

UC San Diego

UC San Diego Previously Published Works

Title

Role of short interval FLIP panometry in predicting long-term outcomes after per-oral endoscopic myotomy.

Permalink

<https://escholarship.org/uc/item/74p6f8qy>

Journal

Surgical Endoscopy, 37(10)

Authors

Pessorrusso, Fernanda

Pisipati, Sailaja

Han, Samuel

et al.

Publication Date

2023-10-01

DOI

10.1007/s00464-023-10319-z

Peer reviewed



Published in final edited form as:

Surg Endosc. 2023 October ; 37(10): 7767–7773. doi:10.1007/s00464-023-10319-z.

Role of short interval FLIP panometry in predicting long term outcomes after per-oral endoscopic myotomy

Jennifer M Kolb, MD MS¹, Fernanda Pessorusso, MD PhD², Sailaja Pisipati, MBBS FRCS³, Samuel Han, MD, MS⁴, Paul Menard-Katcher, MD², Rena Yadlapati, MD MS⁵, Mihir S Wagh, MD²

¹Vatche and Tamar Manoukian Division of Digestive Diseases, David Geffen School of Medicine at UCLA, Greater Los Angeles VA Healthcare System, Los Angeles, CA

²Division of Gastroenterology, University of Colorado Anschutz Medical Campus, Aurora, CO

³Division of Gastroenterology and Hepatology, Mayo Clinic, Scottsdale, AZ

⁴Division of Gastroenterology, Hepatology, and Nutrition, The Ohio State University Wexner Medical Center, Columbus, OH.

⁵Division of Gastroenterology, University of California San Diego, San Diego, CA

Abstract

Background: The Eckardt score (ES) is used to assess symptom response to Per-Oral Endoscopic Myotomy (POEM), but reliable methods to assess physiologic success are needed. Functional lumen imaging probe (FLIP) panometry has a potential role in post-POEM follow-up to predict long-term outcomes. The aim of this study was to assess the correlation between clinical success and FLIP parameters following POEM to determine if short interval FLIP could predict long term outcomes.

Methods: This was a prospective study of adult patients who underwent POEM with short interval follow-up FLIP between 11/2017–3/2020. Clinical success was defined as post-procedure ES ≤ 3 . Physiologic success was based on an esophagogastric junction distensibility index (EGJ-DI) >2.8 mm²/mm Hg on FLIP.

Results: 47 patients (55% female, mean age 55 years) were included in the study. Clinical success after POEM was seen in 45 (96%) patients (mean ES 6.5 ± 2.2 pre and 0.83 ± 1.0 post-POEM, $p < 0.001$). Physiologic success was noted in 43 (91.5%) patients (mean EGJ-DI 6.1 mm²/mm Hg ± 2.5). Among 4 patients not meeting criteria for physiologic success, EGJ-DI was 2.5–2.6. There was no correlation between post-POEM EGJ-DI and ES in the short term or long term. Significant reflux esophagitis was seen in 6 (12.8%) patients with no difference in mean EGJ-DI with vs without esophagitis (5.9 vs 6.1, $p = 0.44$).

Conclusions: Post-POEM endoscopy with FLIP is useful to both assess EGJ physiology and to examine for reflux esophagitis. Short interval FLIP has limited utility to predict long term patient outcomes or risk of acid reflux.

Keywords

Achalasia; esophageal manometry; esophagitis; dysphagia

Introduction

Achalasia has an annual incidence of 1–2 per 100,000 and is characterized by lack of peristalsis and failed relaxation of the lower esophageal sphincter (LES).^{1, 2} Pneumatic dilation and surgical Heller myotomy had been the mainstay of therapy until the introduction of per-oral endoscopic myotomy (POEM) in the last decade. POEM has been shown to be a safe and effective treatment for achalasia and select patients with other esophageal motility disorders.^{3–6} Randomized clinical trials have demonstrated high rates of treatment success with POEM for achalasia compared to pneumatic dilation and Heller,^{7, 8} even after prior surgery or endoscopic intervention.^{9–13} The main disadvantage of POEM is a greater likelihood for acid reflux seen in up to 40% of patients.¹⁴

The most widely used metric for assessing clinical improvement in achalasia is the Eckardt score (ES), a patient reported index for severity of symptoms including dysphagia, regurgitation, chest pain and weight loss.¹⁵ Although patient reported outcomes are the primary measure of success, objective parameters such as myotomy adequacy and GERD development are critical outcomes that should be included in a complete post treatment evaluation.¹⁶ However, this type of comprehensive testing is limited by the fact that diagnostic modalities such as high-resolution esophageal manometry (HRM) or even a timed barium esophagram are often associated with poor patient tolerance and compliance. This is especially true for patients who are finally feeling relief after their POEM and do not want to undergo additional examinations. Conversely, repeat sedated upper endoscopy has become a critical step to evaluate for post POEM GERD and is well tolerated and acceptable to most individuals. Combining this post POEM endoscopy with a test that assesses the LES and provides an objective assessment of myotomy adequacy could potentially improve clinical prognostication.

