



Tools for endoscopic management of benign luminal GI strictures

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The American Society for Gastrointestinal Endoscopy (ASGE) Technology Committee provides reviews of existing, new, or emerging endoscopic technologies that have an impact on the practice of GI endoscopy. Evidence-based methods are used, with a MEDLINE literature search to identify pertinent clinical studies on the topic. This is supplemented by accessing the "related articles" feature of PubMed and by scrutinizing pertinent references cited by the identified studies. Controlled clinical trials are emphasized, but in many cases data from randomized controlled trials are lacking. In such cases, large case series, preliminary clinical studies, and expert opinions are used. Technical data are gathered from traditional and web-based publications, proprietary publications, and informal communications with pertinent vendors. Technology Status Evaluation Reports are drafted by 1 or 2 members of the ASGE Technology Committee, reviewed and edited by the committee as a whole, and approved by the Governing Board of the ASGE. When cost assessment is indicated, the most recent coding data and list prices at the time of publication are provided. For this review, the MEDLINE database was searched through April 2024 for relevant articles related to luminal GI strictures by using key words such as "endoscopy" or "endoscopic" combined with "lumen," "dilation," and "stricture." Technology Status Evaluation Reports are scientific reviews provided solely for educational and informational purposes. Technology Status Evaluation Reports are not rules and should not be construed as establishing a legal standard of care or as encouraging, advocating, requiring, or discouraging any particular treatment or payment for such treatment.

Luminal strictures can occur in any part of the GI tract and can arise from benign and malignant causes. Stricture dilation may be necessary when there is impaired passage of luminal contents, a need for diagnosis at or beyond the stricture, or a need to provide therapy beyond the stricture. A variety of devices and techniques are available for use in the GI lumen. This status evaluation report describes the accessories used to perform dilation of benign luminal strictures and is an update of the report this committee published in 2013. Additionally, pharmacotherapeutic developments to facilitate dilation or reduce the risk of restenosis are also reviewed. The management of malignant stricture is not included in the current report and is discussed separately in other American Society for Gastrointestinal Endoscopy (ASGE) reports.¹

DILATORS FOR THE GI LUMEN

Dilation is accomplished by the application of expandable forces against a luminal stenosis. Dilators used in GI endoscopy can be organized into 2 categories: fixed-diameter push-type dilators (bougienage or "bougie" dilators) and radial-expanding balloon dilators. Fixed-diameter push-type dilators exert radial forces and cause a shearing effect that exerts longitudinal forces as they are advanced through the stenosis.² Conversely, balloon dilators exert radial forces when expanded within a stenosis.

Bougie dilators

Bougie dilators are primarily used to treat esophageal strictures and are available in various designs, calibers,

and lengths (Table 1). They can be non-wire-guided or wire-guided. Hurst and Maloney dilators (Diversatek Healthcare, Milwaukee, Wisc, USA) are non-wire-guided flexible rubber bougie dilators. They are radiopaque, tungsten-filled bougies that mimic the weight and feel of outdated mercury-filled bougies. They are blindly passed with the patient in the upright position.³⁻⁵ Carefully selected patients with recurrent esophageal strictures may be instructed to use these devices for self-dilation. However, this is rarely used now because of safety concerns.⁶ Maloney dilators have an elongated tapered tip, whereas Hurst dilators have a blunt rounded tip.³

Several models of wire-guided bougie dilators are commercially available.^{3,7,8} Wire-guided bougie dilators are flexible, tapered, polyvinyl chloride, latex-free cylindrical solid tubes with a central channel to accommodate a guidewire. Savary-Gilliard dilators (Cook Medical, Winston-Salem, NC, USA), the most commonly used wire-guided bougie dilator,⁶ have a 20-cm-long tapered tip and a radiopaque band to aid in fluoroscopic visualization where the taper reaches the maximal diameter. American Dilation System dilators (ConMed, Utica, NY, USA) and SafeGuide dilators (Diversatek Healthcare, Milwaukee, Wisc, USA) have a shorter tapered tip and a radiopaque band throughout their length. Bougie dilators have external markings indicating the distance from the tip (American System and SafeGuide, ConMed) or the largest diameter (Savary-Gilliard, Cook Medical). CleanGuide (ConMed) is a new disposable wire-guided bougie dilator with length measurements along the dilator's body to help approximate the device's position within the esophagus.

Most bougie dilators are reusable, and operators should refer to the manufacturer's guidelines for reprocessing instructions. A recent large retrospective study demonstrated an extremely low risk of infection transmission by bougie dilators when following Massachusetts General Hospital bougie dilator reprocessing guidelines.⁹ Given the challenges with reprocessing and storing dilators with a small-caliber guidewire channel, there is impetus for using disposable dilators. Similarly, non-wire-guided bougienage catheters, which have traditionally enjoyed a favorable cost economy because of their ability to be reprocessed alongside endoscopes, are experiencing reduction in their cost savings because of the shortening of their lifespans in our current climate of heightened reprocessing standards.

The lifespan of reusable bougie dilators, like the Savary-Gilliard, is affected by the higher cleaning and sterilization standards that are now required in medical facilities and institutions. These reusable devices are exposed to frequent cycles of high temperatures and strong chemicals, making them less durable and cost-effective compared with single-use alternatives. In the push toward "green endoscopy," however, which focuses on reducing the environmental impact of medical procedures, many are moving away from single-use items like Savary dilators. However, switch-

TABLE 1. Esophageal bougie dilators

Name and type of dilators	Size (F)
Non-wire guided	
Diversatek	
Maloney (tapered) tip	16-60
Hurst (blunt) tip	16-60
Set of 23 Maloney dilators	16-60
Set of 10 Maloney dilators	36-54
Set of 23 Hurst dilators	16-60
Set of 10 Hurst dilators	36-54
M-Flex Blue Silicone Bougie	
Maloney (tapered) tip	20-60
Hurst (blunt) tip	20-60
Set of 21 Maloney dilators	20-60
Set of 10 Maloney dilators	36-54
Set of 21 Hurst dilators	20-60
Set of 10 Hurst dilators	36-54
Wire guided	
Diversatek	
SafeGuide dilators	15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45, 48, 51, 54, 57, 60
Individual dilators	
16-piece full set	15-60 dilators, storage case, guidewire, cleaning brush, 25 cleaning adaptors
7-piece mini set	15, 21, 27, 33, 39, 42, 45 dilators, storage case, guidewire, cleaning brush, 25 cleaning adaptors
Conmed	
Individual	15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45, 48, 51, 54, 60
Set of 15 dilators	15-60
CleanGuide disposable	15-60
Cook Medical	
Savary-Gilliard dilators	
Standard set	15, 21, 24, 33
Set of 16 dilators	15-60
Long set	15, 21, 27, 33, 36, 42, 45
Set of 16 dilators	15-60

ing to reusable dilators is not straightforward. We still need to ensure they can be appropriately reprocessed to prevent infection with materials needing to withstand frequent sterilization without breaking down too quickly.¹⁰

One possible solution could be the increased use of non-guided dilators like Hurst and Maloney models, which do not

rely on disposable guidewires and could help reduce waste. It will take developing more durable materials for reusable devices, establishing better cleaning protocols that do not wear down the equipment as quickly, and conducting thorough cost and environmental impact studies to compare reusable and single-use devices.¹⁰

Balloon dilators

Through-the-scope (TTS) radial-expanding balloon dilators, available in various designs, lengths, and calibers from multiple manufacturers, are used to treat stenoses at different GI tract sites^{3,5-8,11,12} (Table 2). These dilators are designed to facilitate direct visual control during dilation and can be used with or without wire guidance. For balloon dilators with wire guidance, one can use the guidewire provided by the manufacturer included in the balloon dilator or exchange it with a different guidewire of provider preference. These disposable dilators are made of low-compliance inflatable thermoplastic polymers, ensuring uniform and reproducible expansion to their prespecified diameter at maximum inflation. Most balloons permit sequential expansion to multiple diameters. Also, a large assortment of wire-guided balloons are designed for dilation under fluoroscopy without the need for endoscopy, such as the Flex-EZ dilator (Hobbs Medical, Stafford Springs, Conn, USA). Dilating balloons are expanded by pressure injection of liquid (water or radiopaque contrast) using a handheld accessory device (Table 3). The hydraulic pressure of the balloon is monitored manometrically to gauge the radial expansion force. Inflation with radiopaque contrast enhances fluoroscopic assessment (Fig. 1).^{3,6}

Achalasia balloon dilators

For pneumatic balloon dilation in achalasia patients, large-diameter (30, 35, and 40 mm) polyethylene balloon dilators with radiopaque markers are used^{13,14} (Table 4). Pneumatic dilation balloons are wire-guided and disposable and do not pass through the endoscope. Positioned across the esophagogastric junction under fluoroscopic guidance, their radiopaque markers aid visualization. The balloons are insufflated with air, and the pressure is monitored manometrically. Although designed for achalasia, these balloons have also been used for off-label indications, such as stenosis after gastric sleeve or fundoplication.^{3,13,15,16} Available achalasia balloons are listed in Table 4.

