



No manometric differences after surgical intervention for anal fistula in infants and toddlers

Yi Fu¹ · Yu-Wen Ding² · Yun-Yuan Li¹ · Hong-Tao Liang¹ · Yan-Ting Sun¹ · Jin-Gen Lu¹ · Chen Wang¹

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Abstract

Background The current study aims to comprehensively evaluate the surgical impact on anal function in pediatric patients with anal fistulas, incorporating anorectal manometry, histopathological examination, and various rating scales.

Methods The study focuses on infants and toddlers diagnosed with anal fistulas who underwent surgical intervention at Longhua Hospital, Shanghai University of Traditional Chinese Medicine, between November 2020 and January 2024. The participants were divided into two age cohorts: infants (0–12 months) and toddlers (13–36 months). Data were meticulously collected for both cohorts, with anal function assessed through intraoperative anorectal manometry, Masson staining of fistula tissue, and the Heikkinen clinical continence scoring (CCS) scale during the postoperative period

Results (1) Both cohorts demonstrated a 100% postoperative healing rate. The average healing duration was 15.58 ± 3.21 days for the infant cohort and 16.57 ± 3.65 days for the toddler cohort. Anorectal manometry indicated the presence of the anorectal inhibitory reflex (RAIR) in both cohorts. Postfistulotomy, there was a slight decrease in anal rectal pressure (ARP), although this reduction was not statistically significant ($p > 0.05$) and was unrelated to the complexity of the fistula. Pathological examination of the fistula tissues revealed low muscle content in both cohorts, accounting for $14.1 \pm 1.35\%$ in the infant cohort and $17.2 \pm 2.86\%$ in the toddler cohort. The muscle composition varied between the cohorts; the infant cohort predominantly had smooth muscle with minimal striated muscle, whereas the toddler cohort had both smooth and striated muscle, with a relatively higher proportion of striated muscle. The CCS scores showed significant improvement at 6 months postoperation and during long-term follow-up compared to preoperative scores, with long-term follow-up results being superior to those at six months ($p < 0.01$).

Conclusion Surgical treatment for pediatric anal fistulas demonstrates is both effective and safe, with a potential for long-term improvement in anorectal function over time.

Keywords Anorectal manometry · Clinical observation · Evaluation of anal function · Pediatric perianal fistula · Surgical treatment

Introduction

A pediatric anal fistula is a pathological tract between the perianal skin and the anal canal, commonly seen in children aged 0 to 3 years. The incidence of the condition ranges from approximately 0.5% to 4.3%. A review of clinical literature involving 490 cases revealed that 89% of affected children were under 1 year old, with a striking 97.5% being male, making female cases relatively rare [1, 2]. The frequent recurrence of anal fistulas can lead to significant discomfort for pediatric patients, imposing considerable psychological stress and financial burden on their families [1]. Due to the young age of these patients, many parents and healthcare professionals express concerns that surgical intervention

Yi Fu and Yu-Wen Ding should be regarded as the joint first authors.

✉ Chen Wang
wangchen_longhua@163.com

¹ Department of Proctology, Longhua Hospital affiliated to Shanghai University of TCM, No.725 South Wanping Road, Shanghai 200032, People's Republic of China

² Department of Proctology, Shanghai Jinshan TCM-Integrated Hospital, Shanghai 201501, China

might impact anorectal function, often recommending a delay in surgery until adulthood for a permanent solution. However, recurrent abscesses and fistula formations can detrimentally affect the physical and mental well-being of a child, hindering their development.

Since the 1970 s, the Proctology Department at Longhua Hospital, Shanghai University of Traditional Chinese Medicine, has gained extensive clinical experience in the treatment of infant anal fistulas [3–5]. For non-acute infectious anal fistulas, initial conservative treatment is recommended, reserving surgical intervention for recurrent cases [3]. Studies report high surgical success rates, ranging from 93.7% to 100% in pediatric anal fistulas [6–9]. Despite these favorable outcomes, there is currently no objective clinical evidence regarding the impact of surgery on anal function. This study aims to comprehensively evaluate the effects of fistulotomy on anal function in children with pediatric anal fistulas, offering valuable insights into the clinical efficacy and safety of these surgical interventions.

Materials and methods

Participants

This study included infants and toddlers diagnosed with anal fistulas who underwent surgical treatment at Longhua Hospital, Shanghai University of Traditional Chinese Medicine, between November 2020 and January 2024. The participants were divided into two cohorts based on age: infants (0 ~ 12 months) and toddlers (13 ~ 36 months), with 83 male patients. Preoperative assessments, including local inspection and perianal ultrasound, were performed to confirm the presence of one or more fistulas in all cases.

Diagnostic and admission criteria

The diagnostic criteria for pediatric anal fistulas are based on the “Guidelines for the Diagnosis and Treatment of Common Anorectal Diseases in Traditional Chinese Medicine” (ZYYXH/T325-2012) [10]: (1) a history of perianal abscess, with recurrent symptoms following spontaneous rupture or surgical incision and drainage, accompanied by a palpable, firm cord connecting the ulcer and the anus; (2) a perianal ulcer exhibiting pus discharge, typically yellow or white and thick in consistency, or adjacent induration, redness, and swelling, usually with one to two external openings; (3) palpable firm cords near the anus extending into the anal canal, with a depression near the dentate line indicating the internal opening; and (4) preoperative perianal ultrasonography showing a simple anal fistula characterized by tubular hypoechoic signals traversing perianal tissues, with a single internal opening to the anal canal, or a complex anal

fistula indicated by two or more internal openings or multiple tubular hypoechoic signals crossing perianal tissues [11].