The functional lumen imaging probe (FLIP) uses a compliant fluid filled bag with impedance planimetry channels to assess esophageal physiology and luminal distensibility across the esophago-gastric junction (EGJ). FLIP is performed during a sedated upper endoscopy and well tolerated. Prior studies have demonstrated strong correlation between EGJ distensibility index (EGJ-DI) on FLIP and findings on high-resolution manometry for both achalasia and normal esophageal function.¹⁷ FLIP has also been used intraoperatively to guide myotomy and predict outcomes.¹⁸ Therefore, FLIP panometry may be a useful tool to assess the adequacy of myotomy during follow up after POEM. The aim of this study was to assess the correlation between clinical success and FLIP parameters following POEM to determine if short interval FLIP could predict long term outcomes. Given the limited data on

the utility of FLIP in GERD evaluation, we also evaluated optimal EGD-DI values related to post POEM esophagitis.

Methods:

Study Design

This was a prospective study of adult patients with a manometric diagnosis of achalasia or EGJ outflow obstruction (EGJOO) who underwent FLIP assessment as part of routine 3-month follow-up after undergoing POEM between 11/2017–3/2020 at a single center tertiary care hospital. As per our protocol, all patients undergoing POEM were scheduled for endoscopy with EndoFLIP at approximately 3 months after POEM. If patients did not keep their follow-up appointments, they were reminded to do so, but unfortunately some patients were still not willing to repeat endoscopy due to travel requirements (referrals from distant locations) or if their symptoms had resolved. Additionally, some patients in this cohort did not complete the follow-up endoscopy or get rescheduled due to the onset of the COVID-19 pandemic requiring elective procedures to be postponed. Therefore, we only included POEM patients from our institution who completed a subsequent endoscopy with FLIP. This study was approved by the Colorado Multiple Institutional Review Board.

Pre-POEM protocol

All patients referred to our hospital for dysphagia and esophageal motility disorders undergo a multidisciplinary evaluation which includes upper endoscopy, barium esophagram, esophageal physiologic testing, evaluation by an esophagologist and consultation with an endoscopist experienced in POEM. Achalasia or EGJOO was confirmed on high-resolution esophageal manometry (Chicago Classification version 3.0).¹⁹ FLIP was utilized before POEM only if testing was inconclusive and further clarification was needed. Symptoms were assessed using the validated Eckardt score (ES) which measures the frequency of symptoms (scale 0–3) in 4 categories (dysphagia, regurgitation, retrosternal chest pain, and weight loss) with higher scores indicating more severe symptoms.^{20, 21} Treatment options were discussed with the patient including endoscopic therapies and referral to surgery. POEM is considered first line therapy at our institution, except in very few cases e.g. not candidate for general anesthesia, advanced age, or end stage achalasia (severely dilated, sigmoid shaped esophagus).

POEM

All POEM procedures were performed by a single experienced endoscopist (MSW) using previously described technique.^{22, 23} Briefly, POEM was performed in the supine position in the endoscopy unit under general anesthesia with endotracheal intubation. Antibiotics were administered peri-procedurally. A posterior submucosal tunnel with a posterior myotomy in the 5 o'clock position was performed with the T-type Hybrid knife (ERBE USA, Marietta, GA). Typically, a 6–8 cm myotomy was performed in the esophagus and extended 2 cm in the cardia. Extension of the submucosal tunnel and myotomy into the cardia was confirmed by typical landmarks (e.g. submucosal tunnel narrowing at the GE junction and then widening in the cardia, presence of palisading vessels/spindle veins, larger vessels in the cardia, and documentation of submucosal bluish bleb in the cardia on retroflexion in the

gastric lumen), and distance from the incisors. Bleeding during the procedure was treated with the dissection knife and/or Coagrasper (Olympus America, Center Valley, PA). The mucosal incision was closed with endoscopic clips (Quick Clip Pro, Olympus America, Center Valley, PA). All patients were admitted for overnight observation and an esophagram was obtained the next morning to exclude leak after POEM. Patients were discharged on a liquid diet and advanced to soft foods in 1 week. Oral antibiotics were continued for 7 days. Patients were not routinely placed on proton pump inhibitor therapy after POEM but were reassessed clinically for acid reflux and endoscopically for evidence of esophagitis at their 3-month follow-up and underwent annual upper endoscopy after that.

Post-POEM Follow-up

As part of our standard practice, all patients had upper endoscopy with FLIP approximately 3 months following POEM for objective assessment. The 16-cm catheter (EndoFLIP EF-322N, Medtronic, Minneapolis, MN) was introduced through the mouth and advanced across the esophago-gastric junction under endoscopic guidance. The balloon was distended to 30ml to confirm adequate positioning and then in 10 mL increments to 60mL. EGJ-DI and maximal diameter were measured. During the endoscopy presence of erosive esophagitis according to Los Angeles classification or candida esophagitis was assessed.