BougieCap

The BougieCap (Ovesco Endoscopy AG, Tübingen, Germany) is a new device with a single-use, transparent, conical, hard plastic cap that can be mounted on the tip of the endoscope and used for endoscopic treatment of upper GI tract strictures.¹⁷ The cap is secured to the endoscope tip using circular tape to prevent displacement during insertion or withdrawal. Two lateral openings in the cap allow for air or CO₂ insufflation and water flushing and

aspiration. The central hole at the tip of the BougieCap permits the insertion of a guidewire, if necessary. Equipped with the cap, the endoscope serves as a mediator for applied radial and longitudinal shear forces. The endoscope, with the cap attached, is inserted into the esophagus, positioning the tip just above the stenosis. Carefully sliding the endoscope through the stenosis with gentle rotations under visual control enables stricture dilation. When using the BougieCap with an ultrathin endoscope, a stiffening guidewire may help prevent scope buckling during insertion.

Direct visual control and tactile feedback while passing the stenosis with the cap can help prevent overdilation, which may lead to perforation.¹⁵⁻¹⁷ Because of the transparent cap, real-time evaluation can be performed immediately after dilation. Moreover, because the device extends only a short distance from the tip of the endoscope, it may be advantageous for treating high cervical esophageal strictures.^{18,19}

The BougieCap is available in sizes ranging from 7 to 18 mm, which come in 1 size per package, allowing the endoscopist to select the appropriate size during the initial inspection of the stricture (Table 5). Sizes 7 to 10 mm are attached to pediatric gastroscopes, whereas larger sizes (11-18 mm) are mounted on standard adult gastroscopes. Sequential bougienage can be performed by increasing the device diameter as needed (Fig. 2).

Two prospective multicenter studies, each with 50 patients, demonstrated technical feasibility, clinical efficacy, and safety when using the BougieCap for dilation in adults with eosinophilic esophagitis and other benign causes of esophageal stenosis.^{17,18} No significant adverse events were reported; however, in 3 cases, slipping of the BougieCap resulted in the cap being lost in the stomach or hypopharynx. Additional prospective studies are needed to compare the BougieCap with conventional esophageal dilation techniques directly and to assess long-term clinical efficacy.¹⁹

EsoFLIP

EsoFLIP (Medtronic Inc, Shoreview, Minn, USA) is a novel, commercially available esophageal dilator that is similar to its diagnostic counterpart, EndoFLIP (Medtronic Inc), that incorporates a high-resolution impedance planimetry and volume-controlled distension to measure several luminal parameters such as diameter, cross-sectional area, compliance, and distensibility index and provides a graphic illustration of the esophageal lumen in real time.^{20,21} Unlike EndoFLIP, EsoFLIP is integrated into a rigid balloon, enabling therapeutic hydraulic dilation of the lower esophageal sphincter in achalasia and dilation of benign esophageal strictures caused by GERD, radiation, or surgery.²⁰⁻²² EsoFLIP is available in 2 sizes to facilitate dilation up to a 30-mm diameter (ES-330) for achalasia or up to a 20-mm diameter (ES-320) for benign esophageal strictures. The fill volume of the balloon is adjustable,

TABLE 2. GI balloon dilators

Name and type of dilator	Balloon length (cm)	Required channel (mm)	Usable length (cm)
Cook Medical			
Hercules balloon dilators			
Non-wire-guided, esophageal: 8, 9, 10; 10, 11, 12; 12, 13.5, 15; 15, 16.5, 18; 18, 19, 20	8	2.8	180
Wire-guided, esophageal/pyloric/colonic: 8, 9, 10; 10, 11, 12; 12, 13.5, 15; 15, 16.5, 18; 18, 19, 20	5.5	2.8	240
Quantum through-the-scope balloon dilators, esophageal: 6, 8, 10, 12, 14, 16, 18, 20	8	2.8	195
Eclipse balloon dilators, wire-guided, esophageal: 6, 8, 10, 12, 14, 16, 19	8	2.8	240
	8	3.2	240
Boston Scientific			
CRE balloon dilation catheters, fixed-wire (non-wire-guided), esophageal: 6, 7, 8; 8, 9, 10; 10, 11, 12; 12, 13.5, 15; 15, 16.5, 18; 18, 19, 20	8	2.8	180
CRE balloon dilation catheters: wire-guided, esophageal/pyloric/biliary: 6, 7, 8; 8, 9, 10; 10, 11, 12; 12, 13.5, 15; 15, 16.5, 18; 18, 19, 20	8	2.8	180
CRE balloon dilation catheters: wire-guided esophageal/pyloric/colonic/biliary: 6, 7, 8; 8, 9, 10; 10, 11, 12; 12, 13.5, 15; 15, 16.5, 18, 19, 20	5.5	2.8	240
Maxforce esophageal balloon dilators: 6, 8, 10, 12, 14, 15, 16, 18	6	2.8	180
ConMed			
Eliminator PET esophageal balloon dilator: 6, 8, 10, 12, 15, 18, 20	8	2.8	180
Hobbs Medical			
Flex-Ez over-the-wire balloon dilators, esophageal/pyloric/colonic			
8, 10, 12	3	2.8	155
14, 16, 18, 20	3	3.7	165
6, 8, 10	4	2.8	155
16, 20	4	3.7	165
8, 10, 12, 14	8	3.7	155
16, 18, 20	8	3.7	165
Stylet wire balloon dilators, esophageal/pyloric/colonic			
12, 14	8	2.8	155
16, 18, 20	8	2.8	165
8, 10, 12, 14	5.5	2.8	155
16, 18, 20	5.5	2.8	165
8, 10, 12, 14	3	2.8	155
16, 18, 20	3	2.8	165
Olympus (Center Valley, Pa, USA)			
EZDilate fixed wire			
6.0, 7.0, 8.0	9	2.8	190
8.5, 9.5, 10.5	9	2.8	190
11.0, 12.0, 13.0	8	2.8	190
13.5, 14.5, 15.5	8	2.8	190
16.0, 17.0, 18.0	8	2.8	190
18.0, 19.0, 20.0	8		190
EZDilate wire guided			
6.0, 7.0, 8.0	6.5	2.8	240
8.5, 9.5, 10.5	6.5	2.8	240
11.0, 12.0, 13.0	5.5	2.8	240

(continued on the next page)

TABLE 2. Continued

Name and type of dilator	Balloon length (cm)	Required channel (mm)	Usable length (cm)
13.5, 14.5, 15.5	5.5	2.8	240
16.0, 17.0, 18.0	5.5	2.8	240
18.0, 19.0, 20.0	5.5	2.8	240

CRE, Controlled radial expansion.

TABLE 3. Common handheld inflation devices for balloon dilation

Boston Scientific (Marlborough, Mass, USA)
CRE SteriFlate Disposable Inflation Device
Alliance II Integrated Inflation Device
Encore Inflator
Cook Medical
Quantum Inflation Device
ConMed
ConMed Balloon Inflation Device
Diagmed Healthcare (Thirsk, England)
Disposable Inflation Device
Merit Medical Inflation Devices (South Jordan, Utah, USA)
Blue Diamond with Digital Pressure Gauge
basixTOUCH
basixCOMPAK
Micro-Tech Endoscopy (Ann Arbor, Mich, USA)
The Micro-Tech Inflation Device
Olympus (Center Valley, Pa, USA)
Olympus EZDilate Inflation System

CRE, controlled radial expansion.

allowing dilation to smaller sizes by adjusting the fill volume and monitoring the real-time FLIP display. Contrary to EndoFLIP, EsoFLIP does not come with a pressure sensor; however, an external pressure sensor can be attached to the EsoFLIP catheter with a 3-way valve, if needed.²⁰ EsoFLIP can offer several potential advantages over other balloon dilators: the potential to avoid fluoroscopy, thereby reducing the risk of radiation; ability to dilate over a more extensive range of diameters with only 1 balloon in a controlled manner; ability to objectively measure stricture size, and ability to assess the response to dilation immediately after the procedure.^{20,21}

Conversely, there are aspects of EsoFLIP that can potentially complicate its use for esophageal dilation, such as the inability of TTS catheter passage, requirement for an external pressure monitor, an external guidewire that requires removal before dilation, and time required to fill and empty the dilator balloon.²⁰ Displacement of the balloon during dilation is a potential risk factor for esophageal perforation. Furthermore, the feasibility and safety of EsoFLIP balloon dilation have been demonstrated only in

small studies, and larger studies with long-term follow-up are essential to further evaluate its application and associated clinical outcomes.

