

Antegrade Methylene Blue Mapping for Identification of Causative Pores in Pilonidal Sinus Disease

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Research Article

Keywords: Keywords: Pilonidal sinus disease, Causative pore, Antegrade methylene blue mapping, Sinusectomy, Minimally invasive surgery, Recurrence

Posted Date: October 16th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10723786/v3>

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Additional Declarations: The authors declare no competing interests.

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Funding

This work received no external funding.

Conflicts of Interest

The authors declare no conflicts of interest.

Ethical Considerations / Patient Consent

Written informed consent for publication was obtained from both patients whose clinical images and case details are presented in Figures 1 and 2, including the patient featured in Video 1.

Data Availability

Data are available from the corresponding author upon reasonable request.

Originality Statement

The manuscript is original, has not been published previously, and is not under consideration for publication elsewhere. All authors have read and approved the final manuscript and agree to its submission.

ABSTRACT

Background

Pilonidal sinus disease (PSD) is common in young adults, yet the optimal surgical strategy remains controversial. Most approaches focus on the extent of excision and wound management, whereas the identification of the causative pore initiating the sinus tract has received less attention. We evaluated Etiology-oriented Antegrade Mapping Sinusectomy (EAMS), an operative approach designed to identify causative pores and guide targeted excision of diseased tissue.

Methods

We retrospectively reviewed 20 patients undergoing 21 procedures for PSD at a single surgical practice between 2010 and 2025. EAMS consisted of systematic cleft exposure and depilation, inspection of candidate pores, gentle antegrade cannulation with methylene blue through suspected pits, confirmation of tract continuity by dye egress from secondary openings, and targeted juxta-capsular excision of dye-defined diseased tissue. Recurrence, intraoperative confirmation of causative pore identification, and postoperative recovery were assessed.

Results

One recurrence occurred among 21 procedures, associated with incomplete identification of a causative pore, and was ultimately resolved with repeat EAMS. Furthermore, in a representative previously recurrent case, an initially suspected pore was non-causative, whereas a subtle occult caudal pit produced dye egress from a cephalad secondary opening after antegrade injection, confirming its role as the causative pore. Overall, postoperative recovery was favorable, with early return to normal activity.

Conclusions

These findings suggest that missed causative pores may contribute to recurrence in PSD. EAMS provides a simple, tissue-sparing approach that may facilitate etiologically targeted surgery. Prospective multicenter evaluation is warranted.

Keywords: Pilonidal sinus disease; Causative pore; Antegrade methylene blue mapping; Sinusectomy; Minimally invasive surgery; Recurrence

INTRODUCTION

Pilonidal sinus disease (PSD) is a common disorder affecting predominantly young adults and is associated with substantial morbidity, impaired quality of life, and variable recurrence after surgery [1,2]. Numerous operative techniques have been advocated, ranging from wide excision with secondary healing to off-midline closure and flap reconstruction; however, current international guidelines continue to acknowledge controversy regarding the optimal surgical approach [3–5]. Reported incidence has ranged from 26 to 100 cases per 100 000 population and appears to be increasing, particularly among younger individuals [2,6]. This ongoing burden highlights the need for practical treatments that combine simplicity, low morbidity, rapid recovery, and durable disease control.

Contemporary operative strategies often emphasize the extent of tissue excision, wound closure method, or off-midline reconstruction, yet long-term success may also depend on accurate delineation of disease anatomy. Methylene blue (MB) has long been used as an inexpensive adjunct to facilitate visualization of sinus tracts during pilonidal surgery [7–14]. However, broader adoption has been limited by inconsistent protocols, non-standardized injection techniques, and variable reported outcomes. In many prior descriptions, MB is injected through visible sinus openings or blindly into presumed tracts, approaches that may incompletely delineate branching tracts and leave residual untreated [7–15].

The accepted pathogenesis of PSD involves hair penetration through vulnerable skin pits or pores, followed by chronic foreign-body reaction, secondary infection, sinus tract formation, and eventual drainage through ulcerated surface openings [2,6]. In clinical practice, however, visible openings are frequently managed as equivalent entities, despite the possibility that they represent biologically distinct structures. Some openings may function as causative pores as hair-entry pits that represent the origin of disease, whereas others may be secondary ulcerated openings that arise downstream from subcutaneous infection spread, rupture, or drainage. Failure to

distinguish these structures during operative planning may lead to incomplete excision, persistent occult tracts, and recurrence.

We therefore focused on midline pits, regarded as suspected causative pores, and hypothesized that antegrade methylene blue injection through these sites might provide more effective tract delineation than retrograde injection through secondary drainage openings. Based on this concept, we developed Etiology-oriented Antegrade Mapping Sinusectomy (EAMS), an operative framework centered on systematic pore identification, antegrade tract mapping, and targeted tissue-sparing excision. The present report describes the rationale for this approach and a retrospective single-practice clinical series illustrating its use.

METHODS

Study Design and Setting

This retrospective case series included consecutive patients undergoing surgery for pilonidal sinus disease between January 2010 and December 2025 at a single surgical practice specializing in ambulatory anorectal and other general surgery procedures. The study evaluated outcomes of a standardized operative protocol developed during routine clinical care. It was designed to assess feasibility, clinical utility, and hypothesis generation rather than comparative efficacy.

Patients

Patients with symptomatic pilonidal sinus disease requiring operative management were eligible for inclusion. Both primary and recurrent cases were included. Recurrent disease was defined as prior surgical or procedural treatment followed by persistent or recurrent symptoms. A total of 20 patients underwent 21 procedures during the study period.

Operative Conceptual Framework

The EAMS framework was developed and progressively refined during the study period. The operative strategy distinguished 2 clinically different surface findings: causative pores, which were presumed hair-entry pores representing the origin of disease, and secondary ulcerated openings, which were considered downstream rupture or drainage sites resulting from subcutaneous infection spread. These structures were not considered interchangeable.

Surgical Protocol

All procedures were performed using a standardized etiology-oriented operative protocol designed to identify causative midline pores, delineate communicating sinus tracts, and permit targeted tissue-sparing excision.

Patients were positioned prone under anesthesia with lateral traction of the buttocks to fully expose the natal cleft. Meticulous depilation was routinely performed after induction of anesthesia, because subtle pits or pores may be obscured during routine awake examination by pain-related guarding, retained hair, moisture, outpatient shaving limitations, or incomplete cleft exposure. Definitive inspection of the midline cleft was therefore repeated after anesthesia under optimized lighting and loupe magnification to identify all visible or suspected pores, pits, epithelial dimples, prior scars, and secondary ulcerated drainage openings.

Following identification of suspected midline pores, gentle cannulation was attempted using a soft flexible catheter. Approximately 2 to 5 mL of 2% methylene blue was slowly injected through each candidate midline pore until dye egress from a secondary opening confirmed functional tract continuity. Pores permitting antegrade tract opacification were designated causative pores.

After completion of mapping, the operative field was prepared in sterile fashion and draped for definitive resection. Incision planning was based on combined surface anatomy and dye mapping. A spindle-shaped excision was designed to encompass all causative pores, the secondary ulcerated opening, palpable fibrotic cord-like

induration, and methylene blue–stained tissue while minimizing removal of uninvolved surrounding tissue. Off-midline orientation was used when required by tract direction or opening location. En bloc juxta-capsular excision was then performed along the stained fibrotic tract with preservation of uninvolved adjacent tissue. The wound was irrigated thoroughly. Closure method was selected according to wound characteristics; in most cases, interrupted single-layer vertical mattress sutures using polyglactin 910 (size 0) without flap reconstruction was feasible when tension-free approximation could be achieved. Drains were used selectively.

Postoperative care included early ambulation, local wound care with drying antiseptic dressings, routine surveillance for infection or dehiscence, and outpatient follow-up for healing and recurrence assessment.

Outcomes

Recurrence and operative confirmation of causative pore identification / tract continuity, and postoperative recovery.

Follow-up

Follow-up was conducted through clinical visits or direct patient communication when necessary.

RESULTS

Patient Cohort and Operative Characteristics

Twenty patients underwent 21 EAMS procedures for symptomatic pilonidal sinus disease. Baseline, operative, and outcome characteristics are summarized in Table 1. Median age was 30 years (range, 19–59 years), 19 patients (95%) were male, and 7 (35%) presented with recurrent disease after prior treatment. Multiple causative pores were identified in 6 patients (30%). (Table 1).

Recurrence and Clinical Outcomes

Median follow-up was 25 months (range, 8–192 months). Recurrence after the index procedure occurred in 1 of 20 patient (5%). At the initial operation, multiple communicating lower midline pores were identified; however, a lowest caudal pore located beyond the inferior margin of the eventual scar was not included in the original excision field. Recurrence subsequently arose from this residual pore with secondary drainage through the previous wound. Repeat EAMS confirmed tract continuity and achieved durable resolution, with no further recurrence during 15 months of follow-up (Figure 1). No additional recurrences were identified after definitive treatment during available follow-up.

Overall postoperative recovery was favorable. Most patients underwent short-stay management with early ambulation and return to routine activity. Primary healing was achieved in most cases without routine flap reconstruction, and no major postoperative complications were documented in available records.

Representative Recurrent Case

A representative recurrent patient who was a practicing colorectal surgeon is shown in Figure 2. He had undergone prior excision with pathologic confirmation of pilonidal sinus disease 3 years earlier but developed recurrent symptoms shortly thereafter, including intermittent pain, swelling, and drainage.

At presentation, the clinically dominant finding was a cephalad crusted lesion within the prior operative field. An initially suspected midline pit was present, whereas no clearly dominant causative pore was evident on routine awake inspection.

Preoperative magnetic resonance imaging demonstrated a subcutaneous inflammatory tract and a punctate cutaneous focus suggestive of a possible pore.

Guided by the etiologic framework of EAMS, systematic inspection after anesthetic-state depilation, cleft exposure, and loupe-assisted examination identified an additional subtle caudal pit beyond the initially suspected pit. Antegrade methylene

blue injection through this lower pit produced dye egress from the cephalad lesion, confirming tract continuity and identifying the lower pore as causative (Figure 2).

Video 1 demonstrated real-time operative confirmation of the occult caudal pore and antegrade dye egress through the secondary opening.

Targeted excision incorporating the mapped tract and involved openings was performed. Gross and histopathologic examination confirmed pilonidal sinus disease. Recovery was uneventful, with satisfactory healing and no recurrence during 1 year of follow-up.

Mechanistic Operative Observations

Across the series, tract delineation was consistently achieved when methylene blue was injected antegrade through suspected midline pits and confirmed as causative pores, with expected dye egress from secondary ulcerated openings. In recurrent or anatomically complex cases, mapping clarified the relationships among subtle midline pits, surface drainage sites, and underlying fibrotic tracts. These operative findings informed the mechanistic framework summarized in Figure 3, in which lower midline causative pores are proposed to represent the likely origin of disease, whereas cephalad secondary ulcerated openings represent downstream rupture or drainage sites. The same framework also illustrates why retrograde injection through a secondary opening may incompletely define disease anatomy.

DISCUSSION

In this retrospective case series, this etiology-oriented framework using EAMS was associated with favorable short-stay recovery and a low observed recurrence burden during available follow-up. Among 20 patients undergoing 21 procedures, 1 recurrence was observed and was associated with an initially unrecognized lower causative pore that was subsequently treated successfully with repeat EAMS. Together with the representative recurrent case, these findings suggest that durable treatment of pilonidal sinus disease may depend not only on wound closure technique

or extent of resection, but also on accurate identification of structures driving disease persistence.

Current guidelines emphasize off-midline closure, individualized wound management, and flap-based procedures for selected complex or recurrent disease. These approaches remain important and often achieve excellent outcomes in appropriate settings. [3-5] The 2024 ESCP guideline also recognizes a potential role for disease mapping and separately addresses perioperative dye use; however, the relationship between the type of surface opening selected for dye instillation and the direction of tract mapping has not been specifically addressed. [4] The present series explored a complementary strategy that shifts attention from reconstructive geometry alone toward etiologic source control: identifying suspected causative pores, defining communicating tract anatomy, and limiting excision to involved tissue.

A central observation in this report is that visible surface openings may not be biologically equivalent. Some midline pits may function as causative pores through which hair penetration initiates chronic foreign-body reaction and sinus formation, whereas secondary ulcerated openings may represent downstream rupture or drainage sites rather than the true origin of disease. Such secondary lesions often appear away from the midline and may occur at variable points of least resistance, although location is not uniform. [1,2,16–18] In the recurrence case, omission of a lower pore was followed by disease persistence and subsequent cure after that pore was targeted at reoperation. In the representative recurrent case, an occult caudal pore not evident on routine inspection was identified only after meticulous depilation, cleft exposure, and antegrade mapping. These observations do not establish pathogenesis but support the practical importance of comprehensive pore identification during surgery.

Methylene blue has long been used as an adjunct in pilonidal surgery, with variable reported outcomes. [7-15] The 2024 ESCP guideline concluded that perioperative dye is not essential for excisional surgery, based on a very low level of evidence, but did not distinguish the route or direction of dye instillation according to the type of

surface opening. [4] One possible explanation for the heterogeneous outcomes reported with methylene blue is variation in operative technique, including differences in injection route, timing, pressure, and volume. In this context, methylene blue may function not merely as a stain, but as a low-cost tracer approximating communicating disease pathways. Instillation through visible drainage openings or established tracts may incompletely define disease anatomy when such openings primarily represent downstream drainage sites. By contrast, antegrade injection through suspected causative pores may better follow communicating pathways and facilitate delineation of involved tissue. The distinction between antegrade and retrograde instillation may therefore be clinically relevant. Notably, prior series also reported favorable outcomes with methylene blue–guided excision and described dye injection through sinus orifices or during tract delineation, but did not specify the functional type of opening selected or the direction of injection. [11,15] Whether such technical differences contributed to the heterogeneous outcomes reported with methylene blue remains uncertain.

The operative implications of this framework are practical. The present approach should be viewed not simply as dye use, but as a standardized workflow integrating depilation, pore identification, antegrade mapping, and incision planning. If causative pores and stained fibrotic tracts can be accurately localized, excision may be limited to involved tissue while preserving surrounding structures. In this series, primary healing was commonly achieved without routine flap reconstruction. EAMS should therefore be viewed not as a replacement for established operations, but as a potentially scalable complementary strategy within the broader treatment armamentarium, particularly where advanced flap expertise or specialized minimally invasive platforms are less available. [2–6]

This study has limitations. It was a retrospective single-practice case series with a small sample size and no comparator group. Documentation and follow-up completeness may have varied over time. Outcomes were not independently

adjudicated, and mechanistic interpretations were based on operative observations rather than direct biologic proof. The representative recurrent case, although illustrative, should not be considered prospective validation. As previously noted, the evidence base for pilonidal surgery remains limited and heterogeneous. [19]

Future investigation should include prospective multicenter studies comparing standardized antegrade mapping with conventional approaches for recurrence, healing, patient-reported outcomes, operative efficiency, and cost. Further mechanistic studies may clarify whether specific pits reliably correspond to disease origin. If validated, a simple low-cost mapping protocol could broaden access to precise tissue-sparing surgery and may also complement contemporary minimally invasive approaches by improving tract localization before intervention. [17,18,20,21]

In summary, recurrence in pilonidal sinus disease may sometimes reflect incomplete identification of causative pores rather than failure of closure strategy alone. An etiology-oriented approach combining meticulous pore detection, antegrade methylene blue mapping, and targeted excision may offer a practical pathway to durable treatment.

ACKNOWLEDGEMENTS

We thank the representative patient, a surgeon, for permitting detailed anonymized case documentation and for sharing thoughtful perspectives arising from his clinical experience as a patient. We also thank Pengdu Cai, MD; Junxi Xue, MD; Xiaofei Zhang; and Junmei Wu for technical assistance related to this work.

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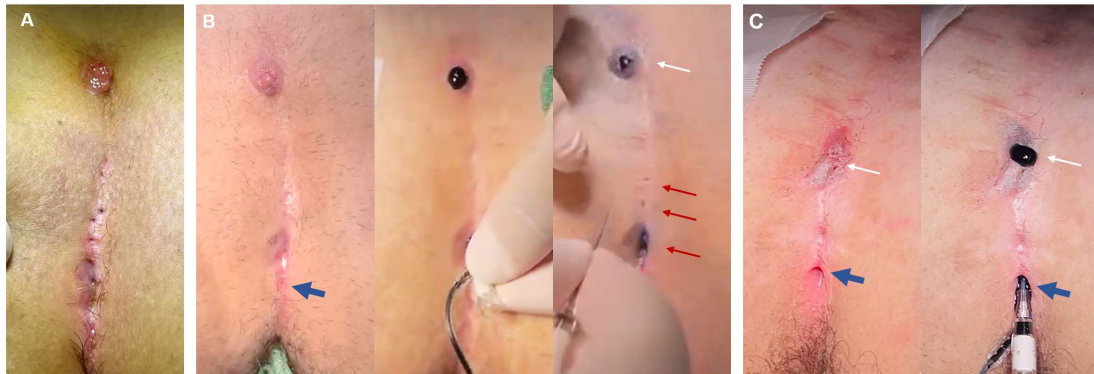
Table 1. Characteristics and Outcomes of 20 Patients Undergoing EAMS

Characteristic	Value
Patient characteristics (n = 20)	
Total patients	20
Age, median (range), yr	30 (19—59)
Male sex, No. (%)	19 (95%)
Primary disease, No. (%)	13 (65%)
Recurrent disease, No. (%)	7 (35%)
Operative characteristics (n = 21 procedures)	
Operative time, median (range), min	40 (25—70)
Postoperative stay, median (range), d	1 (1—2)
Multiple causative pores identified, No. (%)	6 (30%)
Outcomes	
Follow-up duration, median (range), mo	25 (8–192)
Recurrence after index procedure, No. (%)	1 (5%)
Presumed cause of index recurrence	Missed causative pore
Resolution after reoperation, No. (%)	1 (100%)
Recurrence after repeat EAMS, No. (%)	0 (0%)

Footnotes:

Data are presented per patient unless otherwise indicated. Operative characteristics are based on 21 procedures. Percentages may not total 100 because of rounding. Index procedure refers to the initial EAMS operation performed in the patient with recurrence. EAMS indicates Etiology-oriented Antegrade Mapping Sinusectomy.

Figure 1. Recurrence From a Missed Causative Pore and Resolution after Repeat EAMS

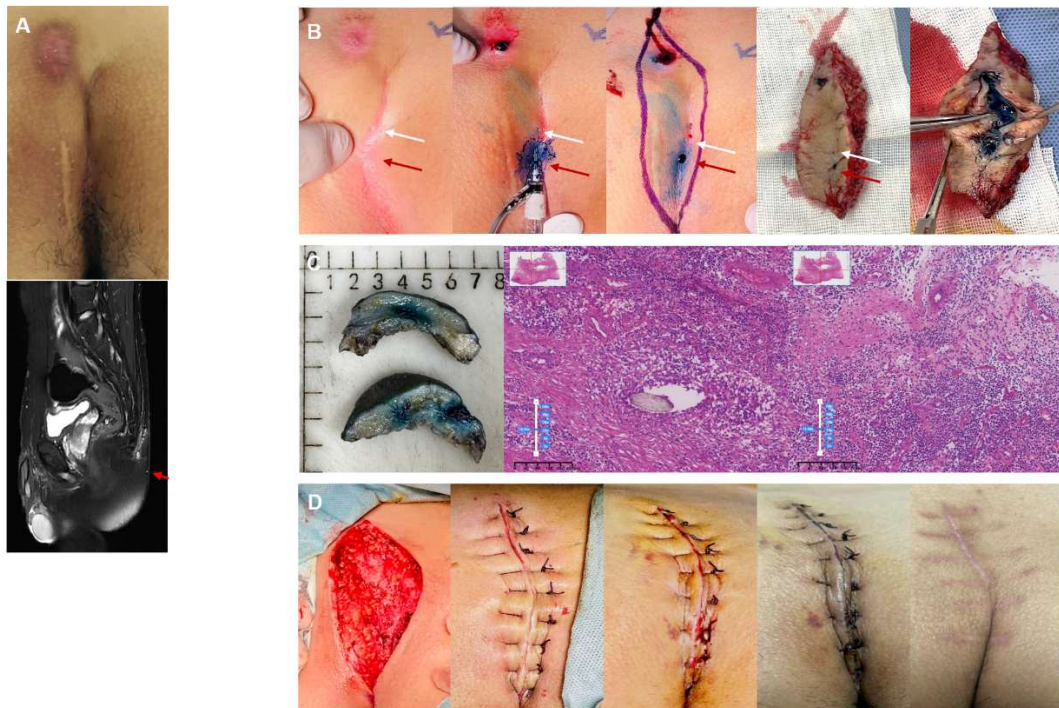


(A) Initial outpatient presentation after shaving demonstrated a cephalad ulcerated secondary opening slightly left of the midline natal cleft. Multiple lower midline pits were visible.

(B) During the index operation, perioperative depilation and closer inspection identified multiple lower pores. Antegrade methylene blue injection through these pores demonstrated tract continuity by dye egress from the cephalad secondary opening; some pores were also intercommunicating (red arrows). The blue arrow indicates the lowest caudal pore that was not included in the original excision.

(C) Recurrence subsequently arose from the residual lowest pore (blue arrows), with secondary drainage through the prior wound (white arrows). Repeat antegrade mapping confirmed persistent tract continuity, and repeat EAMS achieved durable resolution.

Figure 2. Identification of an Occult Causative Pore in a Representative Recurrent Case Treated With EAMS



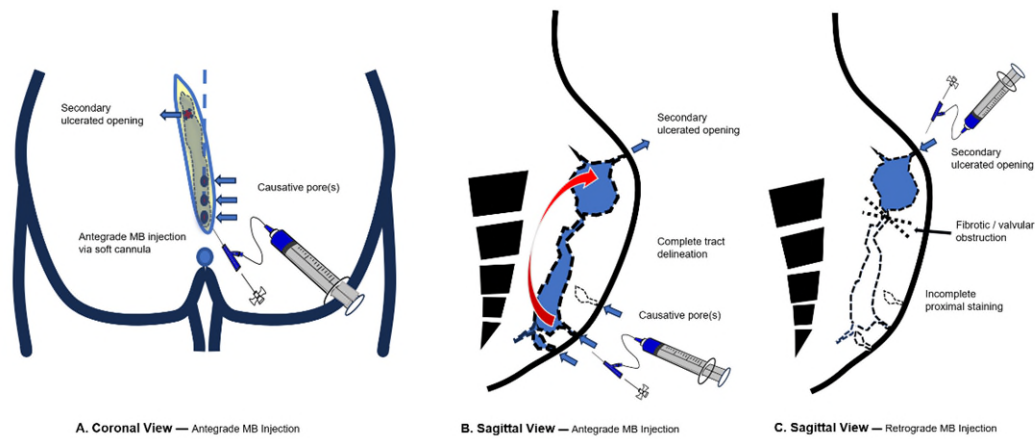
(A) Preoperative findings included a cephalad crusted lesion, prior surgical scar, and magnetic resonance imaging evidence of an inflammatory tract with a punctate cutaneous focus suggestive of a pore.

(B) After depilation, cleft exposure, and loupe-assisted examination, an additional subtle caudal pit (red arrow) was identified beyond the initially suspected pore (white arrow). Antegrade methylene blue injection through this lower pit produced dye egress from the cephalad secondary opening, confirming tract continuity.

(C) Targeted spindle-shaped excision incorporating the mapped tract and involved openings was performed. Gross sectioning demonstrated hair fragments and blue-stained purulent material. Histopathologic examination confirmed pilonidal sinus disease.

(D) Sequential postoperative images demonstrate satisfactory healing and scar maturation.

Figure 3. Proposed Mechanistic Framework of Causative Pores, Secondary Openings, and Antegrade Mapping in Pilonidal Sinus Disease



(A) Coronal view illustrating antegrade methylene blue injection through lower midline causative pore(s). Antegrade flow traverses communicating sinus channels and exits through the secondary opening, helping delineate disease extent for targeted excision.

(B) Sagittal view illustrating the proposed relationship between causative pores and the secondary ulcerated opening. Hair penetration through vulnerable lower midline pores may initiate subcutaneous foreign-body reaction, chronic inflammation, and sinus tract formation. The tract may extend cephalad and eventually rupture to the skin surface, creating a secondary drainage opening. Red arrow indicates antegrade flow.

(C) Sagittal view illustrating potential limitations of retrograde injection through the secondary opening. Because this opening may represent a downstream rupture or drainage site rather than the origin of disease, retrograde filling may incompletely define proximal anatomy owing to branching tracts, fibrosis, debris, or valvular

narrowing, potentially leaving occult causative pores or portions of the lesion unrecognized.

VIDEO 1: Occult Pit Confirmed as Causative Pore

Representative recurrent pilonidal sinus case treated with EAMS

Video 1. Operative Confirmation of an Occult Causative Pore in Recurrent Pilonidal Sinus Disease

Caption / Footnote (1—5 sentences)

Representative recurrent pilonidal sinus case treated with EAMS. A cephalad crusted lesion and a previously suspected pore were initially assessed. No tract continuity was demonstrated. After re-examination, an occult caudal pit was identified. Antegrade methylene blue injection through this pit produced dye egress from the cephalad lesion, confirming continuity and identifying the occult pit as causative pore. Targeted excision was performed. No recurrence was observed during follow-up. Patient consent was obtained.

Long Description (3—10 sentences)

This video presents a representative recurrent pilonidal sinus case treated with Etiology-oriented Antegrade Mapping Sinusectomy (EAMS). Following prior surgery and recurrent symptoms, routine inspection identified a cephalad crusted lesion and an initially suspected pore. After depilation, cleft exposure, and loupe-assisted examination, an additional subtle caudal pit was identified. Gentle antegrade cannulation of this pit with methylene blue produced dye egress from the cephalad secondary opening, demonstrating communicating tract continuity and confirming the lower pore as causative. The mapped anatomy was then used to guide targeted excision. Patient consent for publication was obtained.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Video1.mp4](#)