Outcomes

The primary outcomes were clinical success and physiologic success after POEM. Clinical success was defined as post procedure ES ≥ 3 at 3 months.¹⁵ Physiologic success was defined as post-POEM EGJ-DI >2.8 mm²/mm Hg at 60mL.²⁴ Secondary outcomes included correlation between ES and EGJ-DI, and rate of clinically significant reflux esophagitis (Los Angeles Classification Grade C or D).²⁵ Long term outcomes were also collected (ES) through patient visits and telephone calls.

Data Analysis:

Clinical and physiologic success rates following POEM were reported using proportions. ES before versus after POEM was compared using the paired t-test. Linear regression and Pearson's correlation were used to evaluate the association between clinical success and physiologic success (ES and EGJ-DI). Logistic regression was used to determine the relationship between EGJ-DI and significant reflux esophagitis. P-values less than 0.05 were considered significant. All data was analyzed using Stata (V.15.1 StataCorp, College Station, TX).

Results:

47 patients (55% female, mean age 55 years) underwent POEM for achalasia (60% type II, 15% type III, 13% type I) or EGJOO (11%) with a median integrated relaxation pressure of 27 (IQR 19.9–34.3) (Table 1). Most (70%) had not undergone previous therapy, while 14.9% had previous botox injection and 8.5% previous botox injection and pneumatic dilation. One patient had a previous surgical Heller myotomy (2.1%). The mean ES prior to POEM was 6.5 ± 2.2 . POEM was performed in all patients with a mean myotomy length of $10.5 \pm$

2.2cm. There were two (4.3%) adverse events related to POEM (ER visits for chest pain with negative workup) and none associated with FLIP.

Clinical Success

Clinical success after POEM was seen in 45/47 patients (96%). Mean ES significantly decreased from 6.5 ± 2.2 to 0.83 ± 1.0 after POEM ($p < 0.001$). (Table 2). The dysphagia component of the ES also decreased from mean 2.5 ± 0.78 to 0.53 ± 0.75 after POEM ($p < 0.001$). There were 33/47 patients who were treatment naïve. In this group, clinical success was 97% (32/33) similar to the primary analysis. All patients underwent endoscopy with FLIP at a median 91 days after POEM. Clinically significant (grade C/D) esophagitis was seen in 6 (12.8%) patients and 3 (6.4%) patients had candida esophagitis.

Physiologic Success

During follow up FLIP at 60 mL fill volume, the mean DI was 6.1 ± 2.5 mm²/mm Hg, mean diameter 12.4 ± 2.3 mm, and mean balloon pressure 21.2 ± 5.5 mm Hg (94% over 15 mm Hg). Adequate myotomy as measured by DI ≥ 2.8 on FLIP was seen in 43 (91.5%). In the four patients who did not meet the threshold for adequate myotomy on FLIP, post POEM DI at 60 mL was 2.5 (n=2) or 2.6 (n=2). All 4 of these individuals met criteria for clinical success with post poem ES ≤ 2 . Only one of these patients had FLIP performed prior to POEM (due to equivocal HRM) and DI was 0.4 mm²/mm Hg. In the 33 treatment naïve patients physiologic success was seen in 94%.

Clinical Failures

Of the two patients who were clinical failures in the short term, one individual with achalasia type I and history of prior Heller myotomy reported significant symptom improvement (ES 10 to 4, DI 6 mm²/mmHg). The second patient had achalasia type II and initially reported symptom improvement (ES 6 to 4, DI 6.7 mm²/mm Hg) though by 4.5 years post POEM her ES was back to 6.

Long Term Outcomes

There were 33 (70%) individuals who were followed for a median of 2.89 years beyond POEM. Twenty-eight (84.8%) had ongoing clinical success. There were 5 patients who had worsening symptoms at long term follow up with ES 4–7. One of these was the individual who had a post POEM DI of 2.5. The other 4 who had late clinical failure had normal post POEM FLIP (i.e. had no evidence of impaired distensibility on FLIP at 3 months).

Correlation between clinical success and physiologic success and esophagitis

Linear regression of indices at 3 months post POEM showed a trend that as the EGJ-DI increased, the ES decreased, however this correlation did not reach statistical significance ($r = -0.2231$, $p = 0.13$) (Figure 1). Correlation was also not demonstrated between EGJ-DI and long-term ES ($r = 0.1044$, $p = 0.56$). There was no difference in mean DI in those with versus without Grade C/D esophagitis (5.9 ± 1.5 versus 6.1 ± 2.6 , $p = 0.44$) and DI was not predictive of having clinically significant esophagitis (OR 0.96, 95% CI 0.67–1.37).

