



THE THAI JOURNAL OF SURGERY

Official Publication of The Royal College of Surgeons of Thailand

EDITORIAL

- 111 Editorial
Doonyapat Sa-Nguanraksa

ORIGINAL ARTICLES

- 112 Feasibility of Using Carbon Tattoo for Targeted Axillary Dissection in Node-Positive Breast Cancer Patients Treated with Neoadjuvant Systemic Therapy, Preliminary Results of a Prospective Study
Pornchanok Jaruvongvanich, Vipavee Niyomnaitham
- 121 Feasibility of Low-Cost In-House 3D Printing in Mandibular Reconstruction with Fibula-Free Flap: Initial Regional Experience from Northern Thailand
Thanyanan Panich, Ueaungkun Sitthimongkon
- 130 Long term Outcomes of Surgical Treatment and Anatomical Characteristics of Acute and Chronic Cryptoglandular Anal Fistula Following Surgery
Supoj Laiwattanapaisal
- 143 Reduction Mammoplasty: The Factors that Influence Outcomes and Patients' Satisfaction in Calabar, Nigeria
Mba O. Ozinko, Otei Onda Otei, Rijami Godwin Ekpo, Egi Isiwele

CASE REPORTS

- 149 Sentinel Lymph Node Identification for Breast Cancer Patients Using Fluorescence Navigation with Indocyanine Green: A Case Report Early Experience at Lampang Hospital
Manisara Sorrahong
- 155 Prelaminated Forehead Flap Nasal Reconstruction of Pediatric Nasal Defect Secondary to Necrotizing Soft Tissue Infection :A Case Report
Lee Qai Hoe, Teck Ree Law, Salina Binti Ibrahim
- 160 Primary Epiplonic Appendagitis Mimicking Acute Appendicitis: A Case Report and Diagnostic Insight
Hemanathan Praemanathan, Sivanesan Ramasamy, Kamarul Ariffin Bin Abu Bakar
- 164 Serendipitous Dramatic Resolution of a Large Infected Pancreatic Pseudocyst Through a Pancreaticopleural Fistula after Acute Pancreatitis: A Case Report and Review of Literature
Himanshu Agrawal, Ashish Sikaria, Nitin Agarwal, Nikhil Gupta





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The THAI Journal of SURGERY

Official Publication of The Royal College of Surgeons of Thailand

E-ISSN 2697-5858

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Official Publication of The Royal College of Surgeons of Thailand

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The Thai Journal of Surgery is the official publication of The Royal College of Surgeons of Thailand issued quarterly.

The Thai Journal of Surgery invites concise original articles in clinical and experimental surgery, surgical education, surgical history, surgical techniques, and devices, as well as review articles in surgery and related fields. Papers in basic science and translational medicine related to surgery are also welcome.

Aim & Scope

The Thai Journal of Surgery is dedicated to serving the needs of the Members of The Royal College of Surgeons of Thailand, specifically the younger researchers and surgical training who wish to have an outlet for their research endeavors. The Royal College strives to encourage and help develop Thai Surgeons to become competent researchers in all their chosen fields. With an international outlook, The Thai Journal of Surgery welcomes submissions from outside of Thailand as well.

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References must be listed on a separate sheet in numeric order as referred to in the article, not alphabetically. A simplified Vancouver system is used. Only references mentioned in the text should be listed and should be selective with **no more than 30 references** except under unusual circumstances. Number references consecutively in the order in which they are first mentioned in the text. Identify references in text, tables, and legends by Arabic numerals (in superscript). The references must be verified by the author(s) against the original documents. Example forms of references are given below.

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2. Corporate Author:

- The Committee on Enzymes of the Scandinavian Society for Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gamma glutamyltransferase in blood. *Scand J Clin Lab Invest* 1976; 36:119-25.
- American Medical Association Department of Drugs. AMA drug evaluations. 3rd ed. Littleton: Publishing Sciences Group, 1977.

3. Personal Author(s):

- Osler AG. Complement: mechanisms and functions. Englewood Cliffs: Prentice - Hall, 1976.

4. Editor, Compiler, Chairman as Author:

- Rhooder AJ, Van Rooyen CE, comps. Textbook of virology: for students and practitioners of medicine and the other health sciences. 5th ed. Baltimore: Williams & Wilkins, 1968.

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- Weinstein L, Swartz MN. Pathogenic properties of invading microorganisms. In: Sodeman WA Jr. Sodeman WA, eds. Pathologic physiology: mechanisms of disease. Philadelphia: WB Saunders, 1974:457-72.

6. Agency Publication:

- National Center for Health Statistics. Acute conditions: incidence and associated disability, United States, July 1968-June 1969. Rockville. Md.: National Center for Health statistics, 1972. Vital and health statistics. Series 10: Data from the National Health Survey, No. 69: (DHEW publication no. (HSM) 72-1036).

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- Shaffer RA. Advances in chemistry are starting to

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- Chirappapha P, Arunnart M, Lertsithichai P, et al. Evaluation the effect of preserving intercostobrachial nerve in axillary dissection for breast cancer patient. *Gland Surg* 2019;8:599- 608.doi:10.21037/gs.2019.10.06.

Abbreviations

Use only standard abbreviations of commonly used approved abbreviations. Avoid abbreviations in the title. The full term for which an abbreviation stands should precede its first use in the text unless it is a standard unit of measurement.

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All statistical analyses and the statistical software used must be concisely described. Descriptive statistics for quantitative variables must include an appropriate central tendency measure (e.g., mean or median) as well as a corresponding measure of spread (e.g., standard deviation or range or interquartile range). Categorical variables must be summarized in terms of frequency (counts) and percentage for each category. Ordinal variables can be summarized in terms of frequency and percentage, or as quantitative variables when appropriate. Statistical tests must be named and p-values provided to 3 decimal places. P-values less than 0.001 should be written "< 0.001" and p-values approaching 1 should be written "0.999".

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Randomized controlled trials should be analyzed using the intention-to-treat principle, and as treated analysis should be applied as well if there are significant cross-overs. Further details of statistical issues are available here (<http://www.icmje.org/icmje-recommendations.pdf>).

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(see Format <https://bit.ly/3laP4ZB>)

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Use the common format. *Emphasis is on clinician comprehension.* The **Abstract** uses the same common *structured format*. In the **Main text**, the **Introduction**, in addition to the usual context setting and rationale, should also contain explanations and descriptions of basic science concepts at the level of the educated layman. The **Methods** section should still be concise with sufficient detail for others to replicate the experiment, but one or two paragraphs in between explaining basic processes in plain English would be helpful. In the **Results** section, similar conciseness is still the rule, but a brief simplified summary of the findings should be provided. In the **Discussion**, clinical implications should be clearly stated. The **Conclusion**, again, should answer the research question.

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We encourage publication of case series or case reports if a comprehensive review of the literature is included, with the aim of helping the clinician manage rare and challenging diseases or conditions based on best available evidence in conjunction with practical, local experience. For the Thai Journal of Surgery, this implies that the case report format differs somewhat from that of the common format for research articles.

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The THAI Journal of SURGERY

Official Publication of The Royal College of Surgeons of Thailand

Vol .47

July - September 2026

No. 3

The THAI Journal of SURGERY 2026;47(3):111.
Official Publication of The Royal College of Surgeons of Thailand

Editorial

Doonyapat Sa-Nguanraksa, MD

Editor of The Thai Journal of Surgery

We are immensely gratified by the growing diversity of our submissions, particularly the valuable work from our colleagues in Nigeria, Malaysia, and India in this issue. These insightful works account for half of the articles, reflecting our journal's growing global reach.

This issue comprises 5 original articles and 3 case reports spanning a diverse range of surgical fields. Two articles demonstrated alternative techniques for the identification of sentinel lymph nodes in patients with early-stage breast cancer and in patients who received neoadjuvant systemic therapy. In aesthetic plastic surgery, our international colleagues reported results on reduction mammoplasty, a technique that is not very prevalent in Thailand. In reconstructive plastic surgery, we demonstrated the feasibility of in-house 3D printing for mandibular reconstruction. Despite advances in colorectal surgery techniques, the importance of anatomical characteristics in treating anal fistula, a formidable challenge for surgeons, was emphasized.

The case report of a rare and difficult-to-diagnose primary epiploic appendicitis serves as a reminder to surgeons of the disease's deceptive symptoms. In the treatment of a rare condition, necrotizing soft tissue infection involving the nose in a pediatric patient, an innovative reconstructive technique was highlighted. Despite advances in the surgical procedure, the last case report of pancreatic infected walled-off necrosis complicated by a pancreaticopleural fistula demonstrated that the right simple procedure at the right time can resolve the disease's fatal course.

We thank all contributing authors for their valuable work and our reviewers for ensuring the scientific excellence of this journal. We trust that this issue delivers both practical knowledge and meaningful inspiration to guide your daily surgical practice.

The THAI Journal of SURGERY

Official Publication of The Royal College of Surgeons of Thailand

Vol .47

July - September 2026

No. 3

The THAI Journal of SURGERY 2026;47(3):112-20.

Official Publication of The Royal College of Surgeons of Thailand

Original Article

Feasibility of Using Carbon Tattoo for Targeted Axillary Dissection in Node-Positive Breast Cancer Patients Treated with Neoadjuvant Systemic Therapy: Preliminary Results of a Prospective Study

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Abstract

Background: Neoadjuvant systemic therapy (NST) frequently achieves axillary downstaging in node-positive breast cancer. Targeted axillary dissection (TAD)—combining sentinel lymph node biopsy (SLNB) with removal of pre-NST marked metastatic nodes—provides accurate post-NST axillary restaging. While advanced wireless markers are standard in high-resource settings, carbon tattooing offers an economical, radiation-free visual alternative. This prospective study evaluates the feasibility, accuracy, and volume-optimized safety of carbon tattooing for TAD within Thailand's public health infrastructure.

Materials and Methods: Patients with biopsy-proven axillary metastasis underwent dual marking (metallic clip + cortical carbon tattoo injection) prior to NST. We evaluated a refined injection volume (0.1 mL post-pilot) to minimize background spillage. After NST, we visually identified carbon-tattooed nodes intraoperatively and confirmed clip retrieval via specimen radiography. We performed SLNB using dual mapping with indocyanine green (ICG) fluorescence and blue dye to assess optical clarity between tracers. Primary endpoints were identification rate, accuracy (tattooed matching clipped node), and concordance (tattooed matching SLN).

Results: Twelve patients completed TAD post-NST (mean tattoo-to-surgery interval: 156 days). We visually identified carbon-tattooed nodes in 11 of 12 patients (identification rate: 91.7%). Mean targeted node retrieval was 5.58 nodes. Clipped and tattooed nodes were identical in 11 cases (accuracy: 91.7%), whereas tattooed nodes matched SLNs in 6 cases (concordance: 50.0%). SLN detection was 100% with ICG fluorescence without carbon interference, and 83.3% with blue dye. Cutaneous staining occurred in one patient (8.3%) with no procedural complications.

Conclusions: Carbon tattooing for TAD is a highly accurate, safe, and economical strategy post-NST. By optimizing injection volume and using real-time visual localization, this technique eliminates the need for expensive secondary radiologic localization procedures, providing a scalable TAD solution tailored to resource-constrained surgical oncology settings.

Keywords: Targeted axillary dissection, Carbon tattooing, Node-positive breast cancer, Neoadjuvant systemic therapy, Sentinel lymph node biopsy, Low-resource setting.

Received for publication 28 November 2025; Revised 3 September 2025; Accepted 3 September 2026

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<https://doi.org/10.64387/tjs.2026.278682>

INTRODUCTION

Neoadjuvant systemic therapy (NST) frequently achieves axillary nodal downstaging in node-positive breast cancer, particularly within triple-negative and HER2-positive subtypes.¹ This downstaging allows surgical de-escalation from axillary lymph node dissection (ALND) to sentinel lymph node biopsy (SLNB), significantly reducing long-term upper extremity morbidity such as chronic lymphedema, pain, and shoulder dysfunction.² However, in patients presenting with initial biopsy-proven node-positive disease (cN1/N2) who convert to cN0 post-NST, performing SLNB alone yields an unacceptably high false-negative rate (FNR > 20%).³⁻⁷ Targeted axillary dissection (TAD)—which combines SLNB with selective retrieval of the pre-NST marked metastatic node—suppresses the FNR to below 5%.⁵⁻⁹

Although advanced localization technologies such as radioactive iodine seeds (¹²⁵I), magnetic seeds (Magseed®), and radar reflectors (SAVI SCOUT®) demonstrate high surgical retrieval rates, their widespread adoption remains heavily constrained in resource-limited public healthcare settings like Thailand. High hardware costs (e.g., ~100 USD or 3,500 THB per clip), regulatory burdens surrounding radioactive materials, and the need for secondary pre-operative radiologic re-localization make these devices financially and logistically inaccessible for many institutions.^{10,11} Carbon tattooing offers a compelling, low-cost, radiation-free alternative that enables real-time

visual localization during surgery without requiring additional wire/probe equipment or secondary pre-operative imaging.¹³⁻¹⁶ However, prior international trials utilizing larger carbon injection volumes (0.3–5.0 mL) frequently reported diffuse background tissue staining that compromised intraoperative target identification (reporting detection rates as low as 64%).^{25,27}

This prospective feasibility trial addresses these clinical gaps by evaluating a refined, volume-optimized (0.1 mL) carbon injection protocol designed to prevent background tissue spillage while maintaining high target node visibility. Furthermore, we assess whether carbon tattooing interferes with modern Indocyanine Green (ICG) fluorescence and blue dye dual-tracer mapping. Herein, we report the preliminary intraoperative detection rate, diagnostic accuracy, tracer concordance, and safety profile of carbon-guided TAD at the National Cancer Institute, Thailand.

MATERIALS AND METHODS

Study Design and Ethical Approval

This prospective, single-center, single-arm feasibility trial was conducted at the National Cancer Institute (NCI), Thailand, starting in January 2024 (Clinical Protocol: EC 66028). The trial followed the Declaration of Helsinki and Good Clinical Practice guidelines. We obtained written informed consent from all participants before enrollment.

Table 1 Overview and Diagnostic Metrics of Various Targeted Axillary Dissection (TAD) Localization Modalities¹⁰⁻¹¹

Modality	Placement Timing	Primary Advantages	Technical Limitations & Risks	FNR	IR
Clip + Guidewire	Day of surgery	- Low material cost - Avoids ionizing radiation	- Requires pre-op radiology - Clip migration - Pain - Hematoma - Adjacent tissue injury - Patient discomfort	6.8%	97%
Clip+I seed¹²⁵	5-7 days pre-op	- Minimal migration risk - Excellent patient comfort	- Involves radiation handling - Expensive - Mandates nuclear medicine workflow - Seed loss/migration	4.2%	96.7%
Clip+ Skin mark¹²	Day of surgery	- Non-invasive - Wireless - Radiation-free - Cost-effective	- Highly operator-dependent - Depth limitation	N/A	100%
Clip + Intraoperative US	At initial biopsy	- Cost-effective - Radiation-free - Permits long-term implantation	- Operator-dependent - Potential clip signal obscuration or migration	7%	95.7%
Carbon Suspension Tattoo¹³⁻¹⁶	At initial biopsy	- Highly economical - Stable long-term visual marker; - Requires no localization imaging	- Potential skin hyperpigmentation - Risk of localized dye migration	8.3%	95-100%
Magnetic seeds: (Magseed®)¹⁷⁻¹⁸	Up to 30 + days pre-op	- Highly accurate - Radiation-free - Flexible surgical scheduling	- High equipment costs - Creates MRI signal void artifacts - Depth limitations	1.4%	97-100%
Radar/Infrared (SAVI SCOUT®)¹⁹	At initial biopsy	- Real-time audio feedback - Good depth signal penetration	- High financial cost - Potential signal interference from nickel components	N/A	97%

Abbreviations: FNR, false-negative rate; IR, identification rate; N/A, not available; US, ultrasound.

Patient Selection Criteria

To minimize selection bias inherent to single-arm designs, we prospectively screened all consecutive female patients presenting to the Multidisciplinary Breast Cancer Clinic who met the eligibility criteria and offered participation without physician-directed selection. Certified breast radiologists and pathologists independently evaluated diagnostic imaging and histopathology, blinded to intraoperative trial parameters.

Inclusion and Exclusion Criteria

Patients eligible for inclusion in this study were female patients aged 18 years or older with cytologically (fine-needle aspiration) or histologically (core needle biopsy) confirmed primary invasive breast carcinoma and limited axillary nodal metastasis, defined as 1 to 2 suspicious nodes (clinical stage cN1) prior to treatment. All included patients were scheduled to receive neoadjuvant systemic therapy (NST) followed by surgery and achieved clinical and ultrasonographic conversion to node-negative status (cN0) after completing NST. Conversely, patients presenting with inflammatory breast carcinoma or extensive initial nodal involvement (clinical stage cN2 to cN3) were excluded, as axillary de-escalation via targeted axillary dissection is not oncologically indicated in these settings. Additional exclusion criteria comprised pathologically confirmed distant systemic metastasis (cM1), active pregnancy or lactation, and a documented history of severe hypersensitivity or systemic

allergic reaction to isosulfan blue dye, indocyanine green (ICG), or carbon dye particles.

Rationale for Nodal Selection (cN1) and Baseline Assessment

Initial axillary nodal staging was established using high-resolution bilateral axillary ultrasonography (US). Suspicious nodes were defined morphologically by ultrasound (cortical thickness > 3 mm, asymmetric cortical bulge, or fatty hilum effacement). The rationale for limiting enrollment to patients with limited (1-2 node) cN1 disease is based on international consensus guidelines (NCCN); patients with extensive nodal burden (cN2/N3) have significantly higher residual disease rates after NST, where complete ALND remains mandatory.

Tattoo Injection and Metallic Clip Localization

Under ultrasound guidance, the biopsy-confirmed metastatic node was targeted. A sterile carbon particle suspension (Spot Ex Endoscopic Tattoo, GI Supply, USA) in a volume of 0.1- 0.3 mL was injected directly into the nodal cortex. Simultaneously or immediately following pathological confirmation, a metallic marker clip (UltraClip II, 17G, BD Medical) was deployed into the cortex of the same metastatic node (**Figure 1**). Single-node tattooing and clipping were strictly performed across all participants to establish consistency for targeted retrieval. (**Figure 1**).

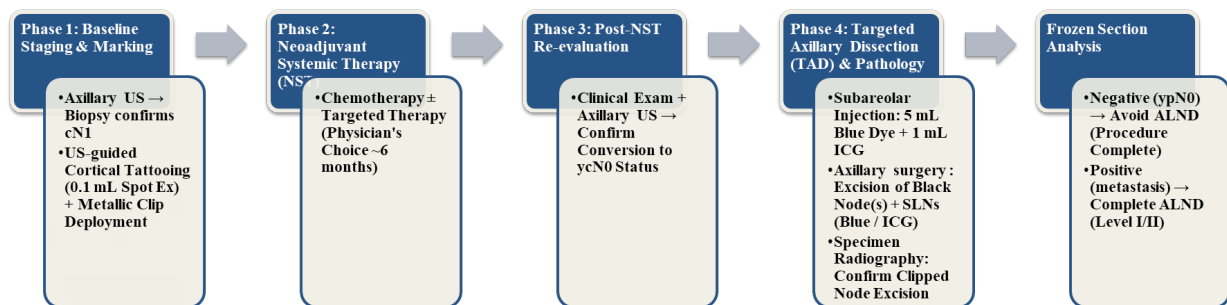


Figure 1 Scheme 1 Flow chart illustration process of this study

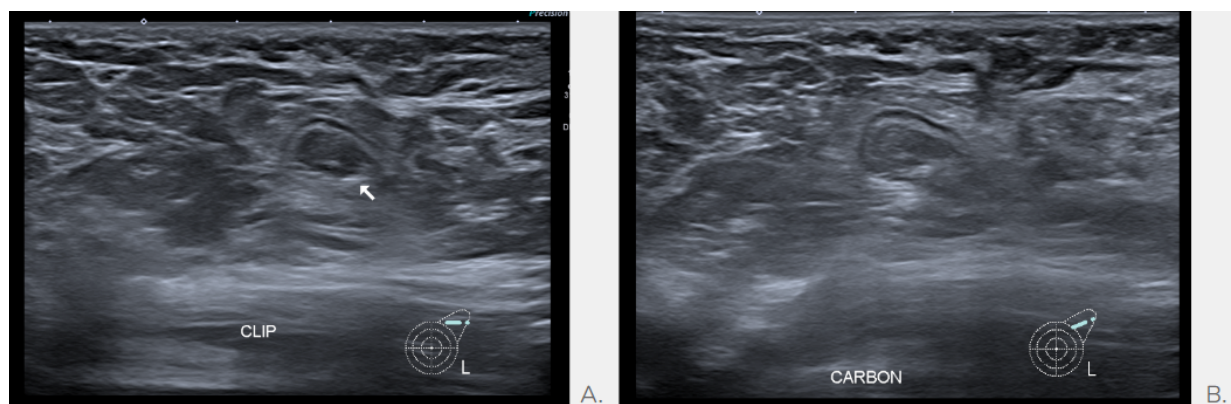


Figure 1 (A) Ultrasound shows metastatic lymph node after clip inserted. (B) Clipped node

Neoadjuvant Systemic Therapy (NST) Regimens

Multidisciplinary consensus determined NST indications based on tumor molecular subtype, clinical T-stage, and eligibility for breast-conserving surgery. Patients received Treatment of Physician's Choice (TPC) over a standard duration of approximately 6 months (24 weeks). Regimens consisted of standard anthracycline- and taxane-based chemotherapy for triple-negative and hormone receptor-positive disease, combined with dual HER2-targeted agents (trastuzumab and pertuzumab) for HER2-overexpressing subtype.

Post-NST Response Evaluation

Nodal response was rigorously evaluated within 2-4 weeks prior to surgery through combined clinical physical examination and repeat high-resolution axillary ultrasonography. Conversion to clinically node-negative status (ycN0) was strictly defined as the complete absence of palpable axillary lymphadenopathy and ultrasonographic resolution of nodal suspicion (restoration of fatty hilum and cortical thickness <3 mm). Patients demonstrating residual clinical or radiological node-positive disease (ycN1) were excluded from TAD and routed directly to completion ALND.

Surgical Technique: Targeted Axillary Dissection (TAD)

All patients underwent TAD using a dual-tracer mapping technique combined with targeted visual pigment retrieval. Intraoperatively, 5 mL of isosulfan blue dye and 1 mL of ICG were injected into the subareolar plexus. Visual inspection of the axilla was performed to identify carbon-tattooed (black) nodes (Figure 2). SLNB was performed simultaneously by tracking blue-stained lymphatic channels and real-time ICG fluorescence imaging using a near-infrared camera system (Figure 3). We respected visualized carbon-tattooed nodes and all identified SLNs. Excision of the clipped node was confirmed intraoperatively via specimen radiography. Resected nodes underwent intraoperative frozen section evaluation; completion Level I/II ALND was executed immediately if frozen section analysis demonstrated metastasis.

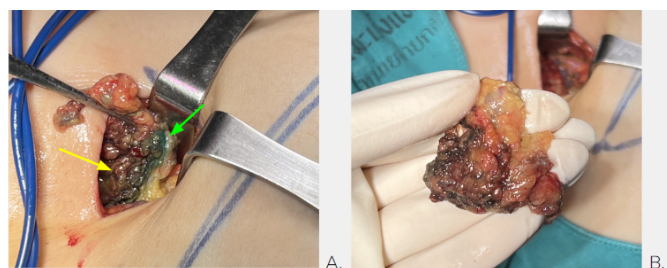


Figure 2 (A) Intraoperative detection of the tattooed perinodal tissue. Yellow arrow: black node. Green arrow: blue lymphatic vessels. (B) Tattooed node immediately after removal

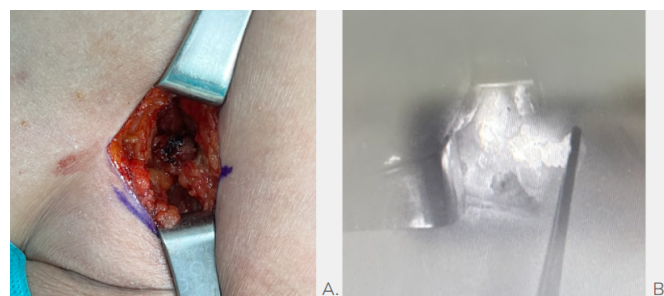


Figure 3 (A) Intraoperative detection of tattooed node(s). (B) Seeking sentinel nodes using fluorescent imaging; ICG-positive node (s) seen

Sample Size Justification and Study Workflow

The study target sample size ($N = 30$) was calculated based on feasibility guidelines for novel surgical localization trials, assuming an expected target node detection rate of 95%, a significance level of $\alpha = 0.05$, and a marginal error of 10%. Because of extended NST durations and patient accumulation timelines, this planned interim feasibility report presents data from the first 12 consecutive patients completing the protocol. Scheme 1 details the structured study workflow.

Statistical analysis

We used descriptive statistics to summarize patient and tumor characteristics. We defined the detection rate as the proportion of patients with black pigment (Black nodes) detected over the total number of patients. Accuracy was the proportion of patients in whom the intraoperatively detected tattooed node and clipped node were identical, out of the total number of patients. Concordance is the proportion of patients in whom tattooed nodes match SLNs. We did not calculate the false negative rate because ALND was not performed in cases with negative SLNs. We performed statistical analyses using SPSS.

RESULTS

A total of 12 consecutive breast cancer patients with biopsy-proven axillary nodal metastasis (cN1) who were scheduled for neoadjuvant systemic therapy (NST) were prospectively enrolled in this trial. All 12 patients underwent ultrasound-guided localization of a single metastatic node via carbon tattooing (0.1 mL Spot Ex) and metallic clip placement before initiating NST. After completing NST, all 12 patients achieved conversion to clinically and ultrasonographically node-negative status (ycN0) and underwent targeted axillary dissection (TAD) with dual-tracer mapping. The clinicopathological and treatment details are shown in Table 2. The mean age was 57 years (range 42-79). All tumors were invasive ductal carcinoma. There were 6 HR-positive cases and 7 HER2-positive cases, but only 3 received HER2-targeted therapy. Breast-conserving surgery was

Table 2 Baseline Clinicopathological Characteristics of Study Participants (N = 12)

Characteristic	Value
Age (years), Mean ($\pm$SD)	57 ($\pm$ 11)
Menopausal status, n (%)	
Premenopausal	4 (33.3)
Postmenopausal	8 (66.7)
Clinical T stage, n (%)	
cT1	2 (16.7)
cT2	9 (75)
cT3	0 (0)
cT4	1 (8.3)
Clinical N stage, n (%)	
cN1	12 (100)
cN2	0 (0)
Histologic grade, n (%)	
1	1 (8.3)
2	6 (50)
3	5 (41.7)
Histologic subtype, n (%)	
Luminal A	1 (8.3)
Luminal B / HER2 negative	3 (25)
Luminal B / HER2 positive	2 (16.7)
HER2 overexpression	5 (41.7)
Triple-negative (TNBC)	1 (8.3)
Tumor Histopathology, n (%)	
Invasive ductal carcinoma	12 (100)
Invasive lobular carcinoma	0 (0)
Others	0 (0)
Neoadjuvant Regimen, n (%)	
Anthracycline–Taxane sequential chemotherapy	9 (75)
Anthracycline–Taxane + Trastuzumab + Pertuzumab	3 (25)
Others	0 (0)
Surgical Procedure, n (%)	
Breast-conserving surgery	7 (58.3)
Mastectomy	5 (41.7)
Mastectomy with reconstruction	0 (0.0)

performed in 58.3%, and the rest underwent total mastectomy. In all cases, carbon injections targeted only 1 node.

Based on the surgical assessment presented in **Table 3**, the mean interval from carbon injection to the day of operation is 156 days (range 26–199). The mean total number of targeted nodes (TLNs = tattooed nodes and/or clipped nodes and/or SLNs) retrieved is 5 nodes (range 3–7). We visualized the tattooed nodes intraoperatively in 11 of 12 cases. The identification rate is 91.7%. The number of black nodes seen intraoperatively varies from 0 to 3. The mean total number of SLNs retrieved is 4 nodes, which are identified by blue dye in 83.3% and by ICG in 100%. Tattooed nodes matched SLNs in 6 of 12 cases. The concordance rate is 50%. Clipped nodes matched tattooed nodes in 11 cases. The accuracy rate is 91.7%. The frozen section of TLNs was positive in 7 cases (58.3%), so axillary dissection was performed in those cases. Pathological tumor response reveals

pCR/pTis in 5 of 12 cases. Pathological nodal response revealed pN0 in 5 out of 12 cases. Four cases appeared as ypT0/is N0; all were HER2-expressing subtypes, and 3 received neoadjuvant systemic chemotherapy combined with targeted therapy. The complications were observed after injecting carbon particles into the axillary nodes. Only one case showed skin staining. Some cases showed minimal spillage during surgery, resulting in retrieval of more than one black node, as shown in **Figure 2**.

