VER
Vascular & Endovascular Review

Endoscopic Management of Post-POEM Gastroesophageal Reflux Disease in Achalasia: Current Evidence, Techniques, and Clinical Decision Pathways

Zeinab mostafa saad[1], Taha mohamed hasanin[2], Shaima elkholy[3], Gasser elzaeem ismail[4], Omar ahmed abdelazim[5]

[1]Professor of tropical medicine, Faculty of medicine, Minia university.
[2]Professor of tropical medicine, Faculty of medicine, Minia University.
[3]Associate professor of internal medicine, Faculty of Medicine , Cairo university.
[4]Assistant lecturer of tropical medicine, Faculty of medicine, Minia University.
[5]Lecturer of tropical medicine, Faculty of Medicine, Minia University

ABSTRACT

Peroral endoscopic myotomy (POEM) has become a standard therapy for achalasia owing to its high efficacy, minimal invasiveness, and technical flexibility. However, elimination of the lower esophageal sphincter (LES) barrier creates a substantial risk of post-procedural gastroesophageal reflux disease (GERD), with reported rates ranging from 30–60% depending on objective testing. While proton pump inhibitors (PPIs) remain first-line therapy, a considerable subset of patients continue to experience persistent or progressive reflux symptoms, esophagitis, or pathological acid exposure. This has led to rapid development of minimally invasive endoscopic anti-reflux techniques tailored to the unique post-POEM anatomy.

This review summarizes the incidence, mechanisms, and diagnostic evaluation of GERD following POEM, followed by a detailed overview of emerging endoscopic management strategies including transoral incisionless fundoplication (TIF), anti-reflux mucosectomy (ARMS), anti-reflux mucosal ablation (ARMA), Stretta radiofrequency therapy, and endoscopic suturing-based fundoplication. The review highlights the strengths and limitations of each modality, comparative effectiveness, and patient selection criteria. A stepwise management algorithm is proposed integrating symptom assessment, endoscopic findings, pH-impedance metrics, and anatomical considerations.

Endoscopic therapies now bridge the gap between medical and surgical approaches, offering durable reflux control with significantly lower morbidity. As POEM becomes increasingly widespread, structured evaluation and individualized management of post-POEM GERD are essential. Future directions include hybrid POEM-fundoplication (POEM-F), artificial valve restoration devices, and AI-driven prediction models for GERD risk stratification.

KEYWORDS: POEM, Achalasia, GERD, Anti-reflux endoscopy, ARMS, ARMA, TIF.

How to Cite: Zeinab mostafa saad, Taha mohamed hasanin, Shaima elkholy, Gasser elzaeem ismail, Omar ahmed abdelazim, (2025) Endoscopic Management of Post-POEM Gastroesophageal Reflux Disease in Achalasia: Current Evidence, Techniques, and Clinical Decision Pathways, Vascular and Endovascular Review, Vol.8, No.14s, 312-323.

INTRODUCTION

Achalasia is a chronic, progressive esophageal motility disorder characterized primarily by impaired relaxation of the lower esophageal sphincter (LES) and the absence of coordinated peristalsis within the esophageal body. These functional abnormalities lead to stasis of ingested material, progressive esophageal dilation, and debilitating symptoms such as dysphagia, regurgitation, chest pain, and weight loss. Over the past century, the therapeutic goal has remained constant: to reduce LES pressure sufficiently to improve esophageal emptying while minimizing treatment-induced complications, particularly gastroesophageal reflux disease (GERD). Traditional therapies—including pneumatic dilation and laparoscopic Heller myotomy (LHM) with partial fundoplication—provided effective relief but were limited by invasiveness, variable durability, and anatomical constraints.
Peroral endoscopic myotomy (POEM), introduced by Inoue and colleagues in 2010, revolutionized the management paradigm by offering a minimally invasive, natural-orifice approach capable of achieving precise myotomy along the inner circular muscle layer. POEM rapidly gained global adoption due to its technical flexibility, high clinical success rates, and applicability across all achalasia subtypes, including type III (spastic) achalasia, which historically responded poorly to conventional interventions. Long-term data now confirm durable symptom resolution in 80–95% of patients, reinforcing POEM as a frontline modality in major international guidelines.

Despite these advantages, the physiologic alteration created by POEM introduces a significant trade-off. Because the procedure deliberately eliminates the LES pressure barrier without incorporating a fundoplication mechanism—as is routinely performed with LHM—the natural anti-reflux defenses at the gastroesophageal junction (GEJ) become compromised. The GEJ flap valve, angle of His, and crural diaphragm synergy contribute to the anti-reflux barrier; however, POEM disrupts the controlled closure mechanism by dividing the muscular fibers while leaving no structural reinforcement behind. This anatomical and functional modification predisposes a substantial proportion of patients to post-procedural GERD. Objective studies consistently show abnormal acid exposure in 35–60% of patients, while endoscopic esophagitis is documented in nearly one-third. Importantly, many patients remain asymptomatic despite significant reflux injury, underscoring the importance of systematic surveillance.

The resulting challenge for clinicians is to maintain the therapeutic benefits of POEM while effectively identifying and managing

reflux-related sequelae. As experience with POEM expands, emphasis has increasingly shifted toward understanding GERD mechanisms unique to post-POEM anatomy and tailoring management strategies accordingly. This has fueled the development of a spectrum of endoscopic anti-reflux interventions aimed at restoring GEJ competence without compromising the advantages of the original procedure.