Discussion:

This study describes the role of post-POEM upper endoscopy with FLIP to gather comprehensive physiologic data on adequacy of myotomy and evaluation for reflux esophagitis. Clinical success rates after POEM were high (96%) with only 2 initial failures, both of whom had DI measurements suggesting adequate myotomy. EGJ-DI at 3 months indicated adequate myotomy in most patients and borderline values in 4 patients who all demonstrated clinical success. Interestingly, one of these individuals with low DI did end up as a clinical failure with worsening symptoms around 3.5 years. No correlation was seen between FLIP and clinical outcomes in the short or long term, though the study was likely underpowered.

Although POEM has gained acceptance as a viable treatment option for achalasia and spastic esophageal motility disorders, there is no set protocol for post-POEM follow-up, with most centers having follow-up testing based on endoscopist experience, equipment availability, personal preferences, and research protocols. Ideally, in addition to clinical follow-up, all patients should have post-POEM HRM, barium esophagram and esophageal pH testing for objective assessment as well. However, these tests are poorly tolerated and in our experience patients are reluctant to undergo these evaluations, especially if their symptoms have resolved.^{26, 27} This scenario has led to a search for an optimal post POEM test to predict clinical success. Timed barium esophagram serves an important role in the initial diagnostic evaluation of esophageal motility disorders as well as post treatment assessment of anatomy.²⁸ Our standard practice is to perform an esophagram the next day after POEM to exclude leak, but we did not routinely perform follow-up/ surveillance esophagrams post-POEM. Dewitt and colleagues evaluated whether a timed barium esophagram 24 hours after POEM could predict short term (6 months) or long term (2 years) outcomes. Similar to our results for FLIP, they found no correlation between the objective metrics on esophagram and clinical outcomes (ES or esophagitis).²⁹ The same group also evaluated 87 patients who underwent POEM with follow up FLIP, esophagram, and HRM and found that a normal IRP had similar sensitivity to normal EGJ-DI and therefore FLIP could be used to predict patient outcomes.³⁰

Our findings that clinical improvement did not appear to correlate with FLIP distensibility metrics are similar to those reported by Teitelbaum et al where there was no correlation between change in DI and post-POEM ES.³¹ Additionally, they found the “ideal” range for final EGJ distensibility to be 4.5–8.2 mm²/mm Hg. FLIP can also be used to guide the length of the myotomy during the procedure and to measure key parameters before and after both surgical and endoscopic myotomy.^{31–36} However, one study showed that EGJ-DI values immediately after myotomy can significantly decrease at 1 year follow-up.³⁷ In a study of 77 patients undergoing surgical or endoscopy myotomy, where FLIP was performed intra-operatively immediately before and after myotomy, patients with a post procedure ES 3 (clinical failures) were more likely to have a final intraoperative DI 3.1 mm²/mm Hg (p=0.014).³⁸ Of note, this study used measurements obtained at 30 mL balloon fill volumes, a protocol not usually followed in most other studies.³⁹ Yoo and colleagues also demonstrated a relationship between FLIP and ES post POEM however it is difficult to compare this to our results since they used atypical balloon volumes (30–40 mL) and DI

thresholds.⁴⁰ In our study there were only 4 patients who had a post-POEM DI <2.8 at 60mL; they had values of 2.5 or 2.6 and did well clinically. Given how close these values are to the 2.8 DI threshold, it is possible that these measurements fall within the margin of error for the FLIP device, raising the question of how precise the cutoff is for “adequate” EGJ-DI after myotomy.

FLIP can provide valuable information for patients who do not have clinical improvement after POEM. For example, if the ES does not meaningfully improve but there is a successful outcome based on DI, this suggests the possibility that symptoms may be driven by other processes (e.g. poor esophageal body motility, gastro-esophageal reflux, or other underlying conditions such as anatomical obstruction from tortuous or sigmoid esophagus) rather than inadequate myotomy. This would help direct further workup. A retrospective multicenter study of 123 patients who had clinical failure at a median of 10.8 months after LHM or POEM looked at the complementary role of FLIP and HRM to diagnose the cause of failure.⁴¹ Although the best outcomes were seen in those who had LES directed therapy for both abnormal IRP and EGJ-DI, there were 29 patients who had discordant findings between IRP and EGJ-DI. Of these, 15 (52%) had a change in their management based on FLIP. Whether FLIP is sensitive enough to predict a physiologic failure first before the recognition of a clinical failure is still not known. This was the case for one individual in our study, however there were 4 other late failures who had normal short interval FLIP.

Follow-up endoscopy (at the time of FLIP) also provides the opportunity to monitor for the development of esophagitis since it can be difficult to predict who will develop clinically significant reflux disease and since there are no specific guidelines on acid suppressant therapy post POEM. We tested the hypothesis that a higher distensibility index (and thus a more open EGJ) might indicate a greater likelihood of reflux esophagitis but we did not find any relationship in the present study. Larger studies are needed to determine if FLIP parameters at the LES can predict development of reflux esophagitis post-POEM. Post POEM ambulatory pH testing has an important role after POEM and future studies correlating post POEM DI and positive ambulatory pH testing would be helpful. We also recommend annual surveillance EGDs post-POEM for our patients due to the lack of clear guidelines for management of potential post-POEM GERD and its associated risks (esophagitis, stricture, Barrett’s esophagus, etc). Another benefit of performing upper endoscopy after POEM is the opportunity to intervene with additional treatment such as same session pneumatic or EsoFLIP dilation in patients with continued symptoms and low EGJ-DI.

