

Effects of preoperative endoanal ultrasound on functional outcome after anal fistula surgery

Kasaya Tantiphlachiva,[Ⓞ] Chucheep Sahakitrungruang, Jirawat Pattanaarun, Arun Rojanasakul

To cite: Tantiphlachiva K, Sahakitrungruang C, Pattanaarun J, *et al.* Effects of preoperative endoanal ultrasound on functional outcome after anal fistula surgery. *BMJ Open Gastro* 2019;**6**:e000279. doi:10.1136/bmjgast-2019-000279

Received 20 January 2019
Revised 17 February 2019
Accepted 23 February 2019

ABSTRACT

Objective Endoanal ultrasound (EAUS) is a recommended preoperative investigation for fistula-in-ano (FiA) which aims to provide the best chance of healing and preservation of continence function. This study aims are (1) to assess effect of EAUS on functional outcome and (2) to determine factors associated with clinical outcomes after FiA surgery.

Design Retrospective analysis of subjects with cryptogenic FiA between January 2011 and December 2016, in a tertiary hospital, was performed by comparing EAUS and no-EAUS groups. Postoperative change in St. Mark's faecal incontinence severity score (cFISS=FISS at 6 months after surgery–FISS before surgery) were compared. General linear model was used to determine factors associated with cFISS. Binary logistic regression was used to assess factors related to clinical outcomes. A p-value of <0.05 is considered significant.

Results We enrolled 339 subjects; 109 (M:F 91:18, mean age 41.7±13.6 years) of 115 in EAUS group and 230 in no-EAUS group (M:F 195:35, mean age 42.6±13.0 years). There were higher proportions of recurrent cases (24.8% vs 13.9%, p=0.014) and complex FiA (80.7% vs 50.4%, p=0.001) in EAUS group. Postoperative FISS (mean±SE) were increased in both groups; preoperative versus postoperative FISS were 0.36±0.20 versus 0.59±0.25 in EAUS group (p=0.056) and 0.31±0.12 versus 0.76±0.17 in no-EAUS group (p<0.001). EAUS had significant effects on cFISS in both univariate analysis, $F(1,261)=4.053$, p=0.045; and multivariate analysis, $F(3,322)=3.147$, p=0.025, Wilk's Lambda 0.972. Other associated factors included recurrent fistula ($F(3,322)=0.777$, p=0.007, Wilk's Lambda 0.993) and fistula classification ($F(3,322)=16.978$, p<0.001, Wilk's Lambda 0.863). After a mean follow-up of 33.6±28.6 weeks, success rate was 63.3%(EAUS) and 60% (no-EAUS), p=0.822. Factors associated with clinical outcomes were fistula complexity, number of tracts, recurrence, number of previous surgery and type of operations. Accuracy of EAUS was 90.8% and not related to clinical outcomes (p=0.522).

Conclusion EAUS had favourable effects on functional outcome after FiA surgery while multiple factors were associated with clinical outcomes. EAUS is useful, accurate, inexpensive and can be the first tool for planning of complex and recurrent FiA.

Summary box

What is already known about this subject?

- ▶ Functional disturbance after anal fistula surgery is common.
- ▶ Endoanal ultrasound is an established investigation for fistula-in-ano.
- ▶ Accuracy of endoanal ultrasound is not associated with postoperative clinical outcomes.

What are the new findings?

- ▶ Beneficial effects of endoanal ultrasound on postoperative functional outcomes of anal fistula surgery has been confirmed.
- ▶ Factors associated with postoperative clinical outcomes has been identified.

How might it impact on clinical practice in the foreseeable future?

- ▶ Endoanal ultrasound can be the first choice for preoperative evaluation of anal fistula surgery for complex and recurrent fistula.

BACKGROUND

Fistula-in-ano (FiA), mostly caused by anal gland infection, has an annual incidence of 12–28 per 100 000 with male predominance (M:F ratio from 2:1 to 6:1).^{1,2} The aim of fistula surgery is to maximize the chance of healing and minimize the chance of anal sphincter dysfunction. Faecal incontinence (FI) has been a known sequela after fistula surgery occurring in 10%–40% of the patients with either complex or simple fistula.^{3,4} Severity of FI had negative impact on their quality of life.^{3,4} Even after sphincter-preservation operations, there was some degree of faecal incontinence.^{5,6} The incidence of FI after most novel methods seems to be decreased but need longer time of follow-up.⁷ Preoperative investigation is recommended in complex or recurrent FiA.^{8,9} Most of the national and international guidelines have recommended MRI for assessment of cryptoglandular FiA.¹⁰ However, the high cost and availability are



© Author(s) (or their employer(s)) 2019. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

