Stenting for benign esophageal strictures

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Bibliography
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Benign esophageal strictures are a common problem in endoscopic practice. The predominant symptom of patients is dysphagia. The initial treatment option for a benign esophageal stricture is dilation. A subgroup of strictures, i.e., those that are long (> 2 cm), tortuous, and have a narrow diameter, tend to recur and are therefore called refractory. Temporary stent placement, either with a self-expanding metal stent (SEMS) or a self-expanding plastic stent (SEPS), can be considered in these patients. The results obtained so far are disappointing, with long-term clinical resolution of the stricture achieved in less than 50% of patients. This is mainly due to hyperplastic tissue ingrowth or overgrowth (experienced with SEMS) and stent migration (SEPS). New stent designs are therefore needed for this indication. Initial results show that biodegradable stents have the promise to be useful for refractory benign esophageal strictures; however, this promise needs to be further elucidated in future studies.

Introduction

Over the past one-and-a-half centuries, esophageal endoprostheses have undergone a remarkable sequence of technological development, from hollow whalebones to the introduction of rigid plastic tubes, followed by self-expanding metal stents (SEMS), and, most recently, self-expanding plastic stents (SEPS). In addition, SEMS have improved from uncovered stainless steel stents to covered nitinol stents, which has made these devices more flexible and nontraumatic while still achieving full expansion and preventing the ingrowth of hyperplastic or tumor tissue through the meshes of the stent [1]. Specific details, such as increasing the stent diameter [2] or adding nitinol wire to the outside of a fully covered stent [3], have been demonstrated to reduce the risk of recurrent dysphagia, particularly that due to stent migration.

SEMS are the most frequently used method for palliation of dysphagia from esophageal or gastric cardia cancer [1]. With SEMS the dysphagia grade usually improves from a median of 3 (able to eat liquids only) to a median of 1 (able to eat most solid foods) after stent placement. Procedure-related complications of SEMS for malignant dysphagia include perforation, aspiration pneumonia, fever, hemorrhage, and severe pain in 5%–15% of patients. Delayed complications and recurrent dysphagia are more common and are reported in 30%–45% of patients. These include hemorrhage, fistula formation, stent migration, tumor or hyperplastic tissue overgrowth or ingrowth, and food obstruction.

Other reported indications for SEMS placement in the esophagus are the sealing of malignant esophagorespiratory fistulas, the palliation of dysphagia due to malignant lesions close to the upper esophageal sphincter [4], and recurrent cancer in a gastric tube interposition following esophagectomy or at the esophagojejunal anastomosis after gastrectomy.

The most recently introduced SEPS are being used for palliation of esophageal and gastric cardia cancer [3], but also for this indication. A recently published randomized trial comparing a partially covered SEMS (Ultraflex; Boston Scientific, Natick, Massachusetts, USA), a fully covered SEMS (Niti-S; Taewoong Medical, Seoul, Korea), and a fully covered SEPS (Polyflex; Boston Scientific) showed that all three devices were safe and offered the same degree of palliation; however, recurrent dysphagia due to stent migration was more likely to occur with SEPS during follow-up [3].

In the context of benign esophageal disease, stents have been used to seal esophageal perforations as a result of postoperative complications (anastomotic or postresection leaks), endoscopic

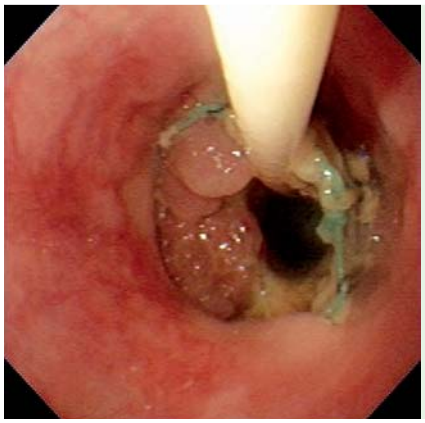

Fig. 1 Hyperplastic tissue ingrowth through the uncovered meshes at the upper end of an Ultraflex stent. Note the feeding tube inside the stent.