There are several limitations to this study. Since all patients underwent HRM up front as the gold-standard diagnostic test, pre-POEM FLIP was not performed and not available for comparison. We also do not routinely perform intraprocedural FLIP or post POEM surveillance esophagrams unless patients had continued symptoms. Since most patients were unwilling to undergo another esophageal manometry after POEM, especially if they were clinically doing well, post-POEM manometry findings were not available. Instead, we performed upper endoscopy with FLIP as a surrogate for HRM. For the 5 patients with delayed clinical failure, we do not have information on the reason for recurrent symptoms, which may not have been due to other causes unrelated to myotomy adequacy. This was

a heterogenous study cohort that included patients with EGJOO (10.6%) and 14.9% had type III achalasia which may have also impacted success rates. Finally, small sample size with high clinical success rates precluded a more robust analysis for correlation between post-POEM ES (clinical success) and EGJ-DI on FLIP, as is often the case in assessing procedures where failure rate is low.

In conclusion, upper endoscopy with FLIP may be useful during follow-up after POEM to provide an objective physiologic assessment of the LES and evaluation for reflux esophagitis. However, our results suggest that short interval FLIP findings provide limited utility in predicting clinical outcomes. This may be due to a true lack of relationship between EGJ-DI and clinical success, flaws in symptom assessment using ES, or because FLIP only evaluates myotomy adequacy and does not account for other causes of recurrent symptoms or longer-term failures. Nevertheless, post-POEM surveillance and follow-up are crucial to appropriately manage these patients with chronic esophageal motility disorders and future studies will hopefully provide optimized algorithms and guidelines for long term management and outcomes.

Funding

Dr. Jennifer M Kolb was supported in part by the NIH Gastrointestinal Diseases Training Grant (T32-DK007038). Dr. Rena Yadlapati is supported by NIH K23 DK125266 (PI: Yadlapati).

Dr. Jennifer M Kolb was supported in part by the NIH Gastrointestinal Diseases Training Grant (T32-DK007038).
Dr. Rena Yadlapati is supported by NIH K23 DK125266 (PI: Yadlapati).

Dr. Jennifer Michelle Kolb, Dr. Fernanda Pessorusso, Dr. Sailaja Pisipati, Dr. Samuel Han, and Dr. Paul-Menard Katcher have nothing to disclose.

Dr. Rena Yadlapati is a consultant for Medtronic, Phathom Pharmaceuticals, StatLinkMD, Reckitt Benckiser Healthcare Ltd, Medscape; Research Support from Ironwood Pharmaceuticals; Advisory Board with Stock Options: RJS Mediagnostix.

Dr. Mihir S Wagh is a consultant for Boston Scientific, Olympus, ConMed, and FujiFilm; Research support from Steris/US Endoscopy and Allurion Technologies.

Dr. Jennifer Michelle Kolb, Dr. Fernanda Pessorusso, Dr. Sailaja Pisipati, Dr. Samuel Han, and Dr. Paul-Menard Katcher have nothing to disclose.

Dr. Rena Yadlapati is a consultant for Medtronic, Phathom Pharmaceuticals, StatLinkMD, Reckitt Benckiser Healthcare Ltd, Medscape; Research Support from Ironwood Pharmaceuticals; Advisory Board with Stock Options: RJS Mediagnostix.

Dr. Mihir S Wagh is a consultant for Boston Scientific, Olympus, ConMed, and FujiFilm; Research support from Steris/US Endoscopy and Allurion Technologies.

REFERENCES

1. Samo S, Carlson DA, Gregory DL, et al. Incidence and Prevalence of Achalasia in Central Chicago, 2004–2014, Since the Widespread Use of High-Resolution Manometry. *Clin Gastroenterol Hepatol* 2017;15:366–373. [PubMed: 27581064]
2. O'Neill OM, Johnston BT, Coleman HG. Achalasia: a review of clinical diagnosis, epidemiology, treatment and outcomes. *World J Gastroenterol* 2013;19:5806–12. [PubMed: 24124325]
3. Akintoye E, Kumar N, Obaitan I, et al. Peroral endoscopic myotomy: a meta-analysis. *Endoscopy* 2016;48:1059–1068. [PubMed: 27617421]