Unlike laparoscopic Heller myotomy (LHM)—which is routinely complemented by a partial fundoplication such as Dor or Toupet to mitigate postoperative reflux—peroral endoscopic myotomy (POEM) is performed entirely via a natural orifice and involves selective myotomy without any anatomical reconstruction of the gastroesophageal junction (GEJ). In LHM, the addition of fundoplication restores a degree of valve competence by reinforcing the angle of His, augmenting the LES flap mechanism, and preventing free reflux while maintaining adequate esophageal emptying. In contrast, POEM relies exclusively on the myotomy itself and preservation of the mucosal tunnel without altering the surrounding anti-reflux structures. While this contributes to its minimally invasive nature and technical simplicity, the absence of a fundoplication layer creates intrinsic vulnerability to gastroesophageal reflux disease (GERD). As a result, POEM produces a physiologic state in which the LES pressure barrier is intentionally abolished while no compensatory mechanism is introduced to counteract retrograde acid flow.
This anatomical imbalance leads to a unique postoperative reflux profile distinct from that seen after LHM. Patients undergoing POEM may exhibit higher rates of pathological acid exposure, non-acid reflux, increased esophageal distensibility, and prolonged acid clearance times. Importantly, a considerable proportion remain asymptomatic despite significant esophagitis or abnormal pH metrics, highlighting the silent yet clinically relevant nature of post-POEM GERD. These features make the management of reflux after POEM particularly challenging, as standard symptom-based assessment alone may underestimate the true burden of disease. The therapeutic dilemma revolves around achieving reliable reflux control while preserving the core advantages of POEM—namely its minimally invasive approach, ability to treat complex or spastic achalasia, and excellent long-term dysphagia relief.

Against this background, the objective of this review is fourfold.
First, it aims to provide an updated synthesis of the incidence and mechanisms underlying GERD after POEM, outlining the physiological and anatomical factors that predispose patients to reflux in the absence of a surgical fundoplication. Understanding these mechanisms is crucial for designing preventive and therapeutic strategies.
Second, the review describes the diagnostic modalities used to assess reflux in post-POEM patients, emphasizing objective measures such as endoscopy, pH-impedance monitoring, high-resolution manometry, and EndoFLIP distensibility assessment. Special attention is given to the limitations of symptom-based evaluation and the importance of risk stratification.
Third, the article presents a comprehensive overview of emerging endoscopic anti-reflux interventions—such as transoral incisionless fundoplication (TIF), anti-reflux mucosectomy (ARMS), anti-reflux mucosal ablation (ARMA), Stretta radiofrequency therapy, and endoscopic suturing or valve-restoration systems. These minimally invasive options have gained traction as attractive alternatives to surgical fundoplication, especially for patients with anatomic configurations unique to POEM.
Finally, the review proposes a practical, evidence-based clinical management algorithm integrating symptom evaluation, objective testing, severity grading, and tailored therapeutic selection. This structured approach aims to provide clinicians with a logical and efficient framework for managing reflux after POEM, balancing efficacy, safety, and durability.
Together, these elements aim to deliver a coherent, clinically meaningful synthesis that reflects current evidence, informs practice, and guides future innovation in the management of post-POEM GERD.

INCIDENCE AND BURDEN OF GERD AFTER POEM

2.1 Symptomatic GERD

Symptomatic gastroesophageal reflux disease represents one of the earliest and most recognizable manifestations of post-POEM reflux; however, its diagnostic value is limited due to the dissociation between symptoms and objective findings. Approximately **20–45%** of patients report classical reflux symptoms—including heartburn, acid regurgitation, sour taste in the mouth, and nocturnal discomfort—during long-term follow-up after POEM. A subset may also present with atypical manifestations such as chronic cough, throat clearing, dysphonia, or non-cardiac chest pain, which may be overlooked unless actively assessed.
Nevertheless, reliance on symptomatology alone significantly underestimates the true prevalence of GERD. Up to **50% of patients with pathological acid exposure remain asymptomatic**, indicating a high prevalence of "silent reflux." This phenomenon is likely multifactorial, arising from impaired esophageal sensation, long-standing motility dysfunction, and dilution of acid by retained food or secretions in dilated or aperistaltic esophageal segments. Given these limitations, symptom-based screening is insufficient, and structured objective evaluation remains mandatory after POEM.

2.2 Endoscopic Esophagitis

Endoscopic evaluation plays a critical role in assessing mucosal injury caused by reflux exposure. Post-POEM esophagitis is observed in **30–40%** of patients, with the Los Angeles (LA) classification serving as the standard grading system. While LA grade A erosions may occur transiently and may not always signify clinically significant reflux, the presence of **LA grade B or higher** typically reflects more severe or persistent acid exposure.

The pattern of inflammation in post-POEM patients may differ from that seen in typical GERD. Chronic stasis of material, reduced clearance, and persistent LES hypotension contribute to prolonged contact time between acid and mucosa, predisposing to deeper epithelial injury. In select patients—particularly those with long-standing achalasia—reflux may coexist with mucosal changes from chronic stasis, making interpretation more complex. Although Barrett's esophagus remains relatively uncommon after POEM, with an incidence of <2%, the combination of chronic reflux and impaired clearance warrants long-term endoscopic surveillance in high-risk individuals.