Self-expandable stents

Self-expandable stents that are potentially removable have been used to accomplish dilation of refractory benign strictures. This is accomplished using their radial expansion forces. A variety of covered self-expandable metal stents (SEMSs) and self-expandable plastic stents are available as well as some that are biodegradable, although biodegradable stents are not available in the United States. Full ASGE Technology Committee reviews of enteral stents²³ and lumen-apposing metal stents (LAMSS),²⁴ including those used primarily to accomplish dilation, are available.

Topical use of antifibrotic drugs

In refractory or recurrent benign esophageal strictures, particularly peptic strictures, intralesional steroid injections and oral steroids have been used for several years. Steroid injections may also be considered in radiation-induced, caustic, and anastomotic strictures. One prospective randomized, double-blind study compared steroid (0.5 mL per quadrant triamcinolone 40 mg/mL) with sham injection combined with balloon dilation in patients with recurrent peptic esophageal strictures. This study found that the patients with intralesional steroid injection required fewer dilations over 1 year than those in the sham injection group.²⁵ A systematic review by Henskens et al²⁶ comprising 341 patients with benign esophageal strictures proposed an advantage of adding intralesional steroid injections to dilation to decrease the need for repeat dilation in the subgroups of peptic, radiation-induced, and caustic strictures. However, the effect was less clear in the case of anastomotic strictures. An emerging entity is the prevention of stricture formation by injection of corticosteroids or treatment with an oral corticosteroid viscous solution immediately after EMR and endoscopic submucosal dissection (ESD) for esophageal lesions.^{6,27,28} In a network meta-analysis, Yang et al²⁹ demonstrated a favorable outcome for oral or intralesional administration of steroids after ESD compared with placebo in reducing the rate of stenosis and number of required dilation sessions.³⁰ There is some evidence for the use of oral steroids in the prevention of post-ESD strictures but limited evidence for oral steroids in the treatment of luminal strictures.³¹



Figure 1. GI balloon dilators. (Used with permission from Olympus.)

TABLE 5. BougieCap dilators

Name and size of dilator	Total length (mm)	Maximum dilation diameter (F)	Scope diameter (mm)
Ovesco BougieCap			
7, 8	19.5	24	5.4-5.9
9, 10	22	30	5.4-5.9
11, 12	17.5	36	9.4-9.9
13, 14	30	42	9.4-9.9
15, 16	32.5	48	9.4-9.9
17, 18	35	54	9.4-9.9

caustic strictures in children has been reported with favorable results in multiple case series and clinical trials.^{30,33,34} Various techniques for the application of MMC have been reported, including 1 common technique using 4-quadrant injections of 0.4 mg/mL of MMC in aliquots of 0.5 mL.³² A systemic review of MMC application in adults and children (mostly children with caustic strictures) demonstrated a complete response of 73% and a partial response of 21% using this treatment.³⁵ In another study of 74 adult patients with either anastomotic or post-ESD strictures, patients were divided into 3 groups: intralesional MMC with dilation, intralesional dexamethasone with dilation, or normal saline solution plus dilation. Patients treated with both MMC and dexamethasone had better results than the control group. The dysphagia-free period was 4.88 ± 1.66 months in the MMC group, 4.02 ± 1.77 months in the dexamethasone group, and 2.41 ± 1.26 months in the dilation group ($P < .05$). No significant differences were found in the postoperative adverse events among the 3 groups, demonstrating that both MMC and dexamethasone were safe.³⁶ More experience and well-designed prospective, randomized trials are needed to determine whether MMC or other antifibrotic agents offer an advantage over continued dilation or intralesional steroids for refractory esophageal strictures.³⁰

Paclitaxel has also been shown to have antifibrotic properties. Low doses of paclitaxel can inhibit the proliferation and migration of fibroblasts, making it suitable for local application in the treatment of stenosis.³⁷ Paclitaxel-coated balloons have been successfully used to treat vascular stenosis and urethral strictures after dilation. A pilot study evaluated paclitaxel-coated balloons in the management of benign esophageal stricture and reported high technical success and no adverse events or stricture recurrence.³⁸ Further large-scale trials with a well-defined control group are necessary to definitively establish the long-term safety and efficacy of this approach.

Another novel approach is the use of topical agents such as PuraStat (3-D Matrix Medical Technology, Newton, Mass, USA), a self-assembling peptide that is hypothesized to act as a biological wound dressing, thereby protecting

TABLE 4. Achalasia balloon dilators

Name and type of balloon	Balloon length (cm)	Usable length (cm)
Cook Medical		
Inflated balloon diameter 30 mm, 16F catheter	8	75
Inflated balloon diameter 35 mm, 16F catheter	8	75
Boston Scientific		
Rigiflex balloon, inflated balloon diameter 30, 35, 40 mm; 14F catheter	10	90
Hobbs Medical		
Inflated balloon diameter 30, 35, 40 mm; 16F catheter	10	100

As an alternative or supplement to steroid injections, mitomycin C (MMC), a chemotherapy agent with antifibrotic properties, has been introduced in the last several years.³² The use of MMC for treating refractory esophageal



Figure 2. BougieCap (Ovesco Endoscopy AG) dilator. (Image adapted from Lafeuille et al¹¹² with permission.)

the esophageal wound from luminal stress and reducing inflammation and fibrosis. Recent studies demonstrated the safety and ease of application,^{37,39,40} but future long-term studies are needed comparing with other approaches.

TECHNIQUE

Dilation can be performed with and without endoscopic, fluoroscopic, and/or wire guidance. The choice of the dilator is determined largely by endoscopist preference and the clinical scenario. Dilator diameters are measured in millimeters or French gauge. Size in millimeters can be converted to French gauge at a ratio of 1:3 (eg, 15 mm = 45F). Choosing the correct dilator size for safe and efficient dilation is crucial. Techniques may need to be modified for complex strictures (eg, length >2 cm, lumen diameter <12 mm, tortuous lumen) and/or specific disease states and locations in the GI tract. Wire-guided bougie dilators (Savary and American dilators) are passed over a guidewire after initial endoscopic guidewire placement and subsequent endoscope removal. Non-wire-

guided bougies (Hurst and Maloney) are passed blindly into the esophagus. In the presence of large hiatal hernias or complex strictures, the risk of perforation may be greater with these dilators.

Balloon dilators can be inserted into the GI tract with or without wire guidance. They are inflated using a handheld inflation device with liquid (eg, water and/or contrast). TTS wire-guided balloon dilators are passed through the endoscope accessory channel over a previously inserted guide-wire. The balloon is positioned at the site of the narrowing and inflated while under direct endoscopic observation. Similarly, non-wire-guided balloons are advanced across the stricture using endoscopic visualization alone (Fig. 3). The ideal duration for balloon inflation remains unknown. Although it is usually performed for 30 to 60 seconds, 1 study demonstrated that the balloon inflation time of 10 seconds was as effective as 2 minutes when dilating benign esophageal strictures.⁴¹ Guidance on the choice of guide-wire and contrast media are discussed separately in other ASGE documents.^{42,43}

The initial selection of a specific size of dilator is based on an estimation of the diameter of the stenosis. The “rule of 3” has been used to determine the dilation strategy to manage a stricture with a bougie dilator during a single session. This rule states that after moderate resistance is encountered, no more than 3 dilators of progressively increasing diameter should be passed in that session (no more than 3 mm per session).⁴⁴ Nonetheless, at least 2 large, multicenter, retrospective studies have shown that noncompliance with the rule of 3 did not appear to increase the risk of perforation or other adverse events after esophageal dilation.^{45,46} When dilating a symptomatic Schatzki ring of the esophagus, passage of a single large-diameter dilator (eg, 16-20 mm) has been advocated to allow for disruption of the ring.^{47,48} In very narrow strictures that cannot accommodate an adult gastroscope (external diameter typically ranging between 8 and 10 mm), the initial dilation should be restricted to 10- to 12-mm diameter. This limit should be no more than 9 mm for extremely tight or filiform strictures.