The inclusion criteria for this study are as follows: (1) pediatric patients aged 0 to 36 months; (2) diagnosis in accordance with the guidelines provided by the China Association of Chinese Medicine, the 2020 Chinese Expert Consensus on the Treatment of Anal Fistula, and the guidelines for managing perianal abscesses, anal fistulas, and rectovaginal fistulas issued by the American Society of Colon and Rectal Surgeons [12, 13]; (3) parents or guardians of pediatric patients must consent to the examination, surgical treatment, and follow-up care for their children and have provided informed consent and relevant notifications.

The exclusion criteria are as follows: (1) congenital conditions such as megacolon, anorectal malformations, anal canal or rectal tumors, suppurative hidradenitis, perianal subcutaneous cyst infection, sacrococcygeal cysts or teratomas with abscesses, pilonidal sinus infections, and cellulitis; (2) children with severe primary diseases, including immunodeficiency, cardiovascular, cerebrovascular, liver, kidney, and hematopoietic system disorders, as well as psychiatric conditions; and (3) children exhibiting abnormal anal function due to previous trauma, surgery, or neurological disorders.

Surgical interventions

The Proctology Department at Longhua Hospital specializes in treating anal fistulas in infants and toddlers, prioritizing the preservation of anal function. For isolated fistulas, they utilize a technique known as anal fistulotomy (Fig. 1). During this procedure, a silver-tipped probe was carefully inserted through the external opening. If the external opening was temporarily closed, a minor incision was made to facilitate entry. The probe was then cautiously advanced to avoid blind probing, with the surgeon using the index finger internally to locate the internal opening. Once the internal opening was identified, the fistula tract was completely incised. Tissue samples from the fistula wall, along with any necrotic tissue, are collected for pathological examination. The surgical site is then checked for active bleeding, and the area was dressed and secured appropriately.

Data collection

Patient data were obtained from outpatient and inpatient medical records, including demographic characteristics, imaging assessments, anorectal manometry results, fistula characteristics and postoperative follow-up information. The study was approved by the Ethics Committee of Longhua Hospital, Shanghai University of Traditional Chinese Medicine (Ethics Approval Number: 2023-LHXS-052).

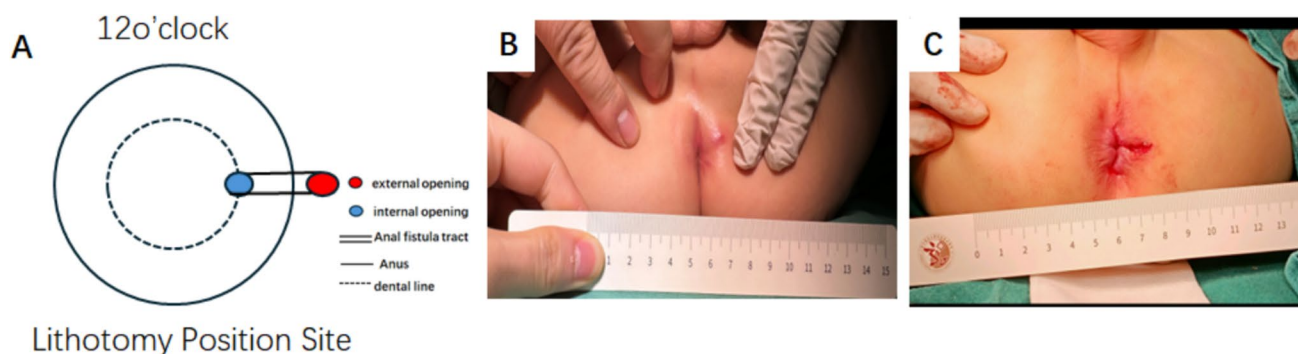


Fig. 1 Images from the surgical procedure of fistulotomy and preoperative ultrasound report images

Instrumentation and equipment

Anorectal manometry equipment: (1) instrument name: XDJ-S8 Model Anorectal Motility Detector (China); (2) pressure catheter: Pediatric Catheter (Model: GC-08 Pressure Catheter, 4.7 mm, Hefei Kelly Photonics Technology Co., Ltd.).

Pressure measurement method: (1) preoperative procedure: preoperatively, under anesthesia, the pressure probe was lubricated with paraffin oil, and it was gently inserted into the anal canal (1–2 cm deep). Once the image stabilized, the anal rectal pressure (ARP) was recorded. Then, the probe was further inserted into the lower rectum (3–5 cm from the anal verge). A decrease in pressure was observed on the image; once stabilized, a 60 ml syringe was attached to the three-way valve of the pressure probe and rapidly injected, and 5 ml of air was withdrawn. The image was monitored for pressure fluctuations (initial rise followed by a fall), indicating the anorectal inhibitory reflex (RAIR). If RAIR was not elicited with 5 ml, incrementally the air was increased by 5 ml, up to a maximum of 20 ml. The balloon volume required to elicit RAIR was recorded. (2) Postoperative procedure: postoperatively, under anesthesia, the probe was replaced with a pediatric catheter while wearing sterile gloves, and follow the same procedure to measure postoperative ARP. (3) The images from both pre- and postoperative measurements were documented, and the pressure testing was concluded. Pressure data analysis should be performed by a colorectal surgery specialist with appropriate training (Fig. 2).

