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The Value of 3D-TVS OmniView Imaging Technology Combined with Tomographic Imaging in the Diagnosis of Intrauterine Adhesions

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Abstract: *Objective*: To investigate the diagnostic efficacy of 3D-TVS OmniView imaging technology combined with tomographic imaging in patients with intrauterine adhesions (IUA). *Methods*: A total of 150 suspected IUA patients admitted to our hospital and confirmed by hysteroscopy were selected as the study sample from January 2024 to December 2025. All patients underwent preoperative 3D-TVS OmniView imaging scans, and the tomographic imaging mode was employed to observe linear interruptions of the endometrium, alterations in uterine cavity morphology, and adhesion bands. The results of hysteroscopy were used as the "gold standard" for this study, and the diagnostic efficacy of 3D-TVS alone versus 3D-TVS OmniView imaging combined with tomographic imaging in diagnosing IUA was compared. *Results*: Among the 150 patients, hysteroscopy diagnosed a total of 112 cases (74.7%) of IUA. The sensitivity, specificity, and accuracy of 3D-TVS alone in diagnosing IUA were 82.1%, 78.4%, and 81.0%, respectively; whereas the sensitivity of 3D-TVS OmniView imaging combined with tomographic imaging significantly increased to 93.7%, with a specificity of 89.2% and an accuracy of 92.0%, all of which were significantly higher than those of 3D-TVS alone ($P < 0.05$). In terms of adhesion degree identification, combined imaging demonstrated higher consistency in judging moderate and severe adhesions ($\kappa = 0.82$), particularly in displaying deformations of the uterine cavity contour, adhesion bridges, and focal atresia with greater clarity. *Conclusion*: The implementation of 3D-TVS OmniView combined with tomographic imaging in patients with intrauterine adhesions yields higher diagnostic accuracy. This non-invasive, intuitive imaging method holds significant clinical value and can serve as an important screening tool prior to hysteroscopy, meriting widespread adoption and application.

Keywords: 3D-TVS OmniView imaging technique; Tomographic imaging; Intrauterine adhesions; Diagnostic value

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1. Introduction

Intrauterine adhesion (IUA) is a relatively common acquired uterine cavity pathology in gynecological clinical

practice, typically caused by curettage, induced abortion, intrauterine procedures, postpartum infection, or endometrial injury [1]. Traditional two-dimensional ultrasound, due to its imaging limitations, struggles to accurately display the three-dimensional structure of the uterine cavity, the orientation of adhesion bands, and the extent of adhesions, often leading to misdiagnosis or misjudgment [2]. In recent years, three-dimensional transvaginal ultrasound (3D-TVS) has rapidly advanced in the field of gynecology. By acquiring volumes and performing multiplanar reconstruction, it presents the patient's uterine morphology in a more three-dimensional manner [3]. However, relying solely on conventional three-dimensional imaging still makes it difficult to comprehensively assess local lesions in the patient's uterine cavity, especially in cases of mild or focal adhesions, where diagnosis remains challenging. The "OmniView" technology of 3D-TVS is not constrained by orthogonal planes, enabling the acquisition of curved or planar images in any direction and at any angle. The multi-line tracing method within the OmniView technology allows for the depiction of a reference line along the curvature of the uterine cavity and the contour of the endometrium, thereby obtaining a complete, flattened coronal image from the fundus to the external os of the cervix. This achieves a virtual sectional view similar to that of hysteroscopy, providing a clearer visualization of the adhesion sites, extent, and their relationship with the endometrium in patients [4]. Based on this, this study aims to explore the value of 3D-TVS OmniView technology combined with tomographic imaging in the diagnosis of intrauterine adhesions, with the report as follows:

2. Materials and methods

2.1. Clinical data

The sample was collected from January 2024 to December 2025, consisting of 150 suspected cases of intrauterine adhesions who were admitted and diagnosed via hysteroscopy in our hospital. The hysteroscopy results were used as the "gold standard" for this study. The patients ranged in age from 22 to 46 years old, with an average age of (31.84 ± 4.27) years old. All patients were examined when the endometrium was thicker before menstruation. Amenorrheic patients underwent transvaginal three-dimensional ultrasonography before hysteroscopy and then underwent hysteroscopy within the following week to confirm the diagnosis. The study strictly adhered to medical ethical requirements, and all participants provided informed consent and signed consent forms.

Inclusion criteria: (1) Patients who sought medical treatment in our hospital and whose clinical manifestations suggested the possibility of intrauterine adhesions; (2) Patients with irregular uterine cavity contours, interrupted endometrial lines, or suspected adhesions as indicated by two-dimensional ultrasound; (3) Patients who were able to cooperate and complete both 3D-TVS examination and hysteroscopy; (4) Patients with complete data, including accessible clinical and imaging information.

Exclusion criteria: (1) Patients previously diagnosed with congenital uterine malformations; (2) Patients with obvious lesions affecting the uterine cavity structure, such as uterine fibroids or endometrial polyps; (3) Patients with acute genital tract infections or a history of uterine cavity procedures in the short term that may affect the evaluation of the uterine cavity environment; (4) Patients who were pregnant or had pregnancy-related diseases; (5) Patients who were unable to tolerate or refused hysteroscopy.

2.2. Methods

All patients underwent preoperative 3D-TVS free-hand omni-view imaging scans, combined with tomographic imaging mode to observe linear interruptions in the endometrium, changes in uterine cavity morphology, and

adhesion bands. The examinations were performed during the mid-to-late phase of the patients' menstrual cycles using a Samsung WS80A three-dimensional color ultrasound diagnostic instrument with a vaginal three-dimensional volume probe operating at a frequency of 5-9 MHz. Before the examination, patients were instructed to empty their bladders and assume a dorsal lithotomy position to minimize the impact of bladder distension and body position on subsequent imaging.

3D-TVS (Three-Dimensional Transvaginal Ultrasound): Routine two-dimensional transvaginal ultrasound was used to examine the position, size, shape, and endometrial thickness of the patients' uterus, as well as to observe the continuity of the endometrial line and endometrial echo patterns. On this basis, switch to the three-dimensional volumetric imaging mode to obtain complete uterine cavity volume data of the patient. Observe the morphology of the uterine cavity in the coronal, sagittal, and transverse planes through multi-planar reconstruction, with a focus on assessing whether the uterine cavity contour is regular, whether the endometrial line is interrupted, and whether there are any abnormal echo structures.

3D-TVS OmniView combined with Tomographic Ultrasound Imaging (TUI): After obtaining three-dimensional volume data of the patient, apply OmniView technology to perform dynamic rotation and layer-by-layer dissection of the uterine cavity at any angle and multiple sections, simulating the perspective of a hysteroscope. This allows for a focused observation of the course, thickness, and distribution range of adhesions in the patient. Simultaneously, activate the TUI mode and adjust the slice distance based on endometrial thickness to conduct multi-layer analysis of the endometrium, evaluating changes in uterine cavity morphology and focal abnormalities layer by layer.

Hysteroscopy: All patients undergo hysteroscopy within one week after completing the ultrasound examination. The procedure is performed under intravenous or local anesthesia, with normal saline used as the distension medium and the distension pressure maintained at 15 kPa. The morphology of the uterine cavity, endometrial status, as well as the location, extent, and degree of adhesions are directly observed under the microscope, and the uterine cavity adhesions are classified accordingly.

2.3. Observation indicators

(1) Compare the detection of intrauterine adhesions between 3D-TVS examination alone and the combination of 3D-TVS OmniView with Tomographic Ultrasound Imaging (TUI);

(2) Calculate the sensitivity, specificity, and accuracy of the two examination methods;

(3) Analyze the consistency of the combined imaging technique in identifying intrauterine adhesions of varying degrees (mild, moderate, and severe);

(4) To further evaluate the diagnostic efficacy of the combination of 3D-TVS OmniView with TUI for intrauterine adhesions, using hysteroscopy results as the gold standard, draw Receiver Operating Characteristic (ROC) curves for 3D-TVS examination alone and the combined imaging technique, respectively, and compare the areas under the curves.

2.4. Statistical methods

Data analysis was performed using SPSS 22.0 statistical software. Count data were expressed as the number of cases and percentages, and comparisons between groups were made using the χ^2 test; consistency analysis was performed using the Kappa test. A P-value < 0.05 was considered statistically significant.

3. Results

3.1. Diagnostic results of 3D-TVS OmniView alone and in combination with TUI

Among 150 patients suspected of having intrauterine adhesions, hysteroscopy confirmed 112 cases (74.67%) of intrauterine adhesions and found no intrauterine adhesions in 38 cases (25.33%). 3D-TVS alone detected 100 positive cases of intrauterine adhesions, including 92 true positives and 8 false positives, with 20 missed diagnoses. Its diagnostic sensitivity was 82.14%, specificity was 78.42%, and accuracy was 81.00%. In contrast, 3D-TVS with free-angle tomographic imaging detected 109 positive cases of intrauterine adhesions, including 105 true positives and 4 false positives, with 7 missed diagnoses. Its diagnostic sensitivity was 93.75%, specificity was 89.21%, and accuracy was 92.00%. Compared to 3D-TVS alone, the sensitivity, specificity, and accuracy of 3D-TVS with free-angle tomographic imaging in diagnosing intrauterine adhesions were significantly improved, with statistically significant differences ($P < 0.05$). See **Tables 1–3**.

Table 1. Diagnostic results of 3D-TVS alone for intrauterine adhesions

3D-TVS Findings	Hysteroscopy Positive	Hysteroscopy Negative	Total
Positive	92	8	100
Negative	20	30	50
Total	112	38	150

Table 2. Diagnostic results of 3D-TVS with free-angle tomographic imaging for intrauterine adhesions

Combined Imaging Findings	Hysteroscopy Positive	Hysteroscopy Negative	Total
Positive	105	4	109
Negative	7	34	41
Total	112	38	150

Table 3. Comparison of diagnostic efficacy of different examination methods for intrauterine adhesions (n, %)

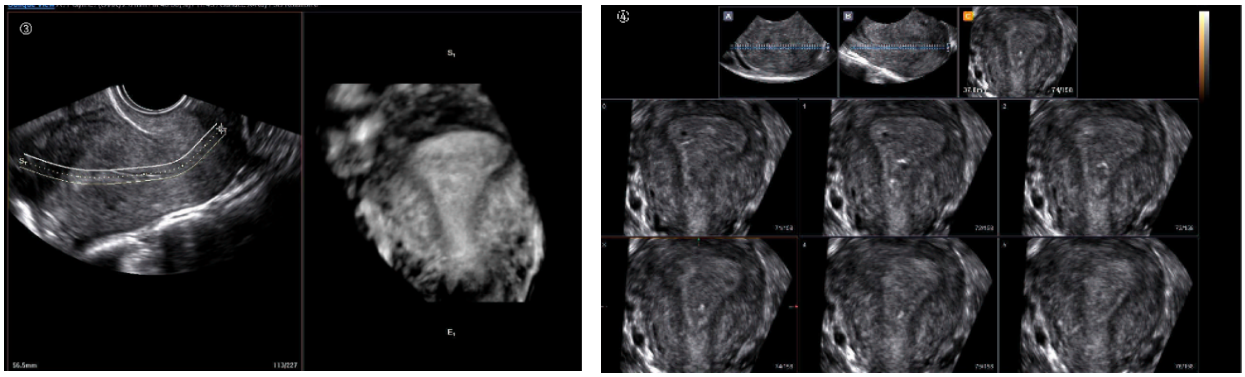
Imaging Modality	Sensitivity	Specificity	Accuracy	χ^2-value	*P*-value
3D-TVS Alone	82.14	78.42	81.00		
3D-TVS Combined with Tomographic Imaging	93.75	89.21	92.00	8.746	0.003