2.3 Objective Reflux on pH-Impedance Monitoring

Ambulatory pH or pH-impedance monitoring represents the gold standard for quantifying acid exposure and detecting non-acid reflux episodes. Objective testing reveals pathological acid exposure in approximately **35–60%** of post-POEM patients. Some high-volume centers report rates exceeding **70%** when a **full-thickness myotomy** is performed or when the gastric extension exceeds 3 cm. pH-impedance testing is particularly important because POEM significantly increases esophageal distensibility and reduces clearance, both of which predispose to prolonged reflux episodes.

Non-acid and weakly acidic reflux—often overlooked in standard pH-only testing—are also common findings after POEM and may explain persistent symptoms in patients who remain symptomatic despite adequate PPI therapy. The DeMeester score, total acid exposure time, number of reflux episodes, and mean nocturnal baseline impedance provide valuable information for risk stratification. Importantly, pH-impedance testing is recommended **off PPI therapy** to obtain accurate physiological data unless specific situations dictate otherwise.

2.4 Predictors of Post-POEM GERD

Multiple procedural, anatomical, and patient-related factors contribute to the risk of developing GERD after POEM. Understanding these predictors is essential for patient counseling, tailored surveillance, and individualized treatment planning.

• Full-Thickness Myotomy

Extending the myotomy through both circular and longitudinal muscle layers may increase EGJ compliance and reduce LES pressure beyond desired therapeutic levels, thereby elevating reflux risk.

• Longer Gastric Extension (>3 cm)

Myotomy extending deeply into the gastric cardia disrupts the oblique "sling fibers" that contribute to the LES valve mechanism, weakening the flap valve and enhancing retrograde flow.

• High EGJ Distensibility (EndoFLIP)

A markedly elevated EGJ distensibility index correlates strongly with pathological reflux. EndoFLIP measurements after POEM can help identify patients at high risk for GERD even before symptoms appear.

• Obesity (BMI ≥30)

Increased intra-abdominal pressure exacerbates reflux by promoting gastric content migration across a compromised LES barrier. Obesity also increases the likelihood of nocturnal reflux and esophagitis.

• Pre-existing Hiatal Hernia

Even small hiatal hernias disrupt the diaphragmatic crura and GEJ alignment. After POEM, these patients may experience disproportionately severe reflux due to additive anatomical impairment.

• Type III Achalasia

The spastic variant may require a longer or deeper myotomy to relieve outflow obstruction, increasing the chance of damaging anti-reflux structures. This subgroup shows a tendency toward higher acid exposure post-procedure.

• Sigmoid Esophagus

Significant dilation and tortuosity impair esophageal clearance, allowing acid to remain in prolonged contact with the mucosa. This leads to increased esophagitis rates, even when acid exposure is modest.

PATHOPHYSIOLOGY OF POST-POEM GERD

Gastroesophageal reflux disease after POEM arises from a complex interplay of anatomical disruption, altered sphincter mechanics, changes in esophageal clearance, and modifications in gastroesophageal junction (GEJ) physiology. Unlike surgical Heller myotomy—where fundoplication provides a compensatory barrier—POEM removes the LES resistance without introducing reconstructive reinforcement. The unique nature of the myotomy, combined with achalasia-related baseline motility abnormalities, leads to several physiologic mechanisms that promote reflux. Understanding these mechanisms is essential to tailoring diagnostic strategies and selecting appropriate therapeutic interventions.

3.1 Loss of Basal LES Pressure

One of the most direct consequences of POEM is the deliberate division of the inner circular muscle fibers responsible for maintaining LES basal tone. This reduction in sphincteric resistance eliminates outflow obstruction and relieves dysphagia, but it simultaneously removes the primary barrier preventing retrograde movement of gastric contents. Studies consistently demonstrate near-complete loss of LES resting pressure post-procedure, resulting in an open and compliant GEJ.

With the LES rendered hypotensive, the esophagus becomes vulnerable to both acid and non-acid reflux, especially when gastric pressure increases during meals, bending, or nocturnal recumbency. Unlike transient LES relaxations in classic GERD, post-POEM reflux tends to be continuous and mechanically driven due to the absence of structural resistance.

3.2 Disruption of the Angle of His and Flap Valve Mechanism

The angle of His and the mucosal flap valve play key roles in maintaining the integrity of the anti-reflux barrier. In healthy

individuals, the acute angle between the esophagus and gastric fundus contributes to a valve-like mechanism that prevents gastric content reflux during intragastric pressure fluctuations.

During POEM, the submucosal tunnel approach and myotomy within the distal esophagus and proximal stomach alter the geometry of the GEJ. Although the mucosa is preserved, underlying muscular disruption diminishes the resting angulation of the GEJ and weakens the flap valve. Additionally, division of sling fibers along the gastric cardia further impairs the oblique muscle mechanism necessary for maintaining one-way flow, thereby facilitating effortless retrograde flow of gastric contents.

3.3 Increased GEJ Distensibility

EndoFLIP technology has shown that POEM consistently results in a substantial rise in GEJ cross-sectional area and distensibility index, values that correlate directly with acid exposure time. A more distensible GEJ behaves as a loose, compliant passageway, unable to generate adequate closure pressure even during transient abdominal pressure increases.
High distensibility not only promotes reflux but also prolongs the dwell time of gastric contents within the lower esophagus. Several studies confirm that post-POEM patients with the highest distensibility values experience the most severe pH abnormalities and a higher incidence of erosive esophagitis. This makes distensibility assessment a key predictor of postoperative reflux severity.