Surgery, Chulalongkorn University, Bangkok, Thailand

Correspondence to

Dr Kasaya Tantiphlachiva; kasaya.tan@gmail.com



important limitations. The other viable tools which is inexpensive and more available is endoanal ultrasound (EAUS). EAUS is a useful tool for mapping FiA anatomy.¹¹ Information including fistula pattern, location of internal opening, associated abscess and secondary tract extension can be obtained. With three-dimensional (3D) and hydrogen peroxide–enhancement techniques, the accuracy of EAUS has much improved over clinical examination and unenhanced EAUS.^{12–14} Surgical treatment can be performed accordingly without compromising anal sphincter complex.¹¹ From meta-analysis, reported sensitivity and specificity for fistula detection was 0.87 (95% CI 0.70 to 0.95) and 0.43 (95% CI 0.21 to 0.69), respectively.¹⁵ The accuracy for determining fistula type and height were 94% and 92%, respectively.^{16,17} For identification of internal opening, secondary tract, associated abscess and horseshoe tract, the accuracy was 91%, 96%, 100% and 96%, respectively.¹⁷ By EAUS guidance leads to curative operation in 98% of patients with lower recurrence and preservation of faecal continence.^{17,18} However, the accuracy of EAUS was not a predictor of operative outcomes, either recurrence rate or total number of operations.^{19,20} This suggested that other factors may have influenced on postoperative FiA outcomes. The effect of EAUS on postoperative functional and curative outcomes needed to be confirmed and other influencing factors needed to be looked for.

This study primarily aims to assess the effect of EAUS on postoperative functional outcomes. Secondly, factors associated with clinical outcomes of surgery, including EAUS, are determined.

METHODS

Study design

This is a retrospective cohort analysis of the prospectively collected clinical data of subjects who underwent anal fistula surgery, in the tertiary hospital, between January 2011 and December 2016. Inclusion criteria were subjects >15 years diagnosed with cryptogenic anal fistula who had complete clinical records. Exclusion criteria were subjects with rectovaginal fistula, inflammatory bowel disease, previous pelvic radiotherapy and presence of tuberculosis within the fistula. After clinic examination, attending surgeons would request for preoperative imaging on his/her demand. Subjects were classified into two groups; *EAUS group* and *no-EAUS group*, according to whether they had undergone preoperative EAUS or not. Information retrieved were demographic data, fistula data, operative data, preoperative and postoperative faecal continence status, and postoperative clinical outcomes.

Demographic data

Demographic data include gender, underlying diseases (diabetes mellitus, HIV infection, pulmonary tuberculosis, dyslipidemia), recurrence status (first diagnosis

or had failed previous curative surgery) and number of previous surgery.

FISTULA DATA

Types of fistula were classified according to Parks classification²¹: intersphincteric, transsphincteric (low and high), suprasphincteric and extrasphincteric fistulas. Because the classification does not include secondary tract and cavity,²² courses of the tract and horseshoe extension were additionally described. Subcutaneous type of the fistula was also added.^{8,23} The other classification which defined a fistula as simple versus complex fistula was also noted.^{8,24} Criteria for complexity were transsphincteric FiA involving more than 30% of anal sphincter complex, anterior fistula in women, FiA with horseshoe extension, recurrent FiA, FiA with more than one external opening and suprasphincteric FiA.^{8,24,25} Complex FiA associated with inflammatory bowel diseases, radiation, malignancy, or chronic diarrhoea and extrasphincteric FiA were not included in the study.⁸ Simple fistulas are subcutaneous fistula, intersphincteric fistula and those with none of the previous findings.

Endoanal ultrasound

EAUS was performed by a trained colorectal surgeon using a 3D-rigid, 360° rotating, endoprobe system (B-K Medical, Herlev, Denmark). Hydrogen peroxide (H₂O₂) enhancement technique was used.²⁶ Subject was examined in the left lateral position without bowel preparation or any sedation. Digital rectal examination was performed before inserting a lubricated probe through the anus up to the lower rectum (about 6 cm from AV).²⁷ The probe was fixed still by the examiner's hand while the mechanical rotating crystal was moving inside from the proximal to distal direction to obtain images from uppermost (level of puborectalis muscle) to the lowermost (level of subcutaneous external anal sphincter) part of the anal canal. Three scans at frequencies of 16, 13 and 10 MHz were obtained before, and another scan at 9 MHz was obtained after injection of 1–3 mL of 3% H₂O₂ via plastic venous catheter into the external opening. Post-examination review of the three-dimensional images was performed by identification of the hypoechoic tract and the internal opening which were hypoechoic in the non-enhanced image and would be brightened or hyper-echoic after H₂O₂ injection. Relationship of the tract and internal opening to the anal sphincters were used to for classification and additional abscess or secondary tracts were noted.

Examination under anaesthesia

Examination under anaesthesia was performed at the time of operation by the surgeon, who had not seen the EAUS results. The type of fistula was noted. Additional findings during operation, such as secondary abscess or extension, were noted later.

Operations were classified as sphincter-preserving and non-sphincter-preserving surgery. Sphincter-preserving

procedures included ligation of fistula tract (LIFT),²⁸ anorectal advancement flap (anodermal or mucosal advancement flap) and drainage procedures (tube drainage, seton drainage or marsupialisation). Non-sphincter-preserving surgery included lay-open fistulotomy with/without external anal sphincter (EAS repair, Parks fistulotomy,²⁹ Hanley fistulotomy and core-out fistulectomy. All operations were performed by or under supervision of the senior colorectal surgeon (AR). The duration from EAUS examination to operation was within 2 weeks in the EAUS group. In complex fistula, tissue of fistulous tract had been sent for pathology to exclude tuberculous infection and malignancy.