4. Inoue H, Sato H, Ikeda H, et al. Per-Oral Endoscopic Myotomy: A Series of 500 Patients. *J Am Coll Surg* 2015;221:256–64. [PubMed: 26206634]
5. Crespin OM, Liu LWC, Parmar A, et al. Safety and efficacy of POEM for treatment of achalasia: a systematic review of the literature. *Surg Endosc* 2017;31:2187–2201. [PubMed: 27633440]
6. Shiwaku H, Inoue H, Sato H, et al. Peroral endoscopic myotomy for achalasia: a prospective multicenter study in Japan. *Gastrointest Endosc* 2019.
7. Ponds FA, Fockens P, Lei A, et al. Effect of Peroral Endoscopic Myotomy vs Pneumatic Dilation on Symptom Severity and Treatment Outcomes Among Treatment-Naive Patients With Achalasia: A Randomized Clinical Trial. *JAMA* 2019;322:134–144. [PubMed: 31287522]
8. Werner YB, Hakanson B, Martinek J, et al. Endoscopic or Surgical Myotomy in Patients with Idiopathic Achalasia. *N Engl J Med* 2019;381:2219–2229. [PubMed: 31800987]
9. Tang X, Gong W, Deng Z, et al. Feasibility and safety of peroral endoscopic myotomy for achalasia after failed endoscopic interventions. *Dis Esophagus* 2017;30:1–6.
10. Tyberg A, Seewald S, Sharaiha RZ, et al. A multicenter international registry of redo per-oral endoscopic myotomy (POEM) after failed POEM. *Gastrointest Endosc* 2017;85:1208–1211. [PubMed: 27756611]
11. Ngamruengphong S, Inoue H, Ujiki MB, et al. Efficacy and Safety of Peroral Endoscopic Myotomy for Treatment of Achalasia After Failed Heller Myotomy. *Clin Gastroenterol Hepatol* 2017;15:1531–1537 e3. [PubMed: 28189695]
12. Hashimoto R, Inoue H, Shimamura Y, et al. Per oral endoscopic myotomy as salvage therapy in patients with achalasia refractory to endoscopic or surgical therapy is technically feasible and safe: Systematic review and meta-analysis. *Dig Endosc* 2020.
13. Kolb JM, Jonas D, Funari MP, et al. Efficacy and safety of peroral endoscopic myotomy after prior sleeve gastrectomy and gastric bypass surgery. *World J Gastrointest Endosc* 2020;12:532–541. [PubMed: 33362906]
14. Repici A, Fuccio L, Maselli R, et al. GERD after per-oral endoscopic myotomy as compared with Heller’s myotomy with fundoplication: a systematic review with meta-analysis. *Gastrointest Endosc* 2018;87:934–943 e18. [PubMed: 29102729]
15. Khashab MA, Vela MF, Thosani N, et al. ASGE guideline on the management of achalasia. *Gastrointest Endosc* 2020;91:213–227 e6. [PubMed: 31839408]
16. Shemmeri E, Louie BE, Katz PO. Outcome Measures for Achalasia: Beyond the Eckardt Score. *Foregut* 2022;2:402–408.
17. Carlson DA, Gyawali CP, Kahrilas PJ, et al. Esophageal motility classification can be established at the time of endoscopy: a study evaluating real-time functional luminal imaging probe panometry. *Gastrointest Endosc* 2019;90:915–923 e1. [PubMed: 31279625]
18. Moran RA, Brewer Gutierrez OI, Rahden B, et al. Impedance planimetry values for predicting clinical response following peroral endoscopic myotomy. *Endoscopy* 2021;53:570–577. [PubMed: 33147642]
19. Kahrilas PJ, Bredenoord AJ, Fox M, et al. The Chicago Classification of esophageal motility disorders, v3.0. *Neurogastroenterol Motil* 2015;27:160–74. [PubMed: 25469569]
20. Taft TH, Carlson DA, Triggs J, et al. Evaluating the reliability and construct validity of the Eckardt symptom score as a measure of achalasia severity. *Neurogastroenterol Motil* 2018;30:e13287. [PubMed: 29315993]
21. Eckardt VF, Aignherr C, Bernhard G. Predictors of outcome in patients with achalasia treated by pneumatic dilation. *Gastroenterology* 1992;103:1732–8. [PubMed: 1451966]
22. Inoue H, Minami H, Kobayashi Y, et al. Peroral endoscopic myotomy (POEM) for esophageal achalasia. *Endoscopy* 2010;42:265–71. [PubMed: 20354937]
23. Mittal C, Wagh MS. Technical Advances in Per-Oral Endoscopic Myotomy (POEM). *Am J Gastroenterol* 2017;112:1627–1631. [PubMed: 29016561]
24. Carlson DA, Lin Z, Kahrilas PJ, et al. The Functional Lumen Imaging Probe Detects Esophageal Contractility Not Observed With Manometry in Patients With Achalasia. *Gastroenterology* 2015;149:1742–51. [PubMed: 26278501]
25. Gyawali CP, Kahrilas PJ, Savarino E, et al. Modern diagnosis of GERD: the Lyon Consensus. *Gut* 2018;67:1351–1362. [PubMed: 29437910]