3.4 Esophageal Hypomotility and Impaired Clearance

Achalasia is fundamentally a motility disorder characterized by loss of peristalsis or severely compromised esophageal body contractions. Although POEM effectively addresses LES outflow obstruction, **it does not restore peristalsis**. In many patients, aperistalsis persists for years—or indefinitely—after treatment.

This persistent motility deficit leads to prolonged retention of both swallowed material and refluxate. Acid or non-acid gastric contents entering the esophagus cannot be quickly expelled, resulting in dramatically extended mucosal exposure times. Prolonged clearance time is a key contributor to mucosal damage and partially explains why post-POEM esophagitis can be more severe than in primary GERD.

In patients with sigmoid esophagus or severe dilation, clearance impairment becomes even more pronounced due to anatomic tortuosity and stasis.

3.5 Gastric Cardia Migration

In a subset of patients, the distal extension of the myotomy into the gastric cardia—particularly beyond 3 cm—may alter the anchoring structures that maintain the esophagus at the diaphragmatic hiatus. This can result in subtle cranial migration of the gastric cardia, which functionally mimics a small hiatal hernia even when not readily visible on imaging.

Cardia migration disrupts the alignment of the crural diaphragm and GEJ, further weakening the external sphincter mechanism and allowing retrograde movement of gastric contents with minimal pressure changes. This mechanism is more pronounced in individuals with pre-existing hiatal hernias or obesity.

3.6 Non-Acid and Mixed Reflux

A frequently overlooked aspect of post-POEM physiology is the high incidence of non-acid and mixed reflux events. Standard PPI therapy suppresses gastric acid secretion but **does not address regurgitation or retrograde movement of non-acidic material**. Because the GEJ barrier is anatomically compromised after POEM, these non-acid reflux events persist despite acid suppression.

pH-impedance monitoring often shows increased weakly acidic or weakly alkaline reflux episodes, particularly in patients who remain symptomatic on PPIs. These events may cause chronic cough, globus sensation, or chest discomfort, complicating postoperative assessment. Recognition of non-acid reflux is essential when selecting candidates for endoscopic anti-reflux procedures, as PPI escalation alone is unlikely to resolve their symptoms.

DIAGNOSIS AND ASSESSMENT

Assessment of Post-POEM GERD

Accurate diagnosis of gastroesophageal reflux after POEM requires a multimodal approach that incorporates symptoms, endoscopy, physiologic testing, and functional evaluation. Because post-POEM reflux has a unique pathophysiological profile—often silent yet objectively significant—relying on a single diagnostic tool is inadequate. A structured framework integrating clinical and instrumental assessments is essential for identifying clinically relevant disease, guiding therapy selection, and monitoring longitudinal outcomes.

4.1 Symptom Assessment

Symptom assessment remains a useful initial screening step but has limited diagnostic specificity in post-POEM patients. The most commonly reported symptoms include:

- **Heartburn:** A burning retrosternal sensation representing classic acid reflux.
- **Regurgitation:** Passive movement of gastric contents into the oropharynx, often exacerbated when bending or lying supine.
- **Chronic cough:** Can result from micro-aspiration or laryngopharyngeal irritation.

- **Chest discomfort:** May mimic cardiac pain and require differentiation from esophageal spasm or residual dysmotility.
- **Nocturnal aspiration episodes:** Particularly concerning in patients with esophageal stasis and severe nocturnal reflux.

Despite being clinically relevant, **symptoms correlate poorly with acid exposure** after POEM. Up to half of patients with significant pH abnormalities remain asymptomatic, while others may report symptoms unrelated to reflux (e.g., esophageal hypersensitivity, stasis-induced discomfort). Therefore, symptom assessment must be complemented by objective testing.

4.2 Endoscopy

Upper endoscopy serves as a cornerstone in evaluating mucosal integrity and structural changes associated with post-POEM reflux. It provides direct visualization of esophageal injury and allows classification of disease severity.
Key findings include:

- **LA Esophagitis:** Graded A to D using the Los Angeles classification. LA grade B or higher typically indicates clinically significant reflux requiring intervention.
- **Barrett's Esophagus:** Although relatively uncommon post-POEM, the presence of intestinal metaplasia warrants long-term surveillance due to increased cancer risk.
- **Hill Classification:** Evaluates the gastroesophageal flap valve at the cardia. High grades (III–IV) reflect impaired valve competence and correlate strongly with reflux.
- **Reflux-Induced Stenosis:** Rare but clinically important; chronic inflammation may lead to stricture formation, dysphagia, or food impaction, requiring endoscopic dilation.

Endoscopy is recommended both at baseline (post-procedure) and during routine surveillance to monitor for progression of disease or complications.

4.3 pH-Impedance Testing

Ambulatory pH-impedance monitoring remains the gold standard for diagnosing acid and non-acid reflux after POEM. It offers comprehensive evaluation of reflux burden through:

- **Quantification of acid exposure time (AET)**
- **Detection of non-acid and weakly acidic reflux events**
- **Analysis of bolus movement and clearance**
- **Symptom correlation indices (SI, SAP)**

Given the high prevalence of non-acid reflux in this population, impedance testing adds critical diagnostic value beyond pH-only monitoring. It is typically performed **off PPI therapy** to avoid masking physiologic reflux. Patients with abnormal AET or elevated total reflux episodes are classified as having objective GERD, regardless of their symptoms.

4.4 EndoFLIP

Functional luminal imaging probe (EndoFLIP) provides real-time assessment of esophagogastric junction (EGJ) distensibility, an important predictor of reflux severity. It measures:

- **Cross-sectional area**
- **Pressure-volume relationships**
- **Distensibility index (DI)**

After POEM, the DI commonly increases due to muscular disruption. **Higher DI values correlate strongly with increased acid exposure**, making EndoFLIP an important tool for early identification of patients at risk for significant postoperative GERD—before mucosal changes develop.
EndoFLIP is particularly valuable during follow-up assessments, allowing clinicians to determine whether excessive GEJ compliance contributes to persistent reflux symptoms.

4.5 High-Resolution Manometry (HRM)

While HRM is not used to diagnose GERD per se, it plays a supportive role in differentiating reflux from motility-related symptoms. After POEM, some patients may experience recurrent dysphagia or chest discomfort unrelated to acid reflux. HRM helps identify:

- **Residual or incomplete myotomy**
- **Persistent esophageal spasm**
- **Outflow obstruction proximal to the EGJ**
- **Aperistalsis or pressurization patterns**

These findings are essential because motility abnormalities may mimic or exacerbate reflux-like symptoms. HRM also complements pH-impedance by providing additional context when symptom correlation is ambiguous.

INITIAL (NON-ENDOSCOPIC) MANAGEMENT

Initial treatment of gastroesophageal reflux disease (GERD) after POEM typically begins with medical therapy. Although POEM has excellent efficacy for relieving outflow obstruction, it simultaneously removes the structural resistance of the LES, resulting in reflux mechanisms that are fundamentally **mechanical rather than biochemical**. For this reason, pharmacologic therapy provides only partial control and does not correct the underlying defect. Nevertheless, medical management remains an essential first step for symptom control, reduction of mucosal injury, and assessment prior to escalating to endoscopic intervention.

5.1 Proton Pump Inhibitors (PPIs)

PPIs are considered **first-line therapy** for managing reflux symptoms and healing erosive esophagitis after POEM. By suppressing gastric acid production via irreversible blockade of the proton pump, PPIs significantly reduce acidity of the refluxate, thereby decreasing mucosal irritation and improving patient comfort. Standard treatment typically involves once- or twice-daily dosing depending on symptom severity and endoscopic findings.

Clinical Rationale and Benefits

- Reduce esophageal acid exposure.
- Heal erosive reflux esophagitis.
- Provide symptomatic relief in many patients.
- Serve as a diagnostic trial to distinguish acid-mediated symptoms from non-acid causes.

However, despite their established role in GERD management, PPIs are limited in their ability to address **structural and functional** abnormalities specific to post-POEM physiology.

Important Limitations

- **Persistent non-acid reflux:**
  Since POEM eliminates the LES barrier, physical reflux of gastric contents continues even when acidity is suppressed. This explains persistent regurgitation, cough, or throat symptoms in many patients despite PPI therapy.
- **Long-term safety concerns:**
  Chronic PPI use has been associated with renal impairment, micronutrient deficiencies (B12, magnesium), bone loss, increased infection risk, and microbiome disturbances. While many associations remain controversial, they underscore the need for alternative long-term strategies.
- **30–40% PPI non-responders:**
  A substantial proportion of post-POEM patients fail to achieve adequate symptom relief or normalization of pH studies. In many, continued reliance on PPIs alone delays more definitive, anatomy-focused intervention.

Thus, PPIs often serve as **a starting point rather than a definitive solution** in post-POEM GERD management.

5.2 Adjunct Medical Options

Adjunct medications may complement PPI therapy, especially in patients with incomplete control or specific symptom patterns. While none of these treatments reverse the underlying mechanical defect, they can help mitigate certain physiological contributors to reflux.

• H2 Receptor Antagonists (H2RAs)

H2RAs, such as famotidine, reduce nocturnal gastric acid output and are particularly useful for **nighttime acid breakthrough**, a common issue in patients on PPIs. However, the development of tachyphylaxis significantly limits their effectiveness beyond 1–2 weeks of nightly use.

• Alginate Therapy

Alginates form a viscous “raft” that floats over gastric contents, reducing the likelihood of reflux during postprandial periods. They are especially beneficial in patients with:

- Meal-related regurgitation
- Positional reflux
- Mild-to-moderate symptoms

Alginates do not affect acid production but offer **mechanical protection** during periods of high reflux risk.

• Baclofen (GABA-B agonist)

Baclofen decreases transient LES relaxations (TLESRs), a major mechanism of reflux in non-POEM populations.
In post-POEM patients:

- It may reduce **regurgitation volume**
- It may help in **mixed or non-acid reflux**

However, its use is limited by adverse effects such as dizziness, fatigue, drowsiness, and mood changes. It is rarely continued long-term and is best suited for select, refractory cases.

ENDOSCOPIC MANAGEMENT OPTIONS

Section 6 — Endoscopic Management Options

As the prevalence of post-POEM GERD becomes increasingly recognized, endoscopic anti-reflux interventions have emerged as an important therapeutic bridge between medical therapy and surgical fundoplication. These techniques aim to restore gastroesophageal junction (GEJ) competence using a minimally invasive, natural-orifice approach that aligns with the core philosophy of POEM. Given the unique anatomical and physiological alterations following POEM—particularly the absence of an anti-reflux reconstruction—these modalities provide tailored solutions designed to recreate or reinforce the anti-reflux barrier while preserving the benefits of the initial procedure.

Endoscopic therapies vary widely in mechanism, complexity, durability, and suitability for different anatomical configurations. Understanding their roles, outcomes, and limitations is essential for individualized patient selection.

6.1 Transoral Incisionless Fundoplication (TIF)

TIF is the most established endoscopic fundoplication technique and currently the strongest non-surgical option for restoring a valve-like mechanism at the GEJ in post-POEM patients.

Mechanism

TIF utilizes the EsophyX device to create a partial fundoplication by folding the gastric fundus around the distal esophagus and securing it with H-shaped fasteners. The reconstructed valve is typically:

- **270° in circumference**
- **2–4 cm in vertical length**

This restored valve serves multiple functions:

- Recreates the **flap valve mechanism**
- Restores the **angle of His**
- Reduces high GEJ compliance
- Decreases retrograde flow even in the absence of LES tone

TIF directly addresses the mechanical defect produced by POEM, making it anatomically logical.

Outcomes After POEM

Clinical studies demonstrate promising efficacy in the post-POEM population:

- **Symptom improvement:** *60–80%*
  Improvement observed for both typical and atypical symptoms.
- **Esophagitis healing:** *≈70%*
  Particularly effective for LA grades A–C.
- **Normalization of acid exposure:** *40–60%*
  Better results in patients without severe esophageal dilation or hiatal hernia.

These outcomes highlight TIF as one of the most durable and robust endoscopic anti-reflux options currently available.

Advantages

- **Minimally invasive** with rapid recovery and same-day discharge.
- **Durability** documented up to 5 years in general GERD populations.
- **No external incisions**, minimizing cosmetic and postoperative pain concerns.
- Can be combined with other endoscopic therapies in staged treatment.

Limitations

- Technically difficult in patients with **severe esophageal dilation** (sigmoid esophagus).
- Outcomes may be inferior in markedly altered **post-POEM anatomy**.
- Requires a **mobile and adequately sized gastric fundus**; reduced fundic mobility limits valve creation.
- Not suitable for large hiatal hernias (>2 cm), which require surgical repair.

In appropriately selected patients, however, TIF remains a strong first-line endoscopic intervention.

6.2 Anti-Reflux Mucosectomy (ARMS)

ARMS is a technique that uses controlled mucosal resection to enhance GEJ tightness through scar-induced contraction.

Technique

- Approximately ¾ **circumferential endoscopic mucosal resection (EMR)** is performed at the cardia and distal esophagus.
- Resection leads to **fibrosis and tissue contraction during healing**, which narrows the GEJ lumen and restores partial anti-reflux competency.

This method mimics early surgical fundoplication concepts using a mucosal approach rather than muscular or serosal manipulation.

Outcomes

- **Symptom resolution:** *60–75%*
- **pH normalization:** *50–60%*
- Particularly effective for patients with **moderate reflux** without severe anatomical abnormalities.

Complications

- **Stenosis:** Up to *15%*, though typically treated successfully with dilation.
- **Post-procedure pain:** Common due to mucosal resection.
- Rare risk of bleeding or delayed ulceration.

ARMS is effective, but its risk profile requires careful selection and postoperative monitoring.

6.3 Anti-Reflux Mucosal Ablation (ARMA)

ARMA represents a less invasive evolution of ARMS, replacing mucosal resection with **argon plasma coagulation (APC)**.

Mechanism

- APC induces **superficial coagulative necrosis** at the GEJ.
- Healing fibrosis tightens the GEJ similar to ARMS—but with less tissue disruption.

Advantages Over ARMS

- **Lower stenosis risk** due to shallower injury.
- **Shorter and technically simpler procedure** with reduced procedural time.
- **Less post-procedural discomfort**.
- Ideal for **mild-to-moderate GERD** and those not suitable for TIF.

Outcomes

- **Symptom relief:** *70–80%*.
- **pH improvement:** *50–55%*.
- Works well in patients with preserved anatomical GEJ alignment.

While less powerful than TIF, ARMA offers a safe and efficient option for selected cases.

6.4 Stretta Radiofrequency Therapy

The Stretta system delivers **radiofrequency (RF) energy** to the LES and gastric cardia, inducing structural and neuromodulatory changes.

Mechanism

- RF energy increases **muscle tone** and reduces tissue compliance.
- Decreases **transient LES relaxations (TLESRs)**.
- Improves **barrier function** without reconstructing an anatomical valve.

Stretta is more physiologic than structural and may work best when anatomy is minimally altered.

Results in Post-POEM Patients

- **Symptom control:** *50–65%*.
- **Reduced regurgitation** due to decreased LES compliance.
- **Useful in minimal anatomical deformity**, especially early in GERD progression.

Limitations

- Limited effectiveness in **severe reflux or advanced esophagitis**.
- Modest objective improvements in pH metrics.
- **Repeat sessions** may be required for sustained benefit.

Best suited for patients with persistent symptoms but preserved anatomy.

6.5 Endoscopic Suturing-Based Fundoplication

Endoscopic suturing—most commonly with the **OverStitch system**—recreates a partial mechanical barrier at the GEJ.

Technique

- Sutures are placed to create **plications** that replicate a partial fundoplication.
- Tissue is approximated to narrow the GEJ and strengthen the flap valve.

This approach resembles surgical techniques but is performed via flexible endoscopy.