Follow-up protocol and outcomes measurement

After operation, subjects were asked to return for clinic visit every 2 weeks until healed. Then the follow-up was scheduled at the next 1-month, 3-month, 6-month and 12-month intervals. The surgical wounds were checked for healing status using the following definitions.²⁸

Healed=cessation of drainage with complete epithelialisation of the wound.

Unhealed=the wound failed to meet the healed criteria beyond 10 weeks postoperation or additional surgery was required.

Recurrent=new onset of drainage after healed.

Both unhealed and recurrent are considered postoperative clinical failure. Healing rate, time to heal, recurrence rate and time to recurrence were assessed. Continence function was assessed by St. Mark's faecal incontinence severity score (FISS) which ranges from 0 (perfect continence) to 24 (totally incontinent).³⁰ FISS was noted before operation and during each visit. A change in FISS after operation (cFISS) was determined by difference of postoperative FISS at 6 months and preoperative FISS (cFISS=FISS at 6 months–FISS before surgery). This study has been approved by the institutional review board of the hospital.

Statistical analysis

Demographic data are presented as mean±SD or median and range. Categorical variables were assessed by χ^2 test and continuous variables were assessed by t-test and non-parametric test. General linear model was used to assess the effects of both categorical and continuous predictors on the change in FISS (cFISS). Multivariate analysis was used to assess the effect of each predictor on operative outcomes. A p value of <0.05 was used to inform on statistical significance for all analysis. All statistical analyses were conducted using SPSS V.22.0.

RESULTS

During the study period, 345 subjects with FiA who had attended the colorectal clinic were eligible. There were 115 subjects who underwent EAUS, but 6 were excluded because they did not complete the operation (3 denied surgery, 2 had lung infection prior to the schedule and 1 had no active fistula from EAUS). Thus, 339 subjects

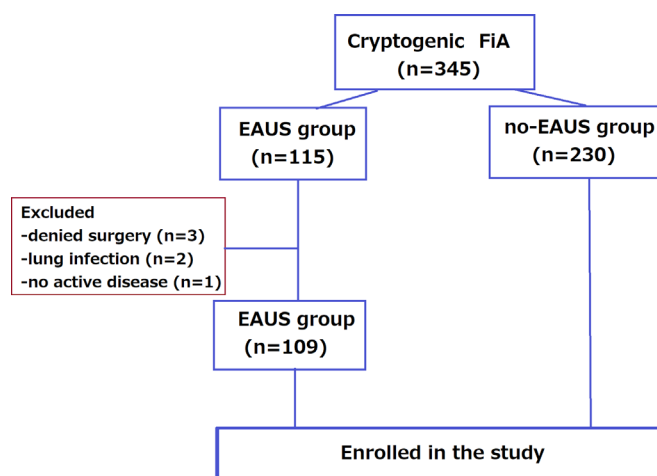


Figure 1 Flowchart of study enrolment. EAUS, endoanal ultrasound; FiA, fistula-in-ano.

were enrolled; 109 (M:F 91:18) were in EAUS group and 230 (M:F 195:35) were in no-EAUS group. **Figure 1** shows the flow of enrolment. Demographic data are shown in **table 1**. There was no difference between groups in age, gender, underlying diseases (diabetes mellitus, HIV infection, pulmonary tuberculosis, dyslipidemia), presence of abscess on first visit, presence of colostomy, preoperative FISS and preoperative MRI. In EAUS group, there were significantly more subjects who had been referred from other institute, whose fistula had recurred and who had undergone previous surgery (abscess drainage, FiA surgery). Mean follow-up time was 33.6 weeks (range, 8–130 weeks).

Type of fistula and EAUS accuracy

The final fistula classification was noted after operative examination. Details of fistula types and classification (simple vs complex) are demonstrated in **table 2**. In EAUS group, types of fistula were noted during examination under anaesthesia by the senior surgeon. Additional information during operation was noted later in the operative notes. Detailed comparison is not shown here. Regarding type of fistula, there was 90.8% (99 in 109) concordance between EAUS results and operative findings. EAUS group had significantly more subjects with high transsphincteric type and complex FiA. There was no difference between group in median numbers of fistula tract. EAUS was able to identify IAS defects in 16 subjects, EAS defects in 1 subject, and both IAS and EAS defects in 2 subjects. All subjects with sphincter defects had no symptoms of FI (FISS=0). In 90 subjects without anal sphincter defects, 4 of them has FI symptoms (median FISS 11, range 2–15).

Operations

Operative techniques were chosen by the attending surgeons. Types of operation are shown in **table 3**. EAUS group had significantly more rate of sphincter-preserving operation than the no-EAUS group.