Masson staining

The Masson's trichrome stain kit was obtained from Fuzhou Maixin Reagent Company. The staining protocol began with deparaffinization and hydration of the tissue samples, followed by immersion in the Masson's complex stain solution for 5 min. Next, the samples were treated with molybdophosphoric acid solution for an additional 5 min, then

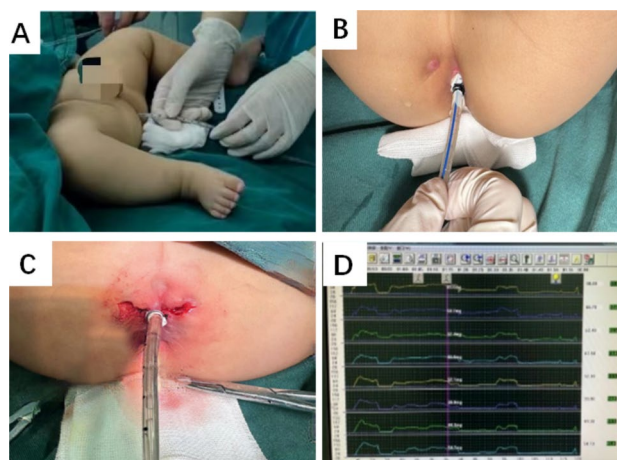


Fig. 2 Pressure testing process. **A** Intraoperative pressure measurement (lateral view). **B** Intraoperative pressure measurement (frontal view). **C** Postoperative pressure measurement (frontal view). **D** Pressure measurement results

stained with aniline blue for 10 min. Differentiation was performed for 60 s, followed by dehydration using 95% ethanol and absolute ethanol. The samples were then cleared with xylene and sealed with neutral gum. All Masson-stained specimens were processed in the pathology department of Longhua Hospital.

Observation indicators

Healing time and rate: Healing time is calculated from the first day after surgery and represents the total duration required for complete epithelialization of the surgical wound.

Anorectal manometry: All patients underwent anorectal manometry (Fig. 2) following effective anesthesia and fistula surgery. Changes in ARP were documented both pre- and postoperatively, along with the volume of gas required to elicit the RAIR.

Analysis of muscle proportion in fistula tissue: Intraoperatively, the stiff tissue was meticulously dissected from the inner wall after the fistula was opened. Postoperatively, the tissues were fixed, embedded, and sectioned for Masson staining. The muscle content and type within the fistula tissue were analyzed under optical microscopy, and ImageJ software was utilized for precise quantification of muscle content (Fig. 3), evaluating the amount and origin of muscle involved in the surgery. In the interpretation of Masson staining, basement membrane collagen fibers stain blue, while muscle fibers stain appear red. Figure 3A presents the Masson staining results of an infant cohort case (light microscopy, 4×), showing a muscle content of 17.7%, predominantly smooth muscle with rare striated muscle. Figure 3B displays the Masson staining results of a toddler cohort case (light microscopy, 4×), showing a muscle content of 13.4% with both smooth and striated muscles present and a higher proportion of striated muscle compared to the infant cohort.

Postoperative anorectal function score: Anorectal function was assessed using the Heikkinen clinical continence scoring (CCS) system (Table 1) preoperatively, 6 months postoperatively, and during the follow-up period, which extends until August 2024 [14, 15]. The CCS score was assessed by a specialized colorectal surgeon both preoperatively and during outpatient follow-up. Before scoring, the surgeon provided a detailed explanation of the questions in the assessment scale to ensure accurate understanding.

Statistical methods

The data analysis was conducted using IBM SPSS Statistics for Windows (version 25.0; IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation ($\bar{x} \pm s$). For datasets that followed a normal distribution, independent sample t-tests were employed. In contrast, the Mann–Whitney *U* test was used for data that did not conform to a normal distribution. A *p*-value of <0.05 was considered statistically significant, while a *p*-value of <0.01 was considered highly statistically significant.

Results

Patient demographics and clinical characteristics

83 pediatric patients diagnosed with anal fistulas were included in this study, comprising 53 infants (0 ~ 12 months) and 30 toddlers (13 ~ 36 months). The mean age of the infant cohort was 8.57 ± 2.18 months, while that of the toddler cohort was 20.27 ± 6.13 months. The average disease duration was 4.89 ± 2.54 months in infants and 16.23 ± 6.01 months in toddlers (Table 2).

In both cohorts, all patients underwent preoperative assessments, including local inspection and perianal ultrasound, which confirmed the presence of one or more fistulas. The number of fistulas per patient ranged from one to seven. Among the infant cohort, 25 patients had a