Evidence

- Data is still emerging, but early results show:
    - **Reflux reduction:** *50–70%*.
    - Improvement in regurgitation and acid exposure in select cases.

Given its flexibility and ability to tailor plication, suturing may become more widely used as techniques evolve.

6.6 Novel Valve Restoration Devices

Several innovative devices aim to mechanically restore GEJ competence without surgery.

Examples

- **GERDx™:**
  Endoscopic full-thickness plication using a stapling-like device to recreate a tight valve.
- **EndoSTITCH-based valves:**
  Adaptations of surgical suture technology for endoscopic fundoplication.
- **Endoscopic ring implants (experimental):**
  Conceptually similar to magnetic augmentation devices but placed endoscopically.

These devices are in early developmental stages but illustrate the growing trend toward **structural, durable endoscopic anti-reflux solutions**.

SURGICAL OPTIONS AFTER FAILED ENDOSCOPY

Surgical Options After Failed Endoscopy

Although endoscopic anti-reflux interventions have transformed the management of post-POEM GERD, a subset of patients continue to experience significant reflux symptoms, persistent esophagitis, or elevated acid exposure despite optimized medical and endoscopic therapy. In such cases, surgery remains the most definitive and durable method for restoring gastroesophageal junction (GEJ) competency. Surgical options must be chosen carefully, considering that POEM alters the anatomy and pressure gradient of the distal esophagus in ways that differ from the typical GERD population.

The goal of surgery in these patients is to recreate or reinforce the anti-reflux barrier, correct anatomical defects such as hiatal hernias, and provide long-term symptom relief. The most commonly considered options include laparoscopic fundoplication, hiatal hernia repair, Roux-en-Y gastric bypass, and the emerging hybrid technique known as POEM-F.

7.1 Laparoscopic Fundoplication

Laparoscopic fundoplication remains the gold standard surgical option for patients with refractory GERD, including those with persistent reflux after POEM.

Common approaches include:

- **Dor fundoplication (anterior 180°)**
- **Toupet fundoplication (posterior 270°)**
- **Nissen fundoplication (complete 360°)** — used less often due to increased risk of dysphagia

Rationale

Fundoplication reconstitutes the flap valve at the GEJ by wrapping the gastric fundus around the distal esophagus. This restores:

- The **angle of His**
- The **flap valve mechanism**
- Increased **LES resting pressure**
- Improved **resistance to retrograde flow**

Considerations After POEM

The myotomy created during POEM is typically located on the posterior (5–6 o'clock) or anterior (2 o'clock) esophageal wall. Surgeons must tailor fundoplication direction to avoid disrupting the myotomy and prevent postoperative obstruction.

Effectiveness

Fundoplication provides excellent control of reflux and normalization of esophagitis in the majority of refractory cases.

7.2 Hiatal Hernia Repair

Even small or occult hiatal hernias can significantly exacerbate reflux in post-POEM patients, particularly because the LES barrier has already been compromised. In individuals with anatomical defects, surgical repair of the diaphragmatic hiatus is essential for durable GERD control.

Indications

- Moderate-to-large hiatal hernias (>2 cm)
- Hill grade III–IV flap valve
- Evidence of gastric cardia migration
- Persistent reflux despite endoscopic measures

Surgical Steps

- Reduction of herniated contents
- Closure of the crural defect
- Reinforcement with fundoplication when appropriate

Hiatal hernia repair is often performed in combination with fundoplication to optimize outcomes.

7.3 Roux-en-Y Gastric Bypass (RYGB)
(Preferential option for BMI ≥ 35 kg/m²)

Roux-en-Y gastric bypass is considered the most powerful anti-reflux operation and is particularly useful in patients with morbid obesity, a population with both increased reflux severity and poorer outcomes with fundoplication alone.

Mechanism

- Diverts bile and gastric contents away from the esophagus
- Reduces acid exposure
- Lowers intra-abdominal pressure after weight loss
- Provides metabolic benefits and sustained weight reduction

Advantages

- Superior reflux control compared with fundoplication in obese patients
- Avoids creating pressure on the esophageal wall where the myotomy lies

- Effective for both acid and non-acid reflux

Limitations

- Major surgical procedure with nutritional implications
- Requires lifelong follow-up
- Not ideal for patients without obesity

For appropriately selected patients, RYGB offers unsurpassed reflux resolution after POEM.

7.4 POEM-F (Hybrid: POEM + Fundoplication)

POEM-F is an emerging hybrid technique combining the therapeutic advantages of POEM with the anti-reflux benefits of fundoplication.

Concept

- POEM is first performed endoscopically.
- A laparoscopic or endoscopic-laparoscopic fundoplication is subsequently added.

This bridges the gap between pure natural-orifice therapy and durable anti-reflux surgery.

Advantages

- Treats achalasia and post-POEM GERD in a **single-session** or staged approach.
- Provides strong anti-reflux protection without eliminating the minimally invasive nature of POEM.
- Early studies show **high rates of symptom control** and significant reductions in acid exposure.

Limitations

- Requires advanced surgical-endoscopic expertise
- Still evolving with limited long-term data
- Not widely available across centers

As techniques evolve, POEM-F may become the standard approach for combining myotomy with immediate anti-reflux reconstruction.