**Table 1** Demographic data

	EAUS group	No-EAUS group	P value
No of subjects (M:F)	109 (91:18)	230 (195:35)	0.759*
Mean age±SD (range) (years)	41.65±13.35 (18–78)	42.55±13.02 (18–79)	0.562†
Underlying diseases			
Diabetes mellitus	10 (9.2%)	16 (6.9%)	0.474*
HIV infection	10 (9.2%)	20 (8.7%)	0.885*
Pulmonary tuberculosis	1 (0.9%)	4 (1.7%)	0.558*
Dyslipidemia	1 (0.9%)	2 (0.87%)	0.965*
No of referred cases	27 (24.8%)	35 (15.2%)	0.034*‡
No of recurrent cases	27 (24.77%)	32 (13.91%)	0.014*‡
Median no of previous surgeries (range)	1 (0–8)	0 (0–10)	0.001*‡
Median no of previous fistulotomies (range)	0 (0–4)	0 (0–3)	0.007*‡
Median no of previous sphincter-preserving surgeries (range)	0 (0–2)	0 (0–3)	0.343†
Clinical presentation			
FiA after spontaneous abscess drainage	24 (22.0%)	97 (42.2%)	<0.001*‡
FiA after operative abscess drainage	54 (49.5%)	70 (30.4%)	0.001*‡
Presence of persistent abscess	31 (28.4%)	62 (26.9%)	0.775*
Presence of colostomy	1 (0.9%)	4 (1.7%)	0.555*
Preoperative FISS (St. Mark's score)	0.36±2.10 (0–15)	0.31±1.77 (0–18)	0.455§
No of subjects with perfect continence (FISS=0)	105 (96.3%)	217 (94.3%)	
Preoperative MRI done	1 (0.9%)	8 (3.5%)	0.171*
Mean follow-up time (weeks (range))	30.9 (8–92)	35.0 (8–130)	0.186

*Pearson's χ^2 .

†Student t-test.

‡p<0.05.

§Mann-Whitney U test.

FIA, fistula-in-ano; FISS, faecal incontinence severity score.

Postoperative functional outcomes

Preoperative FISSs in two groups were not significantly different. There were 105 (96.3%) and 217 (94.3%) subjects with perfect continence in EAUS and no-EAUS groups, respectively. Eight subjects (7.3%) in EAUS group and 28 subjects (12.2%) in no-EAUS group had deteriorated continence. These changes had no significant difference between groups ($p=0.251$). There was no improvement in FISS in either group. Thus, subjects with perfect continence in EAUS and no-EAUS groups decreased to 98 (89.9%) and 197 (85.7%), respectively. Postoperative FISS was slightly higher in no-EAUS group. When comparing postoperative with preoperative FISS in each group, there was a significant increase of FISS in no-EAUS group ($p<0.001$) (table 4).

Factors that affect functional outcomes

From univariate analysis, there was no significant effect of gender, age, underlying diseases (diabetes mellitus,

HIV, pulmonary tuberculosis, dyslipidemia), recurrence status or fistula type on a change in FISS. Preoperative EAUS is the only significant factor which affects cFISS ($F(1,261)=4.053$, $p=0.045$). Factors that had a significant effect on a change in FISS by multivariate analysis included preoperative EAUS ($F(3,322)=3.147$, $p=0.025$, Wilk's Lambda 0.972), recurrence status ($F(3,322)=0.777$, $p=0.007$, Wilk's Lambda 0.993) and fistula classification ($F(3,322)=16.978$, $p<0.0001$, Wilk's Lambda 0.863). Number of previous surgeries ($F(27,972)=1.198$, $p=0.224$, Wilk's Lambda 0.906) and preoperative MRI ($F(3,322)=2.334$, $p=0.074$, Wilk's Lambda 0.979) had shown no significant effect on cFISS.

Postoperative clinical outcomes

Mean follow-up time was 33.6±28.6 weeks (range, 8–130 weeks). Healing rate was 63.3% in EAUS group and 60% in no-EAUS group. Unhealed wounds were found in 24.8% and 26.9%, respectively. Recurrence rate was

Table 2 Fistula classification

	EAUS group (n=109)	No-EAUS group (n=230)	P value
Fistula types			
Subcutaneous	0	24 (10.4%)	0.001*
Intersphincteric	4 (3.7%)	13 (5.7%)	
Low transsphincteric: straight tract	16 (14.7%)	74 (32.2%)	
Low transsphincteric: curved tract	1 (0.9%)	3 (1.3%)	
High transsphincteric: straight tract	47 (43.1%)	61 (26.2%)	
High transsphincteric: curved tract	41 (37.6%)	55 (23.9%)	
Classification by complexity: simple vs complex			
Simple FiA	21 (19.27%)	114 (49.57%)	0.001*
Complex FiA	88 (80.73%)	116 (50.43%)	
Median no of fistula tracts (range)	1 (1–3)	1 (1–2)	0.356

*p<0.05.

EAUS, endoanal ultrasound; FiA, fistula-in-ano.

11.9% and 12.2% in the respective groups (table 5). Median time to healing was 6 weeks (range, 1–31 weeks) and median time to recurrence was 23 weeks (range, 8–54 weeks). There was no significant difference in the clinical outcomes between groups (table 5). In EAUS group, there was no significant difference between groups that EAUS findings are concordant and discordant to operative findings ($p=0.52$). In the concordance group, the healing rate was 62.6% (62 in 99). In the discordance group, the healing rate was 70% (7 in 10).

Factors that affect postoperative clinical outcomes

Factors associated with operative outcomes are demonstrated in table 6. Complex FiA, recurrent FiA, number of tracts, number of previous surgeries and type of operation are significantly associated with increased probability of operative failure. Preoperative EAUS does not

show an effect on operative outcome. Longer follow-up time shows association with increased probability of operative failure. After failure, subjects from either group had a median of 1 additional operation (range, 1–6) before healed.