26. Savarino E, di Pietro M, Bredenoord AJ, et al. Use of the Functional Lumen Imaging Probe in Clinical Esophagology. *Am J Gastroenterol* 2020.
27. Wahba G, Neshkova E, Vuille-Lessard E, et al. Is topical lidocaine beneficial before catheter insertion in esophageal manometry and ambulatory pH monitoring? *Neurogastroenterol Motil* 2019;31:e13687. [PubMed: 31321837]
28. Jain AS, Carlson DA, Triggs J, et al. Esophagogastric Junction Distensibility on Functional Lumen Imaging Probe Topography Predicts Treatment Response in Achalasia-Anatomy Matters! *Am J Gastroenterol* 2019;114:1455–1463. [PubMed: 30741739]
29. DeWitt JM, Siwec RM, Perkins A, et al. Evaluation of timed barium esophagram after peroral endoscopic myotomy to predict clinical response. *Endosc Int Open* 2021;9:E1692–E1701. [PubMed: 34790532]
30. DeWitt J, Siwec R, Kessler W, et al. Comparison of functional lumen imaging probe and high-resolution manometry to assess response after peroral endoscopic myotomy. *Gastrointest Endosc* 2021.
31. Teitelbaum EN, Soper NJ, Pandolfino JE, et al. Esophagogastric junction distensibility measurements during Heller myotomy and POEM for achalasia predict postoperative symptomatic outcomes. *Surg Endosc* 2015;29:522–8. [PubMed: 25055891]
32. Campagna RAJ, Carlson DA, Hungness ES, et al. Intraoperative assessment of esophageal motility using FLIP during myotomy for achalasia. *Surg Endosc* 2019.
33. Ngamruengphong S, von Rahden BH, Filser J, et al. Intraoperative measurement of esophagogastric junction cross-sectional area by impedance planimetry correlates with clinical outcomes of peroral endoscopic myotomy for achalasia: a multicenter study. *Surg Endosc* 2016;30:2886–94. [PubMed: 26487227]
34. Familiari P, Gigante G, Marchese M, et al. EndoFLIP system for the intraoperative evaluation of peroral endoscopic myotomy. *United European Gastroenterol J* 2014;2:77–83.
35. Rieder E, Swanstrom LL, Perretta S, et al. Intraoperative assessment of esophagogastric junction distensibility during per oral endoscopic myotomy (POEM) for esophageal motility disorders. *Surg Endosc* 2013;27:400–5. [PubMed: 22955896]
36. Yeung F, Wong IYH, Chung PHY, et al. Peroral Endoscopic Myotomy with EndoFLIP and Double-Endoscope: Novel Techniques for Achalasia in Pediatric Population. *J Laparoendosc Adv Surg Tech A* 2018;28:343–347. [PubMed: 29215957]
37. Holmstrom AL, Campagna RJ, Carlson DA, et al. Comparison of preoperative, intraoperative, and follow-up functional luminal imaging probe measurements in patients undergoing myotomy for achalasia. *Gastrointest Endosc* 2021;94:509–514. [PubMed: 33662363]
38. Su B, Callahan ZM, Novak S, et al. Using Impedance Planimetry (EndoFLIP) to Evaluate Myotomy and Predict Outcomes After Surgery for Achalasia. *J Gastrointest Surg* 2020;24:964–971. [PubMed: 31939098]
39. Donnan EN, Pandolfino JE. Applying the Functional Luminal Imaging Probe to Esophageal Disorders. *Curr Gastroenterol Rep* 2020;22:10. [PubMed: 32040644]
40. Yoo IK, Choi SA, Kim WH, et al. Assessment of Clinical Outcomes after Peroral Endoscopic Myotomy via Esophageal Distensibility Measurements with the Endoluminal Functional Lumen Imaging Probe. *Gut Liver* 2019;13:32–39. [PubMed: 30400727]
41. Ichkhanian Y, Gutierrez OB, Roman S, et al. Role of Functional Luminal Imaging Probe (FLIP) in the Management of post Myotomy Clinical Failure. *Gastrointest Endosc* 2022.