Modifications to standard dilation are sometimes used, especially in the case of refractory benign strictures. These include the injection of steroids immediately before or after dilation or other antifibrotic agent (as discussed above) using a sclerotherapy needle to reduce the risk of stricture recurrence.^{25,49-51} MMC, a drug demonstrated to be effective for this indication, is an antineoplastic drug and requires special handling.⁵² Disruption of strictures (eg, esophageal webs, Schatzki rings) may be needed for refractory stricture using biopsy forceps or needle-knife electrocautery, either as the sole treatment or in conjunction with dilation.^{51,53} Electroincision therapy using a needle-knife-type accessories can also be performed for anastomotic and inflammatory bowel disease-related strictures in the small bowel to supplement the dilation, especially for refractory strictures.^{54,55}

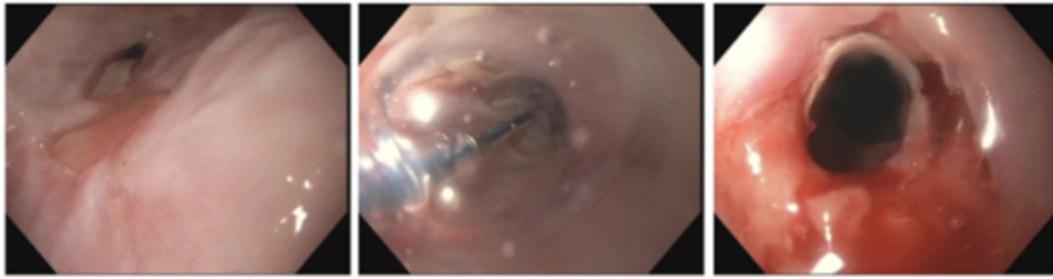


Figure 3. Through-the-scope balloon dilation of a peptic stricture in the esophagus.



Figure 4. Lumen-apposing metal stent placed across a gastrojejunal anastomotic stricture and anchored with a stent fix clip to prevent stent migration.

Do's and don'ts for stricture dilation

- Perform a comprehensive preprocedure assessment of the stricture, including the location, length, diameter, and etiology characterization, using a combination of endoscopy and imaging.
- Obtain biopsy samples to rule out the presence of malignancy before dilation.
- Supplement with medical management, such as antireflux therapy for peptic strictures.
- Consider using fluoroscopy guidance for complex strictures, especially those with angulation, long, or very narrow lumens.
- Wire-guided and endoscopic-guided dilators enhance safety and precision.
- Perform graded dilation with progressively larger dilators and avoid overdilating the strictures.
- Consider appropriate postprocedure monitoring and patient education on dietary modifications.
- Refractory strictures may benefit from alternative therapies, including stent placement or surgery.

OUTCOMES AND COMPARATIVE DATA

Esophagus

Long-lasting GERD is the most common cause of benign esophageal strictures.⁵⁶ Benign esophageal strictures are categorized as simple or complex depending on their diameter, length, location, and etiology.^{30,57} Simple esophageal strictures are short (<2 cm), straight, with a larger diameter

allowing passage of a standard endoscope. Uncontrolled acid reflux, Schatzki rings, or webs usually cause these strictures. They are amenable to the standard endoscopic dilation techniques; however, recurrence of stenosis has been reported in up to 30% to 40% of patients.^{28,58} Complex strictures are long (>2 cm), tortuous, or associated with a small lumen that impedes passage of a standard endoscope. They are usually caused by caustic ingestion, radiation injury, anastomotic strictures, or endoscopic resection or ablation (eg, EMR, ESD, or radiofrequency ablation).^{3,30,59} Treatment is more challenging in these strictures because they are associated with a higher tendency to become refractory, recur more frequently, and with a higher risk of adverse events.^{3,60}

Endoscopic dilation is the treatment of choice for patients with benign esophageal strictures. For patients with simple stenosis, 1 to 3 sessions of esophageal dilation combined with acid suppression are the mainstay of treatment, leading to significant improvement in dysphagia symptoms. On the contrary, for complex strictures and patients with caustic or anastomotic strictures, the number of sessions required to obtain the desired clinical outcome is usually ≥ 4 .^{4,16} Guidewire-directed bougie dilators and TTS balloon dilators are the 2 most common types of dilators.^{8,30} In 2018, Josino et al⁷ published a systematic review and meta-analysis of 5 randomized clinical trials involving 461 patients with various benign esophageal stricture etiologies (including peptic, caustic, Schatzki ring, postradiation, and postanastomotic) treated with either bougie or balloon dilation. The study reported no significant differences between these methods regarding symptomatic

relief, 1-year recurrence, bleeding, and perforation rates. Patients who underwent balloon dilation reported experiencing less-severe postprocedure pain compared with the bougie dilation group.^{7,61-65}

Cricopharyngeal bar. The narrowing of the pharyngo-esophageal segment characterizes the cricopharyngeal bar. It can result from restricted opening, hypertensive quality, abnormal relaxation, or abnormal coordination of the cricopharyngeal muscle (cricopharyngeal achalasia). Additionally, it could be secondary to neurogenic, myopathic, or neoplastic etiologies. Three known treatment options for cricopharyngeal achalasia are botulinum toxin injection, dilation, or myotomy. Dilation may be performed with wire-guided bougie dilators or balloon dilators. Because of the heterogeneity of etiologies and treatments of cricopharyngeal achalasia, several systemic reviews have been inconclusive in assessing the superiority of 1 treatment over another.⁶⁶⁻⁶⁸

Schatzki ring. Symptomatic Schatzki ring is treated by achieving rupture of the ring; therefore, larger-caliber dilators may be needed.^{6,47} A single dilation to 16 to 20 mm has proven to be very effective.^{6,69} Biopsy disruption of the ring using jumbo forceps was shown to be effective and safe in complete obliteration of the ring and resolution of dysphagia symptoms in a small study of 10 patients with dysphagia.⁷⁰ Electrosurgical incision therapy of the ring has been reported to be at least as effective as a single large-caliber bougie dilation in relieving dysphagia due to Schatzki ring in several randomized trials. Moreover, electrosurgical incision therapy was associated with a longer remission of dysphagia compared with bougienage.^{53,71,72} Long-term proton pump inhibitor therapy (omeprazole 20 mg/day) significantly reduces the risk of relapse compared with placebo at up to 4 years of follow-up,⁷³ perhaps because of the association of Schatzki ring with gastroesophageal reflux and eosinophilic esophagitis. Dysphagia due to Schatzki ring was relieved by proton pump inhibitor therapy without any further intervention in a small retrospective case series.⁷⁴

Anastomotic strictures. The best treatment approach for surgical anastomotic strictures in the GI tract involves endoscopic interventions as the first-line therapy. Endoscopic balloon dilation and electrosurgical incision therapy are commonly used techniques. Electrosurgical incision therapy has demonstrated efficacy and may be a reasonable alternative to standard dilation techniques for short anastomotic strictures (<1 cm). A randomized trial compared electrocautery incision with Savary bougienage to relieve anastomotic gastroesophageal strictures in 62 patients. No significant difference in clinical success or adverse event rate was seen between the 2 groups.⁷⁵ In a nonrandomized retrospective cohort study, Muto et al⁷⁶ compared the efficacy of radial incision and cutting with repeated endoscopic balloon dilation in 54 patients with refractory esophageal anastomotic strictures and found no difference in the short-term efficacy or serious adverse events; however, the 6-month and 12-month patency rates

were significantly higher for the radial incision and cutting group. For refractory cases where endoscopic methods fail, surgical options such as redo-anastomosis or stricturoplasty may be considered.

Eosinophilic esophagitis. Esophageal dilation is a safe and effective treatment for eosinophilic esophagitis when combined with other forms of chronic disease modification, such as diet, topical steroids, or other medications.^{3,6,11} A 2017 systematic review and meta-analysis concluded that dilation with a balloon or bougie dilator has similar safety and efficacy profiles for managing strictures or narrow-caliber esophagus in patients with eosinophilic esophagitis.¹¹ At least 1 small pilot and retrospective study demonstrated the feasibility and safety of using Eso-FLIP for esophageal stricture dilation in patients with eosinophilic esophagitis.²¹ Future prospective interventional studies comparing dilation and medical treatments are essential to establish the optimal treatment plan for these patients.

Refractory benign esophageal strictures. Despite the lack of randomized trials comparing stent placement with other dilation methods for benign esophageal strictures, it is generally accepted that esophageal stent placement is a reasonable rescue strategy for patients with refractory or recurrent benign esophageal strictures.^{3,77,78} Available data on the clinical success of stent placement do not identify any significant advantage favoring 1 specific stent over another. Fuccio et al⁷⁸ reviewed 18 studies (total of 444 patients), and the pooled clinical success rate was 40.5% (95% CI, 31.5-49.5). In this systematic review and meta-analysis, treatment with self-expandable plastic stents and SEMSs did not have significantly higher success rates than treatment with biodegradable stents (46.2% vs 40.1% vs 32.9%, respectively). The adverse event rate was 20.6% (95% CI, 15.3-28.1), with no significant difference between stent types (19.4% vs 21.9% vs 21.9%, respectively).