DISCUSSION

FiA is usually diagnosed by disease-specific history and careful physical examination.⁸ Simple fistula does not require radiographic imaging to guide management.⁸ However, complex fistula, including recurrent fistula and perianal Crohn's disease, usually requires preoperative imaging for treatment planning.^{8,9} Most of the national and international guidelines have recommended MRI for assessment of cryptoglandular FiA.¹⁰ The reported sensitivity of MRI for fistula detection was 0.87 (95% CI

Table 3 Types of operation

	EAUS group (n=109)	No-EAUS group (n=230)	P value
Sphincter-preserving operation			
Ligation of intersphincteric fistula tract	49	58	0.0001
+Curette	25	29	
+Core-out fistulectomy			
Drainage (tube, seton, marsupialisation)	9	12	
Anorectal advancement flap	1	1	
Total	84 (77.1%)	100 (43.5%)	
Non-sphincter-preserving operation			
Fistulotomy*	22	119	
Fistulectomy	1	1	
Hanley fistulotomy	2	2	
Core-out fistulectomy	0	8	
Total	25 (22.9%)	130 (56.5%)	

*Fistulotomy techniques included Parks fistulotomy²⁹ and lay-open fistulotomy with or without external anal sphincter repair. EAUS, endoanal ultrasound.

**Table 4** St. Mark's FISS

Parameters (mean±SE (range))	EAUS group	No-EAUS group	P value
Preoperative FISS	0.36±0.20 (0–15)	0.31±0.12 (0–18)	0.455*
Postoperative FISS	0.59±0.24 (0–17)	0.76±0.17 (0–21)	0.299*
P-values preop vs postop FISS	0.056†	<0.001†,‡	
cFISS§	0.31±0.15 (0–11)	0.52±0.12 (0–12)	0.209*
No of subjects with worsening FISS	8 (7.3%)	28 (12.2%)	0.251¶

*Mann-Whitney U test.

†Paired sample t-test.

‡p<0.05.

§cFISS: a change in postoperative from preoperative FISS.

¶ χ^2 test.

FISS, faecal incontinence severity score (St. Mark's score).

0.63 to 0.96) and specificity was 0.69 (95% CI 0.51 to 0.82).¹⁵ Nevertheless, MRI is cost-intensive, not always available and technically demanding.⁹ EAUS is another recommended imaging option.^{8–10} Sensitivity of EAUS for fistula detection is 0.87 (95% CI 0.70 to 0.95) which is considered comparable with MRI even with lower specificity of 0.43 (95% CI 0.21 to 0.69).¹⁵ Higher sensitivity (92%) and specificity (100%) was found in more recent studies.^{27–31} For defining the fistula type and height, EAUS accuracy was 91% and 92%, respectively, with very good interobserver agreement.¹⁶ Diagnostic use of 3D-EAUS was comparable in both primary and recurrent FiA with ability to detect occult anal sphincter defect.³² Hydrogen peroxide (H₂O₂) enhancement technique improved EAUS efficacy in identifying primary tract, internal opening and detection of secondary extension.^{27–33} H₂O₂-enhancement EAUS had good agreement with endoanal MRI with similar discomfort.³⁴ Information obtained is useful for preoperative planning which

Table 5 Postoperative clinical outcomes of fistula surgery

	EAUS group (n=109)	No-EAUS group (n=230)	P-value
Healed	69 (63.3%)	138 (60%)	0.822
Concordant	62		
Discordant	7		
Failed			
Unhealed	27 (24.8%)	62 (26.9%)	
Recurrent	13 (11.9%)	28 (12.2%)	

aims to cure and to preserve anal sphincter function.^{27–35} EAUS is also inexpensive, safe and can be used in subjects not feasible for MRI such as the presence of pacemaker or metal implant.¹⁷

In the current study, EAUS was selectively requested by attending surgeons. Subjects with previous surgery, recurrence, complex fistula, high-transsphincteric type and who were referred from other institutes were likely to be investigated by EAUS. This may be due to anticipated sophisticated anatomy of the fistulas and the caution of current anal sphincter integrity. The concordance of EAUS and intraoperative findings in this study was 90.8% (99 in 109) which is comparable with previous studies.^{17–18–31}

Ratto *et al* had showed that surgical treatment guided by EAUS led to curative operation and preservation of faecal continence.¹⁷ However, other authors had argued that the accuracy of preoperative EAUS had no influence on postoperative outcome in terms of failure rate and total number of surgeries.^{19–20} Thus, apart from EAUS accuracy, other factors may influence postoperative clinical outcomes.

Regarding functional outcome, EAUS had a role in quantifying the length of muscle to be transected during surgery³⁶ and identifying occult anal sphincter defect³² which guides the safer operative option and minimise the rate of FI.^{17–36} Ding *et al* had confirmed the favourable impact of 3D-EAUS on operative outcomes, mainly on continence function.¹⁸ In their study, anorectal manometry (ARM) had been used. There was a significant decrease in anal sphincter resting pressure after operation in all subjects with complex FiA.¹⁶ However, only subjects without preoperative EAUS had significant decrease in squeeze pressure.¹⁸ ARM is a sensitive tool which usually detects a minor change in anal sphincter function after fistula surgery^{18–37} but was not performed routinely in all subjects in the current study. Thus, it is not used in the analysis. We also believe that FISS is an adequate tool to measure clinically significant continence status. Change in FISS after operation is a common consequence of fistula surgery.³⁷ In the current study, significant worsening of FISS was seen in no-EAUS group with higher proportion of subjects with deteriorated continence.

In FiA subjects who had preoperative EAUS, predictors associated with FI after surgery were multiple fistula tracts, multiple previous surgeries and complexity of fistula.³ The current study aims to prove if EAUS itself is a predicting factor of postoperative incontinence. By univariate analysis, EAUS is the only factor that had a significant effect on the change in FISS. By multivariate analysis, EAUS, recurrent fistula and fistula complexity were found to have significant effects on the change in FISS. Thus, the usefulness of EAUS in non-simple fistula in preservation of anal continence has been confirmed.^{8–9} The explanation of a lesser change in FISS may be due to information obtained from EAUS that helped surgeons in decision-making and avoid extensive exploration during operation that may lead to sphincter damage.^{18–27–32} There

Table 6 Factors associated with postoperative clinical outcomes of fistula surgery

Factors	Healed (n=207)	Failed (n=132)	OR (95% CI)	P-value
Gender (M:F)	172:35	114:18	0.77 (0.42 to 1.44)	0.419
Age (mean±SD) (years)	43.2±13.4	40.8±12.6	0.99 (0.97 to 1.00)	0.986
Underlying diseases				
Diabetes mellitus	18	8	1.48 (0.62 to 3.50)	0.376
HIV infection	20	10	1.31 (0.59 to 2.88)	0.511
Pulmonary tuberculosis	20	3	0.42 (0.07 to 2.55)	0.345
Dyslipidemia	2	1	0.78 (0.07 to 8.72)	0.842
Fistula types				
Subcutaneous/intersphincteric	22/12	2/5	1.13 (1.00 to 1.27)	0.061
Low/high transsphincteric	79/94	15/110		
Fistula classification				
Simple/complex	113/94	22/110	6.01 (3.53 to 10.25)	<0.001*
Single/multiple tracts	182/25	126/6	0.36 (0.16 to 0.83)	0.016*
Recurrent cases	27	32	0.47 (0.27 to 0.83)	0.009*
Mean no of previous surgeries	0.6 (0–8)	1.0 (0–10)	1.32 (1.08 to 1.62)	0.008*
Preoperative imaging				
Preoperative EAUS	69	40	1.15 (0.72 to 1.84)	0.560
EAUS-Op concordance	61	36	0.65 (0.16 to 2.55)	0.522
Operations				
LIFT/ARP	77/1	84/1	0.56 (0.46 to 0.70)	<0.001*
Fistulotomy/HF	114/2	27/2		
Fistulectomy/core-out F	1/6	1/2		
Drainage	6	15		
Follow-up time (weeks)	29.5±26.8	40.0±29.8	1.01 (1.01 to 1.02)	0.001*

* $p < 0.05$.

ARP, anorectal advancement flap; EAUS, endoanal ultrasound; Core-out F, core-out fistulectomy; HF, Hanley's fistulotomy; LIFT, ligation of intersphincteric fistula tract; Op, operative finding; SPO, sphincter-preserving operation.

was a higher proportion of sphincter-preserving operation that had been chosen in this group (table 3). Operative techniques that were associated with deteriorated continence function were fistulotomy and rectal advancement flap with damage to internal anal sphincter alone or together with external anal sphincter.³⁷ In the current study, anorectal advancement flap was performed in only one subject in each group and a lower proportion of subjects had fistulotomy in EAUS group.

In terms of postoperative clinical outcomes, there was no significant difference between groups with or without EAUS. This finding corresponded to previous studies by Weisman and Abbas¹⁹ and Benjelloun *et al*,²⁰ which indicated that the accuracy of EAUS had no influence on postoperative outcomes. One explanation may be that the operative outcome after each fistula operation is the summation of interaction between multiple factors, such as fistula type, complexity, recurrent status, multiple fistula tracts, number of previous surgeries and operative technique. By multivariate analysis, all these mentioned factors were confirmed to have a significant association with decreased probability of operative success. MRI

showed a therapeutic impact in 10% of primary FiA³⁸ and reduced further recurrence in recurrent FiA.³⁹ MRI was performed in a small proportion of subjects in this study. Thus, it is not considered in the analysis.

