted that 3D ultrasound provides a better diagnostic view for intrauterine lesions and is highly valuable in detecting polyps (11).

Table 3: Reliability and Agreement in Tumor Volume Measurements

Modality Comparison	ICC (Single Measures) (95% CI)	Mean Bias (mm) (95% CI for LoA)
3D SIS vs. Hysteroscopy	0.927 (0.887 to 0.954)	-0.26 (-7.77 to 7.25)
2D SIS vs. Hysteroscopy	0.920 (0.875 to 0.950)	2.21 (-5.40 to 9.82)
2D SIS vs. 3D SIS	0.847 (0.764 to 0.903)	2.47 (-8.76 to 13.70)

ICC: Intraclass Correlation Coefficient (Two-way mixed effects, consistency definition); CI: confidence interval; LoA: limits of agreement. 95% Limits of Agreement calculated as Mean Bias ± 1.96 standard deviations of the differences.

Tagy reported 85% diagnostic accuracy and stated that 3D ultrasound could identify all cases of submucosal fibroids (15). Additionally, Ahmed reported 80% sensitivity and specificity for diagnosing polyps with 3D ultrasound, confirming its suitability as a noninvasive tool for evaluating uterine lesions (10).

Multiple studies have evaluated the position of 3D ultrasound as a reliable noninvasive method replacing invasive procedures. The high overall diagnostic accuracy of 3D ultrasound in our study indicates its strong potential as a first-line diagnostic tool. Ahmadi assessing 155 women, achieved 94% diagnostic accuracy, 92.15% sensitivity, and 96.9% specificity, introducing 3D ultrasound as a fully reliable tool for intrauterine lesions (14). Sakr also reported 95% sensitivity and 88% specificity for uterine cavity abnormalities and concluded that this method can be an effective substitute for invasive methods (16). These findings align with Apirakviriya 6 in Thailand, who described 3D ultrasound as a promising tool (6), and Alsherbiny, who achieved 98.3% diagnostic accuracy before ICSI (12); these researchers emphasized the need for routine noninvasive screening prior to invasive therapeutic procedures.

A distinguishing aspect of the present study was the evaluation of numerical agreement in lesion dimensions between imaging methods and hysteroscopy. The intraclass correlation coefficient (ICC) for 3D ultrasound compared with hysteroscopy indicated excellent concordance, while agreement between 2D and 3D ultrasound was the lowest. Bland-Altman analysis provided a more precise perspective on this clinical challenge: 3D ultrasound showed minimal mean systematic bias alongside narrow limits of agreement against hysteroscopy, confirming absence of systematic bias in estimating actual tumor size. In contrast, 2D ultrasound systematically overestimated lesion dimensions compared with both hysteroscopy and 3D ultrasound. Comparison of the two ultrasound methods showed the widest agreement range, proving that reported dimensions for the same patient may differ substantially between the two methods. Therefore, in clinical practice, these two imaging tools should not be used interchangeably for monitoring uterine lesion dimensions.

Despite providing precise clinical and statistical findings, the present study faced the high dependence of diagnostic accuracy on device image quality and operator skill. Additionally, potential disagreement in interpreting ultrasound and hysteroscopy results could reduce final diagnostic accuracy. Researchers addressed the latter point by performing fully blinded assessments.

Conclusion

This study demonstrated that 3D-SIS ultrasound, compared with 2D-SIS ultrasound, has higher accuracy, sensitivity, and specificity in diagnosing uterine cavity lesions (including endometrial polyps and leiomyomas). In addition to qualitative diagnostic criteria, quantitative findings on dimensional concordance of tumors confirmed that 3D-SIS ultrasound has much closer agreement and no systematic bias with the gold standard of hysteroscopy. In contrast, 2D-SIS ultrasound shows a high tendency for systematic overestimation of the actual dimensions of lesions, and due to the presence of wide clinically relevant statistical limits of agreement, these two imaging tools should not be used interchangeably in clinical practice for monitoring mass dimensions. Finally, given the noninvasive nature and high overall accuracy of 3D-SIS ultrasound, this technology can be employed as a reliable first-line screening and diagnostic tool in women's treatment protocols prior to invasive procedures, significantly reducing the need for unnecessary diagnostic hysteroscopies and the costs imposed on the healthcare system.

Conflict of Interests

Authors declare no conflict of interests.

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None.

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