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Transperineal ultrasonography with a high-frequency probe and a three-dimensional end-fire probe for imaging perianal abscesses and locating the internal openings of anal fistulas

Hongyun Wu
 Juan Chang
 Xiuhong Zhang
 Yunfei Tao

Rugao Hospital of Traditional Chinese Medicine, Clinic of Ultrasound, Rugao, China

PURPOSE

This study aims to explore the clinical value of transperineal ultrasonography with a high-frequency probe and a three-dimensional (3D) end-fire probe in locating the internal openings of perianal abscesses and anal fistulas.

METHODS

Eighty patients who were diagnosed with perianal abscesses and anal fistulas and treated between June 2023 and December 2024 were enrolled in this study. An observation group (n = 40) and a control group (n = 40) were established, and intergroup comparisons were conducted on the diagnostic efficacy of the intervention in locating internal openings and categorizing abscesses according to the Parks classification system.

RESULTS

The two groups showed no significant differences in baseline data ($P > 0.05$). The observation group showed higher sensitivity, specificity, and overall accuracy in the localization of internal openings than the control group. There was good agreement between the independent image assessments of the two study sonographers (Cohen's kappa = 0.83, $P < 0.001$). The recurrence rate was 7.5% (3/40) in the observation group and 25.0% (10/40) in the control group at 6 months after surgery. The observation group demonstrated higher accuracy in the categorization of abscesses based on the Parks classification system than the control group (92.5% vs. 77.5%).

CONCLUSION

Transperineal ultrasonography using both a high-frequency probe and a 3D end-fire probe can enhance the accurate localization of the internal openings of perianal abscesses and anal fistulas and assist in the accurate classification of abscesses.

CLINICAL SIGNIFICANCE

The combined dual-probe ultrasonography method is a non-invasive, rapid, and highly accurate preoperative imaging approach that aids in precise surgical planning, reduces postoperative recurrence, and offers a practical diagnostic alternative for institutions without access to magnetic resonance imaging.

KEYWORDS

Anal fistula, perianal abscess, probe, surgery, transperineal ultrasonography

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Corresponding author: Hongyun Wu

E-mail: wuhyrhtcm@sdsch.cn

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Perianal abscesses are a common emergency condition in anorectal surgery characterized by a high risk of recurrence and postoperative fistula formation. Surgical success largely depends on the accurate preoperative localization of the abscess cavity and its internal openings, as imprecise identification often results in incomplete drainage and disease recurrence.¹ Therefore, reliable imaging assessment is of great importance for improving surgical outcomes in emergency settings.²

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Physical examination remains the most readily available diagnostic approach for locating perianal abscesses but shows limited accuracy in identifying high and complex abscesses and internal openings, as it relies heavily on clinical experience and is especially challenging in primary hospitals.³ This is challenging because it relies heavily on clinical experience, which is lacking in many primary hospitals. Magnetic resonance imaging (MRI) is widely recognized as the gold standard for evaluating perianal infections, as it provides excellent visualization of the spatial relationship between the abscess cavity and the sphincter complex, thus facilitating surgical planning. However, its application in acute clinical practice is restricted by its high cost, long examination times, and limited accessibility in emergency departments.⁴

Ultrasound-based techniques offer a more practical alternative. Intraluminal ultrasonography can accurately detect internal openings and fistula structures, but its clinical utility in the acute abscess stage is limited by poor patient tolerance, severe pain, and the technical difficulty associated with probe insertion.^{5,6} Two-dimensional (2D) transperineal ultrasound (TPUS), by contrast, is non-invasive, convenient, and well-suited for emergency use.⁷ Nevertheless, conventional 2D TPUS alone lacks sufficient capability to depict the three-dimensional (3D) spatial relationship between deep abscess cavities and the anal sphincter complex, which may result in the underdiagnosis of high and complex lesions.⁸

Main points

- The combined use of high-frequency linear array and three-dimensional end-fire probes in transperineal ultrasonography markedly improves the accurate localization of the internal openings of perianal abscesses and anal fistulas.
- The dual-probe approach achieves higher diagnostic sensitivity, specificity, and overall accuracy compared with conventional two-dimensional ultrasonography.
- Accurate preoperative imaging reduces postoperative recurrence rates and enhances the accurate use of the Parks classification system for abscesses.
- Improved imaging guidance contributes to shorter surgical durations, less intraoperative blood loss, milder postoperative pain, and faster wound healing.
- This non-invasive, convenient, and reliable method offers a practical imaging option for preoperative assessment in primary hospitals lacking magnetic resonance imaging resources.

Previous studies have attempted combined ultrasound approaches, most commonly integrating intraluminal ultrasonography with 2D or 3D imaging.^{9,10} Although these techniques improve anatomical visualization, they still depend on intracavitary probe insertion and therefore remain unsuitable for patients in the acute inflammatory phase. In addition, existing TPUS protocols typically rely on a single probe type, limiting examination to either a superficial or deep anatomical assessment.¹¹ As a result, a fully transperineal, pain-tolerant, combined ultrasound strategy has not yet been systematically established.

To address these limitations, the present study introduces a combined TPUS protocol that integrates a high-frequency linear-array 2D probe with a 3D end-fire probe. The high-frequency linear probe provides a high-resolution visualization of superficial fistulas and subcutaneous tissues, whereas the 3D end-fire probe enables the volumetric reconstruction of deep abscess cavities and their relationship to the anal canal, sphincter complex, and levator ani muscle.^{12,13} Unlike previously reported combined ultrasound techniques, this protocol avoids intraluminal probe insertion, thereby improving patient tolerance in the acute stage while achieving a complementary superficial–deep anatomical assessment.

The aim of this study is to systematically characterize the imaging characteristics of perianal abscesses using this combined TPUS approach and to evaluate its accuracy in locating internal openings using surgical findings as the reference standard. This strategy is expected to fill an important clinical gap and provide a non-invasive, accessible, and reliable imaging tool for emergency and primary hospital settings.

Methods

Sample size estimation

Sample size estimation was performed for a two-sample comparison of mean diagnostic accuracy, with accuracy treated as a continuous variable. The estimates of variability and effect size were derived from a pre-experimental pilot study conducted prior to formal enrollment. In this pilot analysis, the mean diagnostic accuracy was 0.78 ± 0.15 in the conventional TPUS group and 0.90 ± 0.12 in the combined TPUS group. Based on these data, the pooled standard deviation (σ) was estimated to be 0.14, and the expected difference in mean accuracy (δ) was 0.12. With a

two-sided significance level (α) of 0.05 and a statistical power ($1 - \beta$) of 0.90, the required sample size was calculated to be 32 patients per group. Allowing for an anticipated loss-to-follow-up rate of approximately 20%, the final target sample size was increased to 40 patients per group, which resulted in a total minimum sample size of 80 participants.

Study type and participants

Study participants ($n = 80$) were patients diagnosed with perianal abscesses and anal fistulas and treated in the study hospital between June 2023 and December 2024. All eligible patients were screened according to the inclusion and exclusion criteria described below. Those meeting the requirements were informed of the study protocol and provided their written consent before participation. After baseline data were collected, the 80 enrolled patients were randomly assigned to either an observation group or a control group using a computer-generated random number table. Allocation concealment was achieved using sealed, opaque, sequentially numbered envelopes prepared by an independent investigator who was not involved in patient recruitment or outcome assessment. Group assignment was revealed only after patient enrollment and the completion of a baseline evaluation. Each group included 40 patients.

All participants completed a standardized preoperative assessment, received their respective interventions, and were followed up postoperatively for outcome evaluation (Figure 1). The study protocol was approved by the Ethics Committee of Rugao Hospital of Traditional Chinese Medicine (approval number: RGSZYLL26002, date: 03.06.2023).

The following inclusion criteria were applied: 1) Patients who were clinically diagnosed with perianal abscesses and anal fistulas and planned to receive surgical treatment in the study hospital; 2) patients with normal anal appearance and function; 3) patients with hepatic and renal function meeting relevant treatment criteria; and 4) patients who required and could undergo examination and diagnosis by ultrasonography.

The following exclusion criteria were applied: 1) Patients with anal fistulas secondary to other diseases; 2) patients with specific anal fistulas caused by Crohn's disease, ulcerative colitis, tuberculosis, among other conditions; 3) patients with severe cardiovascular, cerebrovascular, hepatic, renal, or hematological diseases not suitable for surgery; and 4) patients with other diseases of the anus or rectum.

Ultrasonography methods

The RS85 Prestige ultrasound system (Samsung, Seoul, Korea) was used to perform ultrasonography on all participants. Patients were asked to empty their bladder and bowels prior to examination. No bowel preparation was especially required. All ultrasonographic examinations were performed by two experienced sonographers who were not involved in patient recruitment or postoperative outcome assessment. Due to the inherent differences in examination procedure between the two protocols, the sonographers were aware of the ultrasonographic technique applied; however, they were blinded to surgical findings and postoper-

ative outcomes. To minimize interpretation and verification bias, ultrasonographic findings were recorded in a standardized manner and stored independently, and no feedback regarding surgical results was provided to the sonographers during the study period. Importantly, ultrasonographic findings, including the predicted locations of internal openings, were not disclosed to the operating surgeons prior to surgery.

In the control group, 2D high-frequency transperineal ultrasonography was applied following a standardized scanning protocol. The relevant ultrasonographic features of perianal abscesses and associated fistulous structures were recorded, including abscess

location, size, and morphology and the estimated locations of internal openings. Detailed anatomical descriptions and scanning planes are provided in the Supplementary Material.

In the observation group, a combined transperineal ultrasonography protocol integrating 2D high-frequency linear array imaging and 3D end-fire ultrasonography was applied. 2D transperineal scanning was performed first, as in the control group, and 3D volumetric acquisition was then conducted using an end-fire probe. The combined approach allowed for the complementary assessment of both superficial and deep lesion characteristics. Detailed procedural steps, anatomical landmarks, and image reconstruction methods are described in the Supplementary Material. Predicted internal opening locations and abscess types were documented for subsequent analysis.

Outcome measures

Primary outcome measures

The accuracy of internal opening localization was defined as the proportion of patients whose fistular internal opening locations as predicted by ultrasonography were consistent with those confirmed by surgical findings, which were taken as the gold standard. The anal fistula recurrence rate at 6 months after surgery was defined as the proportion of patients who required a second surgery due to the appearance of new abscesses or fistula tracts at or near the original surgical site within 6 months after the initial surgery.

Secondary outcome measures

The accuracy of the Parks classification system for abscesses was assessed by the proportion of patients whose abscess type (as determined by the system) was consistent with the type finally confirmed during surgery. Total surgical duration from skin incision to wound closure was recorded in minutes. Intraoperative blood loss was assessed by measuring the volume of fluid in the suction container and calculating the weight differences of used surgical gauze. Patients' pain scores on postoperative day 3 were assessed using the visual analog scale, which ranges from 0 to 10 points, with higher scores indicating more severe pain. Wound healing time was defined as the number of days from surgery to complete wound epithelialization without exudate.

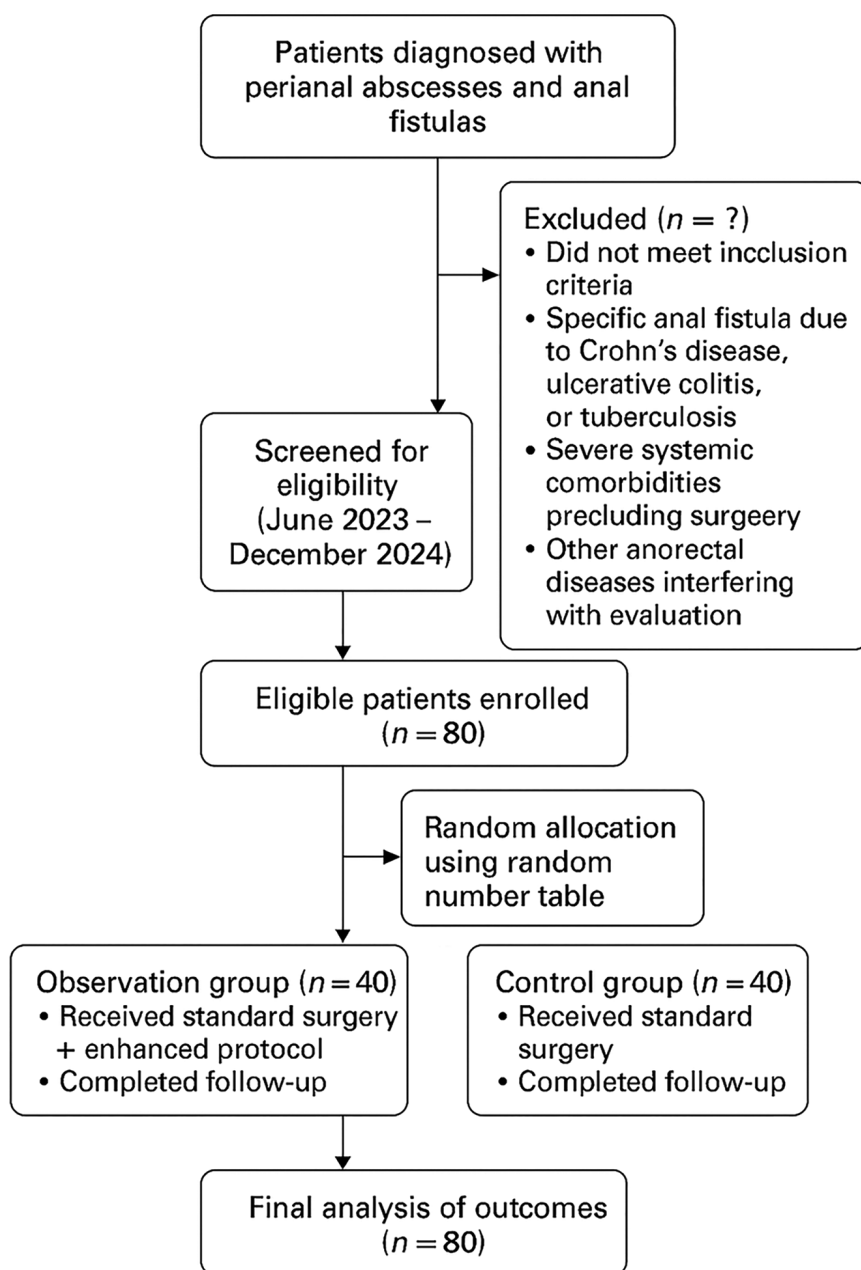


Figure 1. Flow diagram of patient enrollment and study procedures.

Gold standard of surgical findings

Intraoperative findings were used as the gold standard for diagnosis. All surgical procedures were performed independently by two senior anorectal surgeons, each with over 10 years of clinical experience. Both surgeons were blinded not only to group allocation but also to all preoperative ultrasonographic findings, including the predicted locations of internal openings, to prevent incorporation or verification bias in outcome assessments. The intraoperative exploration and identification of internal openings were performed solely based on direct surgical findings. Following the lumbo-sacral or sacral canal block anesthetization of patients, an incision was made, as per standardized procedures, to expose the abscess cavity; pus was thoroughly drained; and a probe was used to gently explore the abscess cavity and any suspicious paths, with the purpose of tracing the course of fistula tracts. For cases with a suspected internal opening, diluted methylene blue or hydrogen peroxide was injected to aid visual identification. Intraoperative records included the specific anatomical location and extent of abscesses, the course and branching of fistula tracts, Parks classification results, and the number and exact locations of internal openings (annotated using the 12-o'clock method, with the height relative to the dentate line specified). To eliminate the effect of postoperative management differences on study results, completely identical standardized protocols for nursing and medication were implemented postoperatively for all participants. After surgery, a drainage gauze strip was routinely placed and removed for 24–72 h, based on the condition of any exudate. Additionally, broad-spectrum antibiotics (covering aerobic and anaerobic bacteria) were administered intravenously for 3–5 days immediately after surgery. Pain was managed with non-steroidal anti-inflammatory drugs.

Follow-up plan

All patients were followed up at 1 and 6 months postoperatively. The follow-up at month 1 was mainly completed in the outpatient clinic and focused on the assessment of complete wound epithelialization, short-term complications (incision infection, exudation, bleeding, etc.), and signs of recurrence. As the 6-month follow-up was the time point for evaluating the primary outcome, a systematic physical examination was performed in the outpatient clinic. For patients unable to attend follow-ups through

clinic visits due to geographical or other objective reasons, assessment was completed by a trained follow-up physician through telephone interviews and supplemented by photos when necessary.

Statistical analysis

Statistical analysis was completed using SPSS software (version 26.0, IBM Corp., Armonk, NY, USA). The normality of continuous variables was assessed using the Shapiro–Wilk test. Normally distributed continuous variables were expressed as mean $\pm$ standard deviation and compared between groups using the independent sample t-test. Categorical variables were expressed as n (%) and compared using the chi-squared test or exact tests, as appropriate. When expected cell counts did not meet the assumptions of the chi-squared test, Fisher's exact test was applied for 2×2 contingency tables, and the Fisher–Freeman–Halton exact test was used for larger contingency tables. All analyses were conducted according to the intention-to-treat principle, and all statistical tests were two-tailed, with $P < 0.05$ denoting a statistically significant difference.

Results

Baseline patient data

There were no statistically significant differences in age, sex ratio, body mass index, duration of symptoms, presence of major clinical symptoms (pain, lumps, and fever), history of perianal abscesses or anal fistulas, diabetes mellitus status, or level of C-reactive protein (an inflammatory indicator) between the two groups ($P > 0.05$), implying comparable baseline characteristics between the two groups (Table 1).

Imaging characteristics

In the two-probe ultrasonography method, superficial abscesses mostly presented as hypoechoic or anechoic zones with relatively clear boundaries, occasionally with liquefied septations. The high-frequency probe accurately demonstrated the extent of each abscess cavity and its relationships to the skin (Figure 2a). For complex or high-grade lesions, 2D end-fire images revealed the anatomical relationship between each abscess cavity and the internal and external sphincters (Figure 2b). Moreover, the 3D end-fire probe enabled the 3D reconstruction of the abscess cavity, visually displaying its space adjacent to the sphincter and levator ani muscle (Figures 2c and 2d). In some typical cases, the fistula tract appeared as a cord-like hypoechoic structure extending from the abscess cavity to the mucosal layer of the anal canal, forming a potential internal opening channel. Atypical cases were characterized by an irregular course of fistula tracts, with branches or concealed internal openings.

Accuracy of internal opening localization

Table 2 displays the comparison between the ultrasonographic predictions for the locations of internal openings and the actual surgical findings in the study cohort. Specifically, 36 cases of true positive, 3 cases of false positive, 37 cases of true negative, and 4 cases of false negative were predicted by ultrasonography. Taking surgical findings as the gold standard, the calculated sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy of ultrasonography for locating internal openings were 90.0% (36/40), 92.5% (37/40), 92.3% (36/39), 90.2% (37/41), and 91.3% (73/80), respectively, hinting at high diag-

Table 1. Baseline patient data

Characteristic	Observation group (n = 40)	Control group (n = 40)	P
Age (years)	42.6 $\pm$ 11.8	43.4 $\pm$ 12.1	0.765
Gender (M/F)	28/12	27/13	1.000
Body mass index (kg/m ²)	24.1 $\pm$ 3.2	23.8 $\pm$ 3.4	0.686
Duration of symptoms (days)	6.3 $\pm$ 2.4	6.5 $\pm$ 2.8	0.733
Main symptoms			
Pain	33 (82.5%)	34 (85.0%)	1.000
Lumps	25 (62.5%)	27 (67.5%)	0.815
Fever	10 (25.0%)	9 (22.5%)	1.000
History of perianal abscesses/anal fistulas	6 (15.0%)	7 (17.5%)	1.000
Diabetes mellitus morbidity	4 (10.0%)	5 (12.5%)	1.000
Serum C-reactive protein (mg/L)	38.6 $\pm$ 12.4	37.9 $\pm$ 13.1	0.807

M, male; F, female.

nostic efficiency. Additionally, the analysis of agreement between the two independent sonographers yielded a Cohen's kappa value of 0.83 ($P < 0.001$), suggesting favorable inter-observer agreement. The diagnostic performance of ultrasonography in locating internal openings was compared between groups (Table 3), and the observation group

consistently demonstrated higher sensitivity, specificity, and overall accuracy than the control group, though the differences did not reach statistical significance. This trend indicates the potential advantage of combining a high-frequency probe with a 3D end-fire probe for locating the internal openings of fistulas.

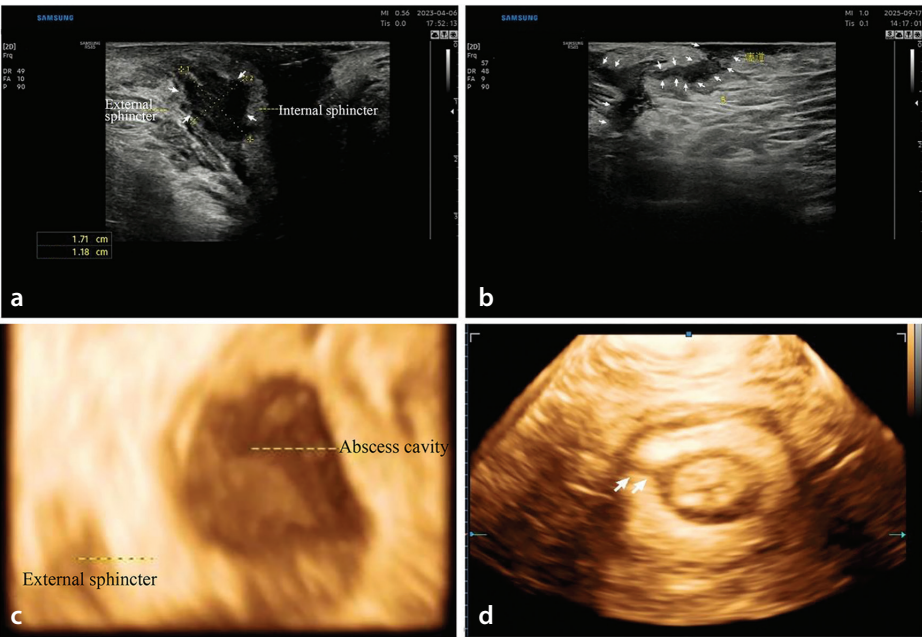


Figure 2. Typical imaging characteristics; (a) Superficial abscesses and subcutaneous fistula tracts displayed using the high-frequency probe; (b) relationship between the abscess cavity and sphincter in two dimensional mode; (c, d) image of three dimensional (3D) reconstruction visually demonstrating the 3D shape of the abscess cavity and the spatial structure of the anal canal. All images are clearly illustrated with arrows and annotations for easy interpretation.

Table 2. Comparison between ultrasonographic diagnosis results and surgical findings (with the latter considered as the gold standard)			
	Presence of internal openings confirmed by surgery	Absence of internal openings confirmed by surgery	Total
Presence of internal openings indicated by ultrasonography	TP = 36	FP = 3	39
Absence of internal openings indicated by ultrasonography	FN = 4	TN = 37	41
Total	40	40	80
TP, true positive; FP, false positive; TN, true negative; FN, false negative.			

Table 3. Diagnostic efficacy of ultrasonography in locating inner openings			
Indicator	Observation group (n = 40)	Control group (n = 40)	P
Sensitivity (%)	92.5 (37/40)	75.0 (30/40)	0.066
Specificity (%)	95.0 (38/40)	80.0 (32/40)	0.087
Positive predictive value (%)	94.9	79.0	-
Negative predictive value (%)	92.7	76.2	-
Overall accuracy (%)	93.8	77.5	-
P values were calculated for sensitivity and specificity using a two-sided Fisher's exact test.			

Anal fistula recurrence rate at 6 months after surgery

Recurrence was observed in 13 of the 80 study participants at 6 months postoperatively, with an overall recurrence rate of 16.3%, including 3 (7.5%) from the observation group and 10 (25.0%) from the control group. Although the difference between the two groups did not reach statistical significance (Fisher's exact test, $P = 0.066$), the recurrence rate in the observation group was numerically reduced by approximately two-thirds compared with that in the control group. This magnitude of reduction suggests there is potentially a clinically meaningful benefit in combining a high-frequency probe with a 3D end-fire probe to lower the risk of postoperative recurrence. All patients who experienced a recurrence presented with newly formed abscesses or fistula tracts at the original surgical site or adjacent areas and received secondary surgical intervention.

Accuracy of the Parks classification system for abscesses

Compared with classification by surgical findings, the accuracy of classification by ultrasonography was higher in the observation group than in the control group (92.5% vs. 77.5%), though the difference did not reach statistical significance (Fisher's exact test, $P = 0.115$). Notably, a consistent improvement in diagnostic accuracy was observed across multiple fistula subtypes, including intersphincteric, low and high transsphincteric, and ischiorectal (Table 4). This consistent pattern across different anatomical classifications supports the clinical value of combining a high-frequency probe with a 3D end-fire probe, as it may enhance the stability and reproducibility of abscess and fistula tract characterization, particularly in complex anatomical settings.

Other secondary outcome measures

The observation group outperformed the control group in surgical efficiency, intraoperative blood loss, and postoperative recovery outcomes. Specifically, shorter surgical durations, less intraoperative blood loss, milder pain on postoperative day 3, and significantly shortened wound healing times were noted in the observation group, and the differences were statistically significant ($P < 0.05$) (Table 5).

Discussion

Perianal abscesses and anal fistulas are common and frequently encountered dis-

Classification	Number of cases in observation group	Correct cases in observation group (n)	Accuracy in observation group (%)	Number of cases in control group	Correct cases in control group (n)	Accuracy in control group (%)
Intersphincteric type	14	13	92.9	15	11	73.3
Low transsphincteric type	12	11	91.7	11	9	81.8
High transsphincteric type	8	7	87.5	7	5	71.4
Ischiorectal type	5	5	100.0	6	5	83.3
Others (suprasphincteric type, etc.)	1	1	100.0	1	1	100.0
Total	40	37	92.5	40	31	77.5

Measure	Observation group (n = 40)	Control group (n = 40)	P
Surgical duration (minute)	42.3 ± 8.5	49.6 ± 9.1	<0.001
Intraoperative blood loss (mL)	28.4 ± 10.2	36.9 ± 12.7	0.002
VAS pain score on postoperative day 3 (points)	3.2 ± 1.1	4.5 ± 1.3	<0.001
Wound healing time (days)	22.6 ± 5.8	28.3 ± 6.2	<0.001

VAS, visual analog scale.

eases in anorectal surgery, and the cornerstone of their treatment lies in the accurate identification and management of their internal openings, the complete removal of infectious lesions, and the protection, to the greatest extent, of anal sphincter function. Surgical failure and postoperative recurrence are usually ascribed to a failure to accurately identify the locations of internal openings and the course of complex fistulas. In the present study, the combined application of a high-frequency linear array probe and a 3D end-fire probe in the observation group achieved greater accuracy in locating internal openings and Parks classifications, lower postoperative recurrence rates, and greater improvements in surgery-related indicators compared with the control group, demonstrating that a more refined preoperative imaging assessment is capable of effectively guiding surgical decision making and thus improving patient prognoses.

The accurate preoperative assessment of anal fistulas is pivotal for formulating surgical plans.¹⁴ For complex and recurrent anal fistulas, digital examination, probing, and other traditional examination methods achieve low accuracy.¹⁵ In recent years, intraluminal ultrasonography and MRI have become major imaging evaluation methods.⁸ In the present study, the combined examination mode used in the observation group fully leveraged the advantages of two different ultrasound techniques. The high-frequency probe offers excellent superficial tissue resolution for the clear visualization of subcutaneous fistula tracts and superficial abscesses and their re-

lationship to the skin, which is valuable for exploring lesions around external openings. The 3D end-fire probe provides panoramic anatomical images of the anal canal, rectal wall, and surrounding sphincters and, with the help of 3D reconstruction technologies, enables an observation of the shape and size of any abscess cavity or fistula tract and its spatial adjacency to such deep structures as the internal and external sphincters and the levator ani muscle from multiple angles and cross-sections. A systematic review and meta-analysis reports that 3D intraluminal ultrasonography demonstrates high diagnostic accuracy for most anal fistulas and can serve as a first-line diagnostic tool.¹⁶ The combination of shallow-to-deep and surface-to-internal imaging capacity makes the overall judgment of fistula tract course from this method more comprehensive and accurate, thereby enhancing sensitivity and specificity in locating fistular internal openings. Research has shown that intraluminal ultrasonography has a sensitivity of 87.38% and a specificity of 38.46% for diagnosing perianal fistulas¹⁷—markedly inferior to the results in the observation group of the present study. This may be attributable to the technical advantages of the combined examination mode.