Visscher *et al* reported secondary tracts identified during preoperative EAUS as a strong predictor of fistula recurrence (HR 2.4 (95% CI 1.2 to 51), $p=0.016$)⁴⁰ and Roig *et al* had emphasised on the importance of preoperative recognition of anal sphincter defect on preoperative plan.³⁷ However, we had seen four subjects with anal sphincter defect from preoperative EAUS and none of them had symptoms of FI preoperatively. This dimension needs to be studied in more detail and maybe with subjective measurement such as ARM. Also, comparison between EAUS and operative findings in detail would be useful. In this study, we found a higher proportion of LIFT operation in the unhealed group compared with the healed group. This may be explained by first, LIFT has been a preferred technique for complex and recurrent fistula which, by themselves, is considered a poor prognostic factor for clinical outcome. Second, the report on long-term result of LIFT shows that the healing



rate for high transsphincteric (60%), semihorseshoe (89%) and horseshoe (40%) fistulas was not as good as the simple types.⁴¹

In summary, this study has confirmed the beneficial effect of preoperative EAUS on postoperative functional outcome of fistula surgery, that is, subjects who underwent EAUS are likely to have less change in FISS. Preoperative EAUS also has a positive effect on postoperative clinical outcome of fistula surgery, that is, improves the chance of healing. Here, the follow-up time is longer than 1-year duration used in previous studies.^{18 19 36} Limitations of this study are that it is a retrospective analysis and had not included ARM data which is considered a precise objective tool to assess anal sphincter function.^{18 37} Second, there was also no quality-of-life assessment which is supposed to be decreased in the group with FI.³ Third, the decision-making on operative options had not been related to EAUS findings. Further studies which correlate EAUS findings to surgical decision-making would be useful.

CONCLUSION

EAUS is an accurate technique for evaluation of FiA. It is associated with greater preservation of continence function. However, postoperative clinical outcomes depend on multiple factors. EAUS is also a safe, inexpensive and available preoperative investigation for fistula surgery.

Acknowledgements We would like to thank Associate Professor Cameron Hurst, QIMR Berghofer Medical Research Institute, Brisbane, Australia, and the Former Head of Biostatistics Center, Research Affair, Faculty of Medicine, Chulalongkorn University, for his advice and assistance in statistical analysis.

Contributors KT planned the study and performed endoanal ultrasound, data collection, analysis and report. CS performed data collection, surgery and study consultation. JP performed data collection, surgery and study consultation. AR performed surgery, surgical consultation and study consultation.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval This study has been approved by the institutional review board of the hospital.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

REFERENCES

- Pommaret E, Benfredj P, Soudan D, *et al*. Sphincter-sparing techniques for fistulas-in-ano. *J Visc Surg* 2015;152(2 Suppl):S31–S36.
- Emile SH, Elgendy H, Sakr A, *et al*. Gender-based analysis of the characteristics and outcomes of surgery for anal fistula: analysis of more than 560 cases. *J Coloproctol* 2018;38:199–206.
- Visscher AP, Schuur D, Roos R, *et al*. Long-term follow-up after surgery for simple and complex cryptoglandular fistulas: fecal incontinence and impact on quality of life. *Dis Colon Rectum* 2015;58:533–9.
- Jayarajah U, Wickramasinghe DP, Samarasekera DN. Anal incontinence and quality of life following operative treatment of simple cryptoglandular fistula-in-ano: a prospective study. *BMC Res Notes* 2017;10:572–6.
- Balciscueta Z, Uribe N, Balciscueta I, *et al*. Rectal advancement flap for the treatment of complex cryptoglandular anal fistulas: a systematic review and meta-analysis. *Int J Colorectal Dis* 2017;32:599–609.
- Chen H-J, Sun G-D, Zhu P, *et al*. Effective and long-term outcome following ligation of the intersphincteric fistula tract (LIFT) for transsphincteric fistula. *Int J Colorectal Dis* 2017;32:583–5.
- Narang SK, Keogh K, Alam NN, *et al*. A systematic review of new treatments for cryptoglandular fistula in ano. *Surgeon* 2017;15:30–9.
- Vogel JD, Johnson EK, Morris AM, *et al*. Clinical practice guideline for the management of anorectal abscess, fistula-in-ano, and rectovaginal fistula. *Dis Colon Rectum* 2016;59:1117–33.
- Ommer A, Herold A, Berg E, *et al*. German S3 guidelines: anal abscess and fistula (second revised version). *Langenbecks Arch Surg* 2017;402:191–201.
- de Groof EJ, Cabral VN, Buskens CJ, *et al*. Systematic review of evidence and consensus on perianal fistula: an analysis of national and international guidelines. *Colorectal Dis* 2016;18:O119–O134.
- Visscher AP, Felt-Bersma RJF. Endoanal ultrasound in perianal fistulae and abscesses. *Ultrasound Q* 2015;31:130–7.
- Nagendranath C, Saravanan MN, Sridhar C, *et al*. Peroxide-enhanced endoanal ultrasound in preoperative assessment of complex fistula-in-ano. *Tech Coloproctol* 2014;18:433–8.
- Sun MRM, Smith MP, Kane RA. Current techniques in imaging of fistula in ano: three-dimensional endoanal ultrasound and magnetic resonance imaging. *Semin Ultrasound CT MR* 2008;29:454–71.
- Kim Y, Park YJ. Three-dimensional endoanal ultrasonographic assessment of an anal fistula with and without H(2)O(2) enhancement. *World J Gastroenterol* 2009;15:4810–5.
- Siddiqui MRS, Ashrafian H, Tozer P, *et al*. A diagnostic accuracy meta-analysis of endoanal ultrasound and MRI for perianal fistula assessment. *Dis Colon Rectum* 2012;55:576–85.
- Kotodziejczak M, Santoro GA, Obcowska A, *et al*. Three-dimensional endoanal ultrasound is accurate and reproducible in determining type and height of anal fistulas. *Colorectal Dis* 2017;19:378–84.
- Ratto C, Grillo E, Parello A, *et al*. Endoanal ultrasound-guided surgery for anal fistula. *Endoscopy* 2005;37:722–8.
- Ding J-H, Bi L-X, Zhao K, *et al*. Impact of three-dimensional endoanal ultrasound on the outcome of anal fistula surgery: a prospective cohort study. *Colorectal Dis* 2015;17:1104–12.
- Weisman N, Abbas MA. Prognostic value of endoanal ultrasound for fistula-in-ano: a retrospective analysis. *Dis Colon Rectum* 2008;51:1089–92.
- Benjelloun EB, Souiki T, El Abkari M. Endoanal ultrasound in anal fistulas. Is there any influence on postoperative outcome? *Tech Coloproctol* 2014;18:405–6.
- Parks AG, Gordon PH, Hardcastle JD. A classification of fistula-in-ano. *Br J Surg* 1976;63:1–12.
- Lundby L, Hundby L, Hagen K, Christensen P, *et al*. Treatment of non-IBD anal fistula. *Dan Med J* 2015;62.
- Rizzo JA, Naig AL, Johnson EK. Anorectal abscess and fistula-in-ano: evidence-based management. *Surg Clin North Am* 2010;90:45–68.
- Sneider EB, Maykel JA. Anal abscess and fistula. *Gastroenterol Clin North Am* 2013;42:773–84.
- Navarro-Luna A, García-Domingo MI, Rius-Macias J, *et al*. Ultrasound study of anal fistulas with hydrogen peroxide enhancement. *Dis Colon Rectum* 2004;47:108–14.
- Cheong DM, Noguera JJ, Wexner SD, *et al*. Anal endosonography for recurrent anal fistulas: image enhancement with hydrogen peroxide. *Dis Colon Rectum* 1993;36:1158–60.
- Brillantino A, Iacobellis F, Di Sarno G, *et al*. Role of tridimensional endoanal ultrasound (3D-EAUS) in the preoperative assessment of perianal sepsis. *Int J Colorectal Dis* 2015;30:535–42.
- Rojanasakul A, Pattanaarun J, Sahakitrungruang C, *et al*. Total anal sphincter saving technique for fistula-in-ano; the ligation of intersphincteric fistula tract. *J Med Assoc Thai* 2007;90:581–6.
- Parks AG. Pathogenesis and treatment of fistula-in-ano. *Br Med J* 1961;1:463–460.
- Vaizey CJ, Carapeti E, Cahill JA, *et al*. Prospective comparison of faecal incontinence grading systems. *Gut* 1999;44:77–80.
- Sun Y, Cui L-G, Liu J-B, *et al*. Utility of 360° real-time endoanal sonography for evaluation of perianal fistulas. *J Ultrasound Med* 2018;37:93–8.
- Emile SH, Magdy A, Youssef M, *et al*. Utility of endoanal ultrasonography in assessment of primary and recurrent anal