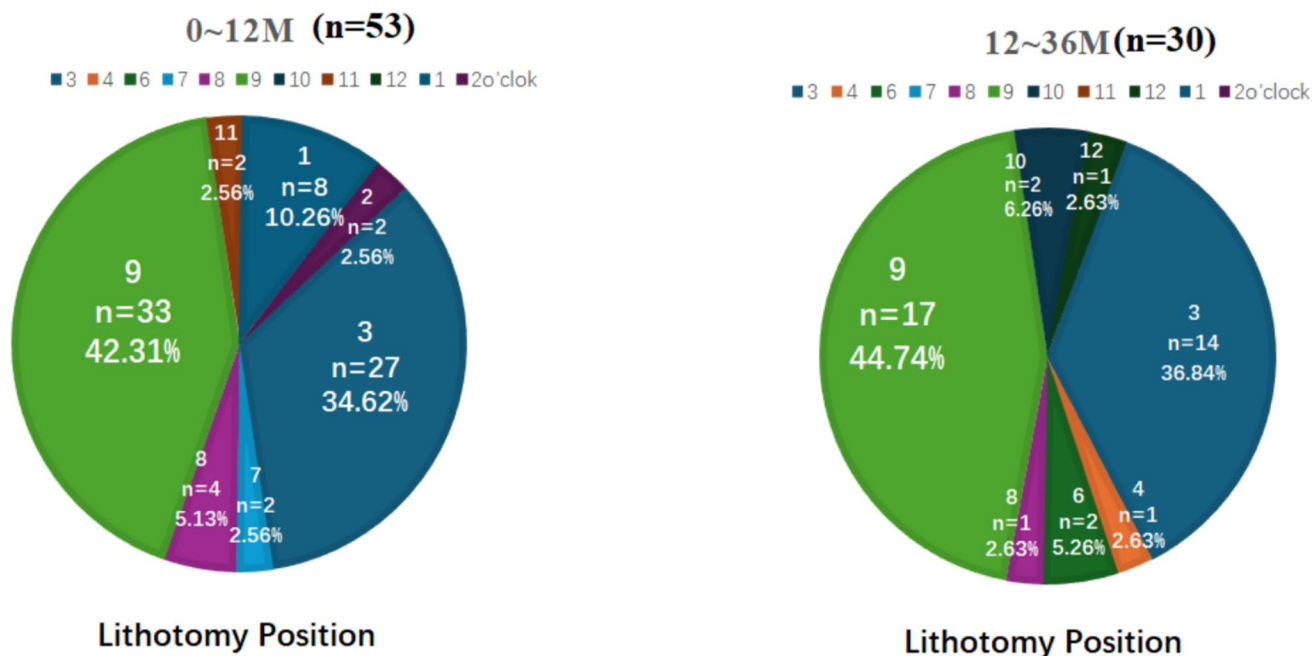


Fig. 3 The location of IOs (lithotomy position)

Table 1 Clinical continence scoring

<i>Frequency of defecation</i>	
Normal (1–2/day)	2
Often (3–5/day)	1
Very often	0
<i>Fecal consistency</i>	
Normal	2
Loose	1
Liquid	0
<i>Soiling</i>	
No	2
Stress or diarrhea	1
Constant	0
<i>Rectal sensation</i>	
Normal	2
Defective	1
Missing	0
<i>Ability to hold back defecation</i>	
Minutes	2
Seconds	1
Missing	0
<i>Discrimination between formed, loose, or gaseous stools</i>	
Normal	2
Defective	1
Missing	0
<i>Need for therapy (enemas, drugs, napkins)</i>	
No	2
Occasionally	1
Always	0

14 points, excellent bowel habits; 10–13 points, good (social continence, few limitations in social life); 5–9 points, fair (marked limitations in social life); 0–4 points, poor (total incontinence)

Table 2 General information of two cohorts of patients

Characteristics	Infant (n = 53)	Toddler (n = 30)
Age (months)	8.57 ± 2.18	20.27 ± 6.13
Weight (kg)	7.81 ± 2.23	16.73 ± 6.21
Height (cm)	65.79 ± 3.74	83.54 ± 7.54
Clinical duration (months)	4.89 ± 2.54	16.23 ± 6.01

single fistula, 14 had two, nine had three, four had four, and one had five fistulas. In the toddler cohort, 15 patients had a single fistula, eight had two, four had three, two had four, and one had seven fistulas (as shown in Table 3). The most common locations of internal openings were at the 3 o'clock and 9 o'clock positions (as shown in Fig. 4). Generally, the locations and numbers of internal openings and fistulas in both cohorts corresponded on a one-to-one basis, except for one toddler in whom the internal opening

Table 3 Number of the fistula

No. of the fistula(n)	Infant n = 53	Toddler n = 30	p-value
1	25 (47.16)	15 (50.00)	0.326
2	14 (26.42)	8 (26.67)	
≥ 3	14 (26.42)	7 (23.33)	

at the 9 o'clock position bifurcated toward both the 8 and 9 o'clock positions.

The mean recovery duration for the 83 pediatric patients is detailed in Table 4. At the 6-month postoperative follow-up, the wound-healing rate reached 100%, with no statistically significant differences in healing time observed between the two cohorts.

Results of anorectal manometry

Tables 5 and 6 show that the mean volumes required to induce RAIR for the two cohorts of pediatric patients were 10.47 ± 3.29 ml and 10.67 ± 3.40 ml, respectively. Post-operatively, ARP values demonstrated a slight reduction compared to preoperative values; however, these differences were not statistically significant ($p > 0.05$). To assess the surgical impact on ARP in pediatric patients with varying complexities of fistulas, we compared preoperative and post-operative ARP values in patients with simple anal fistulas (one fistula tract) and complex anal fistulas (multiple fistula tracts) across different age brackets. The ratio of simple to complex anal fistulas was 40:43, as detailed in Table 7. The findings indicate that surgical intervention does not significantly affect ARP values in pediatric patients, regardless of the severity of fistula complexity or age cohort ($p > 0.05$).

Analysis of Masson staining results for fistula tissue

The results of Masson's trichrome staining analysis are detailed in Table 8 and Fig. 4. The fistula tissues primarily consist of fibrous connective tissue, indicated by blue-stained regions, with a minor presence of muscle tissue. Light microscopy revealed age-dependent variations in the relative content of striated and smooth muscle within the fistula tissues. Among the 83 pediatric patients, muscle content in the fistula tissue ranged from 11.45% to 19.41%. In the infant cohort, the mean muscle proportion was $12.17 \pm 2.35\%$, characterized by a predominance of smooth muscle and minimal striated muscle. In contrast, the toddler cohort exhibited a mean muscle proportion of $15.27 \pm 1.78\%$, which included both smooth muscle and a higher proportion of striated muscle compared to the infant cohort. There was no statistically significant difference in the muscle proportion between the two cohorts ($p > 0.05$).

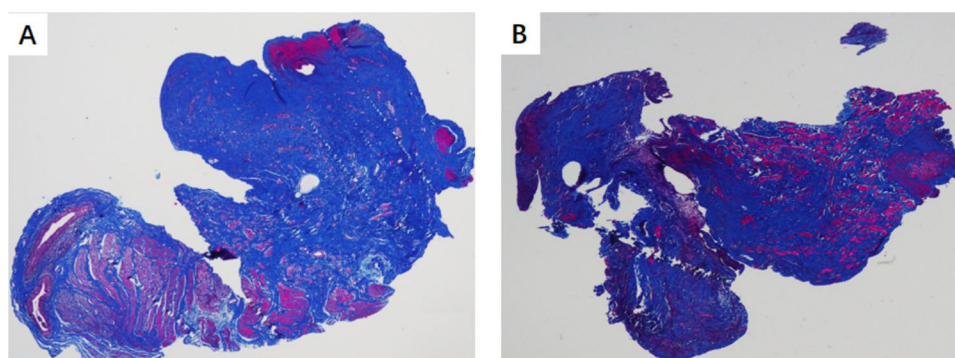


Fig. 4 Masson staining technique and results schematic diagram. **A** The Masson staining results of an infant cohort case (light microscopy, 4×), showing a muscle content of 17.7%, predominantly smooth muscle with rare striated muscle. **B** The Masson staining

results of a toddler cohort case (light microscopy, 4×), showing a muscle content of 13.4% with both smooth and striated muscles present and a higher proportion of striated muscle compared to the infant cohort

Table 4 Wound-healing time of the two cohorts

	Infant (<i>n</i> = 53)	Toddler (<i>n</i> = 30)	<i>p</i> -value
Average healing time (months)	15.58 ± 3.21	16.57 ± 3.65	0.153

Table 5 ARP pre- and postoperation of the infant cohort

	Infant (<i>n</i> = 53)		<i>p</i> -value
	Preoperation	Postoperation	
ARP (mmHg)	35.14 ± 17.52	33.11 ± 12.64	0.056
RAIR (mmHg)	10.47 ± 3.29	–	–

ARP anal rectal pressure, RAIR anorectal inhibitory reflex

Table 6 ARP pre- and postoperation of the toddler cohort

	Toddler (<i>n</i> = 30)		<i>p</i> -value
	Preoperation	Postoperation	
ARP (mmHg)	40.46 ± 10.46	39.32 ± 10.60	0.139
RAIR (mmHg)	10.67 ± 3.40	–	–

ARP anal rectal pressure, RAIR anorectal inhibitory reflex

Table 7 Analysis of the complexity of anal fistulas with ARP

		ARP (mmHg)		<i>p</i> -value
Age cohort		Preoperation	Postoperation	
Simple	Infant (<i>n</i> = 25)	35.05 ± 10.12	31.41 ± 9.68	0.346
	Toddler (<i>n</i> = 15)	39.56 ± 9.44	37.94 ± 9.70	0.271
Complex	Infant (<i>n</i> = 28)	32.12 ± 11.64	29.64 ± 10.08	0.388
	Toddler (<i>n</i> = 15)	38.36 ± 8.33	38.27 ± 5.87	0.961

Table 8 Comparison of Masson staining results in two cohorts of pediatric patients

Age Cohort	Muscle ratio in Masson staining (%)	<i>p</i> -value
Infant (<i>n</i> = 53)	12.17 ± 2.35	0.423
Toddler (<i>n</i> = 30)	15.27 ± 1.78	

Postoperative follow-up status

The Heikkinen CCS system was employed to assess the anorectal function of pediatric patients at three time points: preoperatively, 6 months postoperatively, and during the most recent follow-up in August 2024. This scoring system evaluates seven dimensions: frequency of defecation, stool consistency, fecal soiling, sensation during defecation, continence ability, stool discrimination, and the necessity for treatment. The comprehensive scores are detailed in Table 9. Among the 83 pediatric patients, the follow-up periods varied, ranging from a minimum of seven months to a maximum of 43 months, with a median duration of 17 months and an average duration of 21.46 months.

No significant difference was found in CCS scores between simple and complex anal fistulas across the three follow-up periods ($p > 0.05$). However, significant statistical differences emerged in CCS scores among different age cohorts at various follow-up intervals ($p < 0.01$; Table 10). For both infants and toddler cohorts, significant differences in CCS scores were observed when comparing preoperative scores to those 6 months postoperative scores, as well as between preoperative scores and long-term follow-up scores and between 6-month postoperative scores and long-term follow-up scores ($p < 0.01$). The average scores recorded during the long-term follow-up were higher than both the preoperative scores and those taken at six months

Table 9 CCS of pediatric patients by age cohort

Follow-up	Excellent		Good		Fair		Poor	
	Infant	Toddler	Infant	Toddler	Infant	Toddler	Infant	Infant
Preoperation	0 (0%)	0 (0%)	1 (6.25%)	15 (93.75%)	39 (72.22%)	15 (27.78%)	13 (100%)	13 (100%)
6-month-post	0 (0%)	2 (100%)	25 (48.08%)	27 (51.92%)	28 (96.55%)	1 (3.45%)	0 (0%)	0 (0%)
Long-time follow-up	13 (39.39%)	20 (60.61%)	39 (79.59%)	10 (20.41%)	1 (100%)	0 (0%)	0 (0%)	0 (0%)

Table 10 CCS of pediatric patients pre- and postoperation by disease complexity level and age cohort

Grade of CCS	Cohort	X ²	p-value
Preoperation	Complexity level	0.585	0.747
	Age	32.000	0.000**
6-month postoperation	Complexity level	3.065	0.216
	Age	22.575	0.000**
Long-time follow-up	Complexity level	0.944	0.624
	Age	14.379	0.001**

** $p < 0.01$

postoperatively (Table 11). In addition, during outpatient follow-up, the anorectal function of patients was assessed based on the perianal appearance, clinical symptoms, and defecation patterns reported by parents. None of the young patients, including those with three or more fistulous tracts, exhibited signs of anal stricture. Moreover, all patients maintained normal bowel habits without experiencing defecation difficulties, and their CCS scores remained stable.

Discussion

The recurrence and chronicity of pediatric anal fistula not only cause persistent discomfort in affected young patients but also impose significant psychological burdens on their families. In cases where conservative treatment is ineffective, the disease continues to progress, or the external opening repeatedly discharges pus, surgical intervention should be promptly considered to prevent further deterioration. Conservative management primarily aims to control symptoms and promote spontaneous healing through non-surgical approaches, including local wound care, warm sitz baths,

perianal hygiene maintenance, and, when necessary, antibiotic therapy. Typically, patients undergo at least 3 months of conservative treatment; if the fistula fails to heal, symptoms persist, or recurrent abscess formation occurs, surgical treatment is warranted. However, whether surgical intervention affects anal function in pediatric patients remains a critical concern for both clinicians and parents, yet systematic research on this issue is still lacking. Therefore, this study aims to comprehensively evaluate the impact of surgery on anal function in pediatric patients through anorectal manometry, histopathological analysis, and standardized assessment scales, providing a more evidence-based reference for clinical decision-making.

Our study reveals that most pediatric anal fistulas are simple linear tracts, with internal openings commonly located at the 3 and 9 o'clock positions. Notably, over 51% of cases involved multiple tracts. Intraoperative manometry data demonstrated a slight decrease in postoperative ARP compared to preoperative levels in both patient cohorts; however, this difference was not statistically significant ($p > 0.05$). This suggests that the immediate impact of anal fistula surgery on ARP in infants and toddlers is minimal. The surgery typically involves cutting through part of the perianal skin, anal verge tissue, and the mucosa in the anal canal of the infants, which is similar to rectal mucosa and more sensitive to surgical stimuli, though the effect remains minor.

Our analysis revealed no significant differences in ARP pre- and postoperatively for both simple and complex anal fistulas in either the infant or toddler cohorts ($p > 0.05$). This finding suggests that surgical interventions for complex anal fistulas are equally safe and do not significantly affect ARP. It is possible to address multiple fistula tracts in a single surgical procedure. Infants and toddlers are at a critical stage of growth and development and often lack self-control, which makes them particularly sensitive to

Table 11 Intracohort comparison of CCS between infant and toddler cohorts

Age cohort	Preoperation	6-month postoperation	Long-time follow-up	p-value
Infant ($n = 53$)	7.0 ± 2.162	9.0 ± 1.549	12.0 ± 1.581	0.00**
Toddler ($n = 30$)	9.0 ± 1.858	12.0 ± 1.039	14.0 ± 0.979	0.00**

** $p < 0.01$

discomfort in the anal area. These factors complicate the use of anorectal manometry in this age cohort, as crying and struggling can significantly compromise the accuracy of measurements. However, intraoperative manometry provides real-time data on changes in anorectal pressure, effectively reflecting the immediate impact of surgical interventions on anal function. When appropriate anesthesia is administered, pediatric patients are more likely to cooperate better during manometry, thereby minimizing errors caused by distress.

Current debates surrounding anorectal manometry in pediatric patients center on the adverse effects of anesthesia on growth and development, as well as the accuracy of post-anesthesia manometry data. However, both existing literature and our clinical observations indicate that maintaining a reasonable depth of anesthesia does not adversely affect the growth and development of infants and toddlers [16–19]. Intraoperative manometry, conducted twice under anesthesia, facilitates the assessment of surgical impacts on the anorectal region under controlled conditions. Our findings from 83 cases are consistent with national and international pediatric manometry data [20–22], reinforcing the validity and applicability of intraoperative manometry as a reliable assessment tool.

The maintenance of anal function is largely dependent on the integrity of both the inner and outer anal sphincters. Therefore, meticulous surgical techniques during fistula repair are essential to minimize any potential damage to the perianal muscles. Our analysis using Masson staining to assess the fibrous and muscular components of fistula tissues yielded several key findings: (1) pediatric fistula tracts are typically superficial, primarily composed of fibrous connective tissue, with muscular involvement being minimal $\leq 16\%$ muscle content across both age cohorts, though comparative data are limited; (2) the proportion of striated vs. smooth muscle within the fistula tissues varies by age cohort. Infantile fistulas predominantly contain smooth muscle, with only sparse striated muscle present. In contrast, toddler fistulas exhibit a notable presence of striated muscle, particularly near the external opening. Surgical interventions in infants and toddlers typically engage fewer muscle cohorts, primarily affecting the internal sphincter. However, surgeries in toddlers may involve both sphincters due to more developed muscular layers in this age cohort. Previous literature corroborates this observation, noting that in many cases involving infants and toddlers, the sphincters and levator ani muscles remain largely uninvolved. Considering the stages of growth and development, early surgical intervention may lead to reduced damage to the perianal muscles. The fistulotomy technique is designed to prioritize the protection of the sphincters, thereby minimizing disruption to the surrounding normal tissues, especially the muscles. Postoperative CCS demonstrated a significant improvement in anal function

over time, indicating that the surgery had no adverse effects on anal function.

The follow-up assessments based on CCS scoring revealed several key observations: (1) over extended follow-up periods, the anorectal function scores of infants and toddlers demonstrated significant improvement. For children aged 6–36 months, the enhancement of defecation control ability is likely influenced primarily by the natural developmental process rather than solely by the surgical intervention. However, this finding suggests to some extent that anal fistula surgery does not lead to a decline in anal function in infants and toddlers, and age growth may serve as a protective factor. (2) No statistically significant differences were found in CCS scores between patients with complex and simple anal fistulas ($p > 0.05$), possibly due to the shallow, straight, and minimally muscular nature of the tracts typically seen in pediatric anal fistulas. This finding, along with the results from anal manometry, reinforces the safety and effectiveness of surgical interventions for complex anal fistulas in pediatric patients. (3) Although the CCS scoring scale is a nationally recognized and authoritative tool for assessing anal function in children with congenital megacolon, it has limitations when applied to infants and toddlers. Due to their limited ability to articulate their experiences, young patients often cannot communicate rectal sensations or accurately describe stool characteristics. Their reliance on diapers and pads further complicates the precise assessment of their bowel control abilities. Therefore, developing an objective evaluation scale that aligns with the physiological characteristics of infants and toddlers is an essential goal for future research. In addition, postoperative follow-up regarding healing time and rates suggests that fistulotomy is a safe and effective treatment for pediatric anal fistulas. This study indicates that the application of appropriate surgical techniques does not negatively impact anal function in pediatric patients.

This study employed intraoperative anorectal manometry, recognized as the most effective method for securing cooperation from infants and toddlers during pressure measurements. We anticipate future advancements in devices that will better meet the anatomical and comfort needs of this demographic. Our ongoing efforts will focus on developing comprehensive and objective evaluation methods for assessing anal function in infants and toddlers and providing scientific evidence to inform clinical treatments. Infants and toddlers are in a critical phase of growth and development characterized by dynamic changes in perianal muscle structure. However, there is a notable lack of literature addressing the muscle development process during this stage. Further investigation into this area is essential, as it will provide valuable anatomical references for conducting precise surgical interventions. While Masson staining was used in this study, it lacked the

specificity required to differentiate between muscle types, precluding quantitative comparisons of smooth and skeletal muscles.

The duration of follow-up in this study varied, with the longest being 43 months and the shortest at 7 months, resulting in a median follow-up period of 17 months and an average of 21.46 months. As some patients progressed from infancy to toddlerhood or childhood—a period marked by rapid growth—it became challenging to ascertain whether the observed improvements in anal function were attributable to natural growth or the surgical intervention itself. To validate these findings, larger sample sizes and extended follow-up periods utilizing evaluation scales that align more closely with infant physiology are necessary. Future research designs should be refined to include expanded sample sizes and should ideally consist of multicenter, randomized, controlled, double-blind studies, along with more specific detection methods to accurately assess the impact of surgical treatment on anal function in infants with anal fistulas.

Several limitations of this study should be acknowledged. First, anorectal manometry was performed under general anesthesia, which inherently alters physiological conditions by inducing muscle relaxation and eliminating voluntary anal sphincter activity. This compromises the reliability of the measurements in reflecting true functional status. While anesthesia was necessary to ensure patient safety and procedural feasibility in this age group, the recorded values may not accurately represent conscious anorectal function. Second, the evaluation of anal continence in infants and toddlers presents inherent challenges, as voluntary bowel control typically has not yet developed. Although an objective scoring system was applied with the support of caregivers during follow-up, the functional assessment remains indirect and may be subject to bias. These limitations should be carefully considered when interpreting the results and drawing broader conclusions from this study.

Conclusion

Surgical intervention for pediatric anal fistulas has been shown to be both safe and effective, with a relatively short healing time and no adverse effects on anal function.