COMPARISON OF ENDOSCOPIC OPTIONS (TABLE PROVIDED BELOW)

(Tables come later…)

PATIENT SELECTION ALGORITHM

(Flowchart Provided Below)

FUTURE DIRECTIONS

The management of post-POEM GERD continues to evolve, and several promising developments hold the potential to significantly enhance outcomes over the coming decade. As our understanding of the altered physiology and anatomical consequences of POEM deepens, research is moving toward more targeted, durable, and minimally invasive solutions. The future landscape of reflux management will likely be shaped by innovations in endoscopic technologies, refinements in hybrid procedures, and the integration of computational modeling and artificial intelligence.

Improved ARMS/ARMA Energy Modalities

Next-generation energy platforms—including hybrid APC, laser-assisted mucosal modification, and bipolar plasma devices—aim to refine the precision and depth of mucosal remodeling at the GEJ. These technologies may significantly reduce the risk of post-procedure stenosis while offering more predictable tightening and better long-term durability. Additionally, development of real-time feedback systems that monitor tissue response during energy delivery may help standardize outcomes.

POEM-F With Immediate Valve Reconstruction

Hybrid POEM-fundoplication (POEM-F) techniques are gaining attention as a potential solution to prevent post-procedural reflux rather than treat it after it develops. Combining POEM with same-session transoral or laparoscopic fundoplication could create an immediate anti-reflux barrier without compromising the advantages of natural-orifice myotomy. Early data show promising safety and efficacy, and future refinements—especially fully endoscopic fundoplication systems—may transform POEM into a more complete therapeutic package.

Robotic Fundoplication After POEM

Robotic platforms offer enhanced dexterity, precision, and visualization, which are particularly advantageous when operating on altered anatomy after POEM. Robotic fundoplication may allow more delicate handling of the distal esophagus and fundus, avoid disrupting the myotomy plane, and enable more tailored wrap configurations. As robotic systems become more accessible, they may become the preferred surgical option for complex post-POEM reflux or patients with significant anatomical abnormalities.

AI-Based Prediction Scores for GERD

Artificial intelligence is rapidly emerging as a transformative tool in gastroenterology. Machine learning algorithms incorporating clinical variables, EndoFLIP metrics, baseline anatomy, pH-impedance patterns, and procedural details may allow clinicians to identify patients at the highest risk of post-POEM GERD before symptoms occur. Such predictive scoring systems could guide personalized follow-up schedules, inform decision-making regarding early intervention, and refine procedural strategy (e.g.,

tailored myotomy length, selective fundoplication).

Personalized Reflux Treatment Maps

With the increased availability of integrated diagnostic modalities—structural imaging, manometry, EndoFLIP, impedance, and endoscopic visualization—there is growing interest in designing individualized reflux management pathways. These "treatment maps" would combine patient-specific reflux phenotypes, anatomical features, and functional metrics to identify the optimal therapeutic sequence. The ability to stratify patients into categories—such as acid-dominant reflux, non-acid reflux, anatomical failure, or clearance-dominant dysfunction—may allow clinicians to select the most appropriate therapy from the full spectrum of medical, endoscopic, and surgical options.

CONCLUSION

Section 11 — Conclusion

Gastroesophageal reflux disease (GERD) following peroral endoscopic myotomy (POEM) represents an increasingly recognized challenge in the long-term management of achalasia. Although POEM is highly effective in relieving esophageal outflow obstruction and improving patient quality of life, the procedure's inherent disruption of the lower esophageal sphincter barrier creates a physiological environment prone to reflux. Importantly, post-POEM GERD is often **underdiagnosed**, as symptoms correlate poorly with objective measures and a substantial proportion of patients harbor silent mucosal injury or significant acid exposure without notable complaints. This highlights the critical need for structured and routine post-procedural surveillance.

Over the past decade, a spectrum of endoscopic anti-reflux interventions has emerged, offering meaningful alternatives to traditional surgical fundoplication. Techniques such as **transoral incisionless fundoplication (TIF)**, **anti-reflux mucosectomy (ARMS)**, **anti-reflux mucosal ablation (ARMA)**, **Stretta radiofrequency therapy**, and **endoscopic suturing-based fundoplication** provide durable symptom relief and objective improvement without the morbidity associated with surgery. Each modality brings distinct benefits, technical considerations, and patient suitability profiles. Their collective evolution underscores a broader paradigm shift toward minimally invasive, physiology-oriented solutions tailored to the unique anatomical consequences of POEM.

Optimal management of post-POEM reflux requires **individualized treatment selection**, integrating anatomical assessment, physiologic testing, severity of reflux, presence of esophagitis, and patient preferences. For some individuals, medical therapy remains sufficient; for others, endoscopic reconstruction of the GEJ barrier offers the best balance between efficacy and invasiveness. Only a minority require surgical intervention, underscoring the growing clinical utility of endoscopic therapies.

As POEM continues to expand globally and becomes a mainstay in the management of achalasia, the emphasis on long-term reflux surveillance, early identification of high-risk phenotypes, and timely intervention will become increasingly important. Future advances—such as hybrid POEM-fundoplication techniques, artificial valve restoration devices, and predictive modeling through advanced imaging and AI—hold the promise to further refine management strategies.

In summary, GERD after POEM is a common but manageable complication. With the expanding arsenal of endoscopic anti-reflux therapies, clinicians can now adopt a **precision-based, stepwise approach** that maximizes symptom control, protects the esophageal mucosa, and preserves the benefits of POEM. A tailored, patient-centered strategy will remain the cornerstone of comprehensive achalasia care in the years ahead.

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