- fistulas and for detection of associated anal sphincter defects. *J Gastrointest Surg* 2017;21:1879–87.
33. Buchanan GN, Bartram CI, Williams AB, *et al*. Value of hydrogen peroxide enhancement of three-dimensional endoanal ultrasound in fistula-in-ano. *Dis Colon Rectum* 2005;48:141–7.
 34. West RL, Dwarkasing S, Felt-Bersma RJF, *et al*. Hydrogen peroxide-enhanced three-dimensional endoanal ultrasonography and endoanal magnetic resonance imaging in evaluating perianal fistulas: agreement and patient preference. *Eur J Gastroenterol Hepatol* 2004;16:1319–24.
 35. Regadas FSP, Murad-Regadas SM. Commentary on 'Impact of 3-dimensional endoanal ultrasound on the outcome of anal fistula surgery: a prospective cohort study'. *Colorectal Dis* 2015;17:1112–3.
 36. Murad-Regadas SM, Regadas FSP, Rodrigues LV, *et al*. The role of 3-dimensional anorectal ultrasonography in the assessment of anterior transsphincteric fistula. *Dis Colon Rectum* 2010;53:1035–40.
 37. Roig JV, Jordán J, García-Armengol J, *et al*. Changes in anorectal morphologic and functional parameters after fistula-in-ano surgery. *Dis Colon Rectum* 2009;52:1462–9.
 38. Buchanan GN, Halligan S, Williams AB, *et al*. Magnetic resonance imaging for primary fistula in ano. *Br J Surg* 2003;90:877–81.
 39. Buchanan G, Halligan S, Williams A, *et al*. Effect of MRI on clinical outcome of recurrent fistula-in-ano. *Lancet* 2002;360:1661–2.
 40. Visscher AP, Schuur D, Slooff RAE, *et al*. Predictive factors for recurrence of cryptoglandular fistulae characterized by preoperative three-dimensional endoanal ultrasound. *Colorectal Dis* 2016;18:503–9.
 41. Malakorn S, Sammour T, Khomvilai S, *et al*. Ligation of intersphincteric fistula tract for fistula in ano: lessons learned from a decade of experience. *Dis Colon Rectum* 2017;60:1065–70.