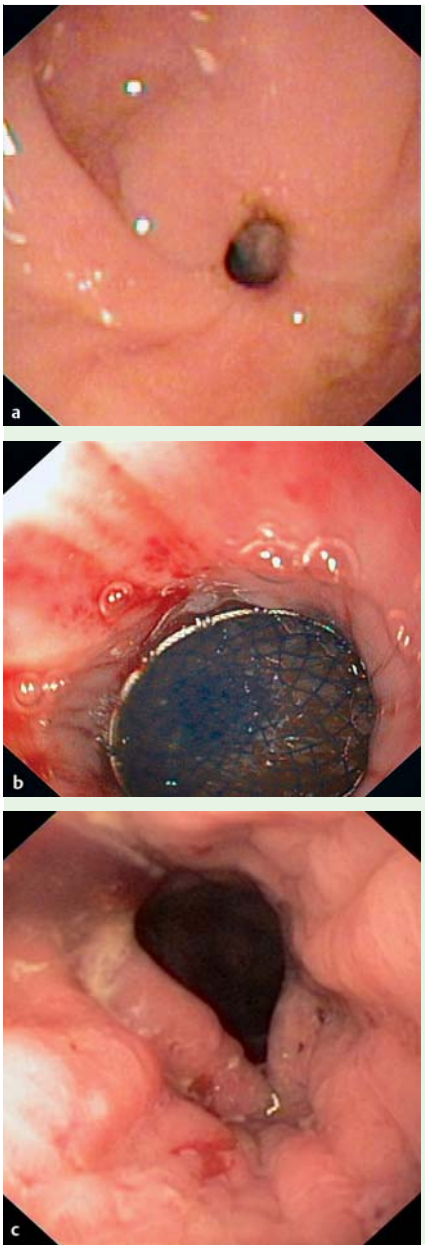

Fig. 2 Esophagogastric anastomotic stricture (**a**). After eight dilation sessions and incisional therapy, a fully covered SX-Ella esophageal HV stent (Ella-CS, Hradec Králové, Czech Republic) was placed (**b**). The anastomosis was significantly wider after removal of the stent (**c**).

procedures (balloon dilation of achalasia), Boerhaave's syndrome, and those associated with dilation of postradiation strictures and foreign-body ingestion. SEMS have been used for this indication [5], but experience has also been gained with SEPS. In our experience, which includes 78 patients with different types of nonmalignant esophageal perforations or leaks, adequate drainage and placement of a SEMS or SEPS was successful in more than 85% of patients (unpublished results). Another benign indication for placement of SEMS or SEPS includes benign esophageal strictures.

Types of benign esophageal stricture treated with stents

In order to predict which type of stricture is most likely to recur and may benefit from stent placement, it is important to differentiate between esophageal strictures that are simple and those that are more complex [6].

Simple esophageal strictures are focal, straight, and most have a diameter that allows passage of a normal-diameter endoscope. These strictures can successfully be treated with bougie or balloon dilation. Common etiologies include peptic injury, Schatzki ring, or a web. One to three dilations are usually required to relieve symptoms.

Complex esophageal strictures are long (> 2 cm), tortuous, and have a narrow diameter that does not allow the passage of any size of endoscope. The most common causes include caustic ingestion, radiation injury, anastomotic stricture, and severe peptic injury. These strictures are more difficult to treat, requiring at least three dilation sessions, and are associated with high recurrence rates. If these strictures cannot be dilated to an adequate diameter, recur within a short time interval, or require ongoing dilation, they are considered to be refractory. Various stent designs, both SEMS and SEPS, have been used to dilate these types of strictures.

SEMS for refractory benign esophageal strictures

In total, 12 studies have reported on 168 patients who underwent SEMS placement for benign esophageal strictures (**Table 1**) [7–18]. Indications for stent placement included achalasia (n = 85), caustic strictures (n = 35), postradiation strictures (n = 18), anastomotic strictures following esophagectomy or gastrectomy (n = 14), peptic strictures (n = 10), and other causes (n = 4).

Initially, uncovered SEMS were used [7, 8, 10, 11, 13]; however, in the more recent studies, partially or fully covered SEMS were placed [9, 12, 14–18]. Hyperplastic tissue ingrowth in uncovered stent parts and at both stent ends is, however, a problem with partially or fully covered SEMS as well (**Fig. 1**).

As can be seen from **Table 1**, migration was seen in 24 patients (14%) treated with SEMS, whereas hyperplastic tissue ingrowth or overgrowth was the cause of recurrent dysphagia in 28 (17%). Mayoral et al. [19] reported hyperplastic tissue growth as the cause of recurrent dysphagia in 32% of patients who had undergone stent placement for esophageal malignancies, with a mean interval of 22 weeks between stent placement and the appearance of dysphagia. The authors suggested that the type of metal used in the stent might have played a causative role. In addition, it can be speculated that hyperplastic tissue growth may also be related to the radial force of the stent, the size of stent, or possibly the duration of stenting, with prolonged duration of stenting increasing the risk.

Table 1 Published results of placement of self-expanding metal stents for treatment of benign esophageal strictures.

Author	Year	Design	Patients (n)	Stricture	Previous therapy	SEMS(n)	Technical success (%)	Dysphagia improvement	Dwell time SEMS	Complications (%)	Long-term effect (%)
Cwikiel et al. [7]	1993	Retrospective	5	Caustic (n = 3)	Multiple dilations	Strecker (uncov.) (n = 5)	100	Signif. improvement	Stents not removed	2 / 5 (40): hyperplastic tissue growth	2 / 5 (40) no recurrent stricture (mean FU: 12 mo)
				Peptic (n = 2)					(FU: 8 – 16 mo)	1 / 5 (20): pain for 3 mo	
Tan et al. [8]	1997	Retrospective	4	Peptic (n = 3)	4 – 14 dilations	Wallstent (uncov.) (n = 5)	100	3.5 → 1	Stents not removed	2 / 4 (50): hyperplastic tissue growth	2 / 4 (50) no recurrent stricture (mean FU: 14 mo)
				Protracted nasogastric tube (n = 1)							
Song et al. [9]	1997	Retrospective	5	Caustic (n = 3)	Multiple dilations	Custom-made Z-type stent (n = 3)	100	3 → 1	2 mo	1 / 5 (20): migration	3 / 5 (60) improvement of dysphagia (FU: 15 – 36 wk)
				Peptic (n = 1)					(Stents removed)	1 / 5 (20): pain	
				Extrinsic mass (n = 1)							
Song et al. [10]	1997	Retrospective	12	Caustic (n = 6)	Unknown	Strecker (uncov.) (n = 1)	100	3 → 1	Stents not removed	6 / 12 (50): migration	Unknown
				Anastomotic (n = 5)		Modified Z-stent (uncov.) (n = 2)				5 / 12 (42): hyperplastic tissue growth	
				Unknown (n = 1)		Song stent (cov.) (n = 11)				1 / 12 (8): migration + hyperplastic tissue growth	
Lee et al. [11]	2000	Retrospective	2	Achalasia (n = 2)	Myotomy (n = 1)	Esophacoil (uncov.) (n = 2)	100	3 → 1	Stents not removed	1 / 2 (50): ulcerative esophagitis → stent removal	0 / 2 (0) no recurrent stricture
					Pneum. dilation (n = 1)				(FU: 2 – 6 mo)	1 / 2 (50 %): migration	
Mukherjee et al. [12]	2000	Retrospective	4	Achalasia (n = 4)	Pneum. dilation (n = 2 – 6)	Wallstent (part. cov.) (n = 5)	100	Unknown	Stents not removed	1 / 4 (25): migration	2 / 4 (50) no recurrent stricture (mean FU: 14 mo)
						Gianturco-Z (cov.) (n = 3)			(FU: 2 wk – 6 mo.)	1 / 4 (25): stent occlusion by tortuous esophagus	
										1 / 4 (25): food bolus obstriction	

Author	Year	Design	Patients (n)	Stricture	Previous therapy	SEMS(n)	Technical success (%)	Dysphagia improvement	Dwell time SEMS	Complications (%)	Long-term effect (%)
										1 / 4 (25): hyperplastic tissue growth	
Fiorini et al. [13]	2000	Retrospective	10	Postradiation (n = 5)	Unknown	Esophacoil (uncov.) (n = 11)	100	3.5 → 1	Stents not removed	3 / 10 (30): migration	5 / 10 (50) no recurrent stricture (FU: 3 – 40 mo)*
				Anastomotic (n = 2)		CMD-F (uncov.) (n = 3)				1 / 10 (10): perforation due to stent breakage	
				Peptic (n = 2)						1 / 10 (10): pain	
				Achalasia (n = 1)						1 / 10 (10): recurrent stricture	
Song et al. [14]	2000	Retrospective	25	Caustic (n = 22)	Multiple dilations	Type A (custom-made):	Type A: 92	3 → 0 – 1	1 – 8 wk	5 / 25 (20): pain → stent removal	Cumulative improvement plateau at 7wk after stent removal†
				Postradiation (n = 1)		24 – 16 – 20 mm (cov.) (n = 12)			(Stents removed)	12 / 25 (48): hyperplastic tissue growth	
				Postsclerotherapy (n = 1)		Type B (custom-made):	Type A: 100			3 / 25 (12): migration	
				Peptic (n = 1)		26 – 16 – 26 mm (cov.) (n = 13)					
De Palma et al. [15]	2001	Retrospective	8	Achalasia (n = 8)	Myotomy (n = 2)	Esophacoil (uncov.) (n = 4)	100	After stent placement: grade 0	Stents not removed	Early:	Unknown
					Pneum. dilation (n = 2)	Ultraflex (cov.) (n = 4)			(FU: 35.5 mo)	3 / 8 (38): migration (in 1 pat. surgery for stent impaction)	
					Botox + dilation (n = 2)					1 / 8 (12): pain	
					Myotomy + dilation (n = 2)					1 / 8 (12): reflux	
										Late:	
										2 / 8 (25): pain	
										1 / 8 (12): migration	
										1 / 8 (12): reflux esophagitis	
Wadhwa et al. [16]	2003	Retrospective	3	Anastomotic (n = 2)	Multiple dilations	Ultraflex (cov.) (n = 1)	100	Symptom relief	Stents removed	1 / 3 (33): cervical discitis	Unknown

Author	Year	Design	Patients (n)	Stricture	Previous therapy	SEMS(n)	Technical success (%)	Dysphagia improvement	Dwell time SEMS	Complications (%)	Long-term effect (%)
				Peptic (n = 1)		Diamond (cov.) (n = 1)				1 / 3 (33): stent erosion into aorta	
						Gianturco-Z (cov.) (n = 1)				2 / 3 (66): hyperplastic tissue growth	
Cheng et al. [17]	2003	Retrospective	83	Achalasia (n = 70)	Unknown	Nitinol stent (part.-cov.) (n = 85)	100	3 → 1	3 – 7 days	37 / 83 (45): pain	Unknown
				Anastomotic (n = 5)					(Stents removed)	After stent removal: 12 (14) bleeding	
				Postradiation (n = 5)						and 13 (16) reflux	
				Caustic (n = 3)							
Conio et al. [18]	2007	Retrospective	7	Postradiation in hypopharynx (n = 7)	Multiple dilations	Custom-made Niti-S (cov.) (n = 11)	100	4 → 2	Stents not removed	4 / 7 (65): migration	Unknown
						(sizes: 12 – 10, 14 – 12 and 16 – 14 mm)			(FU: 1 – 6 mo)	1 / 7 (14): hyperplastic tissue growth	
										1 / 7 (14): migration + hyperplastic tissue growth	

Uncov., uncovered; signif., significant; mo, month(s); wk, week(s); FU, follow-up;

* Best clinical success and fewer complications in patients with postradiation strictures compared to those with peptic, anastomotic, and achalasia strictures.

† An association was found between symptom recurrence after stent removal and length of stricture but not duration of stent placement, severity of stricture, or type of stent.

In 52 / 168 patients (31 %) treated with a SEMS for a benign esophageal stricture, the stent was not removed and was left in the esophagus for periods of up to 35.5 months (**Table 1**). Apart from the type of metal used, the duration of stenting could therefore also have been a causative factor in the occurrence of hyperplastic tissue ingrowth or overgrowth in these patients.

Long-term effects of SEMS placement were reported in only 30 patients, with no clinical evidence of recurrent stricture in 14 (47 %) [7 – 9, 11 – 13] (**Fig. 2**).

Factors related to long-term success were type of stricture, with postradiation strictures being more successful than peptic, anastomotic or achalasia strictures [13], and length of stricture, with shorter strictures being at lower risk of re-stricturing [14].

Patients with refractory hypopharyngeal strictures after surgery in combination with radiation therapy are a specific group. Conio et al. [18] treated 7 of these patients with custom-made Niti-S stents. The stent body diameters were smaller than usual, i. e., 10 mm, 12 mm, and 14 mm, with flares to 12 mm, 14 mm, and 16 mm, respectively (**Fig. 3**).

When these stents were placed, both the use of enteral nutrition and the need for periodic dilation were no longer indicated in these patients.

SEPS for refractory benign esophageal strictures

Because SEMS are associated with a high incidence of hyperplastic tissue growth when used in refractory benign esophageal strictures, SEPS were introduced. The Polyflex stent, which is currently the only SEPS commercially available, is a silicone device with an encapsulated monofilament braid made of polyester. The material of this SEPS has been proposed to reduce hyperplastic tissue ingrowth and overgrowth [20].

In total, 9 studies have reported on 162 patients who underwent Polyflex stent placement for benign esophageal strictures (**Table 2**) (**Fig. 4**) [21 – 28].

Indications for stent placement were anastomotic strictures (n = 50), peptic strictures (n = 27), caustic strictures (n = 26), postradiation strictures (n = 23) (**Fig. 3**), and other causes (n = 36).

As expected, hyperplastic tissue overgrowth was rare after Polyflex stent placement; it was not reported in any of the 129 patients in 8 series including our own [20 – 26, 28]. It was, however, seen after 15/83 procedures (18 %) in one series [27] (**Table 2**). This suggests that Polyflex stents are indeed able to reduce the hyperplastic tissue reaction of the esophagus. This is likely due to the material used and/or to Polyflex stents having a different expansion force to that of SEMS (**Table 2**).

On the other hand, migration rates were high after Polyflex stent placement, occurring in 60/129 patients (47 %) [20 – 26, 28], and after 53/83 procedures (64 %) in another series [27] (**Table 2**). This may at least partly explain why only 50/129 patients (39 %) experienced long-term improvement of dysphagia after Polyflex stent removal [20 – 26, 28], while in one series this proportion was even lower with only 5/83 interventions (6 %) resulting in long-term success [27]. Risk factors for migration included location (migration occurred more often in distal and proximal esophageal strictures than in mid-esophageal strictures) [23, 27] and indication (more often in peptic strictures, followed in order by anastomotic strictures, fistulas/leaks, and postradiation strictures) [27].

Overall, 10 major complications were seen (6 %): 2 perforations, 2 fistulas, 3 bleedings, and 3 patients with severe pain who required stent removal. This is a relatively high rate and is probably explained by the fact that the Polyflex stent applicator is large and stiff compared to metal stent applicators.

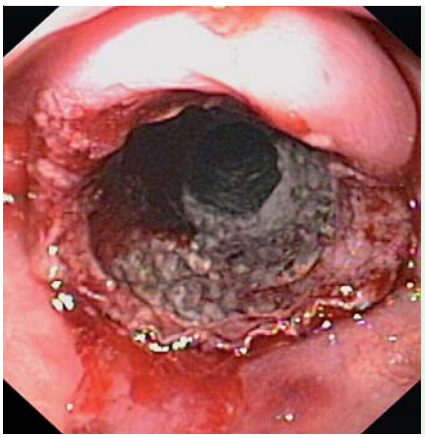

Fig. 3 Niti-S stent with a 10-mm body and a 12-mm flare placed for a refractory hypopharyngeal stricture after radiation therapy for head and neck cancer.

Why are results of stent placement for refractory benign strictures disappointing?

As the long-term clinical success rate of both SEMS and SEPS in refractory benign strictures was well below 50 %, it is important to analyze what factors could have played a part in these disappointing results.

First, the type of insult to the esophagus may be important in determining the success rate of stent placement. In general, patients with nonmalignant perforations or leaks have better results after stent placement than those with benign esophageal strictures. This is probably explained by the fact that, if the stent is completely sealing a perforation or leak and the mediastinal or pleural cavity is adequately drained, the inflammatory reaction usually quickly resolves, with closure of the perforation or leak within 2 – 4 weeks.

The pathologic processes in refractory benign esophageal strictures are more diverse. An inflammatory component can often be found in all benign strictures, but not to the same degree or for the same period of time. For example, the initial inflammatory reaction in peptic and caustic strictures can be severe, but this will ultimately resolve with a satisfactory outcome for the stricture as well. On the other hand, transmural (ischemic) insults to the esophagus, such as are seen in postoperative anastomotic and postradiation strictures, may be more difficult and need more time to resolve and sometimes need prolonged dilation and/or stenting. An esophageal stent in these situations is a temporizing maneuver, allowing the inflammatory reaction to resolve over time.

The differences in clinical success rates of stent placement for benign esophageal strictures in various series may therefore be at least partly explained by the different types of strictures included in each series and the duration between the insult to the esophagus and placement of the stent. Other factors affecting clinical success include the type and duration of treatment prior to stent placement, and the unknown optimal duration for which the stent should remain in situ for various types of benign strictures.

A second issue involved in the disappointing results of stent placement in refractory benign esophageal strictures is the type of stent used for this indication. As was shown, the currently used nitinol SEMS are associated with a hyperplastic tissue reaction of

Table 2 Published results of placement of self-expanding plastic stents for treatment of benign esophageal strictures.

Author	Year	Design	Patients (n)	Stricture	Previous therapy	SEPS (n)	Technical success (%)	Dysphagia improvement	Dwell time SEPS	Complications (%)	Long-term effect after stent removal (%)
Broto et al. [20]	2003	Retrospective	10	Caustic (n = 9)	Caustic: 9 dilations	Unknown	100	Unknown	Success (n = 5): 20 days – 4 mo	3 / 10 (30): migration	5 / 10 (50) no dysphagia
				Atresia (n = 1)	Atresia: 1 dilation				Restricture (n = 5): 20 – 133 days	4 / 10 (40): esophagitis	
									(stents removed)		
Repici et al. [21]	2004	Retrospective	15	Caustic (n = 5)	9.5 (mean) dilations	15	100	3 → 1	6 wk	1 / 15 (7): migration	12 / 15 (80) no dysphagia (mean FU: 22.7 mo)
				Anastomotic (n = 4)					(stents removed)		
				Postradiation (n = 4)							
				Peptic (n = 2)							
Evrard et al. [22]	2004	Retrospective	21	Hyperplastic after previous SEMS (n = 5)	6 (med.)/year dilations	26	100	2 → ?	2 wk – 18 mo	12 / 21 (57): migration	16 / 21 (76) no dysphagia (median FU: 21 mo)
				Anastomotic (n = 4)					(stents removed)		
				Fistula/leak (n = 4)							
				Postradiation (n = 3)							
				Caustic (n = 3)							
				Peptic (n = 2)							
Karbowski et al. [23]	2008	Retrospective	14	Anastomotic (n = 5)	Unknown	19	100	Unknown	52 (14 – 256) days	7 / 14 (50): migration*	0 / 14 (0) no dysphagia
				Peptic (n = 4)					(stents removed)	1 / 14 (7): severe pain → stent removal	
				Postradiation (n = 2)						1 / 14 (7): fistula	
				Caustic (n = 1)							
				Autoimmune (n = 1)							
				post-Nissen (n = 1)							
Garcia-Cano [24]	2008	Retrospective	4	Peptic (n = 3)	Unknown	11	100	Unknown	4 mo-2 y	4 / 4 (100): migration	2 / 4 (50) no dysphagia
				Anastomotic (n = 1)					(stents removed)		
Barthel et al. [25]	2008	Retrospective	8	Anastomotic (n = 8)	≥ 3 dilations	13	100	3 → 1	83 (14 – 295) days	11 / 13 (85): migration	1 / 8 (12) no dysphagia

Author	Year	Design	Patients (n)	Stricture	Previous therapy	SEPS (n)	Technical success (%)	Dysphagia improvement	Dwell time SEPS	Complications (%)	Long-term effect after stent removal (%)
									(stents removed)	1 / 13 (8): nausea/ vomiting → stent removal	
Pennathur et al. [26]	2008	Retrospective	17	Esophageal:	Unknown	Unknown	100	Unknown	Unknown	14 / 17 (82): migration	Esophageal: 2 / 9 (22) no dysphagia
				Postradiation (n = 2)					(stents removed)	1 / 17 (6): severe pain → stent removal	Anastomotic: 0 / 5 (0) no dysphagia
				Peptic (n = 6)							
				Other (n = 1)							
				Gastric conduit (n = 3)							
				Anastomotic (n = 5)							
Holm et al. [27]	2008	Retrospective	33	Benign esophageal (n = 8)	Unknown	Benign esophageal: 22	99	Unknown	53 (1 – 131) days	53 / 83 (64) proc.: migration†	5 / 83 (6) proc.: no dysphagia
				Anastomotic (n = 11)		Anastomotic: 25			(stents removed)	23 (28) proc.: chest pain, dysphagia, etc.	
				Fistula/leak (n = 9)		Fistula/ leak: 22				8 (10) proc.: nausea/ vomiting	
				Postradiation (n = 5)		Postradiation: 15				8 (10) proc.: other	
										15 proc. (18): hyperplastic tissue overgrowth	
Dua et al. [28]	2008	Prospective	40	Anastomotic (n = 12) (+ 4 fistula)	12 (mean) dilations	38	95	3 → 0.6	4wk	8 / 38 (22): migration	12 / 38 (32) no dysphagia
				Caustic (n = 8)						4 / 36 (11): severe chest pain	
				Postradiation (n = 7)						3 / 36 (8): bleeding	
				Pill-induced (n = 4)						2 / 36 (6): perforation	
				Post-trauma (n = 3) (+ 3 fistula)						2 / 36 (6): reflux	
				Peptic (n = 2)						2 / 36 (6): inability to remove the stent	
				Others (n = 4) (+ 1 fistula)						1 / 36 (3): fistula	

* Migration was affected by location [gastroesophageal junction + distal (68 %) > proximal 25 % > mid (11 %)].
† Migration was affected by location [distal (70 %) > proximal (68 %) > mid (30 %)], indication [benign (82 %) > anastomotic (72 %) > fistula/leak (59 %) > postradiation (29 %)], but not by stent size or prestent dilation.

Table 3 Management of benign esophageal strictures.

Step 1: Patient selection
Define the stricture as refractory [long (> 2 cm), tortuous, narrow diameter, etc).
Perform at least three dilations before using an alternative treatment modality, such as (temporary) stent placement.
Combine dilation with four-quadrant injections with 0.5 mL triamcinolone (40 mg/mL) in refractory peptic strictures.
Use first incisional therapy in refractory anastomotic esophageal strictures before stent placement is considered.
Step 2: Stent placement
Longer strictures in the mid-esophagus (caustic injuries or radiation therapy) → Polyflex stent.
Anastomotic strictures in the proximal esophagus and strictures in the distal esophagus (refractory peptic strictures) → Ultraflex stent
Complex hypopharyngeal strictures → Modified Niti-S stent (10 or12 mm)
Step 3: Follow-up after stent placement
Polyflex stent:
4 – 16 weeks, depending on the stricture (type and characteristics). Upper endoscopy only if recurrent symptoms.
Ultraflex stent:
4 – 16 weeks, depending on the stricture (type and characteristics). Upper endoscopy at 4-week intervals to see whether embedding of the uncovered part of the stent in the esophageal wall has occurred. If indicated, stent removal and placement of a second stent.
Modified Niti-S stent:
6 – 12 months. If hyperplastic tissue overgrowth or ingrowth or if stent migration occurs, a new stent is placed, if possible with a larger diameter.

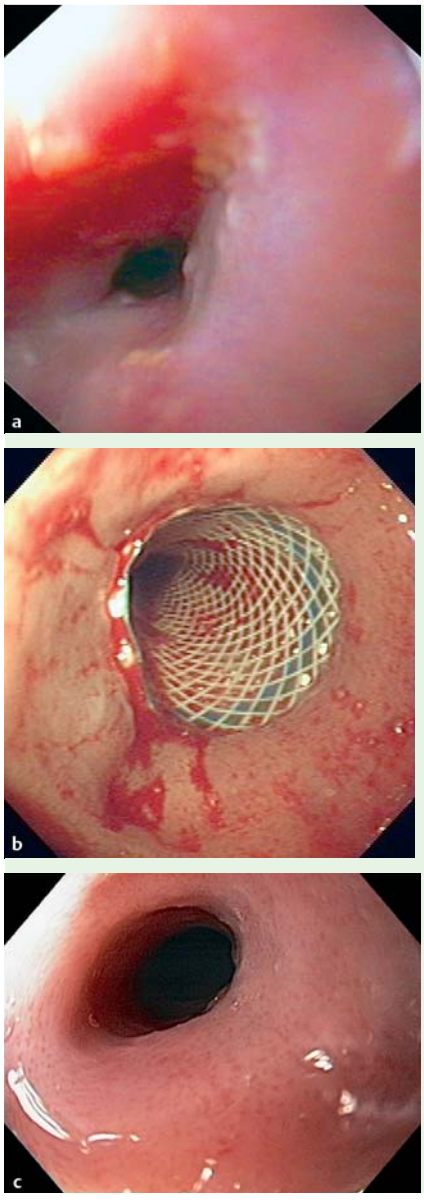

Fig. 4 Refractory post-radiation stricture (**a**), treated with a Polyflex stent (**b**). After stent removal, the stricture was less stenotic (**c**).

the esophagus, particularly if the stent remains in the esophagus for a prolonged period. The problem of hyperplastic tissue growth can be overcome with stents that are not made of nitinol, such as the Polyflex stent. A disadvantage of Polyflex stents is, however, their high rate of migration. In the design of the next generation of SEPS for benign strictures, therefore, a major focus should be on preventing stent migration. An interesting option in this regard could be the use of biodegradable stent designs.

Biodegradable stents

The search for an ideal biodegradable material with adequate mechanical properties has resulted in the testing of various materials. Natural materials, such as catgut collagen and fibrin, were shown to be of limited use because of their low mechanical strength and the difficulty of converting them to fiber form [29]. Synthetic biodegradable materials, such as polylactide and polyglycolide, which can provide good mechanical strength, may be more useful for making biodegradable stents [29]. Due to polylactide's slower degradation rate, this is currently the most frequently investigated material for biodegradable stents.

Goldin et al. [30] used a polylactide-made biodegradable stent (InStent, Eden Prairie, Minnesota, USA) in five patients with benign esophageal strictures. In the first three patients the stent collapsed within 3 weeks, causing recurrence of symptoms. For placement in the next two patients, the stent design was improved by using thicker wires, and this improved stent patency.

Fry et al. [31] report the use of a coil spring made of polylactide (AB Esophacoil; InStent). The projected biologic life of this stent was 3 – 6 months, with an expected time to loss of mechanical strength of 4 – 8 weeks. The stent was placed in a patient with a stricture after radiation therapy for esophageal cancer. This patient developed recurrent dysphagia after 6 weeks due to fracturing of the stent. At that time the esophagus had not yet remodeled.

The same biodegradable material was used by Saito et al. [32], but with a design that resembled an Ultraflex stent (Tanaka-Marui stent, Marui Textile Machinery, Osaka, Japan). These authors treated 13 patients: 2 with caustic strictures, 4 with anastomotic strictures, and 7 for prevention of stricture after endoscopic submucosal dissection. The stent was deployed by fitting it over an endoscope and releasing it once the tip of the endoscope had reached 20 mm beyond the distal end of the stricture. This necessitated dilation of the stricture before stent placement. The measured radial force of this stent was higher than that of commercially available SEMS. The stent migrated in 10/13 patients between 10 and 21 days after placement; in 3 patients it remained in its position up until 21 days. None of the patients complained of dysphagia after a follow-up of 7 – 24 months.

Although these results are promising, further developments are obviously needed. More information is needed on the safety of the material used. Moreover, it would be of great clinical value

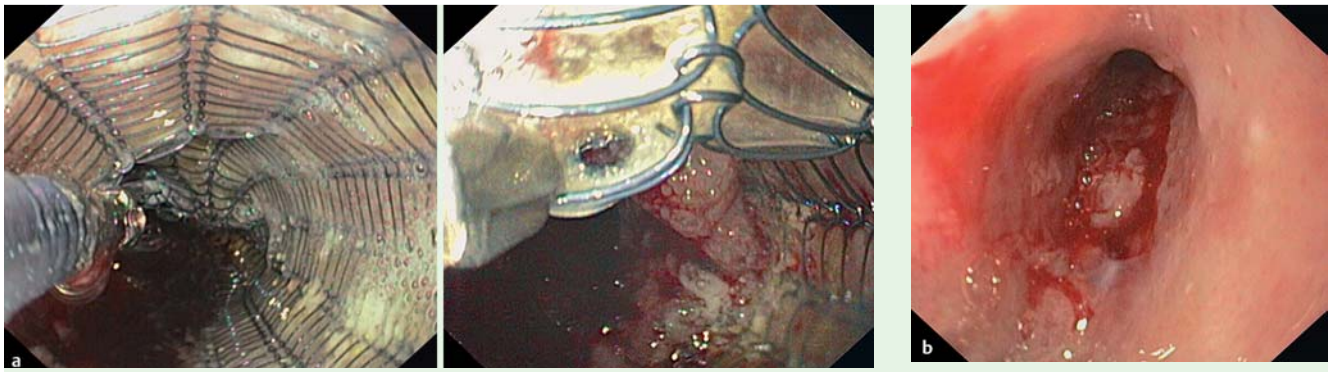

Fig. 5 Removal of a partially covered Ultraflex stent by grasping the distal end of the stent with a forceps (**a**), resulting in invagination of the stent into itself (**b**). After removal of the stent, some mucosal but clinically insignificant bleeding was noted at the level where the uncovered part of the stent had been (**c**).

to have a selection of biodegradable stents with variable durations of mechanical expansion force depending on the stricture that is being treated. Finally, long-term clinical results of biodegradable stents in patients with refractory benign esophageal strictures are needed.

Management of refractory benign esophageal strictures (Table 3)

The first step in the management of refractory benign esophageal strictures is to define the stricture as refractory. Is it long (> 2 cm), tortuous, or does it have a narrow diameter, as is seen with caustic, postradiation, and anastomotic strictures? We always perform at least three balloon or Savary-Gilliard dilations in these patients before the decision is taken to use an alternative treatment modality, such as (temporary) stent placement.

In patients with refractory peptic strictures, we often combine dilation with four-quadrant injections of 0.5 mL triamcinolone (40 mg/mL). This is the only indication for which a benefit of steroid injections has been demonstrated [33]. In the case of refractory anastomotic strictures after esophageal resection with gastric tube interposition, we prefer incisional therapy using electrocautery when dilation is not successful and before stent placement is considered [34].

Only if the stricture cannot be dilated to an adequate diameter, recurs within a short time interval, requires ongoing dilation, and other therapies have failed, do we consider placement of a stent. We prefer Polyflex stents in patients with longer strictures in the mid-esophagus, such as after caustic injuries or radiation therapy. In patients with anastomotic strictures in the proximal esophagus and with strictures in the distal esophagus – for example, peptic strictures following grade D reflux esophagitis according to the Los Angeles classification – we prefer the more flexible, partially-covered Ultraflex stents, particularly as in our experience the risk of migration is lower with this stent (unpublished results).

For proximal strictures, we prefer to place the stent under fluoroscopic guidance. In more distally located strictures, we use either endoscopy or fluoroscopy for stent placement. When a stent is placed under fluoroscopic guidance, we mark the stenosis with lipiodol; however, in the proximal esophagus placement of an external marker in the neck is easy and is helpful for accurate placement of a stent. When a Polyflex stent is placed, it is important to remember that this type of stent tends to jump from the release catheter, and as a result is positioned more distally than expected. It is therefore advisable to place the upper end of a Polyflex stent 1 – 2 cm higher than needed to correct for this.

The length of time for which a stent remains in place varies between 4 and 16 weeks depending on the type and characteristics of the stricture. In the case of Ultraflex stents, we always perform upper endoscopy at 4-week intervals to visualize whether embedding of the uncovered stent part in the esophageal wall has occurred. If it has, we remove the stent and place another Ultraflex stent.

In patients with complex hypopharyngeal strictures, modified Niti-S stents are preferred. In our experience, the best results can be obtained with 10- or 12-mm stent types that are flared and fully covered. In these patients, the duration of stent placement is longer, usually 6 – 12 months. We perform follow-up endoscopy at 3- to 4-month intervals. If hyperplastic tissue overgrowth or migration is seen, the stent is endoscopically removed (see below) and a new stent is placed, if possible with a larger diameter.

A recommended technique for stent removal is to grasp the nylon loop that is attached to the proximal end of most stents. It is our experience that these loops quite often break during stent removal. We therefore prefer to grasp the proximal end of the stent with a polyp snare or a rat-toothed forceps if a fully covered type of stent, such as the Polyflex stent, is used. When a stent is firmly embedded in the esophageal wall, we use a double-channel endoscope and grasp the two opposite sides of the stent. Partially covered stents, such as the Ultraflex stent, can better be removed by grasping the distal end of the stent with a forceps, which will result in invagination of the stent into itself (Fig. 5).

We prefer to remove stents that have migrated into the stomach, as some patients become symptomatic. In addition, there is a small but definite risk that the stents may migrate into the small bowel and cause an obstruction, particularly at the level of the cecal valve. We usually remove migrated stents by grasping them close to one end with a snare. As an endoscope of sufficient size is needed for this, dilation of the stricture prior to stent removal is sometimes indicated. Only when the stent cannot be removed in this way – for example, when the snare is not positioned at the end of the stent but more in the middle, or when removal is only possible with a grasping forceps – do we use an overtube to remove the stent.

Competing interests: None

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