The most recent guidelines from the European Society of Gastrointestinal Endoscopy suggest considering temporary placement (6-12 weeks) using fully covered SEMSs (FCS-EMSS) for refractory benign esophageal strictures, mainly because of their very low risk of embedment and ease of removability.^{77,79} The LAMS, a distinct type of SEMS, was designed for drainage of pancreatic fluid collections but has more recently been used as an off-label treatment for GI luminal stenosis, including benign esophageal strictures.³⁰ A systematic review reported a clinical success rate of 63% (95% CI, 0.365-0.914) for LAMS placement in benign esophagogastric strictures with an adverse event rate of 27.9% (95% CI, 0.101-0.458).⁸⁰

Achalasia. Pneumatic balloon dilation of the lower esophageal sphincter with a large diameter (≥ 30 mm) wire-guided balloon is an accepted therapy for the treatment of achalasia, along with laparoscopic Heller myotomy and peroral endoscopic myotomy.⁸¹ Dilation with 30-mm, 35-mm, and 40-mm balloon diameters has been shown to result in good to excellent symptom relief in 74%,

86%, and 90% of patients, respectively, with an average follow-up of 1.6 years (range, 0.1-6).⁸² A recently published randomized controlled trial by the same European group demonstrated that pneumatic balloon dilation and laparoscopic Heller myotomy were equivalently effective after 10 years of follow-up without significant risk of developing gastroesophageal reflux.⁸³ One small single-center study of 28 treatment-naïve achalasia patients demonstrated good efficacy and safety of hydraulic dilation performed with EsoFLIP during a short-term follow-up. The maximum dilation diameter was 25 mm. Significant reductions in Eckardt scores and barium column height were reported at 1 to 4 weeks after the intervention.²²

Stomach and small bowel

Benign strictures of the gastric outlet and proximal small bowel are caused mainly by inflammation (eg, peptic ulcer disease, nonsteroidal anti-inflammatory drug-induced stricture), postsurgical changes, or pancreaticobiliary disease (eg, chronic pancreatitis, pseudocysts, walled-off pancreatic necrosis). These structures are typically treated by using TTS balloon dilators given their proximal location. As described above, SEMs or LAMSs can be used in the treatment of gastric outlet or duodenal strictures with or without the use of an anchoring mechanism (Fig. 4).^{23,24} Mid to distal small-bowel strictures are typically secondary to Crohn's disease. Because they are typically inaccessible to standard endoscopes, they have been accessed using single-balloon or double-balloon enteroscopy with successful stricture dilation using TTS balloons.

Gastric outlet obstruction. Endoscopic balloon dilation is typically the first-line treatment for patients with benign gastric outlet obstruction (GOO), whereas surgery is reserved for "salvage" therapy if endoscopic interventions fail or lead to severe adverse events such as perforation.¹ Guidelines for the endoscopic management of GOO from the ASGE in 2021 concluded that insufficient evidence exists to support endoscopic or surgical management for mixed varieties of benign GOO. Patients with benign GOO secondary to long strictures (>3 cm), caustic ingestion, and chronic pancreatitis are more likely to fail endoscopic balloon dilation and need surgery.¹ Surgical pyloroplasty and laparoscopic gastrojejunostomy are more established surgical treatment options because of their lower morbidity and mortality risk compared with other surgical techniques.^{84,85}

Crohn's disease. Crohn's disease-related fibrotic strictures that are symptomatic should be treated, ideally after optimization of medical therapy. Endoscopic balloon dilation is an efficacious treatment in these patients. Small-bowel strictures beyond the reach of conventional endoscopes dictate the use of balloon-assisted enteroscopy.⁸⁶ Endoscopic intervention can be challenging and is associated with a high risk of adverse events when dilating inflamed and friable strictures, especially in the presence of deep ulcers, fistulas, abscesses, or sinus tracts that can

occur in conjunction with strictures.^{86,87} A systematic review and meta-analysis of nonrandomized trials for endoscopic balloon dilation in the management of Crohn's disease included 2664 Crohn's disease strictures in 1089 patients, most of which were anastomotic strictures. The review reported a technical and clinical response rate of 92.6% and 70.2%, respectively. Overall, adverse event and perforation rates were 6.4% and 3%, respectively. The cumulative surgery rate at the 5-year follow-up was 75%.⁸⁸ Balloon dilation is more successful in strictures <4 cm.^{87,88} Medical optimization such as withdrawal of offending agents (nonsteroidal anti-inflammatory drugs), smoking cessation, and use of biologics plays a crucial role in maintaining luminal patency after the intervention.⁸⁶

FCSEMSs, used off-label, may work in cases of small-bowel strictures refractory to endoscopic balloon dilation or with an extended length. However, currently available evidence does not support the use of stents as a first-line therapy.⁸⁶ A multicenter, open-label, randomized trial compared FCSEMSs with endoscopic balloon dilation to treat strictures in Crohn's disease (ProtDilat study).⁸⁹ Eighty percent of patients in the endoscopic balloon dilation group and 51% of patients in the FCSEMS group were free of a new therapeutic intervention at the 1-year follow-up (odds ratio, 3.9; 95% CI, 1.4-10.6; $P = .0061$). Only 1 patient in each group had severe adverse events (perforation).⁸⁹

Colon

Dilation of benign colorectal strictures of varying etiologies (eg, anastomotic, nonsteroidal anti-inflammatory drug use, diverticulitis, radiation, and inflammatory bowel disease) using balloon or bougie-type dilator has been demonstrated to be effective in multiple uncontrolled series.⁹⁰⁻⁹⁷ A prospective trial randomized 30 patients with symptomatic benign postoperative anastomotic colorectal strictures to dilation with either an 18-mm TTS balloon dilator or an over-the-wire 35-mm pneumatic balloon dilator designed for achalasia. Dilation was successful in all patients, and no adverse events occurred in either group. However, the over-the-wire group required fewer sessions (1.6 vs 2.6, $P = .009$) and had a longer duration of response (560.8 days vs 245.2 days, $P = .016$).⁹⁸ SEMs and LAMSs have been used off-label to treat benign and anastomotic strictures in the colon and are discussed separately in other guidance documents.^{99,100}

SAFETY

All methods of GI dilation are intended to displace the stenotic tissue. Hence, some disruption of mural elements, including mucosal tears and minor bleeding, is expected. Generally, endoscopic dilation is a safe and effective treatment when performed by experienced endoscopists.¹⁰¹

The clinically significant adverse events of esophageal stricture dilation include chest pain, bleeding, bacteremia,

TABLE 6. Current Procedural Terminology codes and reimbursement for endoscopic dilation procedures, 2023 Medicare National Average Payment

Codes	Description	Hospital outpatient payment* (U.S.\$)	Ambulatory surgery center payment (2023 averages)* (U.S.\$)	Professional fee (facility)* (U.S.\$)
43220	Esophageal endoscopy, dilation balloon (<30 mm)	1742	752	118
43226	Esophageal endoscopy, dilation over guidewire	1742	752	130
43248	EGD, dilation guidewire	826	430	165
43249	EGD, balloon dilation of the esophagus (<30 mm)	1742	752	153
43233	Dilation of the esophagus with a balloon >30 mm for achalasia	1742	752	227
43245	EGD with dilation of gastric outlet obstruction, any method	1742	752	175
45340	Flexible sigmoidoscopy, balloon dilation stricture	1083	564	78
45386	Colonoscopy, balloon dilation	1083	564	210
45303	Proctosigmoidoscopy, dilation any method	1083	564	86
44381	Ileoscopy through stoma, with transendoscopic balloon dilation	1742	752	85

Source: <https://www.cms.gov/medicare/physician-fee-schedule/search>.

*These values could vary due to different insurance contracts and/or regions.

and perforation.^{3,102} The type of stricture and degree of dilation performed may influence the risk of adverse events. Perforation is the most clinically significant adverse event of stricture dilation and has been reported in 0.1% to 0.6% of esophageal stricture dilations.³⁰ Perforation occurs because of transmural disruption or the creation of a false tract.¹⁰³ Transmural disruption may occur when axial or radial forces exceed the structural integrity limits of the wall. A false tract occurs when the dilator directly or partially penetrates and damages the integrity of the wall.³ Factors associated with an increased risk of esophageal perforation are narrow or angulated strictures, severe esophagitis, large hiatal hernia, esophageal diverticula, caustic or radiation strictures, prior esophageal perforation, and inexperienced operator.^{30,104}

Endoscopic dilation in patients with eosinophilic esophagitis is not associated with a higher risk of adverse events such as perforation compared with other causes of esophageal stricture.^{6,11} No significant difference in perforation (and other adverse events) rates with bougie versus balloon dilators has been reported.^{3,7} However, a retrospective analysis reported an increased risk of perforation associated with the blind passage of Maloney dilators versus Savary-Gilliard and balloon dilators in patients with complex esophageal strictures.¹⁰³ Guidewire use may reduce this risk of perforation.⁴³

Although transient bacteremia has been reported in up to 23% of cases, current ASGE guidelines do not recommend routine prophylactic antibiotics at the time of endoscopic dilation.¹⁰⁵ Although intraprocedural oozing may be seen in a large portion of cases after endoscopic dilation, clinically significant bleeding has been reported in less than 0.5% of endoscopic

dilations.^{30,106} Electrosurgical incision therapy for esophageal strictures has been associated with a risk of perforation in up to 3.5% of the cases, probably because of the inability to estimate the length of the stricture or the depth of the esophageal wall during the incision.^{30,107}

The risk of esophageal perforation with graded pneumatic balloon dilation for achalasia has been stated as an overall median rate of 1.9% (range, 0-16) when performed by an experienced endoscopist (>100 patients treated).^{81,108,109} Every patient undergoing pneumatic dilation must be aware of the risk and possibility of necessary surgical intervention. However, conservative therapy with antibiotics, parenteral nutrition, and stent placement may be effective in cases with small perforations.⁸¹ In patients with GOO, multiple studies have shown a favorable success rate using balloon dilators with a low adverse event rate. In 2018, Kochhar et al¹¹⁰ evaluated the data of 264 patients with benign GOO who underwent endoscopic balloon dilation over a 20-year period. Overall, clinical success was reported in 92%, and perforation occurred in 3.4% of cases.^{110,111}

FINANCIAL CONSIDERATIONS

Reusable dilators offer cost benefits compared with disposable devices, even after factoring in reprocessing expenses. Additionally, expenses related to single-use and reusable guidewires, contrast agents, manometry gauges, inflation devices, and fluoroscopy are significant. However, the costs associated with stents are much higher than those of dilation catheters and balloons. Payment codes

for dilation during endoscopy and reimbursement rates are listed in [Table 6](#).

AREAS FOR FUTURE RESEARCH

Previously published research has shown that dilating catheters and balloons are safe and effective for treating strictures across the GI tract. However, the optimal technique for treating refractory strictures needs to be clarified. Prospective studies are needed to evaluate the role of drugs with antifibrotic properties to understand their efficacy in reducing the risk of stricture recurrence after dilation. With the advancements in SEMSs, the introduction of LAMSs, and their demonstration of efficacy even in the setting of refractory benign luminal strictures, head-to-head comparisons between stents and dilation techniques are needed.

CONCLUSIONS

Fixed-diameter push-type dilators and radial expansion balloon dilators are deemed safe, effective, and efficient for treating benign strictures across the digestive tract. Both approaches demonstrate similar efficacy and safety profiles, although wire-guided balloon dilators are typically necessary for areas beyond the esophagus. Newer technologies such as EsoFLIP, BougieCap, stent placement, and electroincision therapy using a needle-knife have additional features to address the limitations of previously available dilators. More work is needed to evaluate the role of antifibrotic drugs in preventing stricture recurrence. Moreover, further studies are required to determine the safety, efficacy, and cost comparisons of different techniques and tools in the management of GI luminal strictures.

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tific Corporation; royalties from UpToDate. All other authors disclosed no financial relationships.

REFERENCES

1. ASGE Standards of Practice Committee; Jue TL, Storm AC, Naveed M, et al. ASGE guideline on the role of endoscopy in the management of benign and malignant gastroduodenal obstruction. *Gastrointest Endosc* 2021;93:309-22 e4.
2. Abele JE. The physics of esophageal dilatation. *Hepatogastroenterology* 1992;39:486-9.
3. ASGE Technology Committee; Siddiqui UD, Banerjee S, Barth B, et al. Tools for endoscopic stricture dilation. *Gastrointest Endosc* 2013;78:391-404.
4. Patterson DJ, Graham DY, Smith JL, et al. Natural history of benign esophageal stricture treated by dilatation. *Gastroenterology* 1983;85:346-50.
5. Wesdorp IC, Bartelsman JF, den Hartog Jager FC, et al. Results of conservative treatment of benign esophageal strictures: a follow-up study in 100 patients. *Gastroenterology* 1982;82:487-93.
6. Sami SS, Haboubi HN, Ang Y, et al. UK guidelines on oesophageal dilatation in clinical practice. *Gut* 2018;67:1000-23.
7. Josino IR, Madruga-Neto AC, Ribeiro IB, et al. Endoscopic dilation with bougies versus balloon dilation in esophageal benign strictures: systematic review and meta-analysis. *Gastroenterol Res Pract* 2018;15:5874870.
8. Ravich WJ. Endoscopic management of benign esophageal strictures. *Curr Gastroenterol Rep* 2017;19:50.
9. Memel ZN, Flynn DJ, Hernandez-Barco Y, et al. Infectious transmission from Savary dilators is uncommon: retrospective review from a large tertiary academic center. *Clin Endosc* 2022;55:691-4.
10. Beilenhoff U, Neumann CS, Rey JF, et al. ESGE-ESGENA Guideline: cleaning and disinfection in gastrointestinal endoscopy. *Endoscopy* 2008;40:939-57.
11. Dougherty M, Runge TM, Eluri S, et al. Esophageal dilation with either bougie or balloon technique as a treatment for eosinophilic esophagitis: a systematic review and meta-analysis. *Gastrointest Endosc* 2017;86:581-91 e3.
12. Abad MRA, Fujiyoshi Y, Inoue H. Flexible endoscopic strategies for the difficult esophageal stricture. *Curr Opin Gastroenterol* 2020;36:379-84.
13. Tuset JA, Lujan M, Huguet JM, et al. Endoscopic pneumatic balloon dilation in primary achalasia: predictive factors, complications, and long-term follow-up. *Dis Esophagus* 2009;22:74-9.
14. Vaezi MF, Richter JE. Current therapies for achalasia: comparison and efficacy. *J Clin Gastroenterol* 1998;27:21-35.
15. Virgilio C, Cosentino S, Favara C, et al. Endoscopic treatment of post-operative colonic strictures using an achalasia dilator: short-term and long-term results. *Endoscopy* 1995;27:219-22.
16. Deslauriers V, Beauchamp A, Garofalo F, et al. Endoscopic management of post-laparoscopic sleeve gastrectomy stenosis. *Surg Endosc* 2018;32:601-9.
17. Schoepfer AM, Henchoz S, Biedermann L, et al. Technical feasibility, clinical effectiveness, and safety of esophageal stricture dilation using a novel endoscopic attachment cap in adults with eosinophilic esophagitis. *Gastrointest Endosc* 2021;94:912-9 e2.
18. Walter B, Schmidbaur S, Rahman I, et al. The BougieCap - a new method for endoscopic treatment of complex benign esophageal stenosis: results from a multicenter study. *Endoscopy* 2019;51:866-70.
19. Ramrakhiani H, Triadafilopoulos G. negotiating dire straits with a bougiecap. *Dig Dis Sci* 2020;65:3107-10.
20. Baumann AJ, Carlson DA. EsoFLIP for esophageal dilation: proposed advantages. *Curr Opin Gastroenterol* 2020;36:329-35.
21. Hoskins B, Almazan E, Hohl B, et al. Esophageal dilation with EsoFLIP is faster than CRE balloon dilation combined with EndoFLIP in children. *Surg Endosc* 2023;37:6308-14.

22. Schnurre L, Murray FR, Schindler V, et al. Short-term outcome after singular hydraulic EsoFLIP dilation in patients with achalasia: a feasibility study. *Neurogastroenterol Motil* 2020;32:e13864.
23. Committee AT, Varadarajulu S, Banerjee S, et al. Enteral stents. *Gastrointest Endosc* 2011;74:455-64.
24. ASGE Technology Committee; Law RJ, Chandrasekhara V, Bhatt A, et al. Lumen-apposing metal stents (with videos). *Gastrointest Endosc* 2021;94:457-70.
25. Ramage JI Jr, Rumalla A, Baron TH, et al. A prospective, randomized, double-blind, placebo-controlled trial of endoscopic steroid injection therapy for recalcitrant esophageal peptic strictures. *Am J Gastroenterol* 2005;100:2419-25.
26. Henskens N, Wauters L, Vanuysel T. Intralesional steroid injections in addition to endoscopic dilation in benign refractory esophageal strictures : a systematic review. *Acta Gastroenterol Belg* 2020;83:432-40.
27. Haidry RJ, Dunn JM, Butt MA, et al. Radiofrequency ablation and endoscopic mucosal resection for dysplastic barrett's esophagus and early esophageal adenocarcinoma: outcomes of the UK National Halo RFA Registry. *Gastroenterology* 2013;145:87-95.
28. Everett SM. Endoscopic management of refractory benign oesophageal strictures. *Ther Adv Gastrointest Endosc* 2019;12:2631774519862134.
29. Yang J, Wang X, Li Y, et al. Efficacy and safety of steroid in the prevention of esophageal stricture after endoscopic submucosal dissection: a network meta-analysis. *J Gastroenterol Hepatol* 2019;34:985-95.
30. Fugazza A, Repici A. Endoscopic management of refractory benign esophageal strictures. *Dysphagia* 2021;36:504-16.
31. Iizuka T, Kikuchi D, Hoteya S, et al. Effectiveness of modified oral steroid administration for preventing esophageal stricture after entire circumferential endoscopic submucosal dissection. *Dis Esophagus* 2018;31:1-6.
32. Siersema PD. How to approach a patient with refractory or recurrent benign esophageal stricture. *Gastroenterology* 2019;156:7-10.
33. Bartel MJ, Seeger K, Jeffers K, et al. Topical mitomycin C application in the treatment of refractory benign esophageal strictures in adults and comprehensive literature review. *Dig Liver Dis* 2016;48:1058-65.
34. El-Asmar KM, Hassan MA, Abdelkader HM, et al. Topical mitomycin C application is effective in management of localized caustic esophageal stricture: a double-blinded, randomized, placebo-controlled trial. *J Pediatr Surg* 2013;48:1621-7.
35. Rustagi T, Aslanian HR, Laine L. Treatment of refractory gastrointestinal strictures with mitomycin C: a systematic review. *J Clin Gastroenterol* 2015;49:837-47.
36. Zhang Y, Wang X, Liu L, et al. Intramuscular injection of mitomycin C combined with endoscopic dilation for benign esophageal strictures. *J Dig Dis* 2015;16:370-6.
37. Ren K, Wang J, Li Y, et al. Paclitaxel-coated balloon catheter for benign esophageal stenosis in a rabbit model. *Sci Rep* 2024;14:2551.
38. Wang KKea. Development and initial clinical experience with a paclitaxel-coated balloon for the treatment of benign difficult esophageal strictures. *iGIE* 2023;2:399-407.
39. Oumrani S, Barret M, Bordacahar B, et al. Application of a self-assembling peptide matrix prevents esophageal stricture after circumferential endoscopic submucosal dissection in a pig model. *PLoS One* 2019;14:e0212362.
40. Yang D, Hasan MK, Xiao Y, et al. The use of a self-assembling peptide gel for stricture prevention in the esophagus after endoscopic submucosal dissection: a U.S. multicenter prospective study (with video). *Gastrointest Endosc* 2024;100:213-20.
41. Wallner O, Wallner B. Balloon dilation of benign esophageal rings or strictures: a randomized clinical trial comparing two different inflation times. *Dis Esophagus* 2014;27:109-11.
42. ASGE Technology Assessment Committee; Mishkin D, Carpenter S, Croffie J, et al. ASGE Technology Status Evaluation Report: radiographic contrast media used in ERCP. *Gastrointest Endosc* 2005;62:480-4.
43. Somogyi L, Chuttani R, Croffie J, et al. Guidewires for use in GI endoscopy. *Gastrointest Endosc* 2007;65:571-6.
44. Langdon DF. The rule of three in esophageal dilation. *Gastrointest Endosc* 1997;45:111.
45. Grooteman KV, Wong Kee Song LM, Vleggaar FP, et al. Non-adherence to the rule of 3 does not increase the risk of adverse events in esophageal dilation. *Gastrointest Endosc* 2017;85:332-7 e1.
46. Vermeulen BD, de Zwart M, Sijben J, et al. Risk factors and clinical outcomes of endoscopic dilation in benign esophageal strictures: a long-term follow-up study. *Gastrointest Endosc* 2020;91:1058-66.
47. Jalil S, Castell DO. Schatzki's ring: a benign cause of dysphagia in adults. *J Clin Gastroenterol* 2002;35:295-8.
48. ASGE Standards of Practice Committee; Egan JV, Baron TH, Adler DG, et al. Esophageal dilation. *Gastrointest Endosc* 2006;63:755-60.
49. Altintas E, Kacar S, Tunc B, et al. Intralesional steroid injection in benign esophageal strictures resistant to bougie dilation. *J Gastroenterol Hepatol* 2004;19:1388-91.
50. Kochhar R, Makharia GK. Usefulness of intralesional triamcinolone in treatment of benign esophageal strictures. *Gastrointest Endosc* 2002;56:829-34.
51. Chotiprasidhi P, Minocha A. Effectiveness of single dilation with Maloney dilator versus endoscopic rupture of Schatzki's ring using biopsy forceps. *Dig Dis Sci* 2000;45:281-4.
52. Haifler M, Lang E, Sabler I, et al. Increasing medical staff safety by using a closed system for intravesical instillation of mitomycin C. *Urology* 2010;76:649-51.
53. Wills JC, Hilden K, Disario JA, et al. A randomized, prospective trial of electrosurgical incision followed by rabeprazole versus bougie dilation followed by rabeprazole of symptomatic esophageal (Schatzki's) rings. *Gastrointest Endosc* 2008;67:808-13.
54. Hordijk ML, Siersema PD, Tilanus HW, et al. Electrocautery therapy for refractory anastomotic strictures of the esophagus. *Gastrointest Endosc* 2006;63:157-63.
55. Lan N, Shen B. Endoscopic stricturotomy with needle Knife in the treatment of strictures from inflammatory bowel disease. *Inflamm Bowel Dis* 2017;23:502-13.
56. Kuo WH, Kalloo AN. Reflux strictures of the esophagus. *Gastrointest Endosc Clin N Am* 1998;8:273-81.
57. Lew RJ, Kochman ML. A review of endoscopic methods of esophageal dilation. *J Clin Gastroenterol* 2002;35:117-26.
58. Spechler SJ. American gastroenterological association medical position statement on treatment of patients with dysphagia caused by benign disorders of the distal esophagus. *Gastroenterology* 1999;117:229-33.
59. Shah JN. Benign refractory esophageal strictures: widening the endoscopist's role. *Gastrointest Endosc* 2006;63:164-7.
60. Chiu YC, Hsu CC, Chiu KW, et al. Factors influencing clinical applications of endoscopic balloon dilation for benign esophageal strictures. *Endoscopy* 2004;36:595-600.
61. Saeed ZA, Winchester CB, Ferro PS, et al. Prospective randomized comparison of polyvinyl bougies and through-the-scope balloons for dilation of peptic strictures of the esophagus. *Gastrointest Endosc* 1995;41:189-95.
62. Yamamoto H, Hughes RW Jr, Schroeder KW, et al. Treatment of benign esophageal stricture by Eder-Puestow or balloon dilators: a comparison between randomized and prospective nonrandomized trials. *Mayo Clin Proc* 1992;67:228-36.
63. Shemesh E, Czerniak A. Comparison between Savary-Gilliard and balloon dilatation of benign esophageal strictures. *World J Surg* 1990;14:518-21; discussion 521-2.
64. Scolapio JS, Pasha TM, Gostout CJ, et al. A randomized prospective study comparing rigid to balloon dilators for benign esophageal strictures and rings. *Gastrointest Endosc* 1999;50:13-7.
65. Cox JG, Winter RK, Maslin SC, et al. Balloon or bougie for dilatation of benign esophageal stricture? *Dig Dis Sci* 1994;39:776-81.
66. Dewan K, Santa Maria C, Noel J. Cricopharyngeal achalasia: management and associated outcomes-a scoping review. *Otolaryngol Head Neck Surg* 2020;163:1109-13.

67. Kocdor P, Siegel ER, Tulunay-Ugur OE. Cricopharyngeal dysfunction: a systematic review comparing outcomes of dilatation, botulinum toxin injection, and myotomy. *Laryngoscope* 2016;126:135-41.
68. Marston AP, Maldonado FJ, Ravi K, et al. Treatment of oropharyngeal dysphagia secondary to idiopathic cricopharyngeal bar: surgical cricopharyngeal muscle myotomy versus dilation. *Am J Otolaryngol* 2016;37:507-12.
69. Eckardt VF, Kanzler G, Willems D. Single dilation of symptomatic Schatzki rings. A prospective evaluation of its effectiveness. *Dig Dis Sci* 1992;37:577-82.
70. Gonzalez A, Sullivan MF, Bonder A, et al. Obliteration of symptomatic Schatzki rings with jumbo biopsy forceps (with video). *Dis Esophagus* 2014;27:607-10.
71. DiSario JA, Pedersen PJ, Bichis-Canoutas C, et al. Incision of recurrent distal esophageal (Schatzki) ring after dilation. *Gastrointest Endosc* 2002;56:244-8.
72. Ibrahim A, Cole RA, Qureshi WA, et al. Schatzki's ring: to cut or break an unresolved problem. *Dig Dis Sci* 2004;49:379-83.
73. Sgouros SN, Vlachogiannakos J, Karamanolis G, et al. Long-term acid suppressive therapy may prevent the relapse of lower esophageal (Schatzki's) rings: a prospective, randomized, placebo-controlled study. *Am J Gastroenterol* 2005;100:1929-34.
74. Novak SH, Shortsleeve MJ, Kantrowitz PA. Effective treatment of symptomatic lower esophageal (Schatzki) rings with acid suppression therapy: confirmed on barium esophagography. *AJR Am J Roentgenol* 2015;205:1182-7.
75. Hordijk ML, van Hooft JE, Hansen BE, et al. A randomized comparison of electrocautery incision with Savary bougienage for relief of anastomotic gastroesophageal strictures. *Gastrointest Endosc* 2009;70: 849-55.
76. Muto M, Ezoe Y, Yano T, et al. Usefulness of endoscopic radial incision and cutting method for refractory esophagogastric anastomotic stricture (with video). *Gastrointest Endosc* 2012;75:965-72.
77. Spaander MCW, van der Bogt RD, Baron TH, et al. Esophageal stenting for benign and malignant disease: European Society of Gastrointestinal Endoscopy (ESGE) Guideline - Update 2021. *Endoscopy* 2021;53:751-62.
78. Fuccio L, Hassan C, Frazzoni L, et al. Clinical outcomes following stent placement in refractory benign esophageal stricture: a systematic review and meta-analysis. *Endoscopy* 2016;48:141-8.
79. Moutzoukis M, Argyriou K, Kapsoritakis A, et al. Endoscopic luminal stenting: Current applications and future perspectives. *World J Gastrointest Endosc* 2023;15:195-215.
80. Tan S, Zhong C, Huang S, et al. Clinical outcomes of lumen-apposing metal stent in the management of benign gastrointestinal strictures: a systematic review and meta-analysis. *Scand J Gastroenterol* 2019;54:811-21.
81. Vaezi MF, Pandolfino JE, Yadlapati RH, et al. ACG Clinical Guidelines: Diagnosis and Management of Achalasia. *Am J Gastroenterol* 2020;115:1393-411.
82. Boeckxstaens GE, Annese V, des Varannes SB, et al. Pneumatic dilation versus laparoscopic Heller's myotomy for idiopathic achalasia. *N Engl J Med* 2011;364:1807-16.
83. Boeckxstaens G, Elsen S, Belmans A, et al. 10-year follow-up results of the European Achalasia Trial: a multicentre randomised controlled trial comparing pneumatic dilation with laparoscopic Heller myotomy. *Gut* 2024;73:582-9.
84. Soreide K, Sarr MG, Soreide JA. Pyloroplasty for benign gastric outlet obstruction—indications and techniques. *Scand J Surg* 2006;95:11-6.
85. Rangarajan M, Subramanian CS, Chandralathan TA. Laparoscopy-assisted truncal vagotomy with antecolic posterior gastrojejunostomy for benign gastric outlet obstruction. *Surg Endosc* 2006;20:61-3.
86. Ashat M, El-Abiad R, Khashab MA. Endoscopic approaches to small intestinal strictures. *Curr Opin Gastroenterol* 2023;39:356-61.
87. Yamamoto H, Yano T, Araki A, et al. Guidelines for endoscopic balloon dilation in treating Crohn's disease-associated small intestinal strictures (supplement to the Clinical Practice Guidelines for Enteroscopy). *Dig Endosc* 2022;34:1278-96.
88. Navaneethan U, Lourdasamy V, Njei B, et al. Endoscopic balloon dilation in the management of strictures in Crohn's disease: a systematic review and meta-analysis of non-randomized trials. *Surg Endosc* 2016;30:5434-43.
89. Loras C, Andujar X, Gornals JB, et al. Self-expandable metal stents versus endoscopic balloon dilation for the treatment of strictures in Crohn's disease (ProtDilat study): an open-label, multicentre, randomised trial. *Lancet Gastroenterol Hepatol* 2022;7:332-41.
90. Gopal DV, Katon RM. Endoscopic balloon dilation of multiple NSAID-induced colonic strictures: case report and review of literature on NSAID-related colopathy. *Gastrointest Endosc* 1999;50:120-3.
91. Sabate JM, Villarejo J, Bouhnik Y, et al. Hydrostatic balloon dilatation of Crohn's strictures. *Aliment Pharmacol Ther* 2003;18:409-13.
92. Thomas-Gibson S, Brooker JC, Hayward CM, et al. Colonoscopic balloon dilation of Crohn's strictures: a review of long-term outcomes. *Eur J Gastroenterol Hepatol* 2003;15:485-8.
93. Araujo SE, Costa AF. Efficacy and safety of endoscopic balloon dilation of benign anastomotic strictures after oncologic anterior rectal resection: report on 24 cases. *Surg Laparosc Endosc Percutan Tech* 2008;18:565-8.
94. Morini S, Hassan C, Cerro P, et al. Management of an ileocolic anastomotic stricture using polyvinyl over-the-guidewire dilators in Crohn's disease. *Gastrointest Endosc* 2001;53:384-6.
95. Oz MC, Forde KA. Endoscopic alternatives in the management of colonic strictures. *Surgery* 1990;108:513-9.
96. Venkatesh KS, Ramanujam PS, McGee S. Hydrostatic balloon dilatation of benign colonic anastomotic strictures. *Dis Colon Rectum* 1992;35:789-91.
97. Werre A, Mulder C, van Heteren C, et al. Dilation of benign strictures following low anterior resection using Savary-Gilliard bougies. *Endoscopy* 2000;32:385-8.
98. Di Giorgio P, De Luca L, Rivellini G, et al. Endoscopic dilation of benign colorectal anastomotic stricture after low anterior resection: a prospective comparison study of two balloon types. *Gastrointest Endosc* 2004;60:347-50.
99. Hong JT, Kim TJ, Hong SN, et al. Uncovered self-expandable metal stents for the treatment of refractory benign colorectal anastomotic stricture. *Scientific Reports* 2020;10:19841.
100. Coles M, Uy P, Madray V, et al. The Off-Label Use of a Lumen-Apposing Metal Stent (LAMS) for a Benign Colon Anastomotic Stricture Causing Recurrent Bowel Obstruction in a Patient with Keloids. *Case Rep Gastrointest Med* 2021;2021:5595518.
101. Sivasailam B, Lane BF, Cross RK. Endoscopic Balloon Dilation of Strictures: Techniques, Short- and Long-Term Outcomes, and Complications. *Gastrointest Endosc Clin N Am* 2022;32:675-86.
102. Eisen GM, Baron TH, Dominitz JA, et al. Complications of upper GI endoscopy. *Gastrointest Endosc* 2002;55:784-93.
103. Hernandez LV, Jacobson JW, Harris MS. Comparison among the perforation rates of Maloney, balloon, and savary dilation of esophageal strictures. *Gastrointest Endosc* 2000;51:460-2.
104. Irani S, Kozarek RA. Techniques and principles of endoscopic treatment of benign gastrointestinal strictures. *Curr Opin Gastroenterol* 2015;31:339-50.
105. ASGE Standards Of Practice Committee; Banerjee S, Shen B, Baron TH, et al. Antibiotic prophylaxis for GI endoscopy. *Gastrointest Endosc* 2008;67:791-8.
106. Silvis SE, Nebel O, Rogers G, et al. Endoscopic complications. Results of the 1974 American Society for Gastrointestinal Endoscopy Survey. *JAMA* 1976;235:928-30.
107. Samanta J, Dhaka N, Sinha SK, et al. Endoscopic incisional therapy for benign esophageal strictures: Technique and results. *World J Gastrointest Endosc* 2015;7:1318-26.
108. Eckardt VF, Kanzler G, Westermeier T. Complications and their impact after pneumatic dilation for achalasia: prospective

- long-term follow-up study. *Gastrointest Endosc* 1997;45:349-53.
109. Vela MF, Richter JE, Khandwala F, et al. The long-term efficacy of pneumatic dilatation and Heller myotomy for the treatment of achalasia. *Clin Gastroenterol Hepatol* 2006;4:580-7.
 110. Kochhar R, Malik S, Gupta P, et al. Etiological spectrum and response to endoscopic balloon dilation in patients with benign gastric outlet obstruction. *Gastrointest Endosc* 2018;88:899-908.
 111. ASGE Standards of Practice Committee; Ben-Menachem T, Decker GA, Early DS, et al. Adverse events of upper GI endoscopy. *Gastrointest Endosc* 2012;76:707-18.
 112. Lafeuille P, Yzet C, Bonniaud P, et al. Use of a bougie-shaped cap for dilation with direct visual control for an esophageal stricture induced by radiation therapy. *Endoscopy* 2023;55:E18-9.

Abbreviations: ASGE, American Society for Gastrointestinal Endoscopy; ESD, endoscopic submucosal dissection; FCSEMS, fully covered self-expandable metal stent; GOO, gastric outlet obstruction; LAMS, lumen-apposing metal stent; MMC, mitomycin C; SEMS, self-expandable metal stent; TTS, through-the-scope.



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