Table 3 Intraoperative Localization Metrics and Pathological Responses (N = 12)

Variable	Value
Interval from tattoo to surgery (days), Mean ($\pm$SD)	156 ($\pm$ 52)
Total targeted nodes retrieved, Mean ($\pm$SD)	5.58 ($\pm$ 1.62)
Intraoperative carbon node visual identification, n (%)	
Yes	11 (91.7)
No	1 (8.3)
Number of carbon-pigmented nodes retrieved, n (%)	
0 node	1 (8.3)
1 node	8 (66.7)
2 nodes	2 (16.7)
3 nodes	1 (8.3)
Number of SLNs retrieved, n (%)	
1 node	0 (0)
2 nodes	3 (25)
3 nodes	0 (0)
4 nodes	3 (25)
> 4 nodes	6 (50)
Sentinel lymph node mapping technique, n (%)	
Isosulfan Blue Dye detection	10 (83.3)
Indocyanine Green (ICG) detection	12 (100)
Tattooed vs. SLN Concordance Rate, n (%)	6 (50)
Confirmed clip removal, n (%)	12 (100)
Clipped vs. Tattooed Node Accuracy Rate, n (%)	11 (91.7)
Frozen Section Result, n (%)	
Negative for metastasis	5 (41.7)
Positive for metastasis	7 (58.3)
Completion ALND Performed, n (%)	7 (58.3)
Pathologic response, n (%)	
pCR/pTis	5 (41.7)
ypT1	7 (58.3)
ypT2	0 (0.0)
ypT3	0 (0.0)
Pathologic nodal response, n (%)	
ypN0	5 (41.7)
ypN1	6 (50)
ypN2	1 (8.3)
ypN3	0 (0)
Tattoo-Related Morbidity, n (%)	
Minor dye spillage	3 (25)
Cutaneous hyperpigmentation	1 (8.3)
Allergic or adverse events	0 (0)
No symptom	8 (66.7)

DISCUSSION

Axillary status is important for planning systemic adjuvant treatment and RT. NCCN guideline²⁰ states that highly selected patients with biopsy-proven axillary metastases who then convert to clinically node-negative after preoperative systemic therapy may undergo SLNB with removal of the clipped lymph node. This is currently a category 2B recommendation, as the rate of false negatives is high when SLNB is performed after preoperative systemic therapy. Based on available data, the false-negative rate can be reduced by marking biopsied lymph nodes to document removal, using dual tracers, and removing 3 or more sentinel nodes (targeted ALND). When sentinel nodes are not successfully identified, level I and II axillary dissection is recommended for axillary staging. NCCN mentions clipping and marking techniques but does not specify which marking technique is best, so our study aimed to validate the feasibility of carbon tattooing, the optimal marking method in Thailand, for the reasons mentioned above. We used clip insertion as the standard technique to calculate accuracy. Choy et al.²¹ performed the first prospective pilot study using carbon marking. The study involved tattooing biopsied ALNs with a sterile black carbon suspension (SpotTM) 0.1–0.5 mL. The study divided 28 patients into two groups. Group I (16 patients) underwent surgery first, and group II (12 patients) underwent NST followed by surgery. The mean interval from tattooing to surgery was 22.9 days (group I) and 130 days (group II). Black tattoo was visualized intraoperatively in all cases, except in one case in which only microscopic black pigment was observed. This trial confirmed that tattooed nodes by SpotTM are visible intraoperatively, even months later. Further studies have been published since then. Two South Korean studies^{22–23} used CharcotraceTM (Charcotrace; Healthdirect, Haymarket, New South Wales, Australia) for tattooing. Park et al. injected 0.2–0.8 mL of the solution into the TLN of 20 patients. The detection rates for TLN and SLN were 100%. Kim et al. conducted a retrospective analysis of 45 patients in whom CharcotraceTM (1.0–3.0 mL) was injected after NST into axillary lymph nodes that remained suspicious on ultrasound. The tattooed lymph nodes were detected during operation in 44 patients (98%) and matched with the SLN in 57%. Neither trial reported complications, so our study aimed to observe complications associated with carbon suspension. In another retrospective trial, 24/75 patients were tattooed pre-NST with a sterile carbon suspension (Spot) 0.3–0.7 mL. Intraoperative identification of tattooed nodes was successful in 71 of 75 patients (94.6%). The concordance rate of SLN and tattooed lymph nodes was 75.7%. The authors reported that pathological examination revealed tattoo ink migration from one node to another, resulting in more stained nodes than initially tattooed. Accordingly, identifying black pigment on pathological

examination of SLNs is not always evidence of marked node retrieval. That is why, in our study, we used both clip and carbon tattoos to confirm pathologic nodes initially and may adjust to using only carbon tattoos in future studies.

This was our initial experience using carbon tattooing for axillary nodes at our institution. In our first case, the protocol specified injecting 0.3 mL of carbon particles into the cortex of the pathological axillary node. Intraoperative findings showed minimal spillage (**Figure 2A**), but the black and blue nodes were still distinguishable. After retrieving targeted lymph nodes (TLN) (**Figure 2B**), the nodes were dissected, and fluorescence imaging showed no ICG signal in the tattooed (clipped) node, in contrast to the remaining blue nodes, which were positive for ICG (**Figure 4B**). Clip removal was confirmed by mammograms of the TLN specimen, as shown in **Figure 4C**. In this case, the tattooed node and clipped node were identical but did not correspond to SLNs.

Multicentre prospective studies (25) have used Spot[®] or Black EyeTM (0.3–2.9 mL); however, only 22 patients received NST. The identification rate was lower at 64%, explained by the higher median volume of carbon solution (2.0 mL), which causes diffuse black staining in the axillary tissue. After observing minimal intraoperative spillage of carbon particles in our first three cases, we adjusted the protocol to reduce carbon injection to 0.1 cc from case four onward. Although localized background carbon spillage occurred in a minority of cases, it did not adversely affect intraoperative decision-making, nodal identification, or histopathological analysis. The volume-optimized (0.1 mL) injection protocol effectively prevented extensive dye diffusion. The distinct, localized black pigmentation of the target node remained easily distinguishable from surrounding soft tissues and did not obscure blue dye uptake or quench Indocyanine Green (ICG) fluorescence mapping. In a prospective study by Patel et al.²⁶, data from 47 patients who received primary systemic therapy were published. 0.1–1.0 mL of Spot[®] was injected, including 12 patients initially reported by Choy et al., and a detection rate of 100% was confirmed. The tattooed nodes corresponded to the sentinel lymph node in 98.5% of cases. The concordance of TLNs and SLNs varies from 50–98%.^{22–24,26} Similar to our study, the identification rate is 91.7%, but tattooed nodes match SLNs in half of patients; the concordance rate is only 50%. Beyond visual masking caused by dense black carbon pigment obscuring blue dye uptake in nearby lymphatic channels, the observed moderate concordance rate (50%) may reflect therapy-induced anatomical alterations within the axillary lymphatic system. Neoadjuvant systemic therapy (NST) frequently induces tumor regression, perilymphatic fibrosis, and microvascular obliteration. These structural changes can physically obstruct or reroute initial lymphatic pathways,

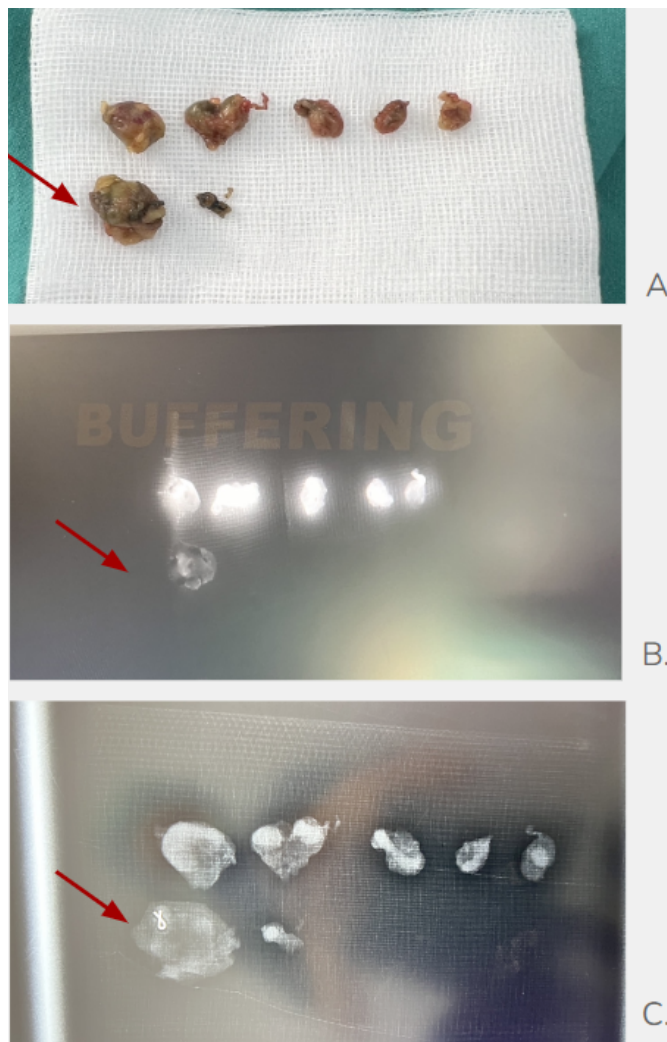


Figure 4 These are samples of all targeted lymph nodes that were retrieved. First row are sentinel nodes. The red arrow indicates the tattooed node.

- (A) Visualized in blue in the first row and in black in the second row. The arrow points to the black tattooed node.
- (B) Under fluorescence imaging: ICG was seen in all sentinel nodes in the upper row but not in the tattooed node.
- (C) Specimen radiograph confirms the clipped node is the tattooed node and confirms the clipped removal

resulting in aberrant lymphatic flow that directs intraoperatively injected tracers (e.g., isosulfan blue or ICG) away from the true index node and toward alternative non-target sentinel nodes. Furthermore, differential tumor response across multiple involvement sites can lead to asymmetric lymphatic drainage. While the pre-NST marked node undergoes fibrotic replacement or complete pathologic response, newly dominant, uninvolved lymphatic channels may preferentially take up blue dye during post-NST mapping. Consequently, the moderate concordance rate of 50% reflects a combination of optical interference from high-density carbon particle retention and true physiological

rerouting of lymphatic channels secondary to NST. These further underscores why dual-tracer mapping paired with targeted axillary dissection (TAD) is necessary to ensure retrieval of the clipped/tattooed node, regardless of post-treatment tracer migration. Fig. 5 demonstrates that the tattooed nodes were also blue and appeared with ICG. This may be due to the use of carbon, which adds darker pigmentation and makes it harder to distinguish blue from black, thereby contributing to higher concordance rates in some other studies. The largest prospective study of tattooing TLNs is the multicentre TATTOO study.²⁷ A total of 110 patients who received NST underwent Spot or CARBO-REP 0.3-5.0 ml injection. TLNs were detected at operation in 93.6%. Skin staining occurred in 4.5% of cases as an undesirable side effect. SLNs were identical to the TLNs in 60%. This TAD study's FNR was 9.1%, slightly higher than in previous studies because fewer patients completed ALND. In our study, the detection rate of tattooed nodes is 91.7%. The accuracy is 91.7%. We identified only one case where we couldn't identify clipped nodes by carbon, but they appeared as blue nodes instead. Pathological tumor response reveals pCR/pTis in 5 of 12 cases. Pathological nodal response reveals pN0 in 5 out of 12 cases. Following neoadjuvant systemic therapy, four patients (33.3%) achieved complete eradication of both invasive and in situ disease in the breast and axilla (ypT0, ypN0), representing strict pathological complete response (pCR). One additional patient (8.3%) demonstrated clearance of invasive carcinoma with residual ductal carcinoma in situ (ypTis, ypN0). While both outcomes represent complete local eradication of invasive breast cancer and carry comparable favorable long-term disease-free survival benefits, we report them separately to preserve precise histopathological distinctions. In our cohort, seven patients were identified as having HER2-positive disease; however, only three received neoadjuvant anti-HER2 targeted therapy (trastuzumab). This discrepancy is primarily due to financial constraints and healthcare reimbursement structures within Thailand's national public health framework. Consequently, four patients were unable to afford anti-HER2 therapy prior to surgery due to financial barriers and received standard neoadjuvant cytotoxic chemotherapy regimens alone. Although seven patients underwent completion ALND, this subgroup cannot be used to estimate the false-negative rate (FNR) of TAD due to verification bias. We performed completion ALND selectively in node-positive cases, while node-negative (ypN0) patients were spared dissection to avoid upper extremity morbidity. Calculating FNR requires routine ALND across all participants, including pathologically negative cases, to identify missed non-target node metastases, a practice no longer ethically justifiable in surgical de-escalation trials. Skin staining was found in 1 of 12 cases, but no other major complications from carbon particles.



Figure 5 (A) Tattooed node with a sentinel also identified by the technique, as shown by a blue-green arrow, and (B) sparkling with ICG. (C) MMG specimen confirms tattooed node concurrence with the node

While dual localization with a metallic clip remains the optimal reference standard for radiological confirmation, carbon tattooing alone represents a highly viable, cost-effective, and practical alternative in resource-limited settings where clips, wireless seeds, or wire-localization technologies are financially or logistically inaccessible. In our prospective cohort, single-node carbon tattooing demonstrated a high identification rate of 91.7%, underscoring its strong visual reliability for direct intraoperative guidance without requiring specialized detection probes or additional preoperative interventional procedures. In middle-income countries like Thailand—where healthcare cost constraints limit access to expensive localization devices—carbon tattooing alone offers surgeons high confidence in localized targeted node retrieval. When combined with standard post-NST dual-tracer sentinel lymph node biopsy (SLNB), carbon tattooing provides a scalable, low-cost strategy for safe axillary surgical de-escalation. Several methodological limitations of this trial must be acknowledged to appropriately contextualize our findings. First, the small sample size ($N = 12$) and single-center prospective design at a national tertiary cancer institution limit the immediate generalizability of our results to broader community healthcare settings. Second, because of the short postoperative follow-up, we could not evaluate long-term oncologic endpoints such as regional axillary recurrence rates and overall survival. Third, because we ethically omitted completion axillary lymph node dissection (ALND) in pathologically node-negative (ypN0) patients to minimize upper extremity surgical morbidity, we could not calculate the true False-Negative Rate (FNR) of this carbon-tattooed TAD protocol without introducing severe verification bias. Larger, multicenter prospective trials with extended long-term follow-up are warranted to confirm the oncologic safety and long-term efficacy of this approach.

CONCLUSION

This prospective evaluation demonstrates that single-node carbon tattooing combined with metallic clip placement is a highly feasible, safe, and cost-effective approach for targeted axillary dissection (TAD) following neoadjuvant systemic therapy. When evaluated against specimen radiography of clipped nodes as the reference standard, carbon tattooing achieved an identification accuracy of 91.7% without requiring additional pre-operative radiological wire localization or nuclear medicine procedures. Furthermore, in clinical scenarios or resource-limited settings where metallic clip deployment is financially or technically unfeasible, carbon tattooing alone provides a reliable, scalable, and radiation-free visual localization alternative to support safe surgical axillary de-escalation.

REFERENCES

1. Spring LM, Fell G, Arfe A, et al. Pathologic Complete Response after Neoadjuvant Chemotherapy and Impact on Breast Cancer Recurrence and Survival: A Comprehensive Meta-analysis. *Clin Cancer Res*. 2020 Jun 15;26(12):2838-48. doi: 10.1158/1078-0432.CCR-19-3492.
2. Ashikaga T, Krag DN, Land SR, et al. National Surgical Adjuvant Breast, Bowel Project. Morbidity results from the NSABP B-32 trial comparing sentinel lymph node dissection versus axillary dissection. *J Surg Oncol*. 2010 Aug 1;102(2):111-8. doi: 10.1002/jso.21535.
3. Kelly AM, Dwamena B, Cronin P, et al. Breast cancer sentinel node identification and classification after neoadjuvant chemotherapy-systematic review and meta analysis. *Acad Radiol*. 2009 May;16(5):551-63. doi: 10.1016/j.acra.2009.01.026.
4. Shirzadi A, Mahmoodzadeh H, Qorbani M. Assessment of sentinel lymph node biopsy after neoadjuvant chemotherapy for breast cancer in two subgroups: Initially node negative and node positive converted to node negative - A systemic review and meta-analysis. *J Res Med Sci*. 2019 Feb 25;24:18. doi: 10.4103/jrms.JRMS_127_18.
5. Kuehn T, Bauerfeind I, Fehm T, et al. Sentinel-lymph-node biopsy in patients with breast cancer before and after neoadjuvant

- chemotherapy (SENTINA): a prospective, multicentre cohort study. *Lancet Oncol.* 2013 Jun;14(7):609-18. doi: 10.1016/S1473-2045(13)70166-9.
6. Boughey JC, Suman VJ, Mittendorf EA, et al. Alliance for Clinical Trials in Oncology. Sentinel lymph node surgery after neoadjuvant chemotherapy in patients with node-positive breast cancer: the ACOSOG Z1071 (Alliance) clinical trial. *JAMA.* 2013 Oct 9;310(14):1455-61. doi: 10.1001/jama.2013.278932.
 7. Boileau JF, Poirier B, Basik M, et al. Sentinel node biopsy after neoadjuvant chemotherapy in biopsy-proven node-positive breast cancer: the SN FNAC study. *J Clin Oncol.* 2015 Jan 20;33(3):258-64. doi: 10.1200/JCO.2014.55.7827.
 8. Shirzadi A, Mahmoodzadeh H, Qorbani M. Assessment of sentinel lymph node biopsy after neoadjuvant chemotherapy for breast cancer in two subgroups: Initially node negative and node positive converted to node negative - A systemic review and meta-analysis. *J Res Med Sci.* 2019 Feb 25;24:18. doi: 10.4103/jrms.JRMS_127_18.
 9. Caudle AS, Yang WT, Krishnamurthy S, et al. Improved Axillary Evaluation Following Neoadjuvant Therapy for Patients With Node-Positive Breast Cancer Using Selective Evaluation of Clipped Nodes: Implementation of Targeted Axillary Dissection. *J Clin Oncol.* 2016 Apr 1;34(10):1072-8. doi: 10.1200/JCO.2015.64.0094.
 10. Woods RW, Camp MS, Durr NJ, et al. A Review of Options for Localization of Axillary Lymph Nodes in the Treatment of Invasive Breast Cancer. *Acad Radiol.* 2019 Jun;26(6):805-19. doi: 10.1016/j.acra.2018.07.002.
 11. Ersoy YE, Kadioglu H. Review of Novel Sentinel Lymph Node Biopsy Techniques in Breast Cancer Patients Treated With Neoadjuvant Chemotherapy. *Clin Breast Cancer.* 2018 Aug;18(4):e555-e559. doi: 10.1016/j.clbc.2018.01.004.
 12. Lim GH, Teo SY, Gudi M, et al. Initial results of a novel technique of clipped node localization in breast cancer patients postneoadjuvant chemotherapy: Skin Mark clipped Axillary nodes Removal Technique (SMART trial). *Cancer Med.* 2020 Mar;9(6):1978-85. doi: 10.1002/cam4.2848.
 13. Khallaf E, Wessam R, Abdoon M. Targeted axillary dissection of carbon-tattooed metastatic lymph nodes in combination with post-neo-adjuvant sentinel lymph node biopsy using 1% methylene blue in breast cancer patients. *Breast J.* 2020 May;26(5):1061-3. doi: 10.1111/tbj.13736.
 14. Kim WH, Kim HJ, Kim SH, et al. Ultrasound-guided dual-localization for axillary nodes before and after neoadjuvant chemotherapy with clip and activated charcoal in breast cancer patients: a feasibility study. *BMC Cancer.* 2019 Aug 30;19(1):859. doi: 10.1186/s12885-019-6095-1.
 15. Park S, Koo JS, Kim GM, et al. Feasibility of Charcoal Tattooing of Cytology-Proven Metastatic Axillary Lymph Node at Diagnosis and Sentinel Lymph Node Biopsy after Neoadjuvant Chemotherapy in Breast Cancer Patients. *Cancer Res Treat.* 2018 Jul;50(3):801-12. doi: 10.4143/crt.2017.210.
 16. Choy N, Lipson J, Porter C, et al. Initial results with preoperative tattooing of biopsied axillary lymph nodes and correlation to sentinel lymph nodes in breast cancer patients. *Ann Surg Oncol.* 2015 Feb;22(2):377-82. doi: 10.1245/s10434-014-4034-6.
 17. Mariscal Martínez A, Vives Roselló I, Salazar Gómez A, et al. Advantages of preoperative localization and surgical resection of metastatic axillary lymph nodes using magnetic seeds after neoadjuvant chemotherapy in breast cancer. *Surg Oncol.* 2021 Mar;36:28-33. doi: 10.1016/j.suronc.2020.11.013.
 18. Greenwood HI, Wong JM, Mukhtar RA, et al. Feasibility of Magnetic Seeds for Preoperative Localization of Axillary Lymph Nodes in Breast Cancer Treatment. *AJR Am J Roentgenol.* 2019 Oct;213(4):953-7. doi: 10.2214/AJR.19.21378.
 19. Kasem I, Mokbel K. Savi Scout® Radar Localisation of Non-palpable Breast Lesions: Systematic Review and Pooled Analysis of 842 Cases. *Anticancer Res.* 2020 Jul;40(7):3633-43. doi: 10.21873/anticancer.14352.
 20. Gradishar WJ, Moran MS, Abraham J, et al. Breast Cancer, Version 3.2024, NCCN Clinical Practice Guidelines in Oncology. *J Natl Compr Canc Netw.* 2024 Jul;22(5):331-57. doi: 10.6004/jnccn.2024.0035.
 21. Choy N, Lipson J, Porter C, et al. Initial results with preoperative tattooing of biopsied axillary lymph nodes and correlation to sentinel lymph nodes in breast cancer patients. *Ann Surg Oncol.* 2015 Feb;22(2):377-82. doi: 10.1245/s10434-014-4034-6.
 22. Park S, Koo JS, Kim GM, et al. Feasibility of Charcoal Tattooing of Cytology-Proven Metastatic Axillary Lymph Node at Diagnosis and Sentinel Lymph Node Biopsy after Neoadjuvant Chemotherapy in Breast Cancer Patients. *Cancer Res Treat.* 2018 Jul;50(3):801-12. doi: 10.4143/crt.2017.210.
 23. Kim WH, Kim HJ, Jung JH, et al. Ultrasound-Guided Restaging and Localization of Axillary Lymph Nodes After Neoadjuvant Chemotherapy for Guidance of Axillary Surgery in Breast Cancer Patients: Experience with Activated Charcoal. *Ann Surg Oncol.* 2018 Feb;25(2):494-500. doi: 10.1245/s10434-017-6250-3.
 24. Natsiopoulou I, Intzes S, Liappis T, et al. Axillary Lymph Node Tattooing and Targeted Axillary Dissection in Breast Cancer Patients Who Presented as cN+ Before Neoadjuvant Chemotherapy and Became cN0 After Treatment. *Clin Breast Cancer.* 2019 Jun;19(3):208-15. doi: 10.1016/j.clbc.2019.01.013.
 25. Goyal A, Puri S, Marshall A, et al. A multicentre prospective feasibility study of carbon dye tattooing of biopsied axillary node and surgical localisation in breast cancer patients. *Breast Cancer Res Treat.* 2021 Jan;185(2):433-40. doi: 10.1007/s10549-020-05961-3.
 26. Patel R, MacKerricher W, Tsai J, et al. Pretreatment Tattoo Marking of Suspicious Axillary Lymph Nodes: Reliability and Correlation with Sentinel Lymph Node. *Ann Surg Oncol.* 2019 Aug;26(8):2452-8. doi: 10.1245/s10434-019-07419-3.
 27. Hartmann S, Kühn T, de Boniface J, et al. Carbon tattooing for targeted lymph node biopsy after primary systemic therapy in breast cancer: prospective multicentre TATTOO trial. *Br J Surg.* 2021 Apr 5;108(3):302-7. doi: 10.1093/bjs/znaa083.

Feasibility of Low-Cost In-House 3D Printing in Mandibular Reconstruction with Fibula Free Flap: Initial Regional Experience from Northern Thailand

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Abstract

Background: Computer-assisted mandibular reconstruction with fibula free flap (FFF) improves accuracy but is often limited by high cost and dependency on external engineering support. This study evaluated the feasibility, workflow, and outcomes of a low-cost, in-house 3D printing protocol for mandibular reconstruction in a regional hospital.

Materials and Methods: Eighteen patients who underwent in-house, open-source-based 3D-planned FFF reconstruction between 2020 and 2025 were retrospectively reviewed. We analyzed demographic, operative, and reconstructive parameters, including ischemia time, operative duration, flap survival, and postoperative outcomes.

Results: The mean age was 60.9 years, with an equal sex distribution. Squamous cell carcinoma was the most common diagnosis (61%), and lateral-type defects predominated (78%). All reconstructions used osteocutaneous FFF with a single skin paddle. The mean defect length was 83.8 mm, ischemia time was 101 ± 32 minutes, and total operative time was 613 ± 110 minutes. No patient required routine ICU admission. All 18 flaps survived (100%). Minor complications included two fistulae (11%) and one plate exposure (5.6%). The average 3D printing cost was approximately 100 THB (USD 2.7) per model.

Conclusion: An in-house, surgeon-driven 3D printing workflow using open-source software is feasible, accurate, and cost-effective for mandibular reconstruction. A regional hospital setting can achieve outcomes comparable to high-cost commercial systems, supporting broader access to digital reconstructive technology.

Keywords: Mandibular reconstruction, Fibula free flap, 3D printing, Open-source software, Virtual surgical planning, In-house workflow

INTRODUCTION

Mandibular defects are among the most challenging problems in head and neck reconstruction, as they affect both function and aesthetics by compromising mastication, speech, swallowing, airway, and facial contour.^{1,2} The fibula free flap, first described by Hidalgo in 1989, has since become the gold standard for mandibular reconstruction, owing to its reliable vascularity, sufficient bone length, and potential for multiple osteotomies.^{1,3} Despite its advantages, the procedure remains technically demanding,

especially when restoring mandibular continuity and symmetry in complex oncological or post-traumatic cases.

Over the past two decades, computer-assisted surgery (CAS) and computer-aided design and manufacturing (CAD/CAM) technologies have revolutionized maxillofacial reconstruction.⁴⁻⁶ Virtual surgical planning (VSP) enables precise preoperative design of osteotomies and reconstruction plates, improving accuracy, reducing ischemia time, and optimizing functional and esthetic outcomes.^{7,8} However, the widespread application of

Received for publication 24 October 2025; Revised 30 January 2026; Accepted 25 August 2026

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<https://doi.org/10.64387/tjs.2026.278453>

CAD/CAM-guided mandibular reconstruction has been limited by high costs, dependency on external engineering support, and time-consuming manufacturing processes.^{4,9} These barriers are especially critical in resource-limited or regional hospitals, where timely treatment is required for malignant conditions.

To overcome these challenges, several groups have explored low-cost, in-house, or open-source workflows for 3D surgical modeling and guide fabrication.¹⁰⁻¹³ Such strategies allow surgeons to independently perform virtual planning, design osteotomy guides, and print models or templates with affordable 3D printers. These methods have shown accuracy comparable to commercial systems while substantially reducing cost and turnaround time. Nonetheless, clinical data on the feasibility and outcomes of low-cost in-house 3D printing protocols, particularly in developing healthcare systems, remain scarce.

In this study, we present our initial regional experience with low-cost, in-house 3D printing for mandibular reconstruction using fibula free flaps in a tertiary referral hospital in Northern Thailand. We aimed to evaluate the feasibility, workflow, and clinical outcomes of this approach compared with traditional methods, emphasizing accessibility and applicability in resource-limited settings.

MATERIALS AND METHODS

Study design and setting

This retrospective cohort study was conducted at Lampang Hospital, a tertiary referral center in Northern Thailand. We reviewed all consecutive patients who underwent mandibular reconstruction using fibula free flap (FFF) between January 2019 and June 2025. We included reconstructed cases using the in-house 3D printing protocol to analyze workflow feasibility, technical aspects, and clinical outcomes. A single reconstructive surgeon (Dr. Thanyanan Panich T.P.) performed all operations, ensuring uniform surgical technique and workflow implementation throughout the study period.

Patient selection

Inclusion criteria

- Segmental mandibular defect requiring reconstruction with fibula osteocutaneous free flap
- Virtual planning and model fabrication performed with in-house 3D printing workflow
- Complete preoperative and postoperative imaging available

Exclusion criteria

- Incomplete records or non-fibular donor site
- Cases reconstructed without the 3D workflow

A total of 18 consecutive patients met the criteria and were included in the analysis.

Preoperative imaging and planning workflow

All patients underwent contrast-enhanced CT of the facial bones (1.0-1.25 mm slice thickness) for mandibular modeling. We obtained leg CT angiography in 15 patients (83%) to evaluate donor-site vascular anatomy. In the remaining three patients (17%), we did not perform preoperative CTA of the lower leg because CTA scheduling times exceeded the planned surgical dates. These patients required expedited surgery because of aggressive or advanced malignancies, in which further delay could have resulted in disease progression.

For these three cases without lower-extremity CTA, we derived fibular models from previously acquired CT datasets of other patients of the same sex with comparable anthropometric characteristics, including body habitus, height, and body mass index (BMI). We used these surrogate fibular models solely for virtual planning and in-house cutting guide design, rather than patient-specific fibular models, while intraoperative assessment of fibular anatomy and the vascular pedicle was performed in the standard manner. We converted DICOM data to STL format using 3D Slicer® and imported them into Blender® (open-source software, Amsterdam, Netherlands) to virtually design resection margins and osteotomies. We planned defect length, osteotomy angles, and segment configuration to restore mandibular continuity. We pre-bent each patient's reconstruction plate on a printed mandibular model before surgery.

The reconstruction plates used in this study were standard, commercially available mandibular reconstruction plates and were not customized or patient-specific implants. The operating surgeon manually pre-bent the plates using an in-house 3D-printed mandibular model. In cases involving segmental mandibular defects, the defect geometry on the printed model was reconstructed virtually by mirroring the contralateral intact mandible to restore the original mandibular contour. This mirrored mandibular model served as a reference for plate contouring and adaptation prior to surgery.

In-house 3D printing protocol

We fabricated three-dimensional mandibular models and cutting guides for the mandible and fibular flap entirely in-house using a desktop fused deposition modeling (FDM) 3D printer (Creality Ender series).

Printing parameters

- Material: Polylactic acid (PLA) filament
- Printing time: 1-10 hours per model

- Average cost: approximately 100 Thai Baht ($\approx$ USD 2.7) per model
- Sterilization: low-temperature hydrogen peroxide plasma system (STERRAD[®])

The surgical team performed all planning and model fabrication without outsourcing or external engineering support. This approach followed the principles of low-cost, surgeon-driven design previously described by Ganry L et al. (2017), Bosc et al. (2017), and Damecourt et al. (2020), adapted to a regional hospital setting (**Figure 1**).

Surgical technique

Mandibulectomy was performed using the mandibular cutting guide (**Figure 1**). Then the recipient vessels were identified.

Fibula osteocutaneous flaps were harvested based on the peroneal pedicle in all 18 cases (100%). Osteotomies were performed according to the printed fibular cutting guide. Then the segment of the fibular bone was rearranged and fixed to the remaining mandible with the pre-bent reconstruction plate.

(**Figure 2**). Microvascular anastomoses were performed to the facial or superior thyroid artery and appropriate venous branches under high magnification using a Zeiss Tivato 700 surgical microscope.

Soft-tissue paddles (mean 4×6 cm) were inset for intraoral lining or external coverage as indicated (**Figure 2**). A well-trained plastic scrub nurse and plastic assistant nurse team supported each operation and were familiar with microsurgical workflow.

Clinical photographs of three patients at 1-year follow-up after fibula free flap reconstruction. All patients demonstrated stable mandibular contour, complete soft-tissue healing, and good functional recovery; they tolerated a regular oral diet and achieved speech intelligibility scores of 4-5. These results illustrate the long-term aesthetic and functional reliability of the low-cost, in-house 3D-planning protocol.

Postoperative management

All patients were cared for in a dedicated plastic surgery ward, without routine intensive care unit (ICU) admission.