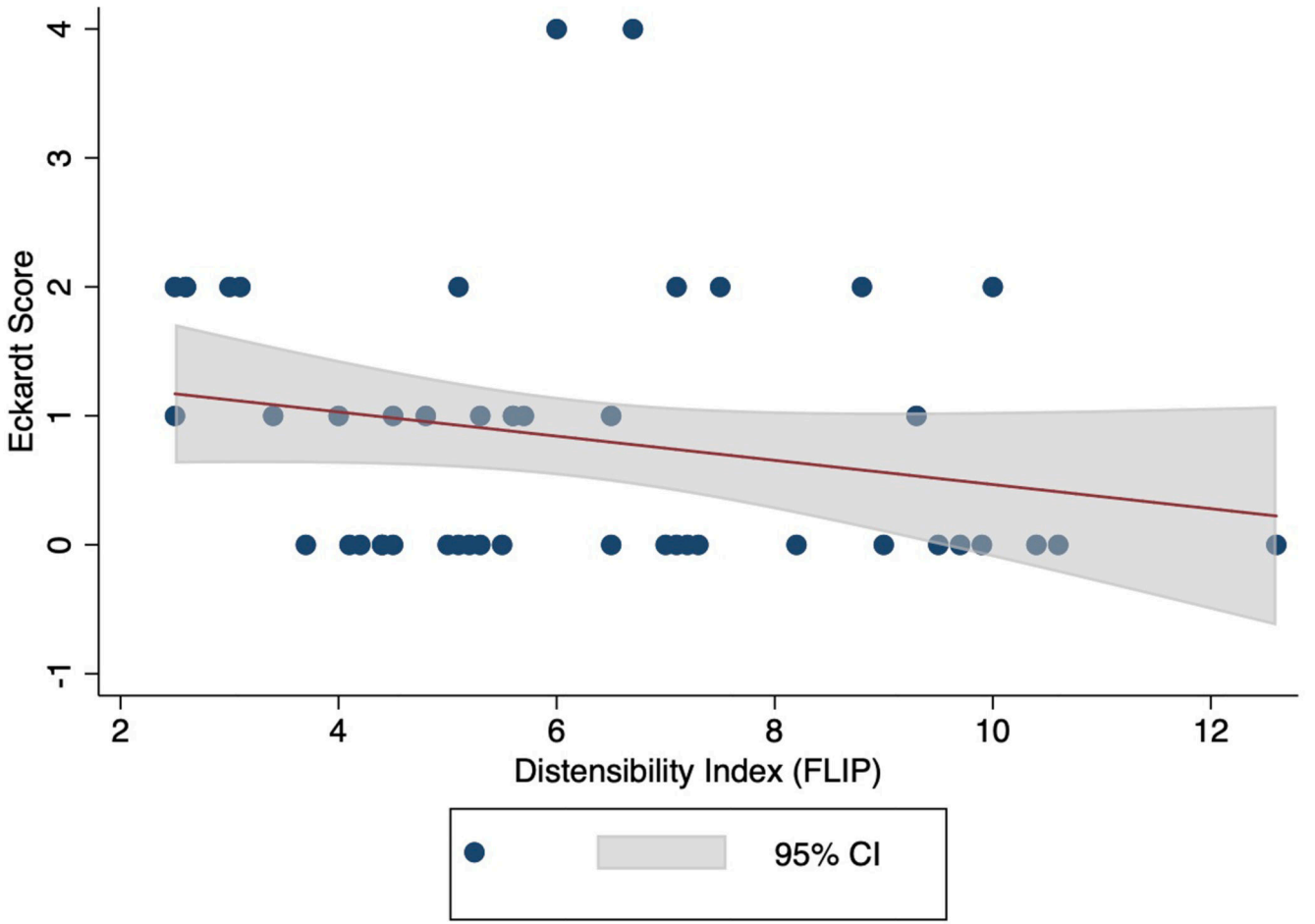


Figure 1: Relationship between Eckardt Score (ES) and Distensibility Index (DI) on FLIP (not statistically significant).

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 1.

Baseline characteristics of individuals who underwent POEM and subsequent EndoFLIP

Baseline Characteristics (n=47)	
Female sex, n (%)	26 (55.3)
Age, years, mean (range)	55.1 (22–82)
Indication, n (%)	
Type I achalasia	6 (12.8)
Type II achalasia	28 (59.6)
Type III achalasia	7 (14.9)
Esophago-gastric junction outflow obstruction	5 (10.6)
Integrated Relaxation Pressure, mm Hg, median (IQR)	27 (19.9, 34.3)
Prior Achalasia Treatment, n (%)	
None	33 (70.2)
Pneumatic dilation	2 (4.3)
Botulinum toxin injection	7 (14.9)
Pneumatic dilation + botulinum toxin injection	4 (8.5)
Surgical Heller myotomy	1 (2.1)
Eckardt Score, median (IQR)	7 (5.8)
EGJ Distensibility Index, 60mL mm ² /mm Hg, mean ± SD (n=5)	1.46 ± 1.56
Maximum Diameter at 60mL, mm, mean ± SD mm (n=5)	7.42 ± 2.61

Table 2.

Post POEM clinical outcomes and endoscopic findings

Post Intervention Characteristics (n=47)	
Eckardt Score, median (IQR)	0 (0,2)
Clinical Success, n (%)	45 (95.7%)
Physiologic success (EGJ-DI > 2.8), n (%)	43 (91.5%)
Time to EndoFLIP, days, median (IQR)	91 (90,100)
Reflux esophagitis (LA Grade), n (%)	
None	27 (57.5)
A	7 (14.9)
B	7 (14.9)
C	2 (4.3)
D	4 (8.5)
Candida	3 (6.4)
EGJ Distensibility Index, 60mL mm ² /mm Hg, mean ± SD	6.1 ± 2.5
Maximum Diameter at 60mL, mm, mean ± SD mm	12.4 ± 2.3
Adverse Events	2 (4.3%)*

* Emergency room visit for chest pain with negative workup

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript