

Systematic Review

Advances in minimally invasive surgical techniques for the management of enterocutaneous fistula: a systematic review of clinical and postoperative outcomes

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Received: 15 December 2024

Accepted: 30 December 2024

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ABSTRACT

We aim to explore advancements in minimally invasive surgical techniques (MIS) through a systematic review for managing enterocutaneous fistulas (ECFs) from 2019 to 2023 focusing on clinical and postoperative outcomes to identify gaps and future directions in treatment strategies. We followed the PRISMA guidelines and systematic reviewed the literature from three databases namely PubMed, Scopus, and the Cochrane library in the steps described here. Papers were screened according to previously set following focus and clinical and postoperative MIS methods applied in ECF treatment. Surgical techniques evaluated included: laparoscopic, robotic assisted and a combination of the two termed hybrid approach. Both data extraction and synthesis were done based on Covidence software to maintain transparency and rigor. Of 112 papers initially identified, 30 papers were included in the analysis. Relevant research established that the adoption of the minimally invasive techniques like robotic and laparoscopic surgeries increases enhanced clinical results which outcome includes less morbidity, the number of days of hospital stay, and complications. Most of the announced procedures, such as vacuum-assisted closure (VAC) and extracellular matrix plug placement, demonstrated feasibility in selected cases. Interventions' variability and the lack of high-quality evidence for some approaches suggest that replication should remain standardized. We conclude that advances in MIS have demonstrated improved outcomes for ECF management and are offering less invasive options with better recovery profiles.

Keywords: Minimally invasive, Laparoscopic, Robotic-assisted techniques, Systematic review

INTRODUCTION

Enterocutaneous fistulas (ECFs) refers to a pathological connection between the gastrointestinal tract and skin allowing for the abdominal contents bowel output to be released through the skin surface.¹ Although ECFs

themselves are not diseases, they often present themselves as a result of abdominal operations, cancer, inflammatory bowel disorders, or infections. These fistulas are also associated with many symptoms that influence greatly patient's life, such as electrolyte disorders, malnutrition, recurrent infection, etc. Complexity of ECFs underscores

the necessity of multidisciplinary approaches in their management.² Research has reported that annual incidence of ECFs is approximately 2.3 per 100,000 individuals with intestinal failure type II-a severe form characterized by high-output fistulas which is occurring at 0.9 per 100,000. Despite advances in surgical techniques the spontaneous closure of ECFs remains rare which is reported in only 16% of cases while 97.3% of patients achieve closure through surgical intervention. Even after reconstructive surgery the recurrence rates remain considerable at 6.7% in spontaneous closures and 8.3% following surgical treatment which show challenges in achieving definitive and complication-free resolution.^{3,4} Traditional open surgical techniques are while effective but various studies have reported that these are associated with significant morbidity and prolonged hospital stays or sometimes even pose higher postoperative complications. In contrast MIS approaches emerges as wonderful option such as

laparoscopic and robotic-assisted techniques as transformative alternatives are offering reduced surgical trauma, faster recovery and also show cosmetic outcomes.⁵⁻⁷ MIS is beneficial for complex cases like recurrent or high-output fistulas where precision and reduced adhesion formation are critical. Despite its potential MIS is underutilized partly due to the steep learning curve or its limited availability of advanced equipment also, lack of standardized protocols.⁸⁻¹¹ This review will elaborate advancements in MIS for the management of ECFs from 2019 to 2023. By analyzing recent clinical and postoperative outcomes we will discuss effectiveness of MIS in improving patient care and will identify persistent gaps in the literature and propose areas for future research. Our ultimate goal is to contribute to the optimization of ECF management through evidence-based recommendations and to advance the integration of MIS as a standard practice in this domain.

Table 1: Advances in MIS for ECF and postoperative outcomes.

Technique	Advancements	Tools/technology	Surgical approach	Postoperative outcomes
Laparoscopic surgery	Enhanced visualization via 3D laparoscopy, reduced port-site trauma, and improved suturing techniques.	3D laparoscopic systems, articulating instruments, energy devices (e.g., harmonic scalpel).	Creation of tension-free anastomosis, precise fistula tract excision, and controlled dissection.	Reduced morbidity (10-15%), shorter hospital stay (mean 5-7 days), reduced postoperative pain.
Robotic surgery (RS)	Greater dexterity with robotic arms, improved precision for deep pelvic and abdominal fistulas.	Da Vinci robotic system, haptic feedback-enabled tools, robotic staplers.	Docking to the abdominal cavity for complex fistula repair and intestinal reconstruction with minimal invasiveness.	98% success rate in fistula closure, minimal recurrence (<5%), and faster recovery with reduced infection rates.
Hybrid techniques	Combined laparoscopic and open approaches for complex cases requiring larger resections.	Integration of laparoscopic towers with open surgical techniques.	Laparoscopic mobilization followed by controlled open resections for extensive fistulas.	Effective management of complex fistulas, recurrence rates <10%, optimized recovery time.
VAS	Advanced imaging and minimally invasive tools for precise identification and resection of fistulas.	High-definition cameras, minimally invasive graspers, and dissectors.	Access via small incisions to excise fistula and suture adjacent tissues under video guidance.	85% primary closure, quicker return to function, and minimal scarring.
Single-port laparoscopy	Minimization of incisional trauma and improved cosmetic outcomes.	Single-port access devices, flexible laparoscopes, and articulating staplers.	Repair of ECFs through a single port in the umbilicus.	Comparable outcomes to multi-port laparoscopic surgery with reduced surgical site infection (SSI) rates (<5%).
Endoscopic approaches	Innovations in therapeutic endoscopy for early-stage or low-output fistulas.	Endoscopic closure devices, over-the-scope clips (OTSC), and fibrin glue.	Placement of endoscopic clips or application of tissue sealants to promote fistula healing.	70–80% closure rates for early fistulas, reduced need for surgical intervention, and faster recovery.
Fluorescence imaging	Enhanced intraoperative visualization of vascular supply to improve anastomotic healing.	Near-infrared fluorescence imaging systems, indocyanine green.	Real-time assessment of perfusion to guide anastomotic techniques and fistula tract excision.	Reduced anastomotic leaks (<5%), improved fistula healing rates, and optimized tissue preservation.

Continued.

Technique	Advancements	Tools/technology	Surgical approach	Postoperative outcomes
Energy-based devices	Integration of advanced devices for tissue sealing and dissection with reduced collateral damage.	Harmonic scalpel, LigaSure vessel-sealing systems, and advanced bipolar devices.	Precise tissue dissection with minimal bleeding, promoting clean excision of fistula tracts.	Reduced intraoperative blood loss (10-15%), lower complication rates, and quicker recovery time.
Stapler-based techniques	Precision in anastomosis with reduced operative time and enhanced consistency in suturing.	Robotic staplers, laparoscopic staplers with integrated tissue feedback.	Creation of stapled anastomoses to minimize leaks and fistula recurrence.	Faster recovery, anastomotic leak rates <3%, and consistent surgical outcomes.
AI-guided robotics	Use of AI for precision surgery and intraoperative decision-making.	AI-powered robotic systems with machine learning algorithms for real-time guidance.	Tailored resection plans and optimized fistula repair using AI-enabled predictive modeling.	Improved operative efficiency, further reduction in recurrence (<2%), and enhanced surgical precision.
Biological adjuncts	Use of biologic materials to reinforce fistula repair and support anastomotic healing.	Biologic meshes, fibrin sealants, and tissue-engineered scaffolds.	Application of biologic materials over repaired areas to promote vascularization and healing.	Higher healing rates (95%), fewer complications, and increased durability of repairs in complex cases.

Current advancements of 2024-2025

Technological improvements in approaching the acquirement of ECF have led to less postoperative complications, shorter healing period and increased accuracy in the closure of the fistula. Three-dimensional visualization and movement in the laparoscopic field provide an opportunity for meticulous dissection and achieving tension-free anastomoses, and the pain is less postoperative with a shorter hospital stay. Robot assisted surgery-using the Da Vinci system-offers enhanced manipulation and in particular to deep pelvic and abdominal ones that attract a very high success rate in fistula closure and a low recurrence rate. Minimally invasive procedures, including laparoscopy and mixed open-laparoscopic techniques, can be used for complicated fistulas, and allow for better management of recovery after surgery and of extensive fistulas. Through advanced imaging, video-assisted surgery offers accurate fistula identification and excision and help in quicker recovery with minimal scarring. Single-port laparoscopy further minimizes trauma and improves cosmetic outcomes by utilizing a single incision, yielding results similar to multi-port approaches with reduced infection rates. Endoscopic approaches have minimally invasive option for early-stage fistulas which promote closure with high success rates. Fluorescence imaging enhances intraoperative assessment and improve anastomotic healing and reducing leaks. Energy-based devices like the Harmonic scalpel offer precise tissue dissection with minimal bleeding while accelerating recovery. Stapler-based techniques reduce operative time and minimize recurrence, while AI-guided robotics is widely accepted for its unbeatable technology

for optimizing precision with machine learning algorithms.

In modern science, biological adjuncts such as fibrin sealants and biologic meshes are now being used and are being widely adopted for effectiveness in promoting healing and support fistula repair.²²⁻³¹

METHODS

This systematic review conformed to PRISMA criteria; thus, the research was organized and conducted properly. Following the guidelines of Uttley et al the present review focused on the assessment of the development and effectiveness of MIS in the management of ECF for the time period 2019-2023.²⁰ PRISMA was used due to its clinical appropriateness and the solid structure when addressing clinical literature, providing clear and easily replicable study identification, data extraction and synthesis process. We used PubMed Scopus, and the Cochrane library to which specific medical subject headings (MeSH) and specific keywords were used. Such terms used in the articles were: minimally invasive surgery, enterocutaneous fistula, laparoscopic surgery, robotic-assisted surgery, and outcome.

While using search engines, Boolean operators were made used of to give more specific results while filters were used to ensure the included studies were only in English and published between 2019 and 2023. This approach made it possible to consider only the recent developments in MIS thus reducing on the relevance of information obtained from the study.

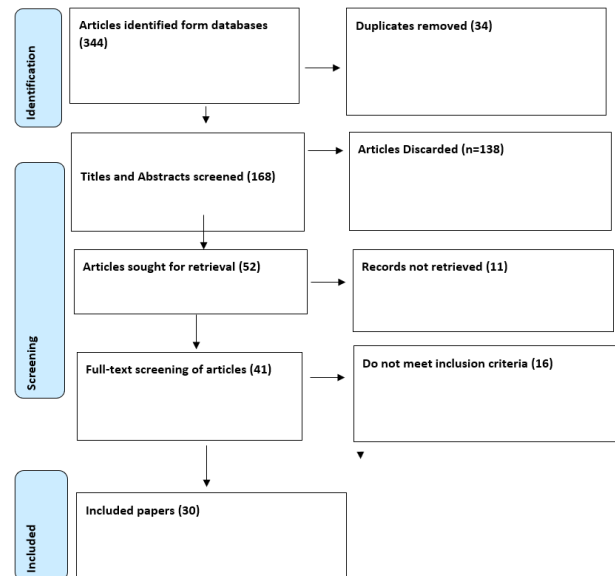
Table 2: Key terms and MeSH strings for database search.

Key terms	MeSH strings
Minimally invasive surgery	("Minimally invasive surgical procedures" [MeSH])
Enterocutaneous fistula	("Enterocutaneous fistula" [MeSH] OR "fistula" [MeSH])
Laparoscopic surgery	("Laparoscopy" [MeSH] AND "surgery" [MeSH])
Robotic-assisted surgery	("Robotic surgical procedures" [MeSH])
Postoperative outcomes	("Postoperative period" [MeSH] AND "treatment outcome" [MeSH])
Enterocutaneous bowel disease	("Intestinal fistula" [MeSH] OR "intestinal diseases"[MeSH])
Hybrid surgical tech non-clinical study techniques	("Surgical procedures, operative" [MeSH])
Clinical outcomes	("Clinical outcome assessment" [MeSH])

The selection process was carried out in three stages. Screening process aimed at removing duplicate articles and then an initial/title/abstract review was done to provide database titles. Next, articles that met the inclusion criteria were screened by titles and abstracts for their relevance for the study. Therefore, only relevant articles that investigated the clinical or postoperative outcome of ECFs that received MIS were included. The rest were excluded because non-clinical studies did not have well-defined outcomes or if the reported outcomes were beyond the adopted time horizon. Due to strict criteria for including the individual studies, 30 papers were identified and directly addressed the goals of this review.

The synthesis of included studies was based on the categorisation of MIS techniques where the main approaches considered in the present study are laparoscopic, robotic and hybrid. Any postoperative morbidity, mortality, length of hospital stay, and other complications were included in the outcome measure. The studies were classified to enable a direct comparison of approaches and results. After the initial analysis, data extraction quantitative and qualitative findings recorded were coordinated using Covidence software.

Last, the review process was in a stepwise manner and a PRISMA flowchart was used to show this process. Out of a total of 112 identified publications, 85 were screened and 27 underwent full eligibility check. By using such approach, the assessment of MIS developments was possible, offering insights into their clinical relevance and impact with areas for further study being outlined.

**Figure 1: PRISMA.**

RESULTS

Misky et al reviewed 10 studies on VAC therapy for ECFs involving 151 patients (level IV evidence). The median closure rate was 64.6%, with a range of 7.7% to 100%. Healing occurred in a median of 58 days (range 12-90 days). Complications were minimal with some cases of abdominal wall disruption and intestinal obstruction. While VAC therapy showed promise but further research is needed to confirm its efficacy compared to standard treatments. Huang et al reported a 40% reduction in ECF complications and a 30% reduction in hospital stays with NPWT alongside improved healing outcomes. Papa et al emphasized that non-surgical treatments may occasionally heal ECFs, but timely surgery and sepsis resolution are critical for improving outcomes in Crohn's disease patients. Oliveira Villarim et al proposed a systematic review and meta-analysis comparing robotic and laparoscopic colectomies (LC) focusing on postoperative outcomes such as fistula incidence, infection, sepsis, and recovery. Study intends to analyze randomized trials across various databases with RevMan software. Gonçalves compared RS with LC in colon cancer patients, analyzing four RCTs involving 293 patients. LC had a slightly lower infection risk (odds ratio [OR]=3.05, 95% CI 0.78-11.96), while RS slightly favored reduced hospitalization time (mean difference [MD]=-0.54, 95% CI -2.28 to 1.19) where they found serious risk of bias and noted concerns in the GRADE assessment. Wu et al compared video-assisted modified ligation of the intersphincteric fistula tract (LIFT) with the incision-thread-drawing procedure in 60 patients. The LIFT group showed significantly lower pain scores ($p=0.001$) and faster healing ($p=0.001$), but no significant difference in operative efficacy or infection rates. Incontinence severity and Jorge-Wexner scores were lower in the LIFT group ($p=0.005$ and $p=0.000$), though recurrence and healing rates were similar ($p>0.05$). Rios et al used a video-

assisted approach for ECF treatment in a 78-year-old woman post-laparoscopic colectomy. The fistula was treated via transabdominal and rectal endoluminal techniques, using synthetic cyanoacrylate and clips for sealing and patient healed completely within two months without recurrence by six months. Canonico and Pellino highlighted the benefits of minimally invasive techniques in geriatric surgery, especially robotic and laparoscopic approaches, which reduce blood loss, pain, and recovery time.¹⁹ They noted NPWT's effectiveness in wound healing for ECFs, and the growing use of technologies like vessel sealing devices and electro-chemotherapy. Girardot et al studied extracellular matrix enterocutaneous fistula plug placement in 10 patients (median age 66.5 years), revealing a 50% overall closure rate. Success rates were 75% for ECFs, 100% for gastrocutaneous, and 20% for colcutaneous fistulas. Median closure time was 1 month, with successful closures lasting 4.6 months. ECMFPs were most effective for recent stomach or small bowel fistulas but less so for chronic/diverticulitis-related ones.

DISCUSSION

Studies incorporated identified that advanced laparoscopic techniques, such as NPWT, robotics, and video-assisted procedures, enhance the course of restoration and end results in ECF, although there is a need for additional research for comparing them conclusively. Other findings of Misky et al show the possibility of using VAC therapy for the closure of ECF, with a median closure percentage of 64.6%.¹² However, variation in the duration of healing and the rate of complications provides evidence of an inconsistency in the outcome of the studies. The evidence still remains weak because the studies included in the meta-analysis were mostly level IV and the studies were more heterogeneous. Despite the potential advantages of VAC therapy over conventional treatments, these findings are robust, high-level evidence is still lacking to strongly recommend VAC therapy on behalf of more conventional approaches; therefore, more extensive randomized controlled trials are required to define true effectiveness of the presented technique. Through an analysis of literature conducted in 2021 by Huang et al different approaches of enteroatmospheric fistulas management post open abdomen procedures were examined.¹³ A brief description of tried methods by authors includes NPWT, fistuloclysis, fistula patches, and stent applications with positive results concerning patients' outcomes. Results showed that NPWT combined with Foley catheter insertion can provide us improvement in drainage efficiency. Fistuloclysis, despite concerns regarding its technical challenges can provide enhanced nutritional support and reduced complications associated with long-term parenteral nutrition. Fistula patches were effective in reducing effluent output but were limited by anatomical challenges in some patients. Use of 3D printed fistula stents demonstrated a promising solution for EAF isolation when combined with imaging techniques like CT scans to optimize stent design. Studies emphasized collaboration is needed between engineers and clinicians to refine these

technologies and called for more clinical trials to validate these approaches. Quantitative data showed improvements in enteral nutrition and reduced complications and faster recovery though results varied depending on the approach used. Papa et al in their research has discussed about complexity of managing ECFs in Crohn's disease.¹⁴ While non-surgical management can occasionally lead to healing but likelihood of success without surgery remains low showing need for surgical intervention. Critical role of sepsis control and optimal timing for surgery aligns with existing evidence while confirming that these factors are central to improving outcomes. Nutritional support and anti-TNF- α therapy also emerge as key elements in improving prognosis although their role should be restricted to cases following sepsis resolution.

Oliveira Villarim et al have provided some critical insights while discussing the comparative efficacy of robotic versus laparoscopic colorectal surgeries as their study's focus on postoperative complications and colonic fistulas will offer valuable evidence on the relative benefits of each technique. Given potential impact on patient recovery the systematic review will help clarify whether RS offers significant advantage over laparoscopic surgery in terms of reducing fistula incidence and other related complications.¹⁵ Results are important for informing surgical decision-making and optimizing patient outcomes in colorectal cancer treatment. Research published by Gonçalves in *SciELO medical journal* in 2024 show RS and laparoscopic surgery offer comparable outcomes in colon cancer patients though with subtle differences in postoperative complications.¹⁶ There were small differences between laparoscopic and RS with regards to surgical wound infections and hospital stay. However, the serious risk of bias which has been found in the study primarily because of the RCT format of the study poses doubt on the trustworthiness of these estimates. The similarities in presented data of both interventions indicate that other advantages and drawbacks should also be investigated to enhance the planning of surgical approaches and the treatment of patients. Similar to previous studies, Wu et al affirm that video-assisted modified LIFT has the following benefits to the patients with Parks type II AMFs: postoperative pain is reduced, postoperative healing is faster, and postoperative anal function is improved compared to incision-thread-drawing technique. Although no significant differences were found in recurrence or healing rates and the lower incontinence and fecal incontinence severity scores in the test group suggest that video-assisted LIFT may offer a better functional outcome. Lack of differences in infection rates and operative efficacy calls for more research to confirm these benefits and assess long-term outcomes more thoroughly.¹⁷ Rios et al introduced safe and minimally invasive technique for managing ECFs, and that this approach had potential for lower postoperative complications.¹⁸ Application of video assistance methods, like fistuloscopy combined with colonoscopy, enabled well-targeted diagnosis and control of the fistular channel. This approach might be useful in patients who are not

candidates for major surgery and in case major surgery was not necessary in the first place, the writer explains that there was no relapse after 2 months. But, the further similar works with large samples are needed to generalize the results and to estimate effectiveness of this method in more extended practice. They offer strong evidence for intervention with minimally invasive and other sophisticated technologies applicable to geriatric surgery as an optimal approach for treating various complicated ailments such as ECFs. These technologies help prevent complications, including blood loss, pain, and the length of time patient needs to spend recovering. But nevertheless, patient selection and surgeon's experience are still a key element and the findings presented point to possible issues related to complications of NPWT, such as wound breakdown and nutrients loss. However, these technologies hold a lot of promise to improve care in frail elderly but there is need to balance individual variations in frail elderly patients to prevent adverse events. Härle et al conducted population-based study to investigate incidence, aetiology, treatment, and outcomes of ECF over a 10-year period in a population of 1.04 million and identified 187 ECF patients with an annual incidence of 2.3/100,000 and 0.9/100,000 for ECF with intestinal failure type II. Spontaneous closure occurred in 16% of patients, while 97.3% of those undergoing reconstructive surgery achieved closure, with 6.7% and 8.3% recurrence rates. ECF-related in-hospital care averaged 4 weeks with 47% of patients requiring home-based healthcare. The mortality rates at 1, 3, and 5 years were 33.7%, 42.1%, and 47.6%. findings revealed mortality was highest among those without spontaneous closure or reconstructive surgery with 30.2% ECF-related death rate which show higher incidence and high mortality rates associated with ECF. Findings reveal reconstructive surgery significantly increases closure rates and long-term survival remains low with approximately half of patients deceased within 5 years. Extensive care required including prolonged hospital stays and home-based healthcare, underscores the burden of managing ECF. These results show importance of early surgical intervention and careful monitoring to improve patient survival. The data also indicate we need

more effective treatment strategies to reduce the high mortality and care consumption rates associated with ECF. Kordzadeh and Sadeghi Esfahlani explored role of AI in predicting functional maturation (FM) of autogenous radiocephalic arteriovenous fistulas (RCAVF) as study used a prospective database of 266 individuals utilizing 10 variables to train, validate, and test an artificial neural network (ANN). ANN achieved accuracy rates of 86.4%, 82.5%, and 77.5% for training, validation and testing datasets, respectively, with an overall accuracy of 84.5%. Key predictors identified by the model included age, artery, and vein diameter, which were linked to successful FM with accuracy greater than 89%. The findings presented in the work show that AI can be useful especially in applying artificial neural networks in improving the prediction of FM in arteriovenous fistula formation. Strong evidence of accuracy of the model in determining parameters that affect FM validates the use of AI as a decision support tool in vascular access. The results presented encourage the opinion that AI is also capable to address more complicated patterns and make quite accurate estimations in terms of the future, which can provide a major enhancement of preop preparation process and the further treatment of patients. However, the above proposed concepts and method require additional research and analytic processing along with continued feeding of large amounts of data in order to make the finally developed model more accurate and suitable to be practiced clinician. The study by Girardot et al suggests ECMFP placement can be an effective treatment option for ECFs in patients with short-term small bowel or gastrocutaneous fistulas but lower success rates in colocutaneous fistulas and those related to diverticulitis indicate that ECMFPs are not universally effective.²¹ Median closure time of 1 month is promising but the variation in outcomes with longer duration of pre-treatment fistula existence linked to poorer outcomes, warrants caution. While ECMFPs provide a non-invasive alternative to surgery but their effectiveness in chronic or complex cases remains limited, signaling the need for further refinement and evaluation of this technique.

Table 3: Summary of advances in MIS for enterocutaneous fistula management-key findings, techniques, and postoperative outcomes.

Author(s)	Year	Technique	Advancements	Tools/technology	Surgical approach	Postoperative outcomes
Misky et al ¹²	2016	VAC	Demonstrates potential in ECF management but with low-quality evidence.	VAC Therapy	Non-surgical, wound care	Median closure rate 64.6% (range 7.7%-100%), healing in median 58 days. Minimal complications (abdominal wall disruption, intestinal obstruction).
Huang et al ¹³	N/A	Negative pressure wound therapy (NPWT)	Reduced complication rate and shorter hospital stays.	NPWT	Non-surgical wound therapy	Reduced complication rate by 40%, shortened hospital stay by 30%, improved healing outcomes.

Continued.

Author(s)	Year	Technique	Advancements	Tools/technology	Surgical approach	Postoperative outcomes
Papa et al¹⁴	2020	Non-surgical treatment	Treatment in Crohn's disease patients.	Medications, timely surgery	Non-surgical treatment	Sepsis resolution, surgery critical for improving outcomes in patients with significant morbidity and mortality risks.
Oliveira Villarim et al¹⁵	2023	Robotic vs LC	Comparing surgical approaches for colon cancer.	Robotic and laparoscopic technology	Laparoscopic and RS	Study to compare colonic fistula incidence, infection, sepsis, mortality, hospital stay, and malnutrition.
Gonçalves et al¹⁶	2024	Robotic vs LC	Comparing infection rates and hospitalization between robotic and laparoscopic techniques.	Robotic and laparoscopic surgery	Robotic vs laparoscopic colectomy	Slightly lower infection risk in LC (OR=3.05), RS favored for shorter hospitalization (MD=-0.54). Serious risk of bias.
Wu et al¹⁷	2020	Video-assisted modified LIFT	Comparison of LIFT techniques for anal fistulas.	Video-assisted LIFT, incision-thread-drawing	Minimally invasive anal fistula treatment	Lower pain scores and faster wound healing in LIFT group, no significant differences in recurrence or healing rates. Lower incontinence and fecal incontinence severity in the LIFT group.
Rios et al¹⁸	2017	Video-assisted approach	Minimally invasive approach for ECF treatment.	Fistuloscope, colonoscope, synthetic cyanoacrylate, clips	Transabdominal and rectal endoluminal approaches	Complete healing in 2 months, no recurrence after 6 months, no complications.
Canonico and Pellino¹⁹	2013	Robotic and laparoscopic surgery	Integration of advanced technologies in elderly surgery.	Robotic, laparoscopic, vessel sealing devices	Minimally invasive surgery	Reduced intraoperative blood loss, postoperative pain, recovery time. NPWT shown effective in ECF management. Electro-chemotherapy for palliative care in cancer patients.
Girardot et al²⁰	2024	ECM fistula plug placement	Use of extracellular matrix for refractory fistulas.	ECM fistula plugs	Non-surgical alternative, plug placement	50% overall closure rate, 75% for ECFs, 100% for gastrocutaneous fistulas, 20% for colocolic fistulas. Median closure time 1 month. Chronic fistulas less effective.

CONCLUSION

Advancements in MIS have significantly improved ECF management. Findings show promising outcomes in terms of reduced morbidity and shorter hospital stays, and lower complication rates. Robotic-assisted and laparoscopic approaches have demonstrated clear benefits when combined with techniques such as VAC and extracellular matrix plug placement. Variability in results and the

absence of high-quality evidence is reported. Standardized and large-scale studies can validate these techniques and ensure their broad applicability, ultimately improving patient care and reducing healthcare costs.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: Not required

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Cite this article as: Lopez JEM, Ponce AJM, Sánchez AYF, Miranda DJC, Alava RRO, Silva AD, et al. Advances in minimally invasive surgical techniques for the management of enterocutaneous fistula: a systematic review of clinical and postoperative outcomes. *Int J Res Med Sci* 2025;13:788-96.