3.2. Consistency analysis of 3D-TVS with free-angle tomographic imaging in identifying the severity of intrauterine adhesions

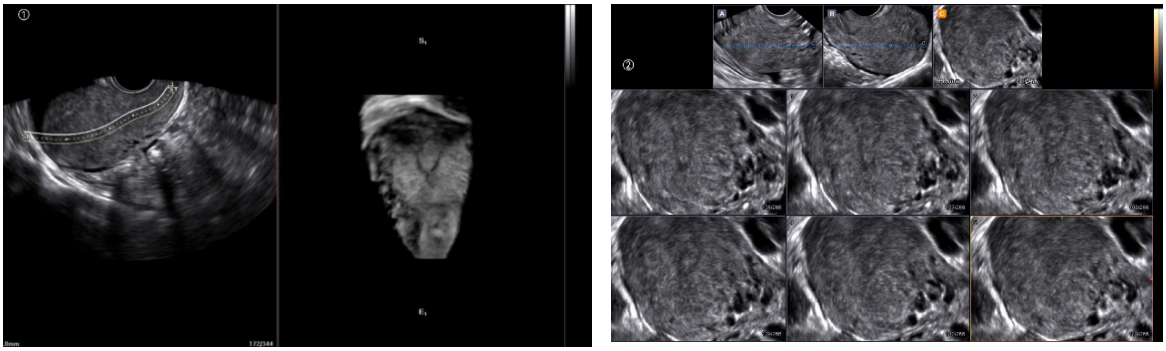
The overall consistency rate of 3D-TVS with free-angle tomographic imaging in identifying the severity of intrauterine adhesions was 82.14%, showing good consistency with hysteroscopy results (Kappa = 0.82, $P = 0.001$). Stratified analysis revealed that the combined imaging technique demonstrated a concordance rate of 86.36% and 86.67% for identifying moderate and severe intrauterine adhesions, respectively, with corresponding Kappa values of 0.81 and 0.84, indicating good agreement. In contrast, the concordance rate for mild adhesions was 73.68%, with a Kappa value of 0.69, suggesting relatively lower agreement. See **Table 4** and **Figures 1–6**.

Table 4. Analysis of concordance between combined imaging technique and hysteroscopy in classifying the severity of intrauterine adhesions (n, %)

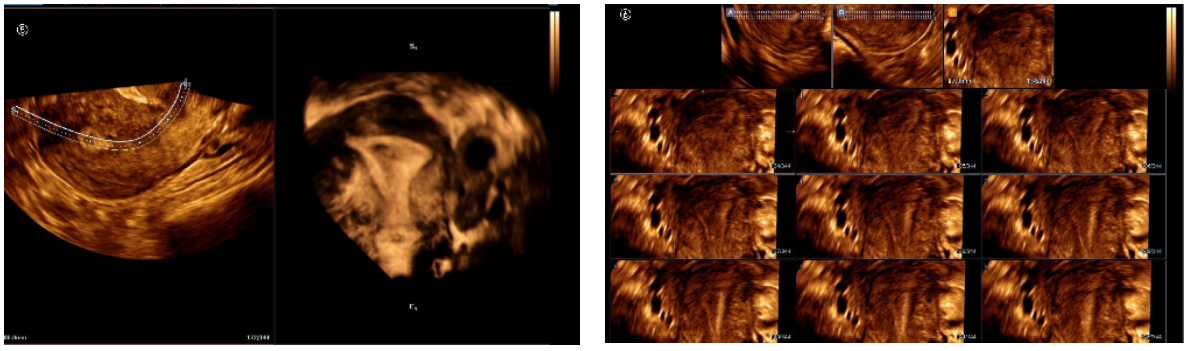
Adhesion Severity	Hysteroscopy Cases (n)	Concordant Cases (n)	Agreement Rate (%)	Kappa Value	*P*-value
Mild	38	28	73.68	0.69	0.012
Moderate	44	38	86.36	0.81	0.002
Severe	30	26	86.67	0.84	0.001
Overall	112	92	82.14	0.82	<0.001



Figures 1–2. Severe intrauterine adhesions with cavity atresia.



Figures 3–4. Moderate adhesions with endometrial defects.



Figures 5–6. Mild intrauterine adhesions with adhesive bands.

3D-TVS OmniView combined with Tomographic Ultrasound Imaging: **Figures 1–2** depict severe adhesions, with unclear visualization of the uterine cavity and atresia. **Figures 3–4** show moderate adhesions, with deformed uterine cavity contours and patchy hypoechoic areas representing endometrial defects. **Figures 5–6** illustrate mild adhesions, with low-echo adhesion bands visible within the uterine cavity.

3.3. ROC curve analysis

The area under the ROC curve for 3D-TVS alone was relatively low, whereas the ROC curve for 3D-TVS OmniView combined with Tomographic Ultrasound Imaging shifted significantly to the upper left, with a notably increased AUC value. This suggests that the overall diagnostic performance of the combined technique is superior to that of 3D-TVS alone, with a statistically significant difference ($P < 0.05$). See **Table 5** and **Figure 7**.

Table 5. Results of ROC curve analysis for diagnosing intrauterine adhesions using different examination methods

Imaging Modality	AUC Value	95% Confidence Interval	*P*-value
3D-TVS Alone	0.803	0.726 – 0.880	0.021
3D-TVS Combined with Free Anatomical Imaging	0.915	0.862 – 0.968	0.000

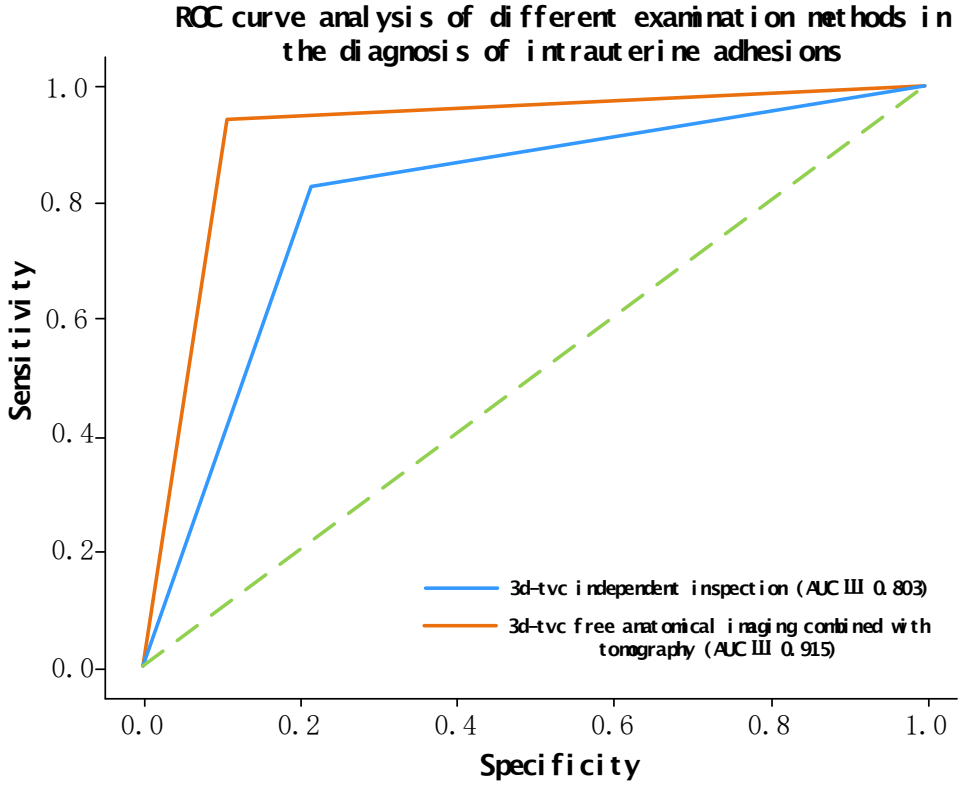


Figure 7. ROC curves of different examination methods for diagnosing intrauterine adhesions. Compared to 3D-TVS alone, the area under the ROC curve for 3D-TVS OmniView combined with Tomographic Ultrasound Imaging was significantly larger, indicating a higher overall diagnostic value for intrauterine adhesions.

4. Discussion

Intrauterine adhesions are a relatively common gynecological condition that significantly impacts women's reproductive health, presenting clinically with issues such as hypomenorrhea, amenorrhea, infertility, and recurrent miscarriages, particularly affecting women of childbearing age with fertility needs [5]. Traditional two-dimensional ultrasound has significant limitations in displaying the overall structure of the uterine cavity, the extent and severity of adhesions, making it prone to missed or misdiagnosed cases [6]. In recent years, three-dimensional transvaginal ultrasound has gradually been applied in the diagnosis of gynecological diseases due to its advantage

of three-dimensional imaging. However, pure three-dimensional imaging still has deficiencies in displaying complex uterine cavity lesions and identifying localized adhesions.

The results of this study show that among 150 patients suspected of having intrauterine adhesions, 112 cases were confirmed by hysteroscopy. The diagnostic sensitivity, specificity, and accuracy of 3D-TVS alone were 82.14%, 78.42%, and 81.00%, respectively. However, after combining 3D-TVS with free-angle tomographic imaging, these indicators significantly improved to 93.75%, 89.21%, and 92.00%, respectively, with statistically significant differences ($P < 0.05$). The reason for this is that free-angle tomographic imaging technology allows for dynamic cutting and rotational reconstruction of the acquired three-dimensional volumetric data at any angle and on multiple planes, breaking free from the limitations of fixed sections in traditional two-dimensional and conventional three-dimensional imaging, thereby presenting the uterine cavity structure in a virtual direct-view effect similar to hysteroscopy [7]. The results of this study demonstrate that the number of missed diagnoses in the combined imaging group decreased from 20 cases with 3D-TVS alone to 7 cases, and the number of false positives also significantly decreased, indicating that tomographic imaging plays a crucial role in detecting occult adhesions and avoiding misdiagnosis. This study further analyzed the consistency of combined imaging technology in identifying the degree of adhesions. The results showed an overall consistency rate of 82.14% and a Kappa value of 0.82, indicating good agreement with hysteroscopy. Stratified analysis revealed that the consistency rates for identifying moderate and severe intrauterine adhesions using combined imaging technology reached 86.36% and 86.67%, respectively, with corresponding Kappa values of 0.81 and 0.84, indicating good agreement. However, the consistency rate for mild adhesions was 73.68%, with a Kappa value of 0.69, which was relatively lower. This discrepancy suggests that combined imaging technology has a more pronounced advantage in adhesion types with more obvious structural changes. The reason for this is that moderate and severe intrauterine adhesions are often accompanied by significant deformation of the uterine cavity contour, disruption of endometrial continuity, formation of adhesion bridges, and even focal atresia. These structural changes are more clearly and stably visualized in both OmniView and tomographic imaging, making them easier to identify and classify [8]. In contrast, mild adhesions manifest as slight interruptions in the local endometrium, with relatively concealed structural changes, still posing some difficulty in identification. This is a significant factor contributing to the relatively lower consistency.

5. Conclusion

In conclusion, the use of 3D-TVS OmniView combined with tomographic imaging for patients with intrauterine adhesions offers higher diagnostic accuracy. It is a non-invasive, intuitive imaging method with high clinical application value and can serve as an important screening tool before hysteroscopy, warranting promotion and application.

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Disclosure statement

The authors declare no conflict of interest.

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