Successful anal fistula surgery requires a balance between the radical treatment of lesions and the preservation of anal function. This, in turn, relies heavily on an accurate assessment of the relationship between the fistula tract course and the sphincter—that is, an accurate Parks classification.¹⁴ The Parks classification system serves as the foundation for guiding the selection of surgical approach.

For instance, fistulotomy is adopted for intersphincteric anal fistulas, whereas sphincter-preserving procedures, such as ligation of the intersphincteric fistula tract, are selected for complex high transsphincteric anal fistulas.¹⁸ In the present study, Parks classification accuracy reached 92.5% in the observation group, exceeding that in the control group (77.5%), especially for more complex types such as transsphincteric and ischiorectal anal fistulas. The latest research has shown that 3D pelvic ultrasonography is highly accurate in locating fistula tracts, identifying internal openings, and determining Parks classifications, rendering a reliable basis for safe treatment.¹⁹ This is attributed to the stereoscopic images provided by 3D ultrasonography, which display the course of the fistula tract passing through the sphincter, offering surgeons a clear surgical roadmap.²⁰ Such accurate preoperative assessment translates directly into clinical benefits. The recurrence rate in the observation group of the present study at 6 months after surgery (7.5%) was much lower than that in the control group (25.0%), a result that suggests that accurate preoperative imaging diagnosis is a pivotal factor in decreasing the postoperative recurrence of anal fistulas. 3D intraluminal ultrasonography has been proven to demonstrate higher accuracy than 2D ultrasonography in assessing the height of the main canal of the transsphincteric fistula tract, with both techniques having good agreement with intraoperative findings in identifying main tracts.²¹ With a complete understanding of the internal opening locations, main tract, and branches of a fistula, as well as any secondary abscess cavities, surgeons can achieve more thorough debridement and more appropriate internal opening management during surgery, effectively preventing recurrence resulting from lesion residue.

Furthermore, better secondary outcomes (e.g., surgical duration, intraoperative blood loss, postoperative pain, and wound healing time) were noted in the observation group compared with the control group in the cur-

rent study, further highlighting the value of accurate preoperative planning. As an accurate and non-invasive imaging technique for diagnosis, intraluminal ultrasonography provides precise details of fistula tracts and is thus useful in preoperative management and surgical planning. With surgical plans based on detailed imaging information, surgeons are spared from having to conduct extensive intraoperative probing, reducing the collateral damage to surrounding tissues. A clearer surgical path also shortens surgical durations and reduces intraoperative blood loss,²² resulting in less surgical trauma, milder postoperative pain, and faster wound healing and thus facilitating patient recovery.²³

The present study has some limitations. First, its single-center design and relatively small sample size may affect the generalizability of its results. Second, ultrasonography depends heavily on operator experience and skill—a condition that may pose a challenge to the repeatability of the results herein. Nevertheless, the kappa consistency test demonstrated good inter-observer agreement. The conclusions of this study should be validated with future, multicenter, prospective randomized controlled trials with larger sample sizes.

In conclusion, transperineal ultrasonography that utilizes both a high-frequency linear array probe and a 3D end-fire probe enhances the accuracy of the preoperative diagnosis of perianal abscesses and anal fistulas, especially with respect to internal opening localization and Parks classification. This improved preoperative evaluation method facilitates more precise surgical planning and may contribute to a reduced risk of postoperative recurrence. Moreover, the combined ultrasonographic approach significantly shortens surgical duration, reduces intraoperative blood loss, alleviates postoperative pain, and accelerates wound healing, thereby promoting postoperative recovery and overall surgical outcomes.

Footnotes

Conflict of interest disclosure

The authors declared no conflicts of interest.

Supplementary Material: <https://d2v96fxpocvxx.cloudfront.net/bda9171a-fae8-4995-8276-2138323f1e16/content-images/05c6b72e-07bd-4811-8be0-a2e13fc7c9d1.pdf>

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