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Author contributions Y.F and Y.W.D conceptualized the study, analyzed the data, and drafted the original manuscript. C.W. oversaw the design and implementation of the research, provided theoretical guidance, and revised the manuscript as the corresponding author. Y.Y.L provided guidance and assistance in the experimental procedures and slide interpretation in the field of histopathology. Y.T.S, H.T.L. and J.G.L contributed to the manuscript revisions.

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Data availability No datasets were generated or analyzed during the current study.

Declarations

Conflict of interest None declared.

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References

1. Emile SH, Elfeki H, Abdelnaby M (2016) A systematic review of the management of anal fistula in infants [J]. *Tech Coloproctol* 20(11):1–10
2. Gosemann JH, Lacher M (2020) Perianal abscesses and fistulas in infants and children. *Eur J Pediatr Surg* 30(5):386–390. <https://doi.org/10.1055/s-0040-1716726>. (Epub 2020 Sep 28)
3. Qiang ZHANG, Jingen LU, Hongtao LIANG (2018) Advance of the diagnosis and treatment of anal abscess and anal fistula of infants[J]. *China Medical Herald* 15(16):34–37
4. Yan-Ting SUN, Hong-Tao LIANG, Shuang HAO (2023) LU Jin-Gen's experience in staging treatment of infantile anal fistula[J]. *J Guangzhou Univ Tradit Chin Med* 40(4):1007–1012
5. Yuzhang ZHU, Xiutian GUO (2020) Current status of anal fistula treatment in infants and young children[J]. *J Shandong Univ Tradit Chin Med* 44(5):591–596
6. Shou-Zhi Z, Qiang W (2009) Surgical treatment of 150 pediatric anal fistulas[J]. *Chongqing Med* 37(9):1141–1142
7. Guang Y, Hong-Fu Z, Shang-Ying S (2006) Forty-eight cases of anal fistula in children were treated by surgery [J]. *Chin J School Doctor* 20(1):46
8. Tianhong X, Songwu J (2011) Ligation therapy treat children anus fistula 28 cases [J]. *J Zhejiang Chin Med Univ* 35(2):49
9. Zhang Xuejun, Zhang Xin, Niu Aiguo. Clinical analysis of 110 cases of anal fistula resection through the rectum in children. *Chin J Pediatr Surg*. 2005;26(11):845–846.

10. Chinese Association of Traditional Chinese Medicine (2011) Guidelines for the diagnosis and treatment of common diseases in the anorectal department of traditional Chinese medicine[M]. China Publishing House of Traditional Chinese Medicine
11. Ding YW, Yin HQ, Liang HT, Lu JG, Wang B, Wang C (2022) Can transcutaneous perianal ultrasonography be the first-line diagnostic instrument for evaluating pediatric perianal fistulas? *Gastroenterol Rep (Oxf)*. 10:goac071
12. Clinical Guidelines Committee, Colorectal Surgeons Branch of Chinese Medical Doctor Association (2020) 2020 Consensus of Chinese experts on the diagnosis and treatment of anal fistula (2020). *Zhonghua Wei Chang Wai Ke Za Zhi* 23(12):1123–1130
13. Vogel JD, Johnson EK, Morris AM et al (2016) Clinical practice guideline for the management of anorectal abscess, fistu-la-in- ano, and rectovaginal fistula[J]. *Dis Colon Rectum* 59(12):1117–1133
14. Heikkinen M, Rintala R, Luukkonen P (1997) Long-term anal sphincter performance after surgery for Hirschsprung's disease. *J Pediatr Surg* 32(10):1443–1446
15. Ji Likang. A comparable evaluation on the efficacy of transumbilical laparoscopy-assisted transanal Soave procedure and conventional laparoscopic Soave procedure in the treatment of Hirschsprung's disease [dissertation]. Hebei Medical University; 2022. Chinese. DOI:10.27111/d.cnki.ghyku.2022.000883.
16. Goligher JC, Leacock AG, Brossy JJ (1955) The surgical anatomy of the anal canal. *Br J Surg* 43(177):51–61
17. Pfefferkorn MD, Croffie JM, Corkins MR, Gupta SK, Fitzgerald JF (2004) Impact of sedation and anesthesia on the rectoanal inhibitory reflex in children. *J Pediatr Gastroenterol Nutr* 38(3):324–327
18. Nicholls J (2012) Fistula in ano: an overview. *Acta Chir Iugosl* 59:9
19. Limura E, Giordano P (2015) Modern management of anal fistula. *World J Gastroenterol* 21(1):12–20
20. Athanasakos E, Cleeve S, Thapar N et al (2020) Anorectal manometry in children with defaecation disorders: BSPGHAN motility working group consensus statement. *Neurogastroenterol Motil* 27:e13797
21. Tang YF, Chen JG, An HJ, Jin P, Yang L, Dai ZF, Huang LM, Yu JW, Yang XY, Fan RY, Li SJ, Han Y, Wang JH, Gyawali CP, Sheng JQ (2014) High-resolution anorectal manometry in newborns: normative values and diagnostic utility in Hirschsprung disease. *Neurogastroenterol Motil* 26(11):1565–1572
22. Banasiuk M, Banaszkiewicz A, Dziekiewicz M, Załęski A, Albrecht P (2016) Three-dimensional high-resolution anorectal manometry analysis of children without lower gastrointestinal symptoms. *Clin Gastroenterol Hepatol* 14(7):993–1000.e3

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