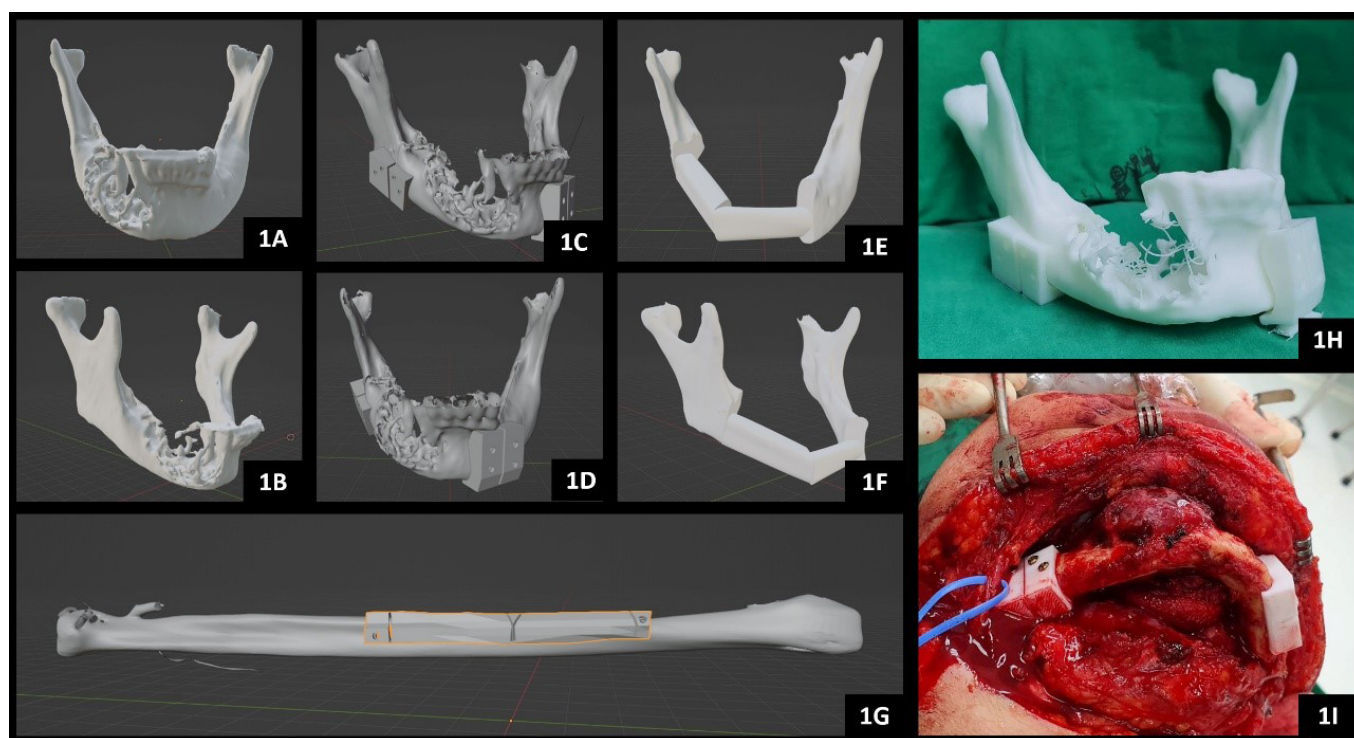


Figure 1 Virtual planning and in-house 3D printing workflow for mandibular reconstruction with fibula free flaps.

(1A, 1B) Three-dimensional mandibular models generated in Blender show tumor invasion involving the mandibular body and angle. (1C, 1D) Virtual simulation of mandibular osteotomy planning demonstrates the cutting planes prepared for intraoperative guidance. (1E, 1F) post-resection reconstruction planning illustrating complete tumor removal and replacement of the missing segment with a fibula free flap.

(1G) Virtual design of the fibular cutting guide based on the planned osteotomies.

(1H) The final 3D-printed surgical model and guide were fabricated in-house for intraoperative use.

(1I) Intraoperative view showing the practical application of the printed cutting guide during actual mandibular reconstruction. This figure illustrates the fully digital-to-surgical workflow of the low-cost, open-source 3D planning protocol used in this study.

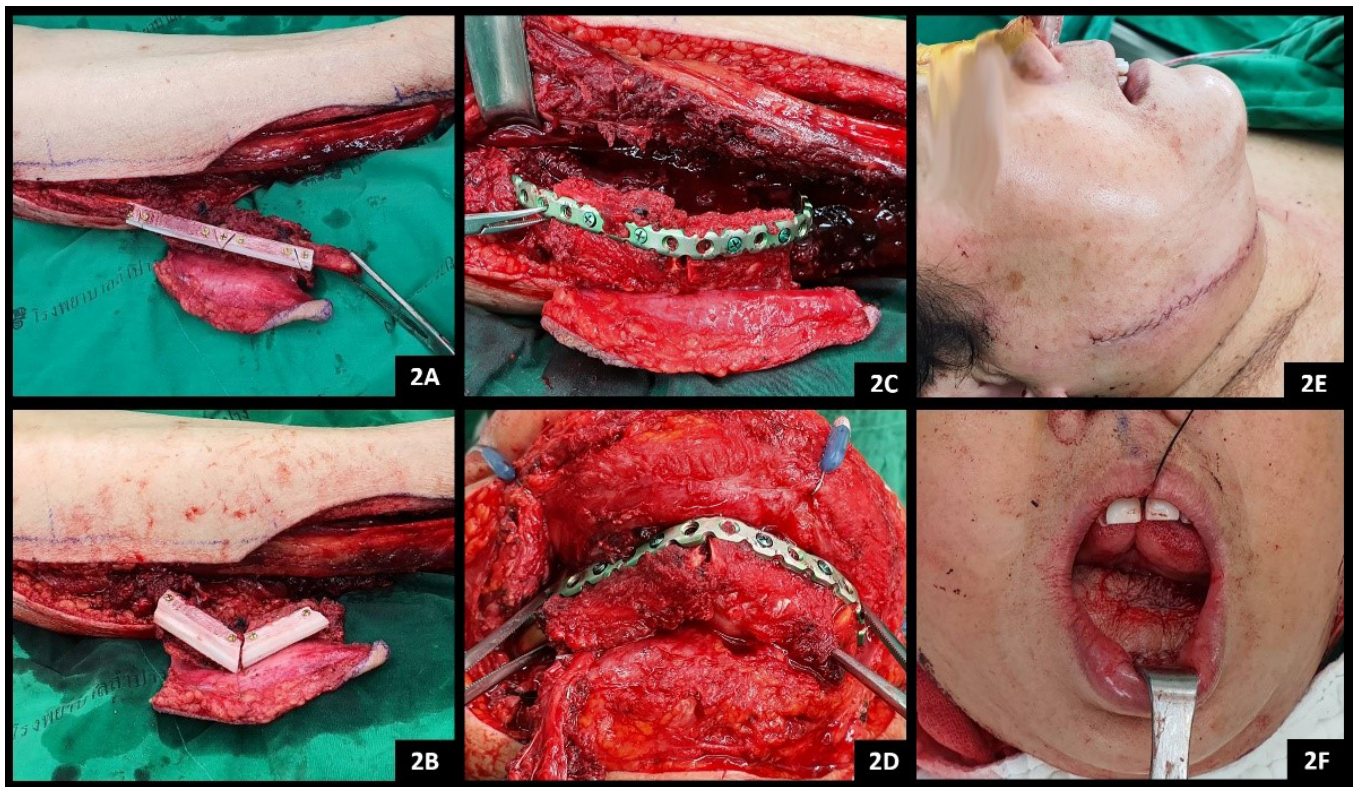


Figure 2 Intraoperative workflow of mandibular reconstruction using an in-house 3D-planned fibula free flap.

(A) Application of the printed cutting guide on the fibula with a skin paddle.

(B) After osteotomies, the fibular segments are aligned and shaped according to the predesigned mandibular template.

(C) Pre-bent reconstruction plate fitted onto the fibula flap with skin paddle before vascular division.

(D) Completed fixation of the fibula flap to the mandible, demonstrating precise alignment and excellent anatomical fit with the preoperative plan.

(E) Submental view after wound closure, showing an esthetically restored mandibular contour.

(F) Intraoral view of the skin paddle used for mucosal lining.

This figure illustrates the translation of the virtual plan into surgical execution, highlighting accuracy and contour restoration achieved through low-cost, in-house 3D planning.



Figure 3 Representative one-year postoperative outcomes following in-house 3D-planned mandibular reconstruction.

We monitored flaps hourly for the first 48 hours using clinical observation and Doppler signal assessment.

We followed institutional standards for antibiotic prophylaxis and anticoagulant regimens for free flap reconstruction. We encouraged early oral feeding and ambulation when tolerated.

Data collection and outcome measures

Collected variables included demographics, comorbidities, diagnosis, defect classification (Jewer), defect length, soft-tissue paddle size, imaging workflow, and pedicle usage.

Primary feasibility outcomes

- Success of model and guide fabrication
- Intraoperative accuracy of fit
- Operative and ischemia times (where available)

Secondary outcomes

- Perioperative complications
- Flap survival
- Postoperative course

Descriptive statistics were reported as mean $\pm$ standard deviation (SD) or percentage, as appropriate.

Ethical considerations

This study was approved by the Institutional Review Board of Lampang Hospital (IRB No. EC170/68). All patients provided written informed consent for surgical treatment and for the use of anonymized data and images for academic publication.

The study followed the Declaration of Helsinki (2013 revision).

RESULTS

Patient demographics and baseline characteristics

Eighteen patients underwent mandibular reconstruction using the in-house 3D-planned fibula free flap protocol at Lampang Hospital between 2020 and 2025. The mean age was 60.9 ± 18.1 years (range, 23-85), with an equal sex distribution (9 males and 9 females). Two-thirds of patients (67%) had at least one underlying comorbidity, most commonly hypertension (50%) and dyslipidemia (39%). The mean body mass index was 21.5 ± 4.7 kg/m². One-third of patients were active smokers, and six patients (33%) had no comorbidities. **Table 1** summarizes these baseline characteristics.

Table 1 Patient demographics and baseline characteristics

	Mean $\pm$ SD, n (%)	Range
Age	60.9 $\pm$ 18.1	23-85
Sex	Male 9 (50)	-
Height (cm)	157.3 $\pm$ 14.0	115-185
Weight (kg)	56.3 $\pm$ 17.7	36.3-114.0
BMI	21.5 $\pm$ 4.7	15.8-33.3
Smoking	6 (33)	-
Underlying disease	12 (67%) $\geq$ 1 comorbidity	-
HT	9 (50)	-
DLP	7 (39)	-
DM	1 (6)	-
Other	4 (22)	-
None	6 (33)	-

Table 1 summarizes the demographic and baseline characteristics of 18 patients who underwent mandibular reconstruction with an in-house 3D-planned fibula free flap at Lampang Hospital. The cohort had a mean age of 60.9 years (range, 23-85) with an equal sex distribution. Two-thirds of patients presented with at least one comorbidity, with hypertension being the most common (50%). The overall profile reflects a typical middle-aged oral cancer population, consistent with prior 3D-assisted reconstruction series.

Operative and reconstructive outcomes

The primary diagnosis was squamous cell carcinoma in 11 patients (61.1%), followed by benign lesions such as ameloblastoma in 5 (27.8%), one case of osteoradionecrosis, and one post-traumatic defect. Most defects were lateral-type according to the Jewer classification—L, LC, or LCL—comprising 14 of 18 cases (77.8%). Two patients (11.1%) had central (C) defects, and two had hemimandibular (H) defects. The mean defect length was 83.8 ± 20.7 mm (range, 50-135 mm). All reconstructions utilized osteocutaneous fibula free flaps with a single soft-tissue paddle; the mean paddle width and length were 38.2 ± 11.6 mm and 64.4 ± 22.8 mm, respectively.

We obtained preoperative CT facial bone imaging in all patients (100%) and performed CTA of the leg in 15 patients (83.3%). We used a peroneal pedicle in all 18 cases (100%). We performed three-dimensional surgical planning using Blender open-source software, and the average 3D printing cost was The mean cost of in-house 3D printing was 108.8 ± 16.0 THB per case (range, 80-150 THB; approximately USD 3.0), covering material costs for printing all mandibular and fibular models and the cutting guides required for each reconstruction. This cost did not include reconstruction plates or fixation screws.

The mean number of fibular osteotomies was 2.1 ± 0.7 (range, 1-3). The mean ischemia time was 101 ± 32 minutes, the mean flap operative time was 437 ± 76 minutes, and the total operative time was 613 ± 110 minutes. No routine post-operative ICU admission was required. The average hospital stay was 15.6 ± 4.8 days (range, 10-50). One patient (5.6%) required re-exploration for venous congestion, and all 18 flaps (100%) survived.

Minor complications included two intraoral fistulae (11.1%), one plate exposure (5.6%), and two donor-site wound dehiscences (11%), all of which healed with conservative management. At discharge, 15 patients (83%) tolerated a soft or blended diet and had excellent speech intelligibility (score 4-5). The mean total hospitalization cost was $244,410 \pm 88,497$ THB (range). All patients completed a minimum follow-up period of 6 months (range 6-60 months), at which time flap survival remained 100%.

Table 2 summarizes operative and reconstructive parameters.

Table 2 Operative and reconstructive characteristics

	n (%) or Mean ± SD	Range / Details
Main diagnosis		
Squamous cell CA	11 (61.1)	-
Ameloblastoma / Benign lesion	5 (27.8)	-
Osteoradionecrosis	1 (5.6)	-
Post-traumatic defect	1 (5.6)	-
Defect side		
Left	8 (44)	-
Right	6 (33)	-
Bilateral/Midline	4 (22)	-
B/J Classification		
L	5 (27)	-
LC	4 (22)	-
LCL	5 (27)	-
C	2 (11.1)	-
H	2 (11.1)	-
L-type (L, LC, LCL)	14 (77.8)	-
Defect length (mm)	83.8 ± 20.7	50-135
Soft tissue paddle usage	18 (100)	All osteocutaneous
Paddle width (mm)	38.2 ± 11.6	FFF
Paddle length (mm)	64.4 ± 22.8	20-60 30-110
Pre-op imaging		
CT facial bone	18 (100)	-
CTA leg	15 (83.3)	-
Peroneal pedicle used	18 (100)	-
3D printing cost per case	108.8 ± 16.0 THB (USD 3.0)	80-150
Peri-operative		
No Fibula osteotomies	2.1 ± 0.7	1-3
Ischemia time (min)	101 ± 32	60-165
Flap operative time (min)	437 ± 76	320-580
Total operative time (min)	613 ± 110	450-840
PRC transfusion (units)	0.7 ± 0.9	0-3
ICU stay (days)	0	0
Length of Stay (days)	15.6 ± 4.8	10-50
Post-operative		
Flap survival (6-month follow-up)	18 (100)	-
Re-exploration	1 (5.6)	-
Thrombosis	0	-
Fistula	2 (11.1)	-
Plate exposure	1 (5.6)	-
Donor site complication	2 (11)	-
Soft diet or BD at discharge	15 (83)	Minor wound dehiscence
Excellent Speech intelligibility (4-5)	15 (83)	-
Total Cost (THB)	244,410 ± 88,497	148,847-445,570

Abbreviations: CA, carcinoma; B/J, Boyd and Jewer classification of mandibular defects (L, lateral; C, central; H, hemimandible; LCL, lateral-central-lateral); CT, computed tomography; CTA, computed tomography angiography; FFF, fibular free flap; ICU, intensive care unit; PRC, packed red cells; SD, standard deviation; THB, Thai Baht; USD, United States dollar; BD, blended diet.

Table 2 presents the operative parameters and reconstructive details of the series. Squamous cell carcinoma accounted for 61% of cases, and lateral-type mandibular defects (L, LC, LCL) represented 78% of reconstructions. All procedures utilized osteocutaneous fibula free flaps with single-paddle soft-tissue components (mean 4 × 6 cm). Preoperative CT facial bone imaging was performed in all cases, and CTA of the leg was performed in 83%, with peroneal pedicle use in 100%. The mean defect length was 83.8 mm, the mean ischemia time was 101 ± 32 minutes, and the total operative time was 613 ± 110 minutes. All flaps survived (100%), no routine ICU admission was required, and the mean hospital stay was 15.6 days. These findings demonstrate the feasibility and reliability of low-cost, surgeon-driven 3D workflow in a regional center setting.

DISCUSSION

This study demonstrates the feasibility and reliability of an in-house, low-cost 3D printing workflow for mandibular reconstruction with fibula free flap (FFF) in a regional hospital setting. All 18 flaps survived with no routine postoperative ICU admission, and both ischemia and total operative times were comparable to those reported from tertiary centers using commercial computer-assisted design/manufacturing (CAD/CAM) systems. These findings confirm that affordable, surgeon-driven virtual planning can achieve high surgical precision and favorable outcomes while substantially reducing cost and logistical barriers.

The fibula free flap remains the gold standard for mandibular reconstruction because of its reliable vascularity, sufficient bone stock, and ability to undergo multiple osteotomies.^{1,3} However, conventional freehand reconstruction is technically demanding and time-consuming. Over the past two decades, computer-assisted surgery (CAS) and virtual surgical planning (VSP) have transformed maxillofacial reconstruction by improving geometric accuracy, flap fitting, and symmetry.⁴⁻⁶ Yet, widespread application of commercial CAD/CAM systems has been limited by high production costs and reliance on external engineering support.^{4,9}

Several groups have therefore explored in-house or open-source approaches that empower surgeons to perform 3D planning and model fabrication independently.¹⁰⁻¹³ Culié et al. (2016) demonstrated that the implementation of virtual planning and guided surgery (VPGS) significantly reduced fibular flap ischemia time from 171 to 98 minutes while maintaining comparable total operative time.⁸ Bosc et al. (2017) confirmed that internal manufacturing of cutting guides improved accuracy and eliminated outsourcing delays.⁷ Damecourt et al. (2020) reported a fully surgeon-performed planning method producing accurate models within 72 hours—compatible with urgent

oncologic surgery.⁹ Similarly, Ganry et al. (2017) achieved sub-millimeter precision (< 1 mm) using an open-source workflow based on OsiriX, MeshLab, and Blender,¹⁰ and Dowgierd et al. (2022) confirmed precise replication of pre-operative design in 3D-planned reconstructions.⁶

Our present results parallel those of these prior studies (Table 3). The mean ischemia time of 101 ± 32 minutes and total operative time of 613 ± 110 minutes fall within the same range reported for European tertiary centers using VSP workflows. Despite being implemented in a regional Thai hospital with limited resources, flap survival reached 100%, and no patient required routine ICU care. These outcomes validate that a locally fabricated, open-source-based workflow can deliver outcomes comparable to high-cost commercial systems.

Table 3 Comparative summary of selected representative studies on 3D-assisted mandibular reconstruction using fibula free flaps. The Lampang series shows ischemia and operative times comparable to high-cost virtual planning systems, while maintaining the lowest model cost (< \$3 USD) and a fully in-house workflow.

Several practical adaptations contributed to this success. All cases were planned using Blender, a freely available open-source modeling platform, and printed with a desktop fused-deposition (FDM) printer at a mean in-house 3D printing cost of 108.8 ± 16.0 THB per case (range, 80-150 THB; approximately USD 3.0). The entire process—from CT segmentation to sterilizable model production—was completed within 24 hours. This turnaround time is critical for oncologic patients requiring prompt resection and reconstruction. Operations were performed under high magnification using a Zeiss Tivato 700 microscope, with assistance from well-trained plastic scrub nurses, who ensured consistent microvascular results. The ability to iterate plate conformation and guide design independently allowed personalized planning without external delays.

3D planning and printing approach shortens preoperative lead time by eliminating coordination and production delays associated with outsourced commercial providers. This streamlined workflow enables earlier surgical scheduling, which is particularly advantageous for patients with head and neck malignancies, in whom delays to definitive surgery may increase

Table 3 Comparison of the in-house 3D printing workflow with previous reports

Study / Year	Country / Setting	Workflow Type	N	Mean Ischemia Time (min)	Total OR Time (min)	Model Production / Lead Time	Estimated Cost (USD)	Key Features / Outcomes
Panich et al. (2025)	Thailand (Regional Hospital)	In-house open source (Blender, PLA, FDM)	18	101 ± 32	613 ± 110	< 24 h (in-house)	3.0 /case (108.8 THB)	Surgeon-driven design; microscope-assisted (Zeiss Tivato 700); plastic-trained nurses; no ICU; flap survival 100%
Bosc et al. (2017) <i>Int J Oral Maxillofac Surg</i>	France (Tertiary cancer center)	In-house CAD/CAM	18	N/A	360-600 (mean 422)	< 48 h (3-15 d, mean 5.1 d)	~200-300	Internal manufacturing reduced ischemia time and improved accuracy
Ganry et al. (2017) <i>J Stomatol Oral Maxillofac Surg</i>	France	Open source (OsiriX + Blender)	3	N/A	N/A	72-96 h	N/A	Accuracy < 1 mm; deformation after sterilization < 0.2 mm; surgeon-operated workflow
Damecourt et al. (2020) <i>Eur Ann ORL HNS</i>	France (CHU Montpellier)	In-house 3D printing by surgical team	7	55	N/A	< 72 h	< 50	All planning, printing, and plate bending are done by surgeons; compatible with urgent cancer cases
Orabona et al. (2018) <i>Surg Oncol</i>	Italy (University Hospital)	Low-cost self-made CAD/CAM	4	N/A	N/A	~72 h	< 100	Demonstrated cost-effective guide fabrication without engineers
Culié et al. (2016) <i>Eur Ann ORL HNS</i>	France (Nice)	Virtual Planning & Guided Surgery (VPGS)	29	98 ± 45	481 ± 95	10-14 days (external vendor)	>500	Significant ischemia time reduction vs conventional (171 → 98 min)
Dowgierd et al. (2022) <i>Oral Oncol</i>	Poland (National Cancer Center)	VSP + Individual Implants	21	N/A	N/A	2-3 weeks	>1000	3D accuracy ± 7.7 mm; validated in pediatric/adult series; high precision but high cost

the risk of tumor progression.

From an economic standpoint, the mean total treatment cost of $\approx$ 244,000 THB was markedly lower than international averages for CAD/CAM-assisted reconstructions, where guide fabrication alone may exceed USD 300 per case.^{7,9,10} Our in-house workflow thus represents a practical model for resource-limited or regional centers, enabling equitable access to digital reconstructive technology.

However, successful implementation depends on the availability of personnel with expertise in three-dimensional planning and 3D printing, which may limit reproducibility and generalizability in centers lacking technical experience or institutional support.

Compared with commercially customized systems, the in-house 3D planning and cutting guide workflow may yield less precise bony apposition, as we occasionally observed small intersegmental gaps between the fibula and mandible. This likely reflects the use of standard, non-customized reconstruction plates. Nevertheless, meticulous intraoperative plate contouring mitigated this issue, and flap survival and early functional outcomes were not compromised.

Nonetheless, certain limitations remain. This was a single-center retrospective series with a limited sample size and heterogeneous indications. We did not objectively validate geometric accuracy using postoperative 3D superimposition. Long-term functional and aesthetic assessments, as well as patient-reported outcomes, remain areas for future study. However, the uniform success rate and reproducibility across 18 cases suggest this low-cost workflow has a short learning curve and is highly reliable once the surgical team is familiar with digital planning.

Future development could include integration of intraoperative navigation, photogrammetry, or augmented-reality guidance to further enhance precision. Regional collaboration networks could also standardize training and share open-source design libraries, thereby extending the benefits of this technology to other reconstructive domains such as midfacial or orbital defects.

CONCLUSION

This study confirms that in-house, low-cost 3D printing using open-source software is a feasible, accurate, and cost-effective solution for mandibular reconstruction with fibula free flap. The protocol enables surgeon-led virtual planning, rapid model production, and dependable clinical outcomes comparable to high-cost commercial CAD/CAM systems. By removing the dependence on outsourced manufacturing, this workflow strengthens reconstructive capability in regional hospitals and

promotes equitable access to advanced microsurgical reconstruction in resource-limited settings.

ACKNOWLEDGMENTS

The authors acknowledge ChatGPT (OpenAI, San Francisco, CA, USA) for language editing and style refinement under the supervision of the corresponding author. The authors independently developed all intellectual content, analysis, and conclusions.

FUNDING

The authors received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors for this study.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest related to this work.

AUTHOR CONTRIBUTIONS

- **Dr. Thanyanan Panich:** Conceived the study concept, collected and compiled patient data, coordinated multidisciplinary collaboration, and contributed to manuscript preparation.
- **Dr. Ueaungkun Sitthimongkon:** Designed the study framework, supervised data analysis and surgical methodology, and performed critical revision of the manuscript for important intellectual content.
- Both authors approved the final version of the manuscript and agree to be accountable for all aspects of the work.

REFERENCES

1. Chim H, Salgado CJ, Mardini S, et al. Reconstruction of mandibular defects. *Semin Plast Surg.* 2010 May;24(2):188-97. doi: 10.1055/s-0030-1255336.
2. Kumar BP, Venkatesh V, Kumar KA, et al. Mandibular Reconstruction: Overview. *J Maxillofac Oral Surg.* 2016 Dec;15(4):425-441. doi: 10.1007/s12663-015-0766-5.
3. Hidalgo DA. Fibula free flap: a new method of mandible reconstruction. *Plast Reconstr Surg.* 1989 Jul;84(1):71-9. PMID: 2734406.
4. Dell'Aversana Orabona G, Abbate V, Maglito F, et al. Low-cost, self-made CAD/CAM-guiding system for mandibular reconstruction. *Surg Oncol.* 2018 Jun;27(2):200-7. doi: 10.1016/j.suronc.2018.03.007.
5. Tarsitano A, Mazzoni S, Cipriani R, et al. The CAD-CAM technique for mandibular reconstruction: an 18 patients oncological case-series. *J Craniomaxillofac Surg.* 2014 Oct;42(7):1460-4. doi: 10.1016/j.jcms.2014.04.011.
6. Dowgierd K, Pokrowiecki R, Wolanski W, et al. Analysis of the effects of mandibular reconstruction based on microvascular free flaps after oncological resections in 21 patients, using 3D planning, surgical templates and individual implants. *Oral Oncol.* 2022 Apr; 127:105800. doi: 10.1016/j.oraloncology.2022.105800.

7. Bosc R, Hersant B, Carloni R, et al. Mandibular reconstruction after cancer: an in-house approach to manufacturing cutting guides. *Int J Oral Maxillofac Surg*. 2017 Jan;46(1):24-31. doi: 10.1016/j.ijom.2016.10.004.
8. Culié D, Dassonville O, Poissonnet G, et al. Virtual planning and guided surgery in fibular free-flap mandibular reconstruction: A 29-case series. *Eur Ann Otorhinolaryngol Head Neck Dis*. 2016 Jun;133(3):175-8. doi: 10.1016/j.anorl.2016.01.009.
9. Damecourt A, Nieto N, Galmiche S, et al. de Boutray M. In-house 3D treatment planning for mandibular reconstruction by free fibula flap in cancer: Our technique. *Eur Ann Otorhinolaryngol Head Neck Dis*. 2020 Dec;137(6):501-5. doi: 10.1016/j.anorl.2020.02.002.
10. Ganry L, Hersant B, Quilichini J, et al. Use of the 3D surgical modelling technique with open-source software for mandibular fibula free flap reconstruction and its surgical guides. *J Stomatol Oral Maxillofac Surg*. 2017 Jun;118(3):197-202. doi: 10.1016/j.jormas.2017.03.002.
11. Ganry L, Quilichini J, Bandini CM, et al. Three-dimensional surgical modelling with an open-source software protocol: study of precision and reproducibility in mandibular reconstruction with the fibula free flap. *Int J Oral Maxillofac Surg*. 2017 Aug;46(8):946-57. doi: 10.1016/j.ijom.2017.02.1276.
12. Mottini M, Seyed Jafari SM, Shafighi M, Schaller B. New approach for virtual surgical planning and mandibular reconstruction using a fibula free flap. *Oral Oncol*. 2016 Aug;59:e6-e9. doi: 10.1016/j.oraloncology.2016.06.001.
13. Wang L, Ma W, Zhang C, et al. Optimized design for using of double-barrel vascularized fibular flap in various types of mandibular defects. *J Dent Sci*. 2025 Jan;20(1):578-85. doi: 10.1016/j.jds.2024.04.022.

Long term Outcomes of Surgical Treatment and Anatomical Characteristics of Acute and Chronic Cryptoglandular Anal Fistula Following Surgery

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Abstract

Background and Objective: Cryptoglandular anal fistula may recur after surgery, particularly when the fistula has complex anatomy. This study evaluated healing, recurrence, anatomical patterns, and factors associated with recurrence in patients treated during either the acute abscess or chronic fistula stage.

Materials and Methods: This retrospective cohort study included 320 adults who underwent surgery for cryptoglandular anal fistula at Rayong Hospital between 2012 and 2025. Patients were classified as having an acute anorectal abscess or a chronic anal fistula. The fistula anatomy was assessed using systematic anal fistula mapping, supplemented by magnetic resonance imaging in selected complex or recurrent cases. We tailored surgical treatment to fistula anatomy. We evaluated healing and recurrence-free survival using Kaplan–Meier analysis and assessed recurrence predictors using Cox proportional hazards regression.

Results: Among 320 patients, 142 had an acute abscess, and 178 had a chronic fistula. The median follow-up was 42 months (95% CI 33-50). Healing rates were higher in the acute group (97.2%) than in the chronic group (92.1%) (95% CI 1.0 - 11.2), $p < 0.017$. Recurrence occurred in 2.8% of the acute group and 7.9% of the chronic group (95% CI 0.2 - 9.9), $p < 0.041$. Estimated mean recurrence-free survival time was 145 months (95% CI 140.8 - 150) in acute and 127 months (95% CI 119.5 - 135.8) in chronic cases, $p < 0.01$. In the multivariable Cox model, high transsphincteric fistula was the only independent predictor of recurrence (adjusted HR 23.13, 95% CI 7.76-68.92; $p < 0.001$). No fecal incontinence was documented, although continence was assessed clinically rather than with a standardized score.

Conclusion: Anatomy-tailored surgical treatment was associated with high healing and relatively low recurrence rates in this cohort. High transsphincteric anatomy was strongly associated with recurrence. One-stage treatment during the acute abscess phase may be appropriate in carefully selected patients when the fistula anatomy can be clearly identified; however, these findings should be interpreted cautiously because of the retrospective, single-center study design.

Keywords: anal fistula, recurrence, healing, prognostic factors, anal fistula mapping

INTRODUCTION

Anal fistula (fistula-in-ano) is a common anorectal condition that results primarily from cryptoglandular infection, with an incidence of 5-12 per 100,000 population and a predominance in men^{1,2}. Acute anorectal abscess and chronic fistula are considered part of the same disease spectrum, with fistula formation reported in 15-60% of cases following abscess^{3,4}. Factors such as recurrent sepsis, secondary tracts, and

greater sphincter involvement are associated with increased risk of treatment failure^{3,5}. The principal aims of surgical management are to eradicate the fistula tract and preserve continence. Fistulotomy is generally recommended for simple fistulas, whereas sphincter-preserving techniques, including advancement flap and ligation of the intersphincteric fistula tract (LIFT), are preferred for complex cases^{2,6}. However, no single technique is universally effective, and recurrence

Received for publication 31 March 2026; Revised 14 August 2026; Accepted 17 August 2026

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<https://doi.org/10.64387/tjs.2026.281231>

remains a challenge, often related to missed secondary tracts or persistent infection³. Previous studies have reported a treatment failure rate of approximately 20%, particularly in patients with complex fistula anatomy⁷. Recent approaches have emphasized anatomical classification and fistula mapping to improve identification of the internal opening and secondary tracts^{3,8}. Fistula mapping defined tract anatomy and complexity, guided surgery, and provided variables for recurrence analysis. Although fistulotomy is effective for simple fistulas and sphincter-preserving procedures are used for complex disease, evidence regarding definitive one-stage treatment during the acute abscess phase remains limited. Long-term outcome data from Thailand are also scarce, and the clinical value of systematic anal fistula mapping for defining tract anatomy and predicting recurrence remains poorly established. Therefore, the primary objective was to determine the recurrence rate and predictors of recurrence after surgical treatment. The secondary objectives were to assess healing, compare outcomes between acute abscess and chronic fistula, and characterize fistula anatomy using systematic anal fistula mapping

MATERIALS AND METHODS

This retrospective cohort study followed STROBE recommendations and included patients who underwent surgery for anal abscess or cryptoglandular fistula-in-ano by a single colorectal surgeon at Rayong Hospital, a tertiary-care referral hospital in Thailand. The Human Research Ethics Committee of Rayong Hospital approved the study (E011/2568). We treated 320 patients between January 1, 2012, and December 31, 2025; the sample included all eligible patients during the study period, and we did not perform a formal sample size calculation. Inclusion criteria were adults (≥ 18 years) with acute anorectal abscess, chronic anal fistula, or recurrent fistula previously treated outside Rayong Hospital. Patients with fistulas secondary to Crohn's disease, tuberculosis, or malignancy were excluded. Patients were classified into two groups based on initial presentation: (1) acute anal abscess group, defined as patients presenting with anorectal abscess who underwent drainage, with fistula treatment performed in the same setting when identified; and (2) chronic anal fistula group, defined as patients with a draining fistula without active abscess who underwent elective surgery. For patients with multiple tracts, we used the most complex fistula for analysis. As shown in **Figure 1**

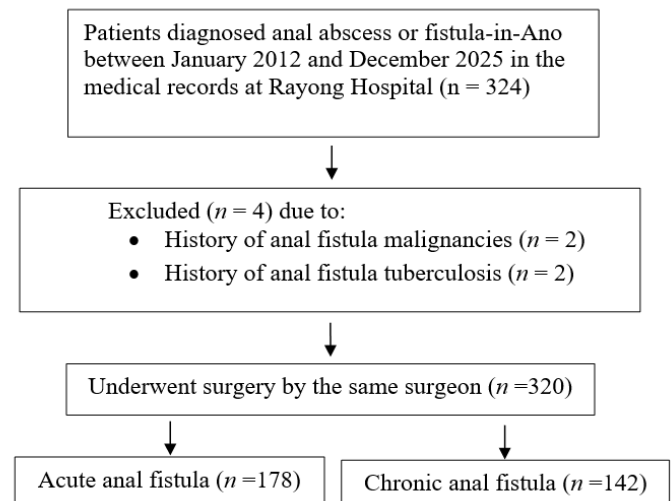


Figure 1 Flow diagram of patient selection

FISTULA CLASSIFICATION

Anal fistulas were classified according to their anatomical relationship to the anal sphincter complex, based on intraoperative findings supplemented by preoperative imaging. We selectively performed pelvic magnetic resonance imaging (MRI) in patients with recurrent or complex fistulas when tract delineation was uncertain on clinical examination. According to the American Society of Colon and Rectal Surgeons (ASCRS) guidelines, fistulas were categorized as simple (intersphincteric and low transsphincteric) or complex, which included high transsphincteric ($>30\%$ external sphincter involvement), suprasphincteric, extrasphincteric, and horseshoe fistulas⁹.

SURGICAL TECHNIQUES

Colorectal surgeons at Rayong Hospital treated all patients using standard techniques. The two main procedures were fistulotomy and ligation of the intersphincteric fistula tract (LIFT). Fistulotomy was performed for simple, low fistulas, involving tract division, curettage, and marsupialization, with healing by secondary intention. LIFT was used for transsphincteric or complex fistulas to preserve sphincter integrity, involving ligation and division of the tract within the intersphincteric space. We selected the procedure based on intraoperative assessment. Simple fistulas were generally treated with fistulotomy, whereas complex or high tracts were managed with LIFT. In patients presenting with acute abscess, a one-stage fistulotomy was performed if the internal opening was identified; otherwise, abscess drainage with seton placement was undertaken, followed by definitive surgery (Fistulotomy with marsupialization) at a later stage.

The FIPS procedure involves identifying the fistula tract and openings, performing fistulotomy or fistulectomy with sphincter division, removing the tract and infected tissue, and immediately reconstructing the sphincter with end-to-end absorbable sutures while ensuring external drainage.

A draining seton is a loose seton placed through the fistula tract to maintain continuous drainage and control sepsis while preserving the sphincter.

POSTOPERATIVE FOLLOW-UP

Patients were followed up at 4 weeks postoperatively and then until clinical healing was achieved, with further visits every 6-12 months or as needed for recurrent symptoms. Fecal incontinence was assessed based on clinical records and patient reports and classified as mild, moderate, or severe¹⁰. Standardized continence scoring was not consistently recorded. We contacted patients who missed follow-up by telephone.

DATA COLLECTION

Acute anal fistula or abscess was defined as a fistulous tract identified during examination under anesthesia and surgical treatment of an acute anorectal abscess, with active local infection or inflammation at the time of presentation^{3,8}.

Chronic anal fistula was defined as an established fistulous tract presenting with persistent or recurrent perianal drainage after spontaneous or surgical drainage of a previous anorectal abscess, with or without recurrent secondary abscess formation^{3,8}.

Recurrence was defined as the re-appearance of an abscess or fistulous drainage at or near the site of the original fistula after an initial period of healing of more than 6 months. This included cases of treatment failure where the fistula never fully healed (persistent fistula at 12 weeks was considered a failure) as well as cases of fistula that healed and then re-developed later^{7,11}.

Persistent non-healing was defined as continued drainage, an unhealed external opening or wound, recurrent abscess, or need for additional fistula treatment within 12 weeks after definitive surgery, without documented complete healing.

True recurrence was defined as the reappearance of fistulous drainage or an abscess at or near the original site after documented complete healing.

Healing: defined as complete closure of the fistula tract with no further drainage. For patients who underwent fistulotomy, "healing" referred to full epithelialization of the fistulotomy wound. For LIFT patients, healing meant the external opening had closed and the intersphincteric incision healed without signs of persistent fistula.

Exposure variables were prespecified and included patient-related, clinical, and anatomical factors. Patient-related variables comprised age, sex, body mass index (BMI), history

of raw food consumption (Laap, bile, Koi Kung, Koi Pla, Pla Ra), American Society of Anesthesiologists (ASA) classification, operative time, operative technique, length of hospital stay (LOS), and fecal incontinence. Comorbidities of interest included diabetes mellitus, hypertension, dyslipidemia, and obesity. Anatomical characteristics were assessed using a standardized Anal Fistula Map based on clinical examination (Goodsall's rule)^{8,12}, intraoperative findings, and magnetic resonance imaging (MRI), when available.

THE ANAL FISTULA MAPPING PROCEDURE

The fistula tract was mapped starting from the internal opening (IO) through the intersphincteric space (ITS), with subsequent assessment of its relationship to the external sphincter at different levels, classified as intersphincteric (IT), low transsphincteric (LT), or high transsphincteric (HT). The tract was then followed through the relevant anal spaces, including the perianal (PRA), postanal (PRN), deep postanal (DPA), ischioanal (ISA), ischiorectal fossa (IFL), and supralelevator (SPL) spaces, until it terminated at the external opening (EO). The distance from the external opening (EO) to the anal verge (AV) was then measured, and the shape of the fistula tract was finally assessed as straight, curved, or horseshoe.

The same surgical team obtained all data from standardized medical records and operative reports and recorded them consistently.

STATISTICAL ANALYSIS

All analyses were conducted using SPSS Statistics for Windows (version 20.0; IBM Corp., Armonk, NY, USA). Categorical variables are presented as frequencies and percentages and were compared between groups using the chi-square test. Continuous variables are presented as medians with interquartile range (IQR) or means with standard deviation and were compared between groups using the independent samples t-test or Mann-Whitney U test, as appropriate based on distribution. We used the Kaplan–Meier method to analyze time-to-event data for two key endpoints: fistula healing and fistula recurrence. For time to healing, we censored patients who had not achieved healing by the last follow-up at their last visit. For time to recurrence, we censored patients without recurrence at the last follow-up (and censored those lost to follow-up before a certain time similarly). We handled missing data using complete-case analysis. We used the log-rank test to compare survival curves between groups. To identify prognostic factors associated with outcomes, we performed univariate and multivariate analyses: for recurrence or healing rate as the outcome, we used Cox proportional hazards regression to estimate hazard ratios (HR) for potential risk factors. Variables with $p < 0.10$ in univariate

Cox analysis were considered for inclusion in a multivariate Cox model by using forward stepwise selection. A two-tailed $p < 0.05$ was considered statistically significant in all analyses. Where appropriate, results are presented with 95% confidence intervals.

Results

Patient Characteristics

The study included 320 patients. **Table 1** summarizes baseline characteristics and the extent of missing data. Both groups showed male predominance, with 83.3% in the acute anal fistula group and 81.5% in the chronic group. The mean age was comparable between groups (34.58 ± 11.32 years in the acute group vs. 35.57 ± 10.09 years in the chronic group; $p = 0.41$; mean difference -0.99 years, 95% CI -3.35 to 1.37). Similarly, mean body weight did not differ significantly (74.07 ± 18.25 kg vs. 72.55 ± 15.12 kg; $p = 0.429$; mean difference 1.52 kg, 95% CI -2.26 to 5.30). The median body mass index (BMI) was 24 kg/m² (IQR 22-29) in the acute group and 25 kg/m² (IQR 22-28) in the chronic group, with no statistically significant difference ($p = 0.292$). Obesity (BMI ≥ 25 kg/m²) was observed in 40.8% of patients in the acute group and 48.9% in the chronic group, while morbid obesity (BMI ≥ 30 kg/m²)

was present in 21.1% and 20.2%, respectively. More than half of patients reported consuming raw food (54.2% in the acute group vs. 60.1% in the chronic group), with no significant difference between groups ($p = 0.402$). Most patients were classified as ASA physical status II (60.6% vs. 63.5%). Regarding comorbidities, HIV infection was present in 8.45% of the acute group and 6.17% of the chronic group, while diabetes mellitus was observed in 7.04% and 5.6%, respectively. The median operative time was shorter in the acute group (35 minutes [IQR 25-40]) compared with the chronic group (45 minutes [IQR 35-60]). Likewise, the median length of hospital stay was shorter in the acute group (2 days [IQR 2-3] vs. 3 days [IQR 2-4]). Loss to follow-up occurred in 16.9% of patients in the acute group and 9.6% in the chronic group.

Natural Chronic Anal Fistula Patterns

For fistulas with an internal opening (IO) at 1 o'clock ($n=13$), all cases demonstrated the tract component in the intersphincteric space (ITS) (13, 100%). The fistula levels were intersphincteric (IT) in 3 cases (23.1%), low transsphincteric (LT) in 9 (69.2%), and high transsphincteric (HT) in 1 (7.7%). Extension into the perirectal/anogenital spaces was observed in

Table 1 Patients' demographic and clinical characteristics

Characteristic	Acute anal fistula (n = 142)	Anal fistula (n = 178)	Missing, n
Sex, n (%)			0
Male	119 (83.8)	145 (81.5)	
Female	23 (16.2)	33 (18.5)	
Age, years, mean $\pm$ SD	34.58 ± 11.32	35.57 ± 10.09	0
Weight, kg, mean $\pm$ SD	74.07 ± 18.25	72.55 ± 15.12	18
BMI, kg/m², median (IQR)	24 (22-29)	25 (22-28)	32
BMI category, n (%)			
<25 kg/m ²	66 (46.5)	77 (43.3)	
≥ 25 kg/m ²	58 (40.8)	87 (48.9)	
Raw-food consumption, yes, n (%)	77 (54.2)	107 (60.1)	25
ASA physical status, n (%)			13
I	31 (21.8)	51 (28.7)	
II	86 (60.6)	113 (63.5)	
III	17 (12.0)	9 (5.1)	
Comorbidities, n (%)			7
Obesity (BMI ≥ 30 kg/m ²)	30 (21.1)	36 (20.2)	
HIV infection	12 (8.5)	11 (6.2)	
Diabetes mellitus	10 (7.0)	10 (5.6)	
Hypertension	4 (2.8)	15 (8.4)	
SLE	0	1 (0.6)	
Marfan syndrome	0	1 (0.6)	
Operative time, min, median (IQR)	35 (25-40)	45 (35-60)	24
Length of hospital stay, days, median (IQR)	2 (2-3)	3 (2-4)	4
Lost to follow-up, n (%)	24 (16.9)	17 (9.6)	0

Data are n (%), mean $\pm$ SD, or median (IQR), as indicated. Percentages use the total group denominator. Patients could have more than one comorbidity. Missing values are totals for both groups; group-specific missing BMI and ASA data are shown separately. No patient was classified as ASA IV. Raw food included Laap, bile, koi kung, koi pla, and pla ra. ASA, American Society of Anesthesiologists; BMI, body mass index; HIV, human immunodeficiency virus; IQR, interquartile range; SD, standard deviation; SLE, systemic lupus erythematosus.

Table 2 The anal fistula map pattern of chronic anal fistula

IO (O'clock)	N	ITS n (%)			Level n (%)			Anogenital spaces n (%)												External opening (o'clock) n (%)														Distance (EO to AV) (cm) mean ± SD	Tract shape n (%)			
								PRA			DPA			ISA			PRN																					I F L
		a	c	t	IT	LT	HT	a	c	t	a	c	t	a	c	t	a	c	t	a	c	t	1	2	3	5	6	7	9	10	11	12	5,7		1,11	Straight	Curve	Horseshoe
1	13	0	0	13 (100)	3 (23.1)	9 (69.2)	1 (7.7)	0	0	9 (69.2)	0	0	0	0	0	0	0	0	6 (46.2)	0	0	10 (76.9)	2 (15.4)	0	0	0	0	0	0	0	1 (7.7)	0	0	0	1.92±0.6	13 (100)	0	0
2	9	0	0	9 (100)	0	9 (100)	0	0	0	9 (100)	0	0	0	0	0	0	0	0	6 (66.7)	0	0	1 (11.1)	8 (88.9)	0	0	0	0	0	0	0	0	0	0	0	2.77±0.8	8 (88.9)	1 (11.1)	0
5	9	0	0	9 (100)	0	8 (88.9)	1 (11.1)	0	0	8 (88.9)	0	0	0	0	0	4 (44.4)	0	0	1 (11.1)	0	0	0	1 (11.1)	0	8 (88.9)	0	0	0	0	0	0	0	0	0	2.22±0.6	7 (77.8)	2 (22.2)	0
6	80	0	2 (2.5)	78 (97.5)	6 (7.5)	54 (67.5)	20 (25)	0	0	49 (61.2)	0	0	20 (25)	0	0	35 (43.8)	0	0	8 (10)	0	0	0	3 (3.8)	6 (7.5)	23 (28.8)	8 (10)	24 (30)	5 (6.2)	1 (1.2)	5 (6.2)	0	5 (6.2)	0	2.66±1.2	41 (51.2)	34 (42.5)	5 (6.2)	
7	6	0	0	6 (100)	0	6 (100)	0	0	0	6 (100)	0	0	0	0	0	2 (33.3)	0	0	0	0	0	0	0	0	0	4 (66.7)	2 (33.3)	0	0	0	0	0	0	1.91±0.3	6 (100)	0	0	
11	13	0	0	13 (100)	0	10 (76.9)	3 (23.1)	0	0	9 (69.2)	0	0	0	0	0	0	0	0	10 (76.9)	0	0	0	0	0	0	0	0	0	1 (7.7)	12 (92.3)	0	0	0	0	3.00±1.0	13 (100)	0	0
12	48	0	0	48 (100)	5 (10.4)	36 (75)	7 (14.6)	0	0	36 (72)	0	0	0	0	0	0	0	0	33 (68.8)	0	0	17 (35.4)	6 (12.5)	2 (4.2)	0	0	0	0	0	0	18 (37.5)	4 (8.3)	0	1 (2.1)	2.85±1.8	44 (91.7)	3 (6.2)	1 (2.1)

Abbreviations: IO=Internal opening (1-12 o'clock), ITS=Intersphincteric space: abscess(a), cavity(c), tract(t), Level at anal sphincters: IT (intersphincteric), LT (low transsphincteric), HT (high transsphincteric). ITS = Intersphincteric space, PRA = Perianal space, PRN = Perineum space, DPA = Deep post-anal space, ISA = Ischioanal space, IFL = Infralelevator space, SPL = Supralelevator space, EO= external opening (1-12 O'clock), AV= anal verge, Distance = from EO to AV

the PRA in 9 cases (69.2%) and PRN in 6 (46.2%). The external opening (EO) was located at 1 o'clock in 10 cases (76.9%), 2 o'clock in 2 cases (15.4%), and 11 o'clock in 1 case (7.7%). The mean EO-to-anal verge (AV) distance was 1.92 $\pm$ 0.6 cm, and all tracts were straight (13, 100%).

For IO at 2 o'clock (n=9), all cases had the tract component in the ITS (9, 100%) and were classified as LT fistulas (9, 100%). PRA involvement was present in all 9 cases (100%), while PRN involvement was found in 6 (66.7%). The EO was located at 1 o'clock in 1 case (11.1%) and at 2 o'clock in 8 cases (88.9%). The mean EO-to-AV distance was 2.77 $\pm$ 0.8 cm. The tract was straight in 8 cases (88.9%) and curved in 1 (11.1%).

For IO at 5 o'clock (n=9), all cases demonstrated the tract component in the ITS (9, 100%). Eight fistulas (88.9%) were LT, and 1 (11.1%) was HT. Extension involved the PRA in 8 cases (88.9%), ISA in 4 (44.4%), and PRN in 1 (11.1%). The EO was located at 5 o'clock in 8 cases (88.9%) and at 2 o'clock in 1 (11.1%). The mean EO-to-AV distance was 2.22 $\pm$ 0.6 cm. Seven tracts (77.8%) were straight, and 2 (22.2%) were curved.

For IO at 6 o'clock (n=80), the ITS showed the tract component in 78 cases (97.5%) and the c component in 2 cases (2.5%). Regarding fistula level, 6 cases (7.5%) were IT, 54 (67.5%) were LT, and 20 (25.0%) were HT. Extension into the anogenital spaces involved the PRA in 49 cases (61.2%), DPA in 20 (25.0%), ISA in 35 (43.8%), and PRN in 8 (10.0%). The EOs were widely distributed, most commonly at 7 o'clock

in 24 cases (30.0%) and 5 o'clock in 23 (28.8%), followed by 6 o'clock in 8 (10.0%), 3 o'clock in 6 (7.5%), 9 o'clock in 5 (6.2%), 11 o'clock in 5 (6.2%), combined 5 and 7 o'clock openings in 5 (6.2%), 2 o'clock in 3 (3.8%), and 10 o'clock in 1 (1.2%). The mean EO-to-AV distance was 2.66 $\pm$ 1.2 cm. The tract was straight in 41 cases (51.2%), curved in 34 (42.5%), and horseshoe-shaped in 5 (6.2%).

For IO at 7 o'clock (n=6), all cases demonstrated the tract component in the ITS (6, 100%), and all were LT fistulas (6, 100%). PRA involvement was present in all cases (6, 100%), and ISA involvement was present in 2 cases (33.3%). The EO was located at 7 o'clock in 4 cases (66.7%) and at 9 o'clock in 2 cases (33.3%). The mean EO-to-AV distance was 1.91 $\pm$ 0.3 cm, and all tracts were straight (6, 100%).

For IO at 11 o'clock (n=13), all cases demonstrated the tract component in the ITS (13, 100%). Ten fistulas (76.9%) were LT, and 3 (23.1%) were HT. PRA involvement occurred in 9 cases (69.2%) and PRN involvement in 10 (76.9%). The EO was located at 11 o'clock in 12 cases (92.3%) and at 10 o'clock in 1 case (7.7%). The mean EO-to-AV distance was 3.00 $\pm$ 1.0 cm, and all tracts were straight (13, 100%).

For IO at 12 o'clock (n=48), all cases demonstrated the tract component in the ITS (48, 100%). The fistula levels were IT in 5 cases (10.4%), LT in 36 (75.0%), and HT in 7 (14.6%). Extension involved the PRA in 36 cases (72.0%) and PRN in 33 (68.8%). The EO was located at 11 o'clock in 18 cases (37.5%),

1 o'clock in 17 (35.4%), 2 o'clock in 6 (12.5%), 12 o'clock in 4 (8.3%), 3 o'clock in 2 (4.2%), and combined 1 and 11 o'clock openings in 1 (2.1%). The mean EO-to-AV distance was 2.85 ± 1.8 cm. Most tracts were straight (44, 91.7%), while 3 (6.2%) were curved and 1 (2.1%) was horseshoe shaped.

Overall, tract patterns varied by the location of the internal opening. IOs at 1, 2, 5, 7, and 11 o'clock were predominantly associated with straight tracts and external openings near the corresponding IO position, whereas the 6 o'clock IO demonstrated the greatest anatomical variability, including a broader distribution of external openings and higher proportions of curved and horseshoe tracts. In contrast, fistulas originating from the 12 o'clock IO were predominantly straight but frequently terminated at anterior external openings, particularly at the 11 and 1 o'clock positions.

Natural Anal Abscess Patterns

For IO at 1 o'clock (n=11), ITS consisted of abscess in 72.7% and tract in 27.3%. Fistula levels were IT 36.4%, LT 54.5%, and HT 9.1%, with PRA and PRN abscesses in 54.5% and 27.3%, respectively. All EOs were located at 1 o'clock, with a mean EO–AV distance of 2.18 ± 1.8 cm, and all tracts were straight.

For IO at 2 o'clock (n=7), all cases had ITS abscesses. Fistula levels were IT 57.1% and LT 42.9%, with PRA abscesses in 42.9%. All EOs were at 2 o'clock; the mean EO–AV distance was 1.21 ± 0.2 cm, and all tracts were straight.

For IO at 5 o'clock (n=17), ITS abscess and tract were

found in 94.1% and 5.9%, respectively. Fistula levels were IT (41.2%) and LT (58.8%), with PRA and ISA abscesses at 58.8% and 5.9%, respectively. EOs were located at 5 o'clock in 94.1% and at 3 o'clock in 5.9%. The mean EO–AV distance was 1.52 ± 0.9 cm; 94.1% of tracts were straight, and 5.9% were curved.

For IO at 6 o'clock (n=55), ITS abscesses and tracts were present in 96.4% and 3.6%, respectively. Fistula levels were IT 56.4%, LT 40.0%, and HT 3.6%, with PRA, DPA, and ISA abscesses in 41.8%, 3.6%, and 10.9%, respectively. EOs were most common at 6 o'clock (36.4%), followed by 5 and 7 o'clock (25.5% each), with less frequent openings at 9 o'clock (1.8%), 10 o'clock (1.8%), paired 3/9 o'clock (3.6%), and paired 5/7 o'clock (5.5%). The mean EO–AV distance was 1.40 ± 0.6 cm; tract shapes were straight 87.3%, curved 5.5%, and horseshoe 7.3%.

For IO at 7 o'clock (n=10), all cases had ITS abscesses. IT and LT fistulas were equally distributed at 50.0%, with PRA and ISA abscesses at 50.0% and 20.0%, respectively. All EOs were at 7 o'clock, with a mean EO–AV distance of 1.50 ± 0.7 cm, and all tracts were straight.

For IO at 11 o'clock (n=10), ITS abscess and tract were found in 90.0% and 10.0%. Fistula levels were IT 30.0% and LT 70.0%, with PRA and PRN abscesses at 40.0% and 10.0%, respectively. All EOs were located at 11 o'clock; the mean EO–AV distance was 1.30 ± 0.4 cm, and all tracts were straight.

For IO at 12 o'clock (n=32), ITS abscess and tract were present in 87.5% and 12.5%. Fistula levels were IT 21.9% and

Table 3 The anal fistula map pattern of anal abscess

IO (O'clock)	N	ITS n (%)		Level n (%)		Anogenital spaces n (%)												External opening (o'clock) n (%)												Distance (EO to AV) (cm) mean ± SD	Tract shape n (%)											
						PRA			DPA			ISA			PRN																			I F L	S P L							
		a	t	IT	LT	HT	a	c	t	a	c	t	a	c	t	a	c	t	a	c	t	a	c	t	1	2	3	5	6		7	9	10	11	12	3,9	5,7	Straight	Curve	Horseshoe		
1	11	8 (72.7)	3 (27.3)	4 (36.4)	6 (54.5)	1 (9.1)	6 (54.5)	0	0	0	0	0	0	0	0	3 (27.3)	0	0	0	0	0	0	0	0	11 (100)	0	0	0	0	0	0	0	0	0	0	0	0	2.18±1.8	11 (100)	0	0	
2	7	7 (100)	0	4 (57.1)	3 (42.9)	0	3 (42.9)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7 (100)	0	0	0	0	0	0	0	0	0	0	0	0	1.21±0.2	7 (100)	0	0	
5	17	16 (94.1)	1 (5.9)	7 (41.2)	10 (58.8)	0	10 (58.8)	0	0	0	0	0	1 (5.9)	0	0	0	0	0	0	0	0	0	0	0	0	0	1 (5.9)	16 (94.1)	0	0	0	0	0	0	0	0	0	0	1.52±0.9	16 (94.1)	1 (5.9)	0
6	55	53 (96.4)	2 (3.6)	31 (56.4)	22 (40)	2 (3.6)	23 (41.8)	0	0	2 (3.6)	0	0	6 (10.9)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14 (25.5)	20 (36.4)	14 (25.5)	1 (1.8)	1 (1.8)	0	0	2 (3.6)	3 (5.5)	1.40±0.6	48 (87.3)	3 (5.5)	4 (7.3)		
7	10	10 (100)	0	5 (50)	5 (50)	0	5 (50)	0	0	0	0	0	2 (20)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10 (100)	0	0	0	0	0	0	0	1.50±0.7	10 (100)	0	0	
11	10	9 (90)	1 (10)	3 (30)	7 (70)	0	4 (40)	0	0	0	0	0	0	0	0	1 (10)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10 (100)	0	0	0	0	0	1.30±0.4	10 (100)	0	0	
12	32	28 (87.5)	4 (12.5)	7 (21.9)	25 (78.1)	0	22 (68.8)	0	0	0	0	0	0	0	0	7 (21.9)	0	0	0	0	0	0	0	7 (21.9)	7 (21.9)	0	0	0	0	0	0	0	0	11 (34.4)	6 (18.8)	1 (3.1)	0	1.79±0.7	31 (96.9)	1 (3.1)	0	

Abbreviations: IO=Internal opening (1-12 O'clock), EO = External opening (1-12 o'clock), ITS=Intersphincteric space: abscess(a), cavity(c), tract(t), Level at anal sphincters: IT (intersphincteric), LT (low transsphincteric), HT (high transsphincteric). ITS = Intersphincteric space, PRA = Perianal space, PRN = Perineum space, DPA = Deep post-anal space, ISA = Ischioanal space, IFL = Infralevator space, SPL = Supralevator space, AV= anal verge, Distance = from EO to AV

LT 78.1%, with PRA and PRN abscesses at 68.8% and 21.9%, respectively. EOs were distributed at 11 o'clock (34.4%), 1 and 2 o'clock (21.9% each), 12 o'clock (18.8%), and paired 3/9 o'clock (3.1%). The mean EO–AV distance was 1.79 ± 0.7 cm; 96.9% of tracts were straight, and 3.1% were curved.

Overall, anal fistula tracts were predominantly associated with intersphincteric abscesses and low fistula levels, with most tracts demonstrating a straight morphology. Internal openings at 1, 2, 5, 7, and 11 o'clock showed strong concordance with the corresponding external opening, whereas IO at 6 and 12 o'clock showed greater variation in tract direction and EO location. The 6 o'clock IO demonstrated the greatest anatomical complexity, including high transsphincteric fistulas, multiple external openings, and horseshoe tracts. The mean EO-to-anal verge distance was approximately 1-2 cm across all IO locations.

Fistula types differ between groups (Table 4). In the acute group (n=142), low-level fistulas predominated, mainly low transsphincteric (54.9%) and low intersphincteric (43.0%), with very few high transsphincteric cases (2.1%) and no high intersphincteric fistulas. In the chronic group (n=178), low transsphincteric fistulas were more common (74.2%), while low intersphincteric fistulas decreased (7.9%). High transsphincteric fistulas were more frequent (17.9%), and no high intersphincteric fistulas were observed.

Table 4 Anal fistula classification

Type	Acute anal fistula n= 142	Anal fistula n= 178
Low intersphincteric	61 (43%)	14 (7.9%)
Low transsphincteric	78 (54.9%)	132 (74.2%)
Anterior high transsphincteric	1 (0.7%)	11 (6.1%)
Posterior high transsphincteric	2 (1.4%)	21 (11.7%)
High intersphincteric	0	0

Operative Procedures According to Clinical Presentation and Fistula Complexity

We stratified patients by presentation and complexity (Figure 2). In acute simple fistula, fistulotomy with marsupialization predominated (94.3%), with minimal use of drainage seton (3.5%). In acute complex fistula, procedures were limited, mainly LIFT (0.7%) and drainage seton (1.4%). In the chronic group, fistulotomy with marsupialization remained common in simple cases (80.3%), while complex fistulas were more often managed with sphincter-preserving techniques, particularly LIFT (14.6%) and drainage seton (3.4%). Overall, fistulotomy with marsupialization was the main approach for simple fistulas in both groups, without a statistically significant difference ($p = 0.089$; 95% CI – 0.015 to 0.205).

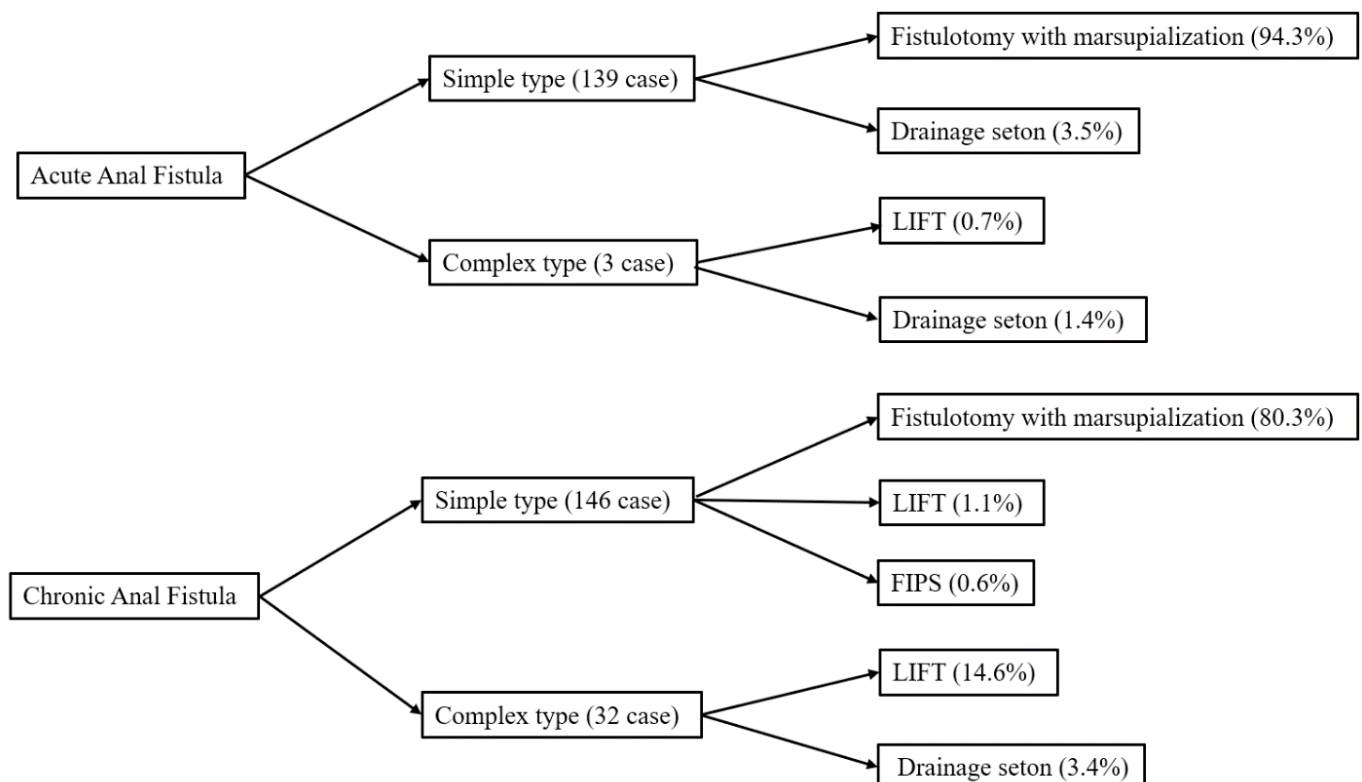


Figure 2 Operative procedures for anal fistula

Functional outcome

No major intraoperative complications occurred. Minor issues (urinary retention, minor bleeding) were managed conservatively, with no pelvic sepsis. We observed no fecal incontinence; only a few patients reported slight perianal dampness.

Healing Outcomes

We followed all patients until healing or the end of the study. Median follow-up was 42 months (95% CI 33-50 months). Median follow-up was 48 months (95% CI 30 - 65 months) in the acute group and 40 months (95% CI 29 - 50 months) in the chronic group. Healing rates were higher in the acute group (97.2%) than in the chronic group (92.1%) (95% CI 1.0 - 11.2), $p < 0.017$. As shown in **Table 5**

Recurrence Outcomes

Recurrence occurred in 2.8% of the acute group and 7.9% of the chronic group (95% CI 0.2-9.9), $p < 0.041$, and recurrence - free survival was significantly higher in the acute group ($p = 0.043$, log - rank), as shown in **Figure 3**. Estimated mean recurrence-free survival time was 145 months (95% CI 140.8 - 150) in the acute group and 127 months (95% CI 119.5 - 135.8) in the chronic group, $p < 0.01$. In recurrent cases, the acute group received curettage (1), fistulotomy (2), and fistulotomy with seton (1), while the chronic group underwent curettage (8), re-LIFT (2), fistulotomy (3), and fistulotomy with sphincteroplasty (1). All recurrent cases achieved complete healing after reoperation (100%), with no further recurrence.

Table 5 Healing and recurrence outcomes in acute and chronic anal fistula

Outcome	Acute anal fistula	Anal fistula	Between-group comparison	p-value
Median follow-up, months (95% CI)	48 (30-65)	40 (29-50)	-	-
Healing rate, %	97.2	92.1	Difference: 6.2 percentage points (95% CI 1.0 - 11.2)	0.017
Recurrence rate, %	2.8	7.9	Difference: 5.0 percentage points (95% CI 0.2 - 9.9)	0.041
Estimated means recurrence-free survival, months (95% CI)	145 (140.8 - 150.0)	127 (119.5 - 135.8)	18 months longer in the acute group	<0.01

Prognostic Factor Analysis

In univariate analysis, recurrence was significantly associated with high transsphincteric fistula (HR 23.37, 95% CI 8.41- 64.92, $p < 0.001$), deep post-anal space involvement (HR 15.05, 95% CI 5.59 - 40.55, $p < 0.001$), ischioanal extension (HR 4.86, 95% CI 1.91 - 12.32, $p = 0.001$), and curved tracts (HR 6.30, 95% CI 2.49 - 15.91, $p = 0.001$). Chronic fistula showed borderline significance (HR 2.98, 95% CI 0.98-9.06, $p = 0.054$), while age, sex, BMI >25, and raw food consumption were not significant.

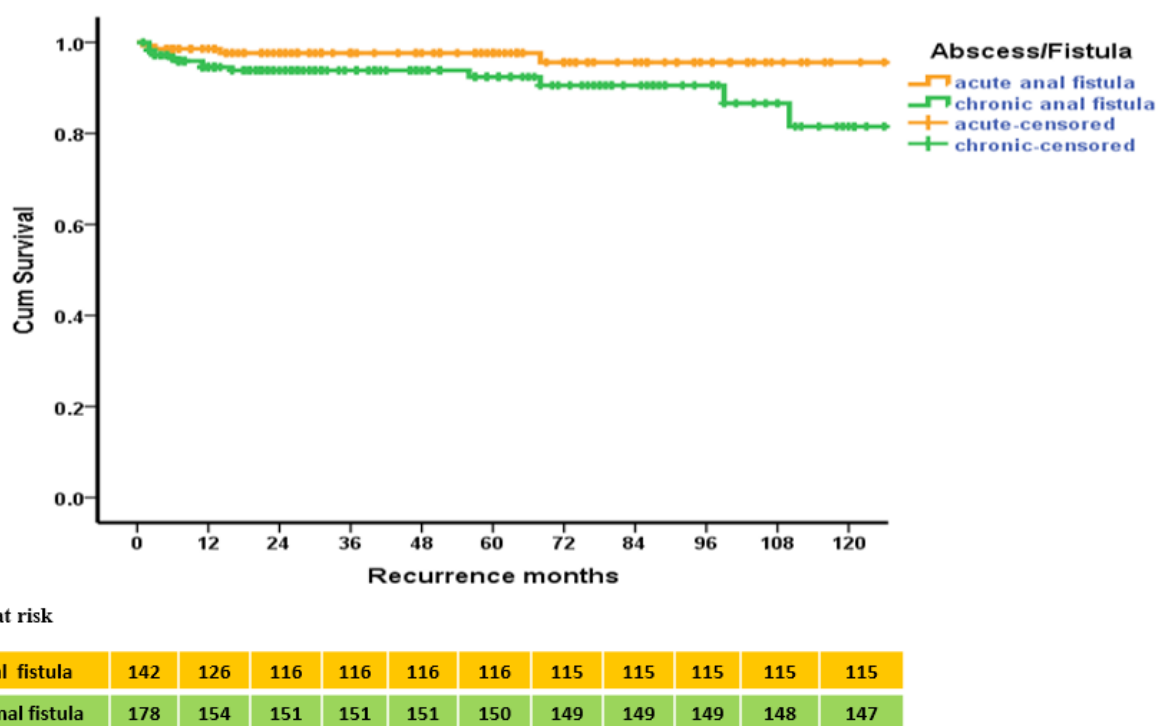


Figure 3 The Kaplan–Meier estimate of recurrence-free survival

In multivariate analysis, only high transsphincteric fistula remained an independent predictor of recurrence (adjusted HR 23.13, 95% CI 7.76 - 68.92, $p < 0.001$). As shown in **Table 6**. The high HR likely reflects greater anatomical complexity. However, the wide 95% CI and small number of recurrence events indicate limited precision, so the finding should be interpreted cautiously and confirmed in larger studies

Complete case analysis

Complete-case analysis retained 16 recurrence events, including 288 patients for BMI and 295 for raw-food consumption. Missing data affected only the univariable analyses because these variables were not included in the multivariable model. The log-minus-log plot showed that the curves for low and high transsphincteric fistulas were approximately parallel and did not clearly intersect, suggesting that the proportional hazards assumption was reasonably satisfied. High transsphincteric fistula remained the only significant predictor of recurrence (HR 43.95, 95% CI 11.84-163.16; $p < 0.001$), confirming a consistent direction of effect.

DISCUSSION

This study summarizes surgical outcomes for acute and chronic anal fistulas at Rayong Hospital, demonstrating success rates and risk factors consistent with both international literature and prior Thai tertiary-care studies.

Healing and recurrence

In this study, acute anal fistula showed a healing rate of 97.2% and recurrence of 2.8%, outperforming prior reports (healing 66.3-79.7%, recurrence 20.9-33.7%)¹³⁻¹⁷, likely due to the predominant use of fistulotomy with marsupialization rather than incision and drainage. Chronic fistula demonstrated a healing rate of 92.1% and recurrence of 7.9%, compared with previous studies (healing 79.4-87.5%, recurrence 12.5-20.6%)^{2,7,18,19}. Median time to recurrence was 8.5 months (IQR 1.5-54.5) in acute cases and 9 months (IQR 2.75-59) in chronic cases, longer than some international reports 3.2 months (IQR, 2.1-4.6)^{13,15,16}, with most recurrences occurring within 6-24 months^{2,7,17-19}, supporting at least 2-year follow-up⁷.

ACUTE ABSCESS VS CHRONIC FISTULA MANAGEMENT

Historically, acute anorectal abscess has been treated with incision and drainage (I&D) alone, with delayed fistula surgery due to concerns about operating in infected tissue. However, increasing evidence supports definitive treatment during the acute stage when feasible³. In this study, 97.7% of acute cases underwent fistulotomy with marsupialization, achieving a low recurrence rate of 2.8% and a high healing rate of 97.2%. These outcomes are consistent with a meta-analysis reporting a recurrence rate of 3.7% for fistulotomy with drainage (RR 0.13, 95% CI

Table 6 Prognostic factors associated with fistula recurrence

Variables	Univariate HR (95% CI)	p-value	Adjusted HR (95% CI)	p-value
Age, years	1.009 (0.965-1.054)	0.703	-	-
BMI, kg/m²				
<25	Reference	-	-	-
≥25	1.950 (0.718-5.297)	0.190	-	-
Sex				
Male	Reference	-	-	-
Female	1.440 (0.470-4.416)	0.523	-	-
Raw food consumption				
No	Reference	-	-	-
Yes	1.387 (0.502-3.832)	0.529	-	-
Anal fistula type				
Acute	Reference	-	-	-
Chronic	2.980 (0.980-9.060)	0.054	-	-
Transsphincteric level				
Low	Reference	-	Reference	-
High	23.373 (8.414-64.924)	<0.001	23.126 (7.760-68.921)	<0.001
Deep postanal space involvement				
No	Reference	-	-	-
Yes	15.050 (5.589-40.549)	<0.001	-	-
Ischioanal space involvement				
No	Reference	-	-	-
Yes	4.857 (1.914-12.322)	<0.001	-	-
Tract shape				
Straight	Reference	-	-	-
Curved	6.297 (2.493-15.907)	<0.001	-	-

0.07-0.24)²⁰. Importantly, outcomes were not inferior to delayed surgery, and many patients were successfully treated in a single procedure, avoiding reoperation. This approach is consistent with the concept that anal abscess and anal fistula represent different stages of the same disease process³. In this cohort, one-stage treatment during the acute abscess phase was associated with high healing and low recurrence. However, because this was a retrospective observational study, these findings do not establish that one-stage treatment is superior to delayed surgery. Treatment selection depended on intraoperative anatomy: patients with clearly identified, low-risk tracts were more likely to undergo immediate fistulotomy, whereas unclear or complex fistulas were managed with drainage, seton placement, and delayed definitive surgery. This confounding by indication may partly explain the favorable outcomes in the one-stage group. Therefore, one-stage treatment may be considered in carefully selected patients when the tract and internal opening are clearly defined, but prospective comparative studies are needed before broader recommendations can be made. Regarding functional outcomes, previous studies have reported low incontinence rates of 2.8% in acute cases¹⁶, with no significant difference in long-term incontinence (RR 3.06, 95% CI 0.7 - 13.45)²⁰. In chronic fistula, mean Wexner scores range from 0-3^{2,7,19}. In the present study, no patients developed fecal incontinence in either group; only occasional mild perianal dampness was reported, indicating favorable functional results alongside high healing rates.

The anal fistula map pattern

Rojanasakul's classification was applied for its practical role in guiding surgical decision-making and facilitating communication among clinicians, surgeons, and radiologists⁸. In this study, fistula mapping using operative findings and imaging was performed in all patients, with successful identification of the internal opening in 100%, a key factor associated with healing and prevention of recurrence^{3,18}. Acute anal fistulas were predominantly low-level (low intersphincteric and low transsphincteric), whereas chronic fistulas showed a higher proportion of high transsphincteric tracts, indicating greater complexity. This pattern is consistent with prior studies showing progression from intersphincteric origin to more complex transsphincteric disease over time²¹. High transsphincteric fistulas are considered complex and often require sphincter-preserving techniques to reduce incontinence risk²². Overall, these findings support that increasing chronicity is associated with greater anatomical complexity, impacting surgical planning and outcomes. At Rayong Hospital, MRI for anal fistula mapping was introduced in 2022 and utilized in 36 patients (20.2%), primarily in chronic or complex cases. MRI is particularly valuable in suspected high transsphincteric or recurrent fistulas, with reported accuracy

of 92.5% and sensitivity of 93.8%²³, and has been associated with reduced recurrence rates⁵. In this study, recurrence was lower in patients who underwent MRI (42.8%) compared with those who did not (57.1%). Goodsall's rule was applied during preoperative and intraoperative assessment, with an accuracy of approximately 71.6-72%²³, while MRI served as an adjunct tool in selected cases. Nevertheless, MRI showed a missed diagnosis rate of 19.44% and an inconclusive-interpretation rate of 25% in the present study. This relatively high proportion may reflect the early phase of MRI implementation at our institution and variations in radiological interpretation during the initial adoption period. Overall, comprehensive fistula mapping - combining clinical assessment, Goodsall's rule, and selective MRI - enhances anatomical delineation, improves surgical planning, increases cure rates, reduces recurrence, and facilitates sphincter preservation. This approach contributes to better functional outcomes, reduced morbidity, and improved patient counseling and surgical confidence.

Comparison of Surgical Techniques

In this study, fistulotomy was predominantly performed for simple fistulas (intersphincteric and low transsphincteric) and achieved high primary cure rates of 97.7% in the acute group and 97.2% in the chronic group. These outcomes are comparable to LIFT results reported by Songphol Malakorn (91%)¹¹. Additionally, fistulotomy required significantly shorter operative time (17.8 ± 11.38 min vs 40.9 ± 16.75 min for LIFT; $p < 0.01$)^{24,25}, reflecting its technical simplicity in appropriately selected cases. In this study, LIFT was mainly reserved for high transsphincteric fistulas, with a healing rate of 68.8%, within the reported range of 57-83%^{6,7}. Staged fistulotomy with seton achieved 83.3% healing, comparable to 85% in previous studies⁷. The relatively higher recurrence observed after LIFT likely reflects greater anatomical complexity and technical factors, including accurate tract identification and secure ligation^{3,6}. Importantly, repeat surgery resulted in 100% healing in all patients in this study, consistent with prior Thai studies reporting 99.2-100%^{6,11}, highlighting the importance of careful reassessment and tailored surgical management in recurrent disease.

Prognostic factors

Fistula complexity was the strongest predictor of recurrence, with high transsphincteric fistulas associated with a markedly increased risk (adjusted HR 23.13, 95% CI 7.76 - 68.92; $p < 0.01$), consistent with previous studies reporting HR 4.74 - 4.81^{7,18}. This emphasizes that patients with complex fistulas require careful counseling regarding recurrence risk and closer postoperative follow-up. The median time to recurrence was 8.5-9 months in both groups, longer than prior reports in

acute fistula (3.2-7 months)^{16,17}, while most chronic recurrences occurred within 24 months^{2,7}. These findings support a follow-up period of at least 2 years to ensure adequate detection of recurrence. Patient-related factors were not significant in multivariate analysis, likely due to the small sample size and low event rate. However, univariate analysis suggested possible associations with sex, BMI >25, and raw food consumption. Notably, comorbidities were common, including obesity (60%), raw food consumption (57.5%), HIV infection (20.9%), and diabetes (18%). Previous studies have identified BMI >30 and diabetes as significant risk factors for recurrence^{6,19}, while broader evidence also highlights obesity (BMI >25), high salt intake, spicy or greasy food consumption, diabetes, smoking, and heavy alcohol use as contributors to fistula development¹. These findings suggest the need for further investigation in larger case – control studies or prospective studies.

Clinical and practical implications

This study's findings have several key clinical implications. Accurate fistula mapping is essential at both initial and intraoperative assessment, using Goodsall's rule and adjunct imaging (MRI, endoanal ultrasound, EUA) in complex cases to improve identification of the tract and internal opening²³. A one-stage approach in selected anorectal abscess patients may shorten disease duration and reduce recurrence without increasing complications³. However, when inflammation obscures anatomy, simple drainage with delayed definitive surgery or seton placement for 8-12 weeks is recommended to allow tract maturation and prevent false tract formation⁶. Tailor surgical management to fistula complexity. Fistulotomy remains the gold standard for simple fistulas, with healing rates of approximately 95-98%^{2,7,20}, whereas sphincter-preserving techniques such as LIFT are preferred for complex fistulas, achieving success rates of around 70-90% with low morbidity^{6,7}. Even after failure, repeat or alternative procedures can still provide favorable outcomes^{6,11}. Modifiable risk factors - including obesity, diabetes, HIV infection, and raw food consumption - should be addressed. Because most recurrences occur within the first 2 years (approximately 80-90%)^{2,7,17-19}, regular follow-up every 4-6 months is recommended for early detection and optimal management.

Generalizability (external validity): The findings may be generalizable to patients with cryptoglandular anal fistula treated in similar tertiary-care settings, particularly where experienced colorectal surgeons perform management guided by anatomical fistula mapping. The favorable outcomes observed likely reflect consistent surgical decision-making within a specialized setting. However, caution is warranted when extrapolating these results to other healthcare environments, such as primary or secondary care centers, where differences in surgical expertise, resources,

and access to imaging (e.g., MRI) may affect outcomes. Additionally, as this was a single-center study conducted in Thailand, variations in patient characteristics and healthcare systems may limit broader applicability. Further multicenter or prospective studies are needed to confirm these findings.

Limitations: Potential sources of bias include selection bias due to retrospective design and surgeon-based decision-making, as well as information bias from incomplete medical records. This study also had a moderate sample size and low event rate. MRI was unavailable in the early phase; therefore, fistula assessment relied on Goodsall's rule and examination under anesthesia using lacrimal probes and water injection. Anal manometry was not performed, and continence was evaluated clinically¹⁰.

Future perspectives: Emerging techniques such as video-assisted anal fistula treatment (VAAFT)²⁶, fistula laser closure (FiLaC)²⁷, and more recently, intra-anal fistulotomy with fistula opening closure (IFOC)²⁸ aim to achieve high cure rates with minimal risk of incontinence. Although this study did not evaluate these approaches, they should be critically compared with established procedures such as fistulotomy and LIFT. This study indicates that, even without advanced technologies, meticulous application of conventional techniques can still provide satisfactory outcomes in most patients. Anal fistula mapping remains a key concept in modern management. Rojanasakul's classification offers a practical framework for identifying the internal opening and guiding appropriate surgical strategies for different fistula patterns⁸. Incorporating this approach into routine practice may help standardize treatment and improve outcomes. Looking forward, advances in imaging and the integration of artificial intelligence and machine learning may further enhance diagnostic accuracy, risk prediction, and support increasingly precise and personalized treatment strategies.

CONCLUSION

Anatomy-tailored surgery was associated with high healing and low recurrence rates in both acute and chronic cryptoglandular anal fistula. High transsphincteric anatomy was strongly associated with recurrence, while one-stage acute management appeared feasible in carefully selected patients. However, these findings should be interpreted cautiously because of the retrospective single-center design, low number of recurrence events, possible treatment-selection bias, and variable MRI availability during the study period. Larger prospective multicentre studies are needed to confirm these findings. A follow-up period of at least two years is recommended to adequately assess long-term outcomes.

What is already known on this topic

Implications based on external evidence: Previous literature supports careful anatomical assessment, selective MRI or endoanal ultrasound for complex or recurrent fistulas, and longer follow-up because some recurrences occur late. These recommendations are consistent with, but were not directly tested by, the present study.

What this study adds

Anatomy-tailored surgery was associated with high healing and low recurrence rates. High transsphincteric fistula was the only independent predictor of recurrence, although the estimate was imprecise because of the small number of recurrence events. One-stage acute management appeared feasible in selected patients, but this observational study cannot establish superiority over delayed treatment.

Acknowledgement

The authors thank the Department of Surgery staff, the medical records team at Rayong Hospital for data collection, the patients whose records were included, and the hospital administration for their support.

REFERENCE

1. Wang D, Yang G, Qiu J, et al. Risk factors for anal fistula: a case-control study. *Tech Coloproctol*. 2014 Jul;18(7):635-9. doi: 10.1007/s10151-013-1111-y.
2. Andreou C, Zeindler J, Oertli D, et al. Longterm outcome of anal fistula - A retrospective study. *Sci Rep*. 2020 Apr 16;10(1):6483. doi: 10.1038/s41598-020-63541-3.
3. Włodarczyk M, Włodarczyk J, Sobolewska-Włodarczyk A, et al. Current concepts in the pathogenesis of cryptoglandular perianal fistula. *J Int Med Res*. 2021 Feb;49(2):300060520986669. doi: 10.1177/0300060520986669.
4. Sanchez-Haro E, Vela E, Cleries M, et al. Clinical characterization of patients with anal fistula during follow-up of anorectal abscess: a large population-based study. *Tech Coloproctol*. 2023 Oct;27(10):897-907. doi: 10.1007/s10151-023-02840-z.
5. Fang F, Wen L. Multifactorial Analysis of Postoperative Recurrence of Anal Fistula: A Retrospective Study. *J Multidiscip Healthc*. 2025 Sep 22;18:6015-24. doi: 10.2147/JMDH.S537028
6. Sirikurnpiboon S, Awapittaya B, Jivapaisarnpong P. Ligation of intersphincteric fistula tract and its modification: Results from treatment of complex fistula. *World J Gastrointest Surg*. 2013 Apr 27;5(4):123-8. doi: 10.4240/wjgs.v5.i4.123.
7. Chadbunchachai W, Lohsiriwat V, Paonariang K. Long-term outcomes after anal fistula surgery: results from two university hospitals in Thailand. *Ann Coloproctol*. 2022 Apr;38(2):133-40. doi: 10.3393/ac.2021.01.06.
8. Arun Rojanasakul, Tsang CB. *Emerging Concepts in Classification of Anal Fistulae*. Springer eBooks. 2020 Dec 10;995-1002.
9. Steele SR, Kumar R, Feingold DL, et al. Standards Practice Task Force of the American Society of Colon and Rectal Surgeons. Practice parameters for the management of perianal abscess and fistula-in-ano. *Dis Colon Rectum*. 2011 Dec;54(12):1465-74. doi: 10.1097/DCR.0b013e31823122b3.
10. Browning GG, Parks AG. Postanal repair for neuropathic faecal incontinence: correlation of clinical result and anal canal pressures. *Br J Surg*. 1983 Feb;70(2):101-4. doi: 10.1002/bjs.1800700216.
11. 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 Oct;60(10):1065-70. doi: 10.1097/DCR.0000000000000880.
12. Zbar AP. David Henry Goodsall: reassessment of the rule. *Tech Coloproctol*. 2009 Sep;13(3):185-8. doi: 10.1007/s10151-009-0511-5.
13. Kheira Gabssi. Risk factors for perianal abscess recurrence after incision and drainage: a review of the literature. *International Surgery Journal*. 2025 Jan 28;12(2):255-9.
14. Skovgaards DM, Perregaard H, Dibbern CB, et al. Fistula development after anal abscess drainage-a multicentre retrospective cohort study. *Int J Colorectal Dis*. 2023 Dec 13;39(1):4. doi: 10.1007/s00384-023-04576-6.
15. Narayanan S, Althans AR, Reitz KM, et al. Drainage of anorectal abscesses in the operating room is associated with a decreased risk of abscess recurrence and fistula formation. *Am J Surg*. 2023 Feb;225(2):347-51. doi: 10.1016/j.amjsurg.2022.09.005.
16. Huseynov A, Kuşlu Çiçek SN. Factors influencing fistula formation following perianal abscess treatment. *Eur Res J*. 2025;11(4):794-9. doi:10.18621/eurj.1678608
17. Lohsiriwat V, Yodying H, Lohsiriwat D. Incidence and factors influencing the development of fistula-in-ano after incision and drainage of perianal abscesses. *J Med Assoc Thai*. 2010 Jan;93(1):61-5.
18. Mei Z, Wang Q, Zhang Y, et al. Risk Factors for Recurrence after anal fistula surgery: A meta-analysis. *Int J Surg*. 2019 Sep;69:153-64. doi: 10.1016/j.ijssu.2019.08.003.
19. Khan S, Kotcher R, Herman P, et al. Predictors of recurrence and long-term patient reported outcomes following surgical repair of anal fistula, a retrospective analysis. *Int J Colorectal Dis*. 2024 Mar 11;39(1):37. doi: 10.1007/s00384-024-04602-1.
20. Malik AI, Nelson RL, Tou S. Incision and drainage of perianal abscess with or without treatment of anal fistula. *Cochrane Database Syst Rev*. 2010 Jul 7;2010(7):CD006827. doi: 10.1002/14651858.CD006827.

21. Xiao J, Santos E, Bonsu NY, Kim W, Eisenberg M, Cusick M, et al. Anal fistula: from diagnosis and classification to surgical management. *IntechOpen*; 2024. doi:10.5772/intechopen.1003888
22. Abe T, Tanaka Y, Kunimoto M, Hachiro Y, et al. Prevalence and Characteristics of Transsphincteric Anal Fistulas Unclassifiable by the Sumikoshi Classification: A Single-center Retrospective Study. *J Anus Rectum Colon*. 2025 Apr 25;9(2):244-51. doi: 10.23922/jarc.2024-086.
23. S DV, Thulasibai L, Paul D, Babu AV, Jayasankar, Kumari B. Goodsall's rule—its predictive accuracy in tracing the tract of fistula in ano. *International Surgery Journal*. 2020 Nov 2;7(12):4116–6.
24. Liu WY, Aboulian A, Kaji AH, et al. Long-term results of ligation of intersphincteric fistula tract (LIFT) for fistula-in-ano. *Dis Colon Rectum*. 2013 Mar;56(3):343-7. doi: 10.1097/DCR.0b013e318278164c.
25. Alapach S, Khaimook A. Comparison between ligation of intersphincteric fistula tract (LIFT) technique and conventional fistulotomy in the treatment of fistula-in-ano at Hat Yai Regional Hospital. *Thai J Surg*. 2014; 35:20-23.
26. Emile SH, Elfeki H, Shalaby M, et al. A Systematic review and meta-analysis of the efficacy and safety of video-assisted anal fistula treatment (VAAFT). *Surg Endosc*. 2018 Apr;32(4):2084-93. doi: 10.1007/s00464-017-5905-2.
27. Elfeki H, Shalaby M, Emile SH, et al. A systematic review and meta-analysis of the safety and efficacy of fistula laser closure. *Tech Coloproctol*. 2020 Apr;24(4):265-74. doi: 10.1007/s10151-020-02165-1.
28. Jearanai S, Pattana-Arun J. A novel technique for treating complex anal fistulas with intersphincteric extension: intra-anal fistulotomy with fistula opening closure (IFOC). *Tech Coloproctol*. 2025 Mar 29;29(1):90. doi: 10.1007/s10151-025-03111-9.

Reduction Mammoplasty: The Factors that Influence Outcomes and Patients' Satisfaction in Calabar, Nigeria

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Abstract

Background: Breast reduction surgery, also called reduction mammoplasty, is a common breast aesthetic surgery.

Objective: We aim to investigate factors that influence reduction mammoplasty outcomes and patient satisfaction at our institution.

Patients and Methods: This 10-year retrospective study included 39 patients who underwent reduction mammoplasty from January 2014 to December 2023. We reviewed patients' records, including sociodemographic parameters, complication types, and patient satisfaction levels. Exclusion criteria included incomplete records and other breast surgeries performed for reasons unrelated to the study's purpose. We analyzed the results using the Statistical Package for the Social Sciences (SPSS) version 20.0, along with questionnaires (5-point Likert scale) and postoperative BREAST-Q outcomes to assess patient satisfaction.

Results: Table 1 shows the socio-demographic parameters, including age range, educational level, and surgeon cadre; all patients were female. The Table showed an age range of 25-50 years, with a mean value of 38 ± 5 years. The 41-50 age group had the most patients. All surgeons were plastic surgeons. Table 2 shows the various complications and their corresponding frequencies. Predictors such as obesity and surgical technique constituted major outcome parameters. Patient satisfaction with the decision, assessed using a 5-point Likert scale, was high (90-98%), and the BREAST-Q outcome was also high ($p = 0.03$).

Conclusion: Reduction mammoplasty is a common breast aesthetic surgery. The factors that influence outcomes were age, educational level, breast asymmetry, obesity, surgical technique, and impact on sexuality. We identified factors that influence patient outcomes. Overall patient outcomes showed a high level of patient satisfaction.

Keywords: Reduction mammoplasty, Breast reduction, Patients' satisfaction, Breast surgery complications, Mammoplasty outcome

INTRODUCTION

Breast Reduction surgery, also known as Reduction Mammoplasty, is a surgical procedure that reduces the size of overly large breasts or removes excess breast tissue, fat, and skin, making the breasts more proportional to the rest of the body.¹ It is commonly done for aesthetic reasons. Large breasts, called macromastia, especially in adult or juvenile mammary hypertrophy in teenagers and young adults, are a

frequent presentation to plastic surgeons. Although macromastia is common, it is rare in men and carries an ominous prognosis.²

Aetiologically, breast enlargement could be due to hormonal imbalance, mammary hypertrophy, or hyperplasia.³ The aetiology of breast enlargement could be grouped into three main headings: (1) Hormonal imbalance, which could be due to menstrual cycle, puberty, pregnancy, use of oral contraceptives,

Received for publication 28 June 2025; Revised 8 April 2026; Accepted 28 August 2026

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<https://doi.org/10.64387/tjs.2026.276251>

or hormone replacement therapy, menopause, gynecological disease (polycystic ovarian disease); (2) Breast Injury could be result from blow to the breast, rough handling, tight brassiere, surgery to the breast and (3) Breast diseases such as fibrocystic breast diseases, benign breast tumours, breast cancers, mastitis, breast cyst and galactorrhea. Differential diagnosis of unilateral breast enlargement should be ruled out, such as giant fibroadenoma, cystosarcoma phyllodes, virginal hamartoma, virginal hypertrophy, hematoma, and breast cancer in adolescence.

In screening patients for breast reduction surgery, a detailed history should be taken to rule out malignant breast disease, and a good breast examination should be done. The patient's history is aimed at evaluating symptoms of hypertrophy, reviewing breast cancer risk factors (both personal and familial), discussing scarring tendencies, reviewing the history of any bleeding disorders, diabetes mellitus, or collagen vascular diseases, and discussing the smoking history, as well as the general medical background.⁴ Indications for reduction mammoplasty include very large breasts, shoulder pain, Cervical and upper thoracic backache, severe embarrassment, which may be physical or sexual, recurrent intertrigo, inability to exercise due to breast discomfort, heaviness, and brassiere sleeve cutting injury could be the presentation of patients with breast hypertrophy.⁵

The presence of benign disease should be diagnosed prior to aesthetic breast surgery. Although a history should be taken, a thorough breast examination should be done to evaluate breast architecture. The use of preoperative and postoperative mammograms in cosmetic surgery of the breast is very important to rule out malignancies and other breast conditions.⁶

Different surgical techniques have been used, including the traditional inverted T (anchor) technique, Vertical (Lollipop), superomedial, and inferior pedicle techniques. A good understanding of each procedure is required by the surgeon.

Why should we reduce the breast size? Does reduction mammoplasty convey any physical, psychological, or aesthetic benefits? Benefits of breast reduction include reduced shoulder pain, improved sleep, easier exercise, better clothing fit, improved self-confidence, better posture, a more proportionate breast size to the body's physique, and reduced chafing. It is a cosmetic surgical procedure aimed at reducing large ptotic or sagging breasts to a more comfortable size or shape.⁷

There are known factors that affect the outcome of reduction mammoplasty such as patients' factors (age, Body Mass Index, smoking habit), obesity with increased BMI, surgical techniques which is dependent on surgeon prefer-

ence and the nature of the breast, inpatients setting, breast asymmetry after surgery, postoperative infection, swelling, scarring, Advanced American Society of Anaesthesiologists, and the association of conditions that makes the patient high-risk patient.⁸

Studies have shown that several factors influence breast reduction outcomes; however, no study has been conducted in our local setting. We aimed to study the factors that influence the outcome of reduction mammoplasty and the level of patient satisfaction in the institution.

PATIENTS AND METHODS

This 10-year retrospective study spans January 2014 to December 2023 and includes 39 patients who underwent reduction mammoplasty at the Teaching Hospital. We reviewed patients' records, including socio-demographic parameters, complication types, and patient satisfaction using questionnaires (5-point Likert scale) and the BREAST-Q Questionnaire. Exclusion criteria were incomplete records and breast surgeries, such as malignancies and cysts. We analyzed the results using the Statistical Package for the Social Sciences (SPSS) version 20.0. We assessed patients' satisfaction with the decision using a 5-point Likert scale and the BREAST-Q outcome.

RESULTS

Table 1 shows the socio-demographic parameters, including age range, educational level, and surgeon cadre; all patients were female. The age range was 20-50 years, with a mean of 38 ± 5 years. The 41-50 age group had the most patients. All surgeons were plastic surgeons, and all patients were female.

Table 1 Socio-demographic parameters of the study

S/N	Parameters	Frequency (N = 39)	Percentage (%)
1	Age		
	20-30 years	10	25.6
	31-40 years	13	33.3
	41-50 years	16	41.1
2	Educational level		
	Primary school	3	7.7
	Secondary school	13	33.3
	Tertiary education	23	59.0
3	Sex		
	Females	39	100.0
4	Cadre of Surgeons		
	Plastic surgeons	4	100.0

Table 2 shows the different complications, frequencies, and percentages of occurrence in 39 Patients

S/N	Complications	Frequency (N=39)	Percentage (%)
1	Breast asymmetry	2	5.2
2	Surgical site infection	6	15.4
3	Scarring	5	12.8
4	Nipple insensitivity	2	5.1
5	Partial nipple necrosis	1	2.6
6	Surgical techniques		
	Lollipop (Vertical)	4	10.3
	Inverted T	2	5.2
	Superomedial pedicle	12	30.7
	Inferior pedicle	11	28.2
	Inferior pedicle	10	25.6
7	Obesity		
	Not obese BMI (25.0-29.9 kg/m ²)	1	2.6
	Low obese BMI (30.0-34.9 kg/m ²)	8	20.5
	Moderately obese BMI (35-39.9 kg/m ²)	16	41.0
	High Risk obese BMI (≥ 40.0 kg/m ²)	14	35.9

Table 2 shows the different complications and their frequency of occurrence. Obesity and the type of surgical technique were among the main challenges. The results were breast asymmetry 1 (5.1%) scarring 5 (12.8 %), postoperative infection 6 (15.4%), Nipple insensitivity 2 (5.1%), surgical techniques - Invert T-2 (5.1%) and vertical method 4 (10.3%), partial nipple necrosis 1 (2.6 %) and obesity related complications, with overall complication rate of 18 (46.2 %).

Upon assessing patients' satisfaction with the decision using a 5-point Likert scale, it was revealed that despite complications, patients still expressed satisfaction, with a score of 90-98%, and a positive BREAST-Q outcome ($p < 0.03$). Patients with partial nipple necrosis and hypertrophic scars expressed their displeasure with the procedures.

DISCUSSION

Reduction mammoplasty is a common aesthetic surgery in developed countries. However, it is gaining much acceptance and beauty value in Sub-Saharan Africa.⁹ It is not completely free from complications. The study population was made up of females who presented themselves for breast reduction. The socio-demographic variables were evaluated as shown in **Table 1**.

Age: The age range was 20 to 50 years, with a mean of 38 ± 5 years. It showed that the age ranges of 31-40 years and 41-50 years had higher numbers of patients coming for breast reduction. The majority of the patients had completed their childbearing before embarking on breast reduction. Studies have shown that Caucasians age peak for reduction breast surgeries was 31-40 years. No significant complications were associated with age-related differences across age ranges. Apha et al con-

ducted a study among different age groups and concluded that there was no significant difference among the groups.¹⁰ Also, in a population-level analysis of reduction mammoplasty, it was indicated that with proper patient selection, the procedure can be performed safely in all ages.¹¹

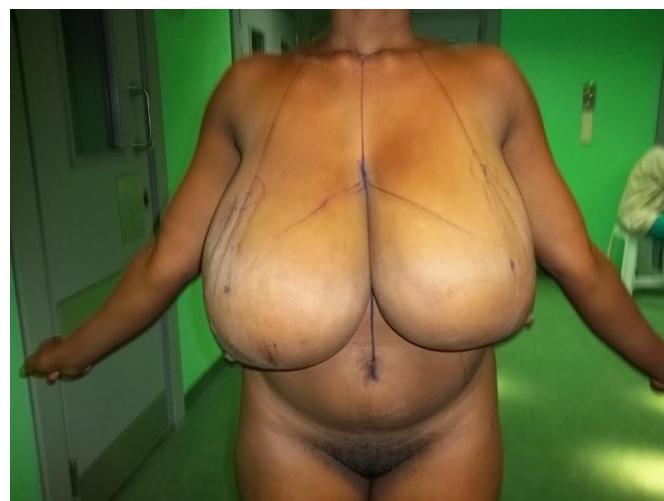


Figure 1 Showing a 42 -year -old female with breast hypertrophy ready to undergo reduction mammoplasty

Educational levels: The study revealed reflections on interest in and acceptance of breast reduction surgery based on participants' educational levels. The study groups consisted of 3 (7.7%) primary school students, 13 (33.3%) secondary school students, and 23 (59.0%) tertiary-level students, representing the percentages of the study groups by highest educational level. One can conclude that education level may influence awareness and acceptance of the procedure. No literature supports a relationship between breast reduction and educational level. However, studies have shown that higher educational standards generally support aesthetic surgeries, but they do not influence the complication rate.¹²

Cadre of surgeons: In this study, all the surgeons were plastic surgeons with an overall complication rate of 2.5%. Masound et al.¹³ evaluated the impact of resident involvement on outcomes in body-contouring procedures using a large National Database. Resident involvement in body-contouring procedures was associated with significantly higher complication rates (7.8% vs. 4.4%; $p = 0.003$) and longer operation times (180.7 minutes vs. 171.9 minutes; $p = 0.005$). For each year increase in resident postgraduate year, there was a significant decrease in the odds of complications (odds ratio = 0.906; $p = 0.013$) and operation time (127 minutes; $p = 0.001$). Therefore, resident involvement in Body-contouring procedures was associated with an increased rate of overall complications in a National Database. However, increased postgraduate year experience as a surgical resident was inversely proportional to the overall complications.¹⁴

Breast asymmetry: Breast asymmetry occurred in 2 (5.1%) of the study population. This occurs when the plastic surgeon removes more or less breast tissue from one of the breasts, inadvertently creating a lopsided appearance. It can also occur when a nipple-areola complex is created and located in the wrong site. Additionally, bottoming out occurs when the lifted and reshaped breast tissue begins to sag over time, resulting in hollowness in the upper breast and a nipple that points too high.¹⁵ Lee and Ock used an acellular dermal matrix disk and fragments to correct breast asymmetry¹⁶, while others prefer a redo surgery.¹⁷

Nipple insensitivity: It is seen as a postoperative complication 2 (5.1%) in the study, which was fully restored in 3-6 months. Inferior pedicle reduction provides the nipple with a generous blood and nerve supply, thereby protecting the breast during surgery. Jairo et al.¹⁸ evaluated the viability and sensibility of the nipple-areola complex (NAC) after peri-areolar dermis section following de-epithelialization in patients who underwent reduction mammoplasty. The study concluded that peri-areolar dermis does not affect NAC viability or pressure sensitivity. Another study measured nipple sensitivity in post-reduction mammoplasty patients and compared it with the general population. It concluded that the peri-areolar dermis release did not compromise the pressure sensitivity at the points evaluated in the nipple-areolar complex.¹⁹



Figure 2 Showing the immediate postoperative condition of a patient after reduction mammoplasty

Surgical techniques: Surgical techniques may influence the outcome of the procedure. Inverted T-2 (5.1%) and vertical incision 8 (20.5%) were the complication rates of the two methods. Other techniques included Strombeck 16 (41%) and inverted T14 (35.9%). This suggests that the technique influences complications and outcomes. The anchor procedure's enriched blood and nerve supply led to fewer complications. In a study by Radosa et al.²⁰ patients' assessments of postoperative symptom relief were comparable across all three surgical techniques. However, the overall outcome rating for both bi-pedicled

approaches (Strombeck and Ribeiro) was higher than for the mono-pedicled Bostwick technique. The type of pedicle used can impact the location of tissue resection, blood supply, and the risk of complications. For example, a study found that patients who received a superomedial pedicle had better scarring and shorter procedure time, while patients who received an inferior pedicle had a higher risk of complications. The incision type can affect complication risk. A meta-analysis found that the vertical incision had a lower overall incidence of complications than the T-inverted incision.²¹ The surgeon's understanding of available techniques and ability to tailor the procedure to the individual patient can positively affect complications. Cunnig et al.²² studied how technique affects clinical aesthetics and patient-reported outcomes. Overall, 101 patients underwent reduction surgeries; 60.3% had a superomedial pedicle and 39.7% had an inferior pedicle. Superomedial pedicle patients were more likely to have grade 3 ptosis ($p = 0.01$) and had a significantly shorter time ($p < 0.01$). Only the inferior pedicle technique resulted in wound dehiscence ($p < 0.03$) and reoperations due to complications ($p < 0.01$). Those who underwent inferior pedicle reduction were 4.3 times more likely to experience postoperative complications ($p = 0.03$). They concluded that the superomedial pedicle reduction technique provided clinical and aesthetic benefits compared with the inferior pedicle technique.

Obesity: Obesity is a risk factor for the development of complications in any major surgery. The study showed a gradual increase in the cohort from non-obese to low-obese, moderate-obese, and high-obese patients. The morbidity rate varied from 2.6% in non-obese patients to 23.1% in highly obese patients. Many studies have proven the high complication rate associated with obesity in reduction mammoplasty.²³ However, Nuzzi et al.'s study results did not vary with Body Mass Index category or age concerning postoperative morbidity rate.²¹

Impact on female sexuality: The study showed an increase in sexuality in the post-reduction mammoplasty patients (23.2%). Janik et al. analyzed the impact of breast reduction on female sexual dysfunction and on sexual well-being. The study concluded that the breast reduction procedure has a positive impact on female sexual function, quality of life, and sexual well-being.²⁴ Emani and Sobhan's study showed a significant improvement in the mean Index of Female Sexual Function (IFSF) and the International Index of Erectile Function (IIEF) Scores after surgery in both patients and their partners. Additionally, patients reported high satisfaction with the surgical outcome, as measured by both physical and psychological scores. It concluded that reduction breast surgery has a positive impact on the health status and psychological function, as well as on the sexual activity of patients and their partners.^{25,26}

Assessment of patients' satisfaction: The index study

assessed overall satisfaction using a 5-point Likert scale (90-98%) and the BREAST-Q OUTCOME score ($p = 0.003$). The study population demonstrated a high level of patient satisfaction. Reported satisfaction ranged from 75% to 98%.²⁷ Reported rates of improved physical quality of life ranged from 76.2% to 98.8%²⁸ and absolute rates of improved psychological quality of Life ranged from 73.6% to 82.5%.²⁹ There was a high level of satisfaction among patients after reduction mammoplasty, with significant improvements in health-related quality of life and relief of breast-related symptoms. Measurable improvements in physical and psychosocial well-being were evident within 6 months postoperatively.

CONCLUSION

Many factors influence patient satisfaction and outcomes of breast reduction mammoplasty. Middle age, high educational level, breast asymmetry, obesity with high Body Mass Index, and impact on sexuality have been noted to influence patients' satisfaction and outcome measures. Although the study reported minor complications, it also noted high patient satisfaction (90-98%) and breast Q-scores (92-96%). Despite minor complications, overall patient outcomes remained highly satisfactory. Proper patient selection, screening out comorbid conditions, and appropriate surgical techniques will help avoid untoward complications and increase postoperative patient satisfaction. Reduction mammoplasty not only relieves physical symptoms but also improves patients' psychosocial, sexual, and mental well-being.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

The University of Calabar Teaching Hospital Ethical Committee approved the study, and the study team read and explained the consent form to the patients.

CONFLICT OF INTEREST

There was no conflict of interest among the co-authors, nor from any funding organization or institution.

FUNDING

The research received no specific grant from any public or commercial funding agency. Funding was solely provided by the contributions of the co-authors.

AUTHOR'S CONTRIBUTION

M.O.O. contributed to the conceptualization, wrote the manuscript, and is the corresponding author. **O.O.O.** contributed to the acquisition of data and analysis. **R.G.E.** contributed to data interpretation. **E.I.** contributed to revising the critical

points for the intellectual content. All co-authors contributed to the final approval of the submitted version.

ACKNOWLEDGMENT

I acknowledge all registrars in the unit for their assistance with data collection.

REFERENCES

- Spaniol JR, Buchanan PJ, Greco RJ. Secondary reduction mammaplasty: does initial pedicle design matter? *J Plast Surg Hand Surg.* 2019;53(2):105-10. doi: 10.1080/2000656X.2018.1556670.
- Sears ED, Lu YT, Chung TT, et al. Pathology evaluation of reduction mammaplasty specimens and subsequent diagnosis of malignant breast disease: a claims-based analysis. *World J Surg.* 2019;43(6):1546-53. doi: 10.1007/s00268-019-04931-1.
- Tapp M, Singh R, Ulm JP, et al. Association of increased body mass index and resection weights on the safety of reduction mammoplasty in the adolescent population. *J Plast Reconstr Aesthet Surg.* 2019;72(7):1219-43. doi: 10.1016/j.bjps.2019.03.006.
- Lee HJ, Ock JJ. How to improve projection in nipple reconstruction: a modified method using acellular dermal matrix disk and fragments. *Plast Reconstr Surg.* 2019;143(4):698e-706e. doi: 10.1097/PRS.0000000000005454.
- William JC, Patricia AC, Christin AH, Olive SLH, Erwin AK, Martinaor- Jorge j, Paget JT. Breast Reduction Surgery, Breast Reduction Surgery Care at Mayo Clinic.
- Spear SL, Howard MA. Evolution of the vertical reduction mammoplasty. *Plast Reconstr Surg.* 2003;112(3):855-68. doi: 10.1097/01.PRS.0000072251.85687.1B.
- Hall-Findlay EJ. A simplified vertical reduction mammoplasty: shortening the learning curve. *Plast Reconstr Surg.* 1999;104(3):748-59.
- Spear SL, Howard MA. Evolution of the vertical reduction mammoplasty. *Plast Reconstr Surg.* 2003 Sep;112(3):855-68; quiz 869. doi: 10.1097/01.PRS.0000072251.85687.1B.
- Momeni A, Sorice SC, Li AY, et al. Breast reconstruction with free abdominal flaps is associated with persistent lower extremity venous stasis. *Plast Reconstr Surg.* 2019;143(6):1144e-1150e. doi: 10.1097/PRS.0000000000005613.
- Ercan A. Feasibility and safety of superomedial pedicle for breast reduction in geriatric patients. *Aesthetic Plast Surg.* 2024;48(19):3847-54. doi: 10.1007/s00266-024-03859-9.
- Nelson JA, Fischer JP, Wink JD, et al. A population-level analysis of bilateral breast reduction: does age affect early complications? *Aesthet Surg J.* 2014;34(3):409-16. doi: 10.1177/1090820X14525393.
- Daley J, Khuri SF, Henderson W, et al. Risk adjustment of the postoperative morbidity rate for the comparative assessment of the quality of surgical care: results of the National Veterans Affairs Surgical Risk Study. *J Am Coll Surg.* 1997;185(4):328-40.
- Malyar M, Peymani A, Johnson AR, et al. The impact of resident postgraduate year involvement in body-contouring and breast reduction procedures: a comprehensive analysis of 9638 patients. *Ann Plast Surg.* 2019;82(3):310-5. doi: 10.1097/SAP.0000000000001714.
- Hashem AM, Waltzman JT, D'Souza GF, et al. Resident and program director perceptions of aesthetic training in plastic surgery residency: an update. *Aesthet Surg J.* 2017;37(7):837-46. doi: 10.1093/asj/sjw275.
- Atterhem H, Holmner S, Janson PE. Reduction mammaplasty: symptoms, complications, and late results. A retrospective

- study on 242 patients. *Scand J Plast Reconstr Surg Hand Surg.* 1998;32(3):281-6. doi: 10.1080/02844319850158615.
16. Letterman G, Schurter M. The effects of mammary hypertrophy on the skeletal system. *Ann Plast Surg.* 1980;5(6):425-31. doi: 10.1097/0000637-198012000-00003.
 17. Saariniemi K, Luukkala T, Kuokkanen H. The outcome of reduction mammoplasty is affected more by psychosocial factors than by changes in breast dimensions. *Scand J Surg.* 2011;100(2):105-9. doi: 10.1177/145749691110000207.
 18. de Sá JZ, Braga ACCR, Barreto RHC, et al. Sensitivity of the Nipple-Areola Complex in Reduction Mammoplasty Following Periareolar Dermis Section. *Aesthet Surg J.* 2020 Aug 14;40(9):NP491-8. doi: 10.1093/asj/sjaa011.
 19. Radosa JC, Radosa MP, Baum S, et al. Reduction mammoplasty for symptomatic macromastia: which factors influence the post-operative outcome? *Arch Gynecol Obstet.* 2013;287(4):715-22. doi: 10.1007/s00404-012-2620-z.
 20. Nuzzi LC, Firriolo JM, Pike CM, et al. The effect of reduction mammoplasty on quality of life in adolescents with macromastia. *Pediatrics.* 2017;140(5):e20171103. doi: 10.1542/peds.2017-1103.
 21. Cuning JR, Mookerjee VG, Alper DP, et al. How does reduction mammoplasty surgical technique impact clinical, aesthetic, and patient-reported outcomes?: a comparison of the superomedial and inferior pedicle techniques. *Ann Plast Surg.* 2023;91(1):28-35. doi: 10.1097/SAP.0000000000003610.
 22. Carpelan A, Kauhanen S, Mattila K, et al. Reduction mammoplasty as an outpatient procedure: a retrospective analysis of outcome and success rate. *Scand J Surg.* 2015;104(2):96-102. doi: 10.1177/1457496914526872.
 23. Janik PE, Charytonowicz D, Miszczyk J, et al. Female sexual function and sexual well-being before and after breast reduction: a pilot cross-sectional study and review of literature. *Ann Plast Surg.* 2019;82(6):609-13. doi: 10.1097/SAP.0000000000001742.
 24. Emami SA, Sobhani R. Impact of reduction mammoplasty on sexuality in patients with macromastia and their partners. *J Plast Reconstr Aesthet Surg.* 2016;69(10):1335-9. doi: 10.1016/j.bjps.2016.07.018.
 25. Fischer JP, Cleveland EC, Shang EK, et al. Complications following reduction mammoplasty: a review of 3538 cases from the 2005-2010 NSQIP data sets. *Aesthet Surg J.* 2014;34(1):66-73. doi: 10.1177/1090820X13515676.
 26. Gonzalez MA, Glickman LT, Aladegbami B, et al. Quality of life after breast reduction surgery: a 10-year retrospective analysis using the Breast Q questionnaire: does breast size matter? *Ann Plast Surg.* 2012 Oct;69(4):361-3. doi: 10.1097/SAP.0b013e31824a218a.
 27. Corrêa MPD, Dornelas MT, de Carvalho EN, et al. Assessment of quality of life in patients who underwent breast reduction using BREAST-Q. *J Plast Reconstr Aesthet Surg.* 2018;71(6):929-31. doi: 10.1016/j.bjps.2018.02.010.
 28. Derby BM, Grotting JC, Redden DT. Vertical Sculpted Pillar Reduction Mammoplasty in 317 Patients: Technique, Complications, and BREAST-Q Outcomes. *Aesthet Surg J.* 2016;36(4):417-30. doi: 10.1093/asj/sjv217.

Sentinel Lymph Node Identification for Breast Cancer Patients Using Fluorescence Navigation with Indocyanine Green: Early Experience at Lampang Hospital

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Abstract

Background: Breast cancer is the most common malignancy among women. Axillary lymph node status is a key determinant of prognosis and treatment decisions. Although axillary lymph node dissection (ALND) provides accurate staging and regional control, it is associated with higher morbidity. Sentinel lymph node biopsy (SLNB) has therefore become the standard approach for axillary staging and avoiding unnecessary dissection. Indocyanine green (ICG) has recently been used as an alternative technique for sentinel lymph node localization via fluorescence imaging. This study presents a case series using ICG fluorescence navigation in breast cancer surgery.

Objective: To describe surgical techniques and clinical outcomes of SLN detection using ICG in breast cancer patients.

Materials and Methods: From June 2022 to June 2024, 18 breast cancer patients underwent SLNB with ICG fluorescence navigation at Lampang Hospital. All patients had been diagnosed with breast cancer. These 18 patients included clinically node-negative cases and node-negative-to-positive patients (N1 to N0) who received neoadjuvant systemic treatment and underwent SLNB (dual mapping: standard isosulfan blue dye with ICG).

Results: Eighteen cases underwent sentinel lymph node biopsy (SLNB) using dual mapping with standard isosulfan blue dye and ICG for localization. No adverse events occurred from intraoperative use of ICG or blue dye. All lymph nodes visualized with either fluorescence or dye were excised. In total, we removed 75 lymph nodes across 18 procedures. ICG identified seventy nodes, while only 29 were detected with blue dye. On average, the ICG method detected 3.88 sentinel lymph nodes (SLNs) (range: 2-8), resulting in a detection rate of 100%. In comparison, only 1.61 SLNs (range: 0-4) were identified, with an identification rate of 88.88%.

Conclusion: Fluorescence-guided SLNB with ICG is safe and highly effective, improving detection rates compared to dye alone. This method enhances lymphatic mapping and supports surgical training for both surgeons and residents.

Keywords: Breast cancer, Indocyanine green, blue dye, Sentinel lymph node biopsy

INTRODUCTION

Breast cancer is the most common malignancy among women. Breast cancer cells primarily spread through the axillary lymphatic system. Consequently, axillary lymph node involvement is crucial for disease prediction and prognosis and guides local, regional, and systemic treatment decisions. A procedure employed to determine nodal staging and regional control is axillary lymph node dissection (ALND). However, this proce-

dures is linked to more complications, such as pain, paresthesia, lymphedema, shoulder joint stiffness, seroma formation, and brachial plexus injuries.^{1,2}

Sentinel lymph nodes (SLNs) are the first lymph nodes to receive drainage from primary breast cancer. The standard method for assessing axillary lymphatic status when there is no clinical or radiological evidence of metastasis is the sentinel lymph node biopsy (SLNB). It is linked to lower morbidity com-

Received for publication 4 November 2025; Revised 30 January 2026; Accepted 14 August 2026

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<https://doi.org/10.64387/tjs.2026.278495>

pared to axillary lymph node dissection (ALND).¹ Recent studies indicate that SLNB is acceptable when used with a dual technique in a post-chemotherapy setting, concerning both the detection rate and the false-negative rate.³⁻⁷ The commonly used method for locating SLNs combines radioisotopes (RI) and blue dye.

RI offers high detection rates for SLNs. Still, it requires specialized detection equipment, exposure to radioactivity, limited availability, high cost, no real-time tracing, and special hospital preparations. Blue dye-guided SLNB is easy to perform and cost-effective.⁸ However, surgeons need experience to develop the skills needed to achieve a high success rate. Using only blue dye results in a lower identification rate (IR) and a higher false negative rate (FNR), which are linked to a substantial risk of anaphylactic reactions and skin necrosis.⁹⁻¹¹

In developing countries like Thailand, radioisotopes are only available at high-volume centers or in medical schools with nuclear medicine departments. Some clinical limitations of RI have led to the development of an alternative tracer technique using a fluorescent dye, indocyanine green (ICG).¹²

ICG is a water-soluble, near-infrared tricarbo-cyanine fluorescent dye. In 1959, the FDA approved its use for measuring cardiac output, hepatic function, and eye perfusion. It absorbs light around 780 nm and emits at 830 nm through a laser imaging device.¹³ We can perform sentinel node identification intraoperatively by injecting ICG dermally or subdermally, along with real-time lymphangiography using near-infrared fluorescence imaging, allowing surgeons to directly visualize lymphatic pathways in the axilla.¹²⁻¹⁴

More evidence supports SLN detection by ICG in early breast cancer. Previous research using ICG alone or combined with blue dye shows it is safe and reports IR exceeding 90%. Multiple meta-analyses have shown that ICG-based SLN detection achieves a high success rate in identifying SLNs.¹⁵⁻¹⁹ This method improves axillary status and offers a useful alternative to RI.

Fluorescence navigation using ICG for SLNB is a novel technique practiced at Lampang Hospital, where it has been implemented for two years. However, no thorough evaluation of surgical outcomes has been reported. This study aims to demonstrate the operative technique and the results achieved with this approach for SLN detection in breast cancer patients.

MATERIALS AND METHODS

Patient selection

This case series included 18 patients who underwent fluorescence-guided SLNB with ICG and isosulfan blue at Lam-

pang Hospital between June 2022 and June 2024. All patients were diagnosed with breast cancer; Some patients were axillary lymph node-negative, and some cases changed from lymph node positive to negative (N1 to N0) in patients who received neoadjuvant systemic treatment. We performed a core needle biopsy to confirm the breast cancer diagnosis, while the axillary diagnosis was made through fine needle aspiration of the axillary lymph node. Patients whose axillary lymph nodes turned negative after receiving neoadjuvant treatment underwent repeat mammograms with ultrasound before surgery to confirm that the positive lymph nodes had disappeared. The exclusion criteria included patients who were pregnant, breastfeeding, or had a history of hypersensitivity to ICG and iodine compounds.

Materials

The SLN tracer utilizes 3 mL of isosulfan blue injection with a concentration of 1% (Pharmaceutical Unit, Chiang Mai University, Chiangmai, Thailand), along with 25 mg of ICG (Daiichi Sankyo Pharmaceutical, Tokyo, Japan), which was diluted in 10 mL of sterile water to reach a concentration of 2.5 mg/mL, using 2 mL for injection. ICG fluorescence was detected with a near-infrared (NIR) camera system (LIGHT VISION, SHIMADZU, Kyoto, Japan) (**Figure 1**). When the fluorescent substance ICG is excited with NIR light (780 nm), it emits NIR light of a longer wavelength (peak WL: 820 nm) as fluorescence.

Operative procedure

SLNB was performed prior to mastectomy or wide excision for primary breast cancer as follows.

1. After anesthesia, 3 mL of 1% isosulfan blue was injected subdermally into the four quadrants of the periareolar area, and the breast was then gently massaged for 10 minutes.
2. After painting and draping, 2 mL of ICG (Diagnogreen) was injected subdermally into the four quadrants of the periareolar area, followed by a 10-minute massage.
3. The NIR camera system was used to identify fluorescent nodes, and the operating room's lights were turned off to visualize lymphatic channels better.
4. The visibility of the lymphatic vessels through the skin helped in precisely locating the skin incision. Make a small cut below the hairline; usually, you can identify this spot by where the subcutaneous lymphatic fluorescence stops in the skin. (**Figure 2**).
5. The dissection proceeded until we reached the cla-

vi-pectoral fascia, which was then opened to access the axilla. Carefully perform dissection along the blue or fluorescence green lymphatic channels to locate the sentinel node. Precise manipulation and careful dissection during SLN identification help reduce lymphatic injury and prevent fluorescent dye contamination of the axilla.

6. Blue nodes, fluorescent nodes, or palpable nodes were removed and sent to the pathologist for metastasis analysis via intraoperative frozen section (**Figure 3**). Finally, a permanent pathological diagnosis is made through postoperative H&E staining.

Treatment

After obtaining SLNs, breast surgery, whether breast-conserving surgery or mastectomy, was performed based on the previous multidisciplinary team decision and the patient's preference. Following the operation, patients received treatment according to the clinical practice guidelines for breast cancer.

Statistical analysis

We collected the patients' demographic and histopathological data, including procedure details such as SLNB time, the number of ICG-stained lymph nodes (LNs), the number of blue LNs, and LN metastasis status. The study aimed to assess the clinical accuracy of ICG-guided fluorescence imaging for SLN detection in breast cancer patients, specifically examining whether combining ICG with blue dye is better than using blue dye alone for SLN detection. We calculated the detection rate by dividing the number of cases with at least one successfully identified, mapped lymph node by the total number of mapping procedures performed. We used SPSS Statistics Version 22.0 for data analysis and reported categorical data as numbers and percentages. For continuous data, we reported the mean and standard deviation if the data were normally distributed. If the data were non-normally distributed, it was reported as the median, along with the lowest and highest values.

RESULTS

Eighteen cases underwent SLNB with both isosulfan blue and ICG localization methods. No adverse events related to the intraoperative use of ICG or isosulfan blue occurred, regardless of dosage. The mean age was 51.28 years (range: 38-72). Patients' body mass index (BMI) ranged from 17.90 to 31.64, with a mean of 24.29. The most common primary site of breast cancer was the upper-outer quadrant (55.55%; $n = 10$), followed by the upper-mid (11.11%; $n = 2$), lower-inner (11.11%; $n = 2$),

and central (11.11%; $n = 2$) regions, as well as the upper-inner (5.56%; $n = 1$) and lower-outer (5.56%; $n = 1$) regions. Among the 18 cases, 2 were grade I, 8 were grade II, and 8 were grade III. Additionally, one case had a Tis lesion, 4 had T1 lesions, 12 had T2 lesions, and one had a T3 lesion (**Table 1**).

Table 1 Patient characteristics

Characteristics	n (%)
Age, years	
Range	38-72
Median	50.5
Mean $\pm$ standard deviation	51.28 $\pm$ 10.89
≥ 50 years old	9 (50)
< 50 years old	9 (50)
BMI, kg/m² (n = 18)	
Mean $\pm$ standard deviation	24.29 $\pm$ 3.80
< 18.5	1 (5.56)
18.5-25	9 (50.00)
25-30	7 (38.88)
> 30	1 (5.56)
Tumor size	
Tis	1 (5.56)
T1	4 (22.22)
T2	12 (66.66)
T3	1 (5.56)
Histological grade	
I	2 (11.11)
II	8 (44.44)
III	8 (44.44)
Tumor location	
Upper-outer	10 (55.55)
Upper-mid	2 (11.11)
Upper-inner	1 (5.56)
Lower-outer	1 (5.56)
Lower-inner	2 (11.11)
Central position	2 (11.11)
Operative procedure	
Breast-conserving surgery	6 (33.33)
Mastectomy	12 (66.67)
Pathology	
Invasive ductal carcinoma	17 (94.44)
Ductal carcinoma in situ	1 (5.56)
Estrogen receptor	
Negative	16 (88.89)
Positive	2 (11.11)
Progesterone receptor	
Negative	13 (72.22)
Positive	5 (27.78)
HER-2	
Negative	5 (27.78)
Positive	10 (55.55)
Negative Equivocal	3 (16.67)

All fluorescing or blue dye-stained lymph nodes (LNs) were collected. In total, we removed 75 lymph nodes across 18 procedures. ICG identified seventy nodes, whereas blue dye

detected only 29 (see **Table 2**). The ICG detected an average of 3.88 sentinel lymph nodes (SLNs) (range: 2-8), with a detection rate of 100%. In contrast, only 1.61 SLNs (range: 0-4) were identified using isosulfan blue, resulting in an identification rate of 88.88% (**Table 3, Figure 4**). Metastases (macro/micrometastases) were found in 13 nodes, all showing blue and fluorescent features. Eight patients had at least one positive node (42.10%).

Table 2 Number of SLNs identified (n = 18)

SLN identification (nodes)	Number of SLNs identified	
	ICG	Blue dye
0	0	2
1	0	8
2	2	4
3	5	3
≥ 4	11	1
Average	3.88	1.61

Table 3 Diagnostic effectiveness of ICG and blue dye in identifying SLNs in breast cancer patients

Variables	ICG (%)	Blue dye (%)
Total number of SLNs	70	29
SLN detection rate	100 (18/18)	88.88 (16/18)
Difference (ICG - blue dye)	2.27	
Total number of metastatic nodes	13	

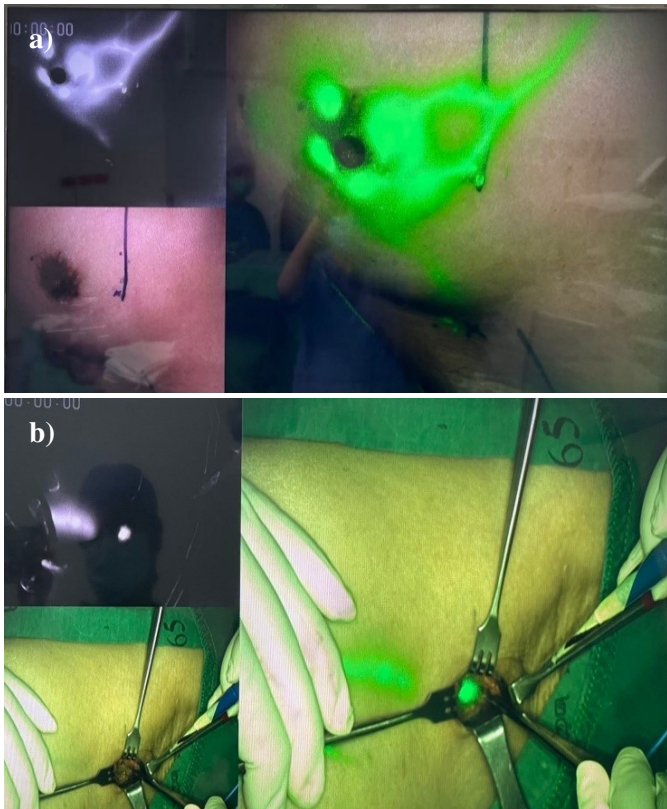


Figure 2 ICG imaging. A Transcutaneous lymphography is used to detect the SLN after injection of ICG. b) ICG fluorescence in the lymph node



Figure 1 Near-infrared (NIR) camera system

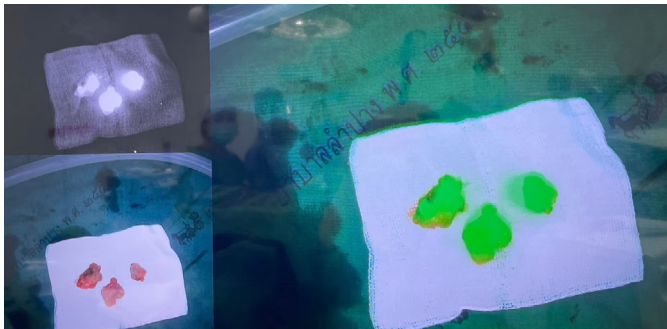


Figure 3 SLNs development status under ICG and Isosulfan blue

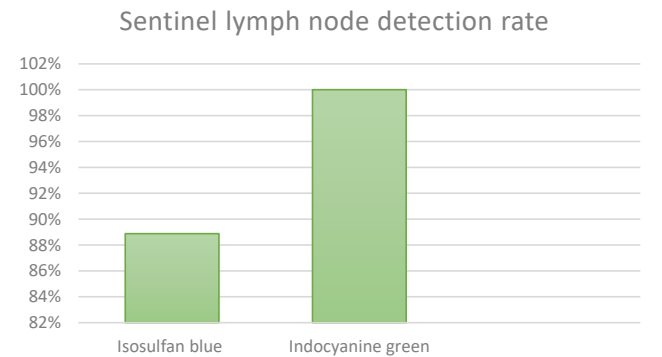


Figure 4 Graph of sentinel lymph node detection rates via each method: Isosulfan blue and Indocyanine Green

DISCUSSION

The most significant prognostic and predictive factor in managing breast cancer is the axillary lymph node status, which affects the choice of adjuvant systemic therapy and radiotherapy.²⁰ Common methods for sentinel node biopsy include the radiocolloid technique, the blue dye procedure, or a combination of the two.

Many studies show that SLNB can be guided by fluorescence after ICG injection, with ICG movement through lymphatic vessels visualized transcutaneously. Depending on the traditional technique (radioactive colloids or blue dyes), the SLN biopsy techniques are complicated procedures with long learning curves. In contrast, ICG/NIR fluorescence-guided SLN biopsy enables direct transcutaneous visualization of lymphatics. This approach offers a gentler learning curve and helps avoid complications from unnecessary dissection.¹²⁻¹⁴

This case series assessed the effectiveness of ICG and blue dye techniques for identifying sentinel lymph nodes (SLN) within the same patient group. The results show that subareolar ICG injections allow safe SLN biopsy, with no allergic reactions or adverse events. ICG showed better SLN localization than blue dye (100% versus 88.88%). The ICG detection rate in this series (100%) is similar to rates reported in previous studies. A meta-analysis by Sugie and Ikeda with 1736 patients reported a detection rate between 88.6% and 100%.¹⁸ The detection rate for blue dye is lower than that of ICG (88.88%) because blue dye has a larger molecule than ICG. Most patients in this series received neoadjuvant chemotherapy before surgery, which caused fibrosis in the lymphatic channels and disrupted lymphatic flow.

A systematic review and meta-analysis by Thongvito-komarn S et al. comparing Indocyanine Green fluorescence with blue dye or radioisotope for detecting sentinel lymph nodes in breast cancer analyzed 30 studies from January 2000 to October 2019. The results showed a statistically significant difference in SLN detection rate between ICG and blue dye (OR, 6.73; 95% CI, 4.20-10.78). However, ICG and RI did not differ significantly.¹⁷

Kitai T et al. reported the detection rate of SLNs using ICG fluorescence navigation in breast cancer. Sentinel nodes were successfully identified in 17 of 18 cases, with a detection rate of 94%.⁸

Takemoto N et al. conducted a retrospective study comparing ICG alone versus a combination of indigo carmine blue dye with ICG fluorescence imaging for SLNB in breast-conserving therapy for stage IIA or smaller breast cancer. Results from 202

patients showed that the combined ICG and indigo carmine group had a significantly higher SLN detection rate than ICG alone (96.4% vs. 83.7%; $p = 0.003$).¹²

Lin J et al. compared indocyanine green (ICG) fluorescence with blue dye for sentinel node detection and evaluated the additional benefit of ICG in 39 cases of breast cancer. The ICG detection rate was significantly higher than that of blue dye (97.5% vs. 70%, $p = 0.001$).¹³

Chirappapha et al. conducted a prospective cohort study assessing SLNB after neoadjuvant therapy in breast cancer patients, utilizing blue dye, radioisotope (RI), and ICG. The detection rates were 95.23% for ICG and 85.71% each for blue dye and RI. Combining ICG with blue dye increased the detection rate to 100%.⁷

In the SENTINA trial, the identification rate was 80.1%, with a false negative rate (FNR) of 14.2%. The FNR decreased to 12% when the radioisotope was combined with isosulfan blue. If more than three sentinel lymph nodes are present, the FNR is 7.3%.⁵ In the ACOZOG Z1071 trial, the identification rate reached 92.7%, with an FNR of 12.6%; using the dual technique lowered the FNR to just 8.6%. When more than three sentinel lymph nodes were identified, the FNR was 9.1%.⁶

In this case series, we used a dual technique for SLNB, combining isosulfan blue dye and ICG in the same patients. ICG fluorescence for lymphatic mapping achieves a high success rate in detecting SLNs and improves mapping when combined with the dye method, as demonstrated in previous studies.^{7,12,15-18,21}

A limitation of this study is that it is a case series reporting only our experience using ICG as a tracer for lymphatic mapping in breast cancer surgery at a single center. The study population was small, which makes the results less reliable than those of other studies. Future studies should use randomized or prospective methods to ensure reliability and clinical applicability.

CONCLUSION

Fluorescence-guided lymphatic mapping with ICG was safe, showed a high detection rate, and improved mapping efficiency when combined with the dye method. The breast cancer patient experienced no complications from the extended axillary dissection. Importantly, both surgeons and residents can improve their sentinel lymph node biopsy skills.

REFERENCES

- Giuliano AE, Haigh PI, Brennan MB, et al. Prospective observational study of sentinel lymphadenectomy without further axillary dissection in patients with sentinel node-negative breast cancer. *J Clin Oncol.* 2000 Jul;18(13):2553-9. doi: 10.1200/JCO.2000.18.13.2553.
- Purushotham AD, Upponi S, Klevesath MB, et al. Morbidity after sentinel lymph node biopsy in primary breast cancer: results from a randomized controlled trial. *J Clin Oncol.* 2005 Jul 1;23(19):4312-21. doi: 10.1200/JCO.2005.03.228.
- Lyman GH, Somerfield MR, Bosserman LD, et al. Sentinel Lymph Node Biopsy for Patients With Early-Stage Breast Cancer: American Society of Clinical Oncology Clinical Practice Guideline Update. *J Clin Oncol.* 2017 Feb 10;35(5):561-4. doi: 10.1200/JCO.2016.71.0947. Epub 2016 Dec 12.
- Kühn T, Classe JM, Gentilini OD, et al. Current Status and Future Perspectives of Axillary Management in the Neoadjuvant Setting. *Breast Care (Basel).* 2018 Oct;13(5):337-41. doi: 10.1159/000492437.
- Kuehn T, Bauerfeind I, Fehm T, et al. Sentinel-lymph-node biopsy in patients with breast cancer before and after neoadjuvant chemotherapy (SENTINA): a prospective, multicentre cohort study. *Lancet Oncol.* 2013 Jun;14(7):609-18. doi: 10.1016/S1470-2045(13)70166-9.
- Boughey JC, Suman VJ, Mittendorf EA, et al. Alliance for Clinical Trials in Oncology. Sentinel lymph node surgery after neoadjuvant chemotherapy in patients with node-positive breast cancer: the ACOSOG Z1071 (Alliance) clinical trial. *JAMA.* 2013 Oct 9;310(14):1455-61. doi: 10.1001/jama.2013.278932.
- Chirappapha P, Chatmongkonwat T, Lertsithichai P, et al. Sentinel lymph node biopsy after neoadjuvant treatment of breast cancer using blue dye, radioisotope, and indocyanine green: Prospective cohort study. *Ann Med Surg (Lond).* 2020 Sep 22;59:156-60. doi: 10.1016/j.amsu.2020.09.030.
- Kitai T, Inomoto T, Miwa M, Shikayama T. Fluorescence navigation with indocyanine green for detecting sentinel lymph nodes in breast cancer. *Breast Cancer.* 2005;12(3):211-5. doi: 10.2325/jbcs.12.211.
- Wilke LG, McCall LM, Posther KE, et al. Surgical complications associated with sentinel lymph node biopsy: results from a prospective international cooperative group trial. *Ann Surg Oncol.* 2006 Apr;13(4):491-500. doi: 10.1245/ASO.2006.05.013.
- Raut CP, Hunt KK, Akins JS, et al. Incidence of anaphylactoid reactions to isosulfan blue dye during breast carcinoma lymphatic mapping in patients treated with preoperative prophylaxis: results of a surgical prospective clinical practice protocol. *Cancer.* 2005 Aug 15;104(4):692-9. doi: 10.1002/cncr.21226.
- Bleicher RJ, Kloth DD, Robinson D, et al. Inflammatory cutaneous adverse effects of methylene blue dye injection for lymphatic mapping/sentinel lymphadenectomy. *J Surg Oncol.* 2009 May 1;99(6):356-60. doi: 10.1002/jso.21240.
- Takemoto N, Koyanagi A, Yasuda M, et al. Comparison of the indocyanine green dye method versus the combined method of indigo carmine blue dye with indocyanine green fluorescence imaging for sentinel lymph node biopsy in breast conservative therapy for stage $\leq$ IIA breast cancer. *BMC Womens Health.* 2018 Sep 18;18(1):151. doi: 10.1186/s12905-018-0646-5.
- Lin J, Lin LS, Chen DR, Lin KJ, Wang YF, Chang YJ. Indocyanine green fluorescence method for sentinel lymph node biopsy in breast cancer. *Asian J Surg.* 2020 Dec;43(12):1149-53. doi: 10.1016/j.asjsur.2020.02.003.
- da Silva Sá R, Von Ah Rodrigues RF, Bugalho LA, et al. Evaluation of the efficacy of using indocyanine green associated with fluorescence in sentinel lymph node biopsy. *PLoS One.* 2023 Oct 25;18(10):e0273886. doi: 10.1371/journal.pone.0273886.
- Yin R, Ding LY, Wei QZ, et al. Comparisons of ICG-fluorescence with conventional tracers in sentinel lymph node biopsy for patients with early-stage breast cancer: A meta-analysis. *Oncol Lett.* 2021 Feb;21(2):114. doi: 10.3892/ol.2020.12375.
- Zhang X, Li Y, Zhou Y, et. Diagnostic Performance of Indocyanine Green-Guided Sentinel Lymph Node Biopsy in Breast Cancer: A Meta-Analysis. *PLoS One.* 2016 Jun 9;11(6):e0155597. doi: 10.1371/journal.pone.0155597.
- Thongvitokomarn S, Polchai N. Indocyanine Green Fluorescence Versus Blue Dye or Radioisotope Regarding Detection Rate of Sentinel Lymph Node Biopsy and Nodes Removed in Breast Cancer: A Systematic Review and Meta-Analysis. *Asian Pacific Journal of Cancer Prevention.* 2020;21(5):1187-95.
- Sugie T, Ikeda T, Kawaguchi A, et al. Sentinel lymph node biopsy using indocyanine green fluorescence in early-stage breast cancer: a meta-analysis. *Int J Clin Oncol.* 2017 Feb;22(1):11-7. doi: 10.1007/s10147-016-1064-z.
- Ahmed M, Purushotham AD, Douek M. Novel techniques for sentinel lymph node biopsy in breast cancer: a systematic review. *Lancet Oncol.* 2014 Jul;15(8):e351-62. doi: 10.1016/S1470-2045(13)70590-4.
- Veronesi U, Paganelli G, Viale G, et al. A randomized comparison of sentinel-node biopsy with routine axillary dissection in breast cancer. *N Engl J Med.* 2003 Aug 7;349(6):546-53. doi: 10.1056/NEJMoa012782.
- Johnson AR, Granoff MD, Lee BT, Padera TP, Bouta EM, Singhal D. The Impact of Taxane-based Chemotherapy on the Lymphatic System. *Ann Plast Surg.* 2019 Apr;82(4S Suppl 3):S173-8. doi: 10.1097/SAP.0000000000001884.

Prelaminated Forehead Flap Nasal Reconstruction of Pediatric Nasal Defect Secondary to Necrotizing Soft Tissue Infection: A Case Report

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Abstract

Background: Necrotizing soft tissue infection (NSTI) in children that involves the nose is a rare presentation and requires serial surgical debridement followed by nasal reconstruction. Nasal reconstruction is often delayed until post-pubertal age due to ongoing facial growth, limited local tissue/donor sites, and poor adherence to post-surgical care. However, the facial defect has a greater psychosocial impact as the child grows.

Case: This case report describes an 8-month-old boy who developed necrotizing fasciitis of the right heminose/cheek following an iatrogenic laceration from a nasal oxygen cannula, which required urgent surgical debridement and antibiotic therapy. We performed a multi-stage reconstruction using a prelaminated forehead flap with a composite concha cartilage and skin graft.

Conclusion: This case highlights the importance of early diagnosis, aggressive treatment, and innovative reconstructive techniques in managing pediatric necrotizing soft tissue infection of the face, particularly in anatomically challenging areas like the nasal region.

Keywords: Naso reconstruction, Paramedian forehead flap, Pediatric necrotizing soft tissue infection

INTRODUCTION

Necrotizing Fasciitis is an aggressive and life-threatening soft-tissue infection involving the skin and subcutaneous tissue that rapidly spreads along the underlying fascial plane and adjacent musculature. In recent literature, the broader term necrotizing soft tissue infection (NSTI) is increasingly used to encompass this clinical entity. Pediatric NSTIs are rare, with reported incidence rates ranging from 0.02 to 0.8 per 100,000 children per year.¹

NSTIs can be classified microbiologically into four categories: Type I (polymicrobial), Type II (monomicrobial), Type III (gram-negative monomicrobial), and Type IV (fungal).² Type I is the most prevalent NSTI, accounting for up to 80% of cases.³ Recent studies using both culture and advanced molecular methods have shown that common

pathogens include group A Streptococcus (GAS), Staphylococcus aureus, Enterococcus, Escherichia coli, Bacteroides, and other gram-negative rods, with obligate anaerobes such as Prevotella, Peptoniphilus, and Porphyromonas being particularly abundant and associated with worse outcomes when present in high proportions.⁴⁻⁶ Klebsiella oxytoca and P. aeruginosa are uncommon isolated organisms associated with NSTI. It frequently affects previously healthy children and results in a significant rate of mortality and morbidity.⁷ Accurate early diagnosis and surgical intervention, combined with the administration of appropriate parenteral antibiotics, are the cornerstones of NSTI treatment.

NSTI of the head and neck can cause extensive soft-tissue loss and deformity, particularly when the nasal structures are involved. In children, the most common aetiologies of

Received for publication 19 December 2025; Revised 25 March 2025; Accepted 26 August 2026

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<https://doi.org/10.64387/tjs.2026.279041>

nasal deformities requiring reconstruction include congenital anomalies (cleft lip and palate, frontonasal dysplasia),⁸ accidental injury,⁹ and complications from medical interventions (nCPAP use).¹⁰ We present a case of a pediatric nasal defect secondary to NSTI caused by *Klebsiella oxytoca* and *Pseudomonas aeruginosa*, which was reconstructed using a prelaminated forehead flap.

CASE PRESENTATION

An 8-month-old boy was referred to our team with a history of progressive skin and soft tissue loss of the right heminose/cheek region. He was initially admitted to a district hospital for acute bronchiolitis that required oxygen supplementation. Alterations made to an adult nasal cannula caused an iatrogenic laceration of the right nasal ala. The wound progressively worsened, leading to sepsis.

At our center, the initial wound was a 1.5 × 1.5 cm full-thickness necrosis of the right nasal ala extending to the nasolabial fold. The patient was septic and required antibiotics. He started on IV cloxacillin but was escalated to IV ceftriaxone and Metronidazole the next day. A computed tomography of the face and brain shows NSTI of the right nasal ala extending to the right preseptal region of the lower eyelid, as shown in **Figure 1**.

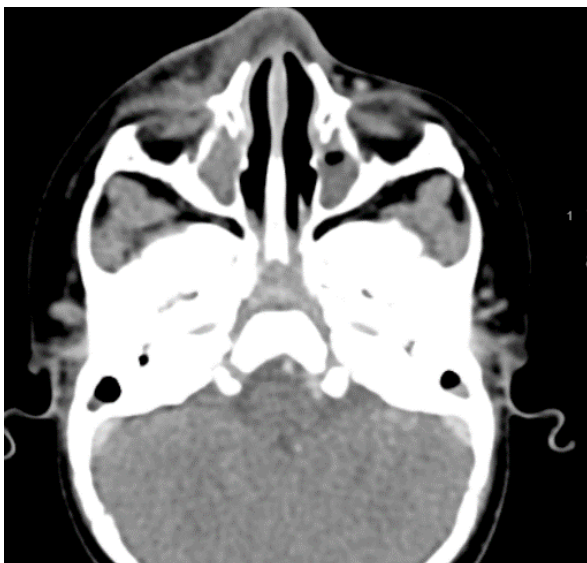


Figure 1 CT Brain prior to surgical debridement.

The child underwent urgent serial surgical debridement until the wound bed had healthy punctate bleeding. The intraoperative tissue culture revealed two organisms: *Klebsiella oxytoca* and *Pseudomonas aeruginosa*. The infectious disease team was consulted, and the antibiotics were changed to IV ceftazidime. Once the infection was controlled, we applied temporary coverage with a full-thickness skin graft. However, he was left with a right alar nasal defect as depicted in **Figure 2**. Therefore, we used a prelaminated forehead flap for nasal reconstruction.



Figure 2 Deformity post debridement at 8 months old

Surgical Technique

A prelaminated forehead flap incorporating a composite concha cartilage and skin graft was chosen for reconstruction. Prelamination enhances the stability and versatility of composite grafts, thereby improving integration and contour restoration. However, the interpolation of the forehead flap to support the composite graft stabilization requires a longer duration and increases the risk of trauma, particularly in a one-year-old patient.

A composite graft consisting of concha cartilage and overlying skin was harvested using the posterior auricular approach. An ipsilateral paramedian forehead flap was elevated according to the designed defect template. The flap was raised in a layered fashion: the distal third in the subcutaneous plane, the middle third in the subfrontalis plane, and the proximal third in the subperiosteal plane. Because the subcutaneous tissue and frontalis muscle were thin, the team performed dissection and hemostasis meticulously. The composite graft was then securely anchored to the distal segment of the forehead flap using absorbable sutures, as shown in **Figure 3**, after which the flap was reinserted into its native position.



Figure 3: Pre-lamination of chondral cartilage graft prior to reinsertion back to the original position at 18 months old

Two weeks after the initial elevation, the forehead flap was interpolated into the defect, as shown in **Figure 4**. However, one week after interpolation, the patient fell forward, resulting in partial flap dehiscence. The dehisced flap was resutured, and healing was uneventful. Subsequent flap division was performed two weeks after the injury, and the postoperative course was uneventful, as shown in **Figure 5**.



Figure 4 Forehead flap post-interpolation



Figure 5 Post division of forehead flap

DISCUSSION

Necrotizing fasciitis was first described in 1871 by Dr. Joseph Jones, a Confederate army surgeon, who referred to the condition as “hospital gangrene.” He documented 2,642 cases with a reported mortality rate of 46%. Over time, several terms, such as suppurative fasciitis, streptococcal gangrene, and necrotizing erysipelas, have been used to describe similar clinical entities. In 1951, Dr. Bernard Wilson popularised the term “necrotizing fasciitis,” emphasizing the disease’s hallmark feature: fascial layer necrosis. In recent years, the broader term “necrotizing soft tissue infection” (NSTI) has gained traction. This terminology aims to encompass all severe, rapidly progressive soft tissue infections with necrotic components, irrespective of the anatomical location or depth, to standardize diagnosis and guide multidisciplinary management.¹¹

Although direct comparative studies between pediatric and adult populations are limited, necrotizing soft tissue infections (NSTIs) are significantly less common in children. The reported incidence in the pediatric population ranges from 0.022 to 0.843 cases per 100,000 children annually, which is markedly lower than the adult incidence, which ranges from 0.4 to 1.5 per 100,000 adults per year.^{1,12} This means NSTIs are 1.8-18 times less frequent in children. Furthermore, pediatric cases are generally associated with lower mortality rates and more favorable outcomes than adult cases.

NSTI over the facial region has been described as ‘ex-

tremely rare,' regardless of age. Only 35 cases have been described in the literature from 1960 to 1997.¹³ The trunk remains the most common site in children aged < 2 years, whereas the extremities are affected in older children at 45.6%.¹⁴ Head and neck involvement is typically limited to isolated case reports and small case series. Notably, in recent years, only a single pediatric case involving the nasal alar region has been reported, necessitating urgent nasal reconstruction and resulting in excellent functional and aesthetic outcomes.¹⁵

Our patient had type 1 NSTI, with cultures that isolated *Klebsiella oxytoca* and *Pseudomonas aeruginosa*. *Klebsiella oxytoca*, a gram-negative rod closely related to *Klebsiella pneumoniae*, is part of the normal gastrointestinal flora but is an uncommon pathogen in NSTI. *Klebsiella oxytoca*-associated NSTIs are rare and typically limited to patients with poorly controlled diabetes or significant immunosuppression.¹⁶ *Pseudomonas aeruginosa*, another isolated organism in this case, is also an atypical cause of NSTI. While it more commonly affects immunocompromised hosts, cases have also been described in otherwise healthy infants, highlighting their unpredictable pathogenic potential.¹⁷

The infection was aggressive, necessitating multiple time-ly debridements to achieve adequate source control. Temporary coverage with a skin graft was performed before definitive reconstruction to facilitate flap planning and allow prelamination of the forehead flap. This interim coverage also minimizes the risk of ongoing blood loss and secondary infection.

Nasal reconstruction with a forehead flap is a well-established technique, and prelamination is a common armamentarium for creating a versatile flap that addresses the nasal lining, cartilage, and skin. In this case, we selected prelamination to achieve a more structurally robust reconstruction, particularly by reinforcing the nasal lining and cartilage framework. Additionally, this approach allowed us to avoid using a nasal stent, which is typically required to maintain graft adherence in composite reconstruction. Given the patient's young age and anticipated noncompliance with postoperative stenting, pre-lamination offered a more practical and reliable alternative.

Despite the traumatic injury causing dehiscence of the lateral part of the flap, division was still possible, demonstrating the flap's resilience. Functional outcomes were satisfactory, with the airway remaining patent without alar collapse, and the reconstruction achieved aesthetic goals with minimal donor-site morbidity, as shown in Figure 6. The child was planned for further thinning of his nasal alar flap. However, parents were not keen on another surgical intervention yet and defaulted on further follow-ups with our clinic.



Figure 6 3 months post-operation

The nasal reconstruction was done earlier than planned, as he became increasingly aware of his self-image. The nasal reconstruction was then performed to minimize the psychological impact on him.

CONCLUSION

Necrotizing fasciitis involving the face in pediatric patients is an exceptionally rare and potentially life-threatening condition that demands prompt recognition and aggressive intervention. Early surgical debridement combined with broad-spectrum antibiotics is essential to reduce morbidity and mortality. Subsequent targeted antibiotic therapy will further decrease infection and prevent antimicrobial resistance. Prelaminated forehead flap reconstruction offers a reliable and effective method for nasal reconstruction, especially in very young children, enabling both functional and aesthetic restoration following extensive tissue loss. Successful outcomes, as demonstrated in this case, highlight the importance of timely multidisciplinary management and tailored reconstructive strategies in pediatric necrotizing fasciitis of the nose.

REFERENCE

1. Al-Qurayshi Z, Nichols RL, Killackey MT, et al. Mortality Risk in Necrotizing Fasciitis: National Prevalence, Trend, and Burden. *Surg Infect (Larchmt)*. 2020 Dec;21(10):840-52. doi: 10.1089/sur.2019.277.
2. Sarani B, Strong M, Pascual J, et al. Necrotizing fasciitis: current concepts and review of the literature. *J Am Coll Surg*. 2009 Feb;208(2):279-88. doi: 10.1016/j.jamcollsurg.2008.10.032.
3. Yahav D, Duskin-Bitan H, Eliakim-Raz N, et al. Monomicrobial necrotizing fasciitis in a single center: the emergence of Gram-negative bacteria as a common pathogen. *Int J Infect Dis*.

- 2014 Nov;28:13-6. doi: 10.1016/j.ijid.2014.05.024.
4. Zhao-Fleming HH, Wilkinson JE, Larumbe E, et al. Obligate anaerobes are abundant in human necrotizing soft tissue infection samples: a metagenomics analysis. *APMIS*. 2019 Aug;127(8):577-87. doi: 10.1111/apm.12969.
 5. Rudkjøbing VB, Thomsen TR, Xu Y, et al. Comparing culture and molecular methods for the identification of microorganisms involved in necrotizing soft tissue infections. *BMC Infect Dis*. 2016 Nov 8;16(1):652. doi: 10.1186/s12879-016-1976-2.
 6. Bruun T, Rath E, Madsen MB, et al. INFECTION Study Group. Risk Factors and Predictors of Mortality in Streptococcal Necrotizing Soft-tissue Infections: A Multicenter Prospective Study. *Clin Infect Dis*. 2021 Jan 27;72(2):293-300. doi: 10.1093/cid/ciaa027.
 7. Szilagyi J, Kuester V, Reznicek J. Pediatric Necrotizing Fasciitis. *J Pediatr Soc North Am*. 2024 Feb 5;5(4):728. doi: 10.55275/JPOSNA-2023-728.
 8. Song SY, Choi JW, Lew HW, et al. Nasal Reconstruction of a Frontonasal Dysplasia Deformity Using Aesthetic Rhinoplasty Techniques. *Arch Plast Surg*. 2015 Sep;42(5):637-9. doi: 10.5999/aps.2015.42.5.637.
 9. Alshaikh N, Lo S. Nasal septal abscess in children: from diagnosis to management and prevention. *Int J Pediatr Otorhinolaryngol*. 2011 Jun;75(6):737-44. doi: 10.1016/j.ijporl.2011.03.010.
 10. Li Y, Sepulveda A, Buchanan EP. Late presenting nasal deformities after nasal continuous positive airway pressure injury: 33-year experience. *J Plast Reconstr Aesthet Surg*. 2015 Mar;68(3):339-43. doi: 10.1016/j.bjps.2014.10.036.
 11. Hakkarainen TW, Kopari NM, Pham TN, et al. Necrotizing soft tissue infections: review and current concepts in treatment, systems of care, and outcomes. *Curr Probl Surg*. 2014 Aug;51(8):344-62. doi: 10.1067/j.cpsurg.2014.06.001.
 12. Choi HK, Seo GH, Han E. The incidence and seasonal variation of necrotizing fasciitis in Korea: a nationwide cross-sectional study. *Clin Microbiol Infect*. 2020 Aug;26(8):1090.e1-1090.e6. doi: 10.1016/j.cmi.2020.01.002.
 13. Shindo ML, Nalbone VP, Dougherty WR. Necrotizing fasciitis of the face. *Laryngoscope*. 1997 Aug;107(8):1071-9. doi: 10.1097/00005537-199708000-00013.
 14. Schröder A, Gerin A, Firth GB, et al. A systematic review of necrotising fasciitis in children from its first description in 1930 to 2018. *BMC Infect Dis*. 2019 Apr 11;19(1):317. doi: 10.1186/s12879-019-3941-3. Erratum in: *BMC Infect Dis*. 2019 May 27;19(1):469. doi: 10.1186/s12879-019-4003-6. doi: 10.1186/s12879-019-3941-3.
 15. Ahmadi Moghadam M, Ahmadi Moghadam S. Use of Forehead Flap for Nasal Tip Reconstruction after Traumatic Nasal Amputation. *World J Plast Surg*. 2017 Sep;6(3):361-4. PMID: 29218287; PMCID: PMC5714983.
 16. Jin L, Fan K, Liu S, et al. Necrotizing fasciitis of the jaw, neck and mediastinum caused by *Klebsiella oxytoca* and *Streptococcus constellatus*: a case report. *Ann Palliat Med*. 2021 Jul;10(7):8431-6. doi: 10.21037/apm-20-2427.
 17. Chen JL, Huang TY, Kuo LT, et al. Monomicrobial Necrotizing Fasciitis and Sepsis Caused by *Pseudomonas aeruginosa* and *Pseudomonas fluorescens*: a Series of Ten Cases. *Jpn J Infect Dis*. 2022 Nov 22;75(6):554-9. doi: 10.7883/yoken.JJID.2022.087.
 18. Chen JL, Huang TY, Kuo LT, et al. Monomicrobial Necrotizing Fasciitis and Sepsis Caused by *Pseudomonas aeruginosa* and *Pseudomonas fluorescens*: a Series of Ten Cases. *Jpn J Infect Dis*. 2022 Nov 22;75(6):554-9. doi: 10.7883/yoken.JJID.2022.087.
 19. Fermi M, Bassano E, Molinari G, et al. Prelaminated flaps in head and neck cancer reconstructive surgery: A systematic review. *Microsurgery*. 2021 Sep;41(6):584-3. doi: 10.1002/micr.30751.

Primary Epiploic Appendagitis Mimicking Acute Appendicitis: A Case Report and Diagnostic Insight

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Abstract

Background and Objective: Epiploic appendagitis is an infrequent and often misdiagnosed cause of acute abdominal pain, commonly mistaken for conditions like appendicitis or diverticulitis due to its nonspecific and localized symptoms. Its underrecognition largely stems from limited clinical awareness and the lack of definitive diagnostic markers, with diagnosis typically made via computed tomography or incidentally during surgical exploration.

Case Description: This report presents a rare case of primary epiploic appendagitis in a 35-year-old male initially suspected to have acute appendicitis. Diagnostic laparoscopy revealed a normal appendix and a necrotic epiploic appendage originating from the mid-ascending colon. Laparoscopic excision of the appendage and prophylactic appendectomy were performed. The patient recovered well postoperatively and was discharged on day three, with follow-up confirming full recovery. Histopathology confirmed necrotic epiploic appendagitis.

Conclusion: Primary epiploic appendagitis should be considered in stable patients with focal abdominal pain and minimal systemic inflammatory features. In diagnostically uncertain patients, computed tomography can establish the diagnosis and help avoid unnecessary antibiotics, hospitalization, and surgery; reserve operative treatment for selected patients with persistent or worsening symptoms, recurrence, complications, or unresolved diagnostic uncertainty.

Keywords: Epiploic appendagitis, Appendicitis, Diagnostic laparoscopy, Primary epiploic appendagitis, Necrosis of epiploic appendage

INTRODUCTION

Epiploic appendages are adipose-rich, serosa-lined peritoneal protrusions originating from the antimesenteric border of the colon, each containing a narrow pedicle comprising terminal arterioles and a solitary venule. Epiploic appendagitis represents an uncommon, non-malignant, and self-limiting inflammatory pathology affecting these peritoneal structures. Primary epiploic appendagitis (PEA) typically arises from spontaneous venous thrombosis within the draining vessels of the appendages, without associated torsion or external ischemic insult. In contrast, secondary epiploic appendagitis results from localized

inflammation due to adjacent intra-abdominal pathologies, such as appendicitis, diverticulitis, or cholecystitis. Clinically, PEA often presents with localized acute abdominal pain, frequently mimicking more common conditions like acute diverticulitis or appendicitis. The absence of specific clinical hallmarks renders its diagnosis particularly challenging.¹ Diagnosis was traditionally achieved during operative interventions such as exploratory laparotomy or laparoscopy, often performed for differential diagnoses of right lower quadrant pain. Recent advances in imaging modalities have markedly increased the preoperative diagnostic yield for this condition. This report describes an uncommon

Received for publication 1 December 2025; Revised 31 August 2026; Accepted 4 September 2026

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<https://doi.org/10.64387/tjs.2026.279001>

presentation of epiploic appendagitis in a 35-year-old male, a case of particular interest given the apparent absence of similar documentation within the regional literature. By outlining the clinical course and therapeutic approach, we aim to contribute to the existing knowledge base and underscore the importance of early recognition.

CASE PRESENTATION

A 35-year-old male with no prior history of abdominal surgery or notable medical conditions was referred to our department with severe abdominal pain localized to the right lower quadrant. The pain had progressively worsened over the preceding 48 hours and was continuous, deep, and aching. He denied vomiting, rectal bleeding, or constitutional symptoms and reported normal bowel habits. On examination, the abdomen was soft and non-distended, with normal bowel sounds and focal tenderness at McBurney's point. There were no signs of peritonism; Rovsing's, psoas, and obturator signs were negative. Vital parameters were within normal limits, with no systemic signs of infection or sepsis. Laboratory investigations showed a normal white cell count, hemoglobin, platelet count, and renal profile, and urinalysis showed no evidence of urinary tract infection. Based on the documented findings, his Alvarado score was 2 (right lower quadrant tenderness), placing him in a low-risk category for acute appendicitis. Nevertheless, acute appendicitis remained an important clinical differential because of the persistent focal right lower quadrant pain and McBurney's point tenderness.

The patient was admitted for surgical observation. Empiric antimicrobial therapy was initiated while acute appendicitis remained the working diagnosis; however, his pain persisted. At the time of this presentation, abdominal computed tomography (CT) was not routinely used at our institution for uncomplicated right lower quadrant pain except in selected cases. Owing to persistent symptoms and unresolved diagnostic uncertainty, diagnostic laparoscopy was undertaken. Laparoscopy demonstrated a macroscopically normal appendix and a twisted, necrotic epiploic appendage arising from the antimesenteric aspect of the mid-ascending colon (**Figure 1**). No mesenteric lymphadenopathy or Meckel's diverticulum was identified. The necrotic epiploic appendage was excised. Although the appendix appeared normal, appendectomy was performed at the operating surgeon's discretion because acute appendicitis had been the principal preoperative diagnosis. We acknowledge that routine prophylactic appendectomy is not required when a normal appendix and an alternative diagnosis are identified. Histopathology confirmed ischemic infarction of the epiploic appendage, while the vermiform appendix showed no pathological abnormality. The postoperative course was uncomplicated, with

resolution of the presenting pain. The patient remained under postoperative observation and was discharged on postoperative day three. He remained well at one-month follow-up.

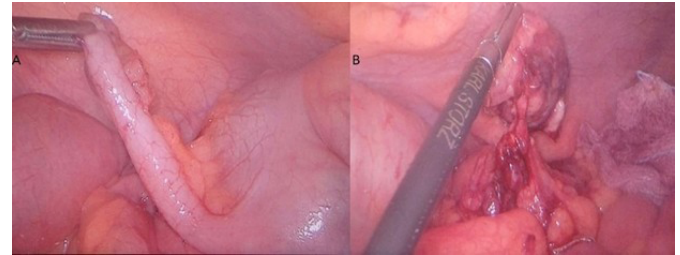


Figure 1 Intraoperative assessment: 1A - Appendix with no gross pathological abnormalities; 1B - twisted necrotic epiploic appendage at the antimesenteric aspect of the mid-ascending colon.



Figure 2 Gross specimen of the resected necrotic epiploic appendage.

DISCUSSION

The incidence of primary epiploic appendagitis has been estimated at approximately 1.3% among patients presenting with acute abdominal pain.¹ Primary epiploic appendagitis results from torsion of an epiploic appendage or spontaneous thrombosis of its central draining vein, causing ischemic or hemorrhagic infarction and localized inflammation. Secondary epiploic appendagitis occurs when adjacent inflammatory disease, including diverticulitis, appendicitis, cholecystitis, or pancreatitis, involves the epiploic appendages.² Clinically, primary epiploic appendagitis is an important mimic of acute appendicitis. Typical features include acute, localized, non-migratory abdominal pain, focal tenderness, normal or only mildly abnormal inflammatory markers, and relative absence of systemic symptoms such as fever or vomiting.^{2,6} This pattern closely resembled our patient; he was hemodynamically stable and afebrile, had focal McBurney's point tenderness, no peritonism, and a normal white cell count. His documented Alvarado score was only 2, which, in retrospect, should have increased consideration of non-appendiceal causes of right

lower quadrant pain. Prior episodes of similar localized pain have been described in patients with epiploic appendagitis.³ Although epiploic appendagitis commonly mimics acute appendicitis, rare coexistence of the two conditions has also been reported.⁴ CT is the key imaging modality for diagnosis and for differentiating epiploic appendagitis from appendicitis or diverticulitis. Typical findings are an oval fat-attenuation lesion adjacent to the colon, a thin hyperattenuating rim, surrounding inflammatory fat stranding, and occasionally a central hyperattenuating focus representing a thrombosed vein.⁵ In a stable patient with localized pain and limited inflammatory response, a CT-first strategy can prevent unnecessary hospital admission, antimicrobial treatment, and surgery.^{5,6} In our case, CT was not obtained because of the institutional diagnostic pathway used at the time. Given the low Alvarado score and clinical stability, we recognize that preoperative CT would have been a less invasive and more appropriate diagnostic step and might have permitted conservative management. This case represents an important learning point.

Most uncomplicated cases are self-limiting and should be treated conservatively with analgesia and, when appropriate, non-steroidal anti-inflammatory medication. Antibiotics are not routinely required once primary epiploic appendagitis has been established, because the condition is ischemic-inflammatory rather than infectious.^{5,6} In this patient, empiric antimicrobials were given before the definitive diagnosis because acute appendicitis remained the working diagnosis; this should not be interpreted as recommended treatment for confirmed epiploic appendagitis.

Surgery is therefore not first-line treatment. General indications for operative management include persistent or worsening symptoms despite an adequate trial of conservative treatment, recurrent symptomatic disease, complications such as obstruction, abscess, or peritonitis, and persistent diagnostic uncertainty when a more serious surgical condition cannot be excluded.^{6,7} When surgery is required, laparoscopic excision of the infarcted appendage is usually sufficient. Routine prophylactic appendectomy of a macroscopically normal appendix is not necessary after an alternative diagnosis has been established. In our case, appendectomy was performed because appendicitis had been the principal preoperative diagnosis and at the discretion of the operating surgeon. This practice should be distinguished from the management of CT-confirmed uncomplicated epiploic appendagitis.

The case also illustrates the value of critically reassessing institutional pathways for right lower quadrant pain. Diagnostic laparoscopy remains useful when symptoms persist and the diagnosis remains unresolved, because it permits complete intra-abdominal assessment and immediate treatment. However,

in a stable patient without peritonitis or marked inflammatory abnormalities, modern cross-sectional imaging should generally precede operative exploration. Our patient recovered uneventfully after excision, with complete symptom resolution and no recurrence at one-month follow-up.

CONCLUSION

In conclusion, primary epiploic appendagitis should be included in the differential diagnosis of focal right lower quadrant pain, particularly in stable, afebrile patients with limited inflammatory abnormalities. CT is the preferred diagnostic tool in clinically indeterminate cases and can prevent unnecessary antimicrobial therapy and operative intervention. Uncomplicated disease is usually managed conservatively; reserve surgery for persistent or worsening symptoms, recurrence, complications, or unresolved diagnostic uncertainty. This case highlights how better recognition of the characteristic clinical pattern and earlier CT use may reduce avoidable surgery.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to the General Surgery team at Hospital Tengku Ampuan Rahimah for their invaluable support.

ETHICAL STATEMENT

The authors are accountable for all aspects of the work and will ensure that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee(s) and the Declaration of Helsinki (as revised in 2013). We obtained written informed consent from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

CONTRIBUTIONS

- (I) Conception and design: Hemanathan Praemanathan
- (II) Administrative support: All Authors
- (III) Provision of study materials or patients: Hemanathan Praemanathan
- (IV) Collection and assembly of data: All Authors
- (V) Data analysis and interpretation: N/A
- (VI) Manuscript Writing: Hemanathan Praemanathan
- (VII) Final approval of manuscript: All Authors

REFERENCES

1. Issa IA, Berjaoui MT, Hamdan WS. Primary epiploic appendagitis: from A to Z. *Int Med Case Rep J*. 2010 Jul 22;3:67-9. doi: 10.2147/imcrj.s11710. PMID: 23754892;
2. Kefala MA, Tepelenis K, Stefanou CK, et al. Primary Epiploic Appendagitis Mimicking Acute Appendicitis: A Case Report and Narrative Review of the Literature. *Korean J Gastroenterol*. 2020 Aug 25;76(2):88-93. doi: 10.4166/kjg.2020.76.2.88.
3. Sand M, Gelos M, Bechara FG, et al. Epiploic appendagitis--clinical characteristics of an uncommon surgical diagnosis. *BMC Surg*. 2007 Jul 1;7:11. doi: 10.1186/1471-2482-7-11.
4. El-Sawaf Y, Alzayani S, Saeed NK, et al. Epiploic appendagitis: An overlooked cause of acute abdominal pain. *World J Gastroenterol*. 2025 Aug 28;31(32):109897. doi: 10.3748/wjg.v31.i32.109897.
5. Giambelluca D, Cannella R, Caruana G, et al. CT imaging findings of epiploic appendagitis: an unusual cause of abdominal pain. *Insights Imaging*. 2019 Feb 22;10(1):26. doi: 10.1186/s13244-019-0715-9.
6. Schnedl WJ, Krause R, Tafeit E, et al. Insights into epiploic appendagitis. *Nat Rev Gastroenterol Hepatol*. 2011 Jan;8(1):45-9. doi: 10.1038/nrgastro.2010.189.
7. Giannis D, Matenoglou E, Sidiropoulou MS, et al. Epiploic appendagitis: pathogenesis, clinical findings and imaging clues of a misdiagnosed mimicker. *Ann Transl Med*. 2019 Dec;7(24):814. doi: 10.21037/atm.2019.12.74.

Serendipitous Dramatic Resolution of a Large Infected Pancreatic Pseudocyst through a Pancreaticopleural Fistula after Acute Pancreatitis: Case Report and Review of Literature

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Abstract

Acute pancreatitis is a common clinical condition with a wide spectrum of local and systemic complications. Pancreaticopleural fistula (PPF) is a rare thoracic complication, more frequently associated with chronic pancreatitis and only infrequently reported following acute pancreatitis. We report a unique case of a 21-year-old female with alcohol-induced acute pancreatitis who developed infected walled-off necrosis (WON), complicated by a pancreaticopleural fistula just prior to planned surgical necrosectomy. We managed the condition with intercostal drainage and conservative therapy, resulting in complete clinical and radiological resolution without surgery. This case highlights an unusual mechanism of spontaneous internal drainage of infected necrosis into the pleural cavity, leading to clinical improvement and avoidance of major surgery. We also present a brief literature review.

Keywords: Acute pancreatitis; Pancreaticopleural fistula; Walled-off necrosis; Pleural effusion; Octreotide; Conservative management

INTRODUCTION

Acute pancreatitis is an inflammatory condition most commonly caused by gallstones and alcohol consumption and represents a significant cause of hospital admissions worldwide. While most cases are mild and self-limiting, severe disease may lead to local complications such as pancreatic fluid collections and systemic complications including respiratory failure and pleural effusion, which may occur in up to 70% of severe cases¹

Pancreaticopleural fistula (PPF) is a rare but serious thoracic complication resulting from disruption of the pan-

creatic duct or extension of a pancreatic collection into the thoracic cavity². It is most associated with chronic pancreatitis, particularly of alcoholic etiology, and is infrequently reported following acute pancreatitis^{3,5}. Diagnosis is often delayed because of nonspecific respiratory symptoms and requires a high index of suspicion.

We report a rare case of infected walled-off necrosis (WON) following acute pancreatitis that underwent spontaneous decompression into the pleural cavity through a pancreaticopleural fistula, resulting in dramatic clinical improvement and avoidance of surgical intervention.

Received for publication 24 November 2025; Revised 30 March 2026; Accepted 17 August 2026

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<https://doi.org/10.64387/tjs.2026.287586>

CASE PRESENTATION

A 21-year-old female presented with severe epigastric pain, vomiting, and hypotension following a history of binge alcohol consumption. On examination, she was tachycardic and hypotensive (90/60 mmHg), with abdominal distension and tenderness. Laboratory investigations revealed elevated serum amylase (1230 U/L). Ultrasonography did not demonstrate gallstones. A diagnosis of alcohol-induced acute pancreatitis was made.

She was managed conservatively with intravenous fluids, analgesia, electrolyte correction, and early enteral nutrition. The patient improved clinically and was discharged after seven days. A chest radiograph during this admission did not reveal significant pleural effusion.

Approximately four weeks later, she re-presented with fever, worsening abdominal pain, vomiting, and features of sepsis. Examination revealed tachycardia, hypotension, and dehydration. Contrast-enhanced computed tomography demonstrated multiloculated peripancreatic collections with internal debris and air foci, consistent with infected walled-off necrosis (Figure 1). Based on the Revised Atlanta Classification, this was classified as infected WON rather than a pseudocyst.

Laboratory investigations showed leukocytosis and electrolyte imbalance. A chest radiograph revealed a mild left-sided pleural effusion.

TREATMENT AND CLINICAL COURSE

The patient was initiated on broad-spectrum antibiotics and supportive care, including parenteral nutrition. Due to worsening sepsis and clinical deterioration, exploratory laparotomy with necrosectomy was planned. A step-up approach was considered; however, it was limited by the diffuse, multiloculated nature of the collections, absence of a well-defined drainage window, and restricted availability of advanced endoscopic interventions.

At induction of anesthesia, we noted high airway pressures. We inserted an emergency left-sided intercostal drain, which yielded approximately 3.5 liters of seropurulent fluid. This resulted in immediate clinical improvement, with reduced abdominal distension. Intraoperative ultrasound confirmed marked reduction in intra-abdominal collections, and surgical necrosectomy was deferred.

Pleural fluid analysis revealed markedly elevated amylase (3935 U/L) and lipase (41,286 U/L) levels with mixed gram-negative organisms. Subsequent imaging showed a diaphragmatic rent (Figure 2), and MRCP suggested communication between the pancreatic collection and pleural cavity, confirming pancreaticopleural fistula.

The patient had a complicated intensive care course, including type 1 respiratory failure and a leukemoid reaction. She was managed conservatively with continued antibiotics, octreotide therapy (100 mcg subcutaneously three times daily for two weeks), chest physiotherapy, and gradual reintroduction of enteral nutrition.

OUTCOME AND FOLLOW-UP

The patient showed progressive improvement over three weeks, with resolution of collections and pleural effusion. The intercostal drain was removed after approximately three weeks. A follow-up chest radiograph showed marked improvement (Figure 3).

She was discharged approximately 15 weeks after the initial episode. Follow-up MRCP at four months demonstrated normal pancreatic and biliary ducts with complete resolution of inflammation (Figure 4A, 4B). At eight months, the patient remained asymptomatic.

The clinical course can be summarized as initial acute pancreatitis, followed by development of infected WON at four weeks, intraoperative diagnosis of PPF with intercostal drainage, and subsequent recovery with complete resolution (Table 1).

Table 1 Timeline of Clinical Events

Time Point	Clinical Event
Day 0	Initial admission with acute pancreatitis
Day 7	Discharge after conservative management
Week 4	Re-presentation with sepsis and infected WON
Pre-operative period	Planned exploratory laparotomy
Intra-operative	Intercostal drain insertion; diagnosis of PPF
ICU course (Week 1)	Respiratory failure and leukemoid reaction
Week 3	Clinical improvement
Discharge	Approximately 15 weeks from initial episode
4 months	MRCP showing resolution
8 months	Asymptomatic follow-up

DISCUSSION

Pancreaticopleural fistula (PPF) is an uncommon but clinically significant complication of pancreatitis, reported in approximately 0.4% of cases and more frequently associated with chronic pancreatitis than acute pancreatitis⁶. It typically results from disruption of the pancreatic duct, allowing pancreatic secretions to track retroperitoneally and enter the thoracic cavity through diaphragmatic hiatuses or direct erosion of the diaphragm^{2,5}.

In the present case, the pancreatic collection is more accurately classified as infected walled-off necrosis (WON)

rather than a pseudocyst, per the Revised Atlanta Classification. Internal debris and air foci, along with evolution beyond four weeks, support this classification. Furthermore, organisms in the pleural fluid support infected pancreatic necrosis with secondary fistulization.

Clinically, PPF often presents with respiratory symptoms that may overshadow abdominal findings. A high index of suspicion is required, especially when pleural effusion is disproportionate to abdominal pathology⁴

Diagnosis relies on elevated pleural fluid amylase levels and imaging findings. CT and MRCP play complementary roles in identifying pancreatic collections and fistulous communication¹⁰⁻¹²

Management is individualized. Conservative treatment, including drainage and octreotide, is often effective, while endoscopic or surgical interventions are reserved for selected cases^{6,10,11}. In the present case, the step-up approach was limited by diffuse collections and resource constraints.

Table 2 summarizes a comparison of previously reported cases. Most cases are associated with chronic pancreatitis and pseudocysts, whereas cases following acute pancreatitis are rare. Notably, spontaneous resolution of infected WON through pleural drainage, as observed in this case, is exceedingly uncommon.

CONCLUSION

Pancreaticopleural fistula is a rare complication of acute pancreatitis requiring high clinical suspicion. Conservative management with pleural drainage can be effective. This case highlights a rare mechanism of spontaneous resolution of infected walled-off necrosis, avoiding surgical intervention.

Learning points

- Pancreaticopleural fistula should be suspected in pancreatitis patients with large pleural effusion
- Pleural fluid amylase is a key diagnostic marker
- Walled-off necrosis should be distinguished from pseudocyst
- Conservative management can be effective in selected cases
- Surgery should be reserved for refractory disease

Ethics statement

Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Care statement

This case report has been prepared in accordance with the CARE guidelines. The CARE checklist is provided as supplementary material.

Author (Year)	Etiology	Type of Collection	Fistula Type	Management	Outcome
Present case	Alcohol-induced acute pancreatitis	Infected WON	PPF	ICD + conservative (octreotide)	Complete resolution
Moorthy et al. (2007)⁵	Acute pancreatitis	Pseudocyst	PPF + mediastinal extension	Conservative	Recovered
Sut et al. (2009)⁵	ERCP-induced acute pancreatitis	Pseudocyst	PPF	Surgery (cystogastrostomy)	Recovered
Poulsen et al. (2011)⁵	Acute pancreatitis	Not specified	PPF	Conservative	Recovered
Pandey et al. (2014)⁴	Mixed (acute & chronic pancreatitis)	Pseudocysts	PPF / bronchial fistula	Conservative ± endoscopic	Variable (mostly recovered)
Choe et al. (2014)²	Recurrent pancreatitis	Minimal peripancreatic inflammation	Mediastinal fistula	Surgery (distal pancreatectomy)	Recovered
Shah et al. (2012)¹¹	Chronic pancreatitis	Pseudocyst	PPF	Endoscopic (ERCP stenting)	Recovered
Francisco et al. (2015)¹²	Pancreatitis (likely chronic)	Pseudocyst	PPF	Conservative	Recovered
McCormick et al. (1990)⁹	Chronic pancreatitis	Pseudocyst	PPF	Mixed (medical/surgical)	Recovered

Table 2 Comparison of Present Case with Reported Pancreaticopleural Fistula Cases

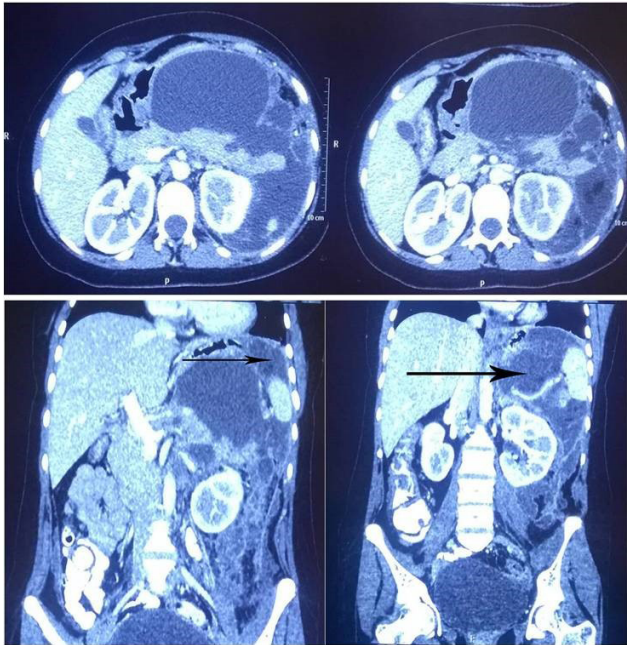
**Figure 1**

Figure 1A (top two): Cross-sectional image of contrast-enhanced CT abdomen showing a multiloculated hypodense fluid collection with peripheral enhancement, lying in the pancreatic, peripancreatic, gastrosplenic, and pararenal areas, likely pancreatic pseudocysts. No evidence of chronic pancreatitis-like calcifications or communication with the pleural cavity is seen.

Figure 1B (bottom two): Repeat CT abdomen after clinical worsening of the patient, suggestive of similar collections as above but with debris and air foci within (arrows). No communication with the pleural cavity is seen here either.

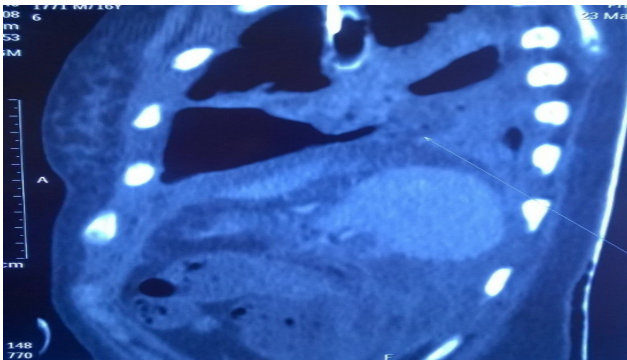


Figure 2 CT abdomen following intercostal drainage demonstrating diaphragmatic rent (arrow) suggesting pancreaticopleural fistula.



Figure 3 Chest radiograph showing marked improvement in pleural effusion following drainage.

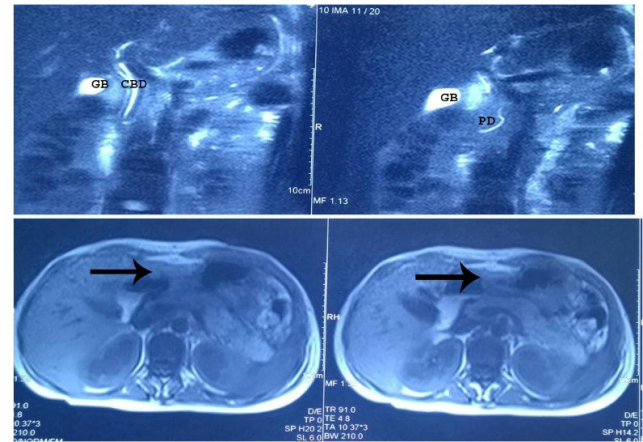
**Figure 4**

Figure 4A (top two): Magnetic Resonance Cholangiopancreatography (MRCP) performed after stabilization of the clinical condition (4 months later) revealed a normal gallbladder (marked 'GB'), biliary duct (marked 'CBD') and pancreatic duct (marked 'PD'), with no strictures or calculi.

Figure 4B (bottom two): Corresponding cross-sectional MR images show significant resolution of the peripancreatic edema and fluid collections (arrows)

REFERENCES

- Párnitzky A, Kui B, Szentesi A, Balázs A, Szűcs Á, Mosztbacher D, et al; Hungarian Pancreatic Study Group. Prospective, Multicentre, Nationwide Clinical Data from 600 Cases of Acute Pancreatitis. *PLoS One* 2016; 11(10): e0165309. doi: 10.1371/journal.pone.0165309.
- Choe IS, Kim YS, Lee TH, Kim SM, Song KH, Koo HS, et al. Acute mediastinitis arising from pancreatic mediastinal fistula in recurrent pancreatitis. *World J Gastroenterol* 2014; 20(40): 14997-5000. doi: 10.3748/wjg.v20.i40.14997.
- Dąbkowski K, Bialek A, Kukla M, Wójcik J, Smereczyński A, Kołacznyk K, et al. Mediastinal Pancreatic Pseudocysts. *Clin Endosc* 2017; 50(1): 76-80. doi: 10.5946/ce.2016.089.
- Pandey S, Shetty SA, Janarthanan K, Balalakshmoji D, Sen KK, Leelakrishnan V. Pancreatico-pleural and bronchial fistulae and associated pseudocysts: case series. *JOP* 2014; 15(5): 478-84. doi: 10.6092/1590-8577/2804.
- Moorthy N, Raveesha A, Prabhakar K. Pancreaticopleural fistula and mediastinal pseudocyst: an unusual presentation of acute pancreatitis. *Ann Thorac Med*. 2007;2(3):122-3. doi: 10.4103/1817-1737.33701
- Sut M, Gray R, Ramachandran M, Diamond T. Pancreaticopleural fistula: a rare complication of ERCP-induced pancreatitis. *Ulster Med J* 2009;78(3):185-6.
- Fielding GA, McLatchie GR, Wilson C, Imrie CW, Carter DC. Acute pancreatitis and pancreatic fistula formation. *Br J Surg* 1989;76(11):1126-8.
- Poulsen A, Sigild UH. (Acute pancreatitis may cause pancreaticopleural fistula). *Ugeskr Laeger* 2011; 173(8): 588-9.
- McCormick PA, Chronos N, Burroughs AK, McIntyre N, McLaughlin JE. Pancreatic pseudocysts cause portal vein thrombosis and pancreaticopleural fistula. *Gut* 1990; 31(5): 561-3.
- Wronski M, Slodkowski M, Cebulski W, Moronczyk D, Krasnodebski IW. Optimizing management of pancreaticopleural fistulas. *World J Gastroenterol* 2011; 17(42): 4696-703. doi: 10.3748/wjg.v17.i42.4696.
- Shah D, Desai AB, Salvi B. Pancreaticopleural fistula complicating chronic pancreatitis. *BMJ Case Rep* 2012; 2012. pii: bcr0320126038. doi:10.1136/bcr-03-2012-6038.
- Francisco E, Mendes M, Vale S, Ferreira J. Pancreaticopleural fistula: an unusual complication of pancreatitis. *BMJ Case Rep* 2015; 2015. pii: bcr2014208814. doi: 10.1136/bcr-2014-208814.