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Woven polydioxanone biodegradable stents: a new treatment option for benign and malignant oesophageal strictures

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Abstract *Background:* We present our initial experience with a new biodegradable (BD) esophageal stent in two patients, one for a therapy-resistant benign esophageal stricture, and the other as a temporary measure during curative radiotherapy for oesophageal carcinoma. *Methods:* The BD stents need to be loaded into a conventional pull-back delivery system but are then placed in a standard fashion.

Pre-dilatation should be avoided to reduce the risk of migration, however if migration occurs the stents can be left to dissolve in the stomach. The stents are radiolucent but easily identified on CT with minimal artefact and thus might even aid with radiotherapy planning. *Results:* BD stents offer an exciting new strategy for therapy-resistant benign strictures as well as a supportive measure for oesophageal cancer undergoing non-surgical treatment.

Keywords Dilatation · Endoscopy · Oesophageal stenosis · Oesophageal neoplasms · Stents · Biodegradable

Introduction

Permanent self-expanding stents (SES) are an established means of palliating malignant dysphagia, but have shown poor long-term results in benign strictures due to complications [1, 2]. Temporary stenting of benign disease has shown variable results [3–5] and is still only regarded as an option when all other treatment has failed.

First cases using stents made from biodegradable materials were reported from 1997 [6, 7]. In 2008 a new biodegradable stent (BDS) became available (SX Ella-BD stent, Ella-CS, Hradec Kralove, Czech Republic), which is woven in a standard construction from a monofilament of polydioxanone, a surgical suture material. It is similar in construction to an uncovered enteral stent and is deployed from an existing delivery system used for metal stents. The stents are manufactured from woven polydioxanone (PDS) monofilament, which was first developed for wound closure sutures. They have a trunk diameter of 25 mm with both ends flaring to 31 mm and are available in

different lengths from 60 to 135 mm. PDS has shape memory and it is degraded by hydrolysis, which is accelerated by a low ambient pH. In the oesophagus, half the mechanical strength is lost after approximately 3 weeks [8] and the stent structure begins to disintegrate within 2 months (Fig. 1). A feasibility study was performed by the manufacturer in 11 patients. This demonstrated 100% technical success, three cases of stent migration, endoscopic evidence of stent degradation in all cases within 12 weeks and variable relief of symptoms. The best results were seen in three subjects with achalasia.

The BD stents are designed to offer longer-term relief of symptoms than balloon dilatation in benign strictures. This may extend beyond the lifetime of the stent if the stricture remodels while being splinted by the stent. The major advantage of BD stents over metal or plastic stents is that they do not require removal, even when migrated, thus avoiding further procedures and potential morbidity.

Biodegradable stents may also have applications in malignant disease, notably in patients with high-grade

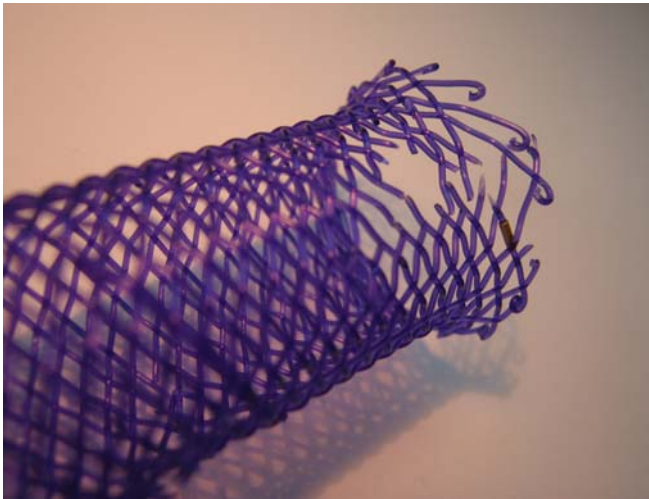


Fig. 1 Demo model of a 25-mm-diameter SX Ella-BD showing signs of degradation after 18 months of exposure to room air

dysphagia undergoing radical radiotherapy. This might allow continued oral nutrition and avoid the need for gastrostomy. However, at present the stents are only licenced for use in benign strictures.

Except for their metal markers the stents are radiolucent but can be indirectly visualised on contrast swallow and are easily seen on endoscopy and CT.

Materials and methods

The stents used in our two patients were 6-cm-long biodegradable SX Ella-BD Stents (Ella-CS, Hradec Kralove, Czech Republic). Insertion was performed by an interventional radiologist with 9 years of experience of endoscopic and radiologic procedures.

Patients received topical pharyngeal anaesthesia and conscious sedation with midazolam and fentanyl under EEG guidance according to a protocol published previously [9]. Stents were deployed in a standard fashion over an 0.035"/185 cm ultra-stiff Meier backup guidewire (Boston Scientific, St. Albans, UK). The stents were loaded manually into the delivery systems, and these were positioned on the basis of the metal stent markers at both ends, as the PDS stent itself is radiolucent.

Deployment was performed by withdrawal of the constraining outer sheath after pre-dilatation according to the instructions for use.

Follow-up was performed by the interventional fellow and the nutrition nurse. Both patients were entered into the national Registry of Oesophageal Stenting (ROST; <http://rost.e-dendrite.com>). A check swallow is not routinely performed in our department but was performed using water-soluble contrast in both patients for clarification of ongoing symptoms.

Approval of the institutional review board was granted for use of the stents in malignant disease.

Case report 1—benign stricture

A 65-year-old male patient with a peptic stricture in the distal oesophagus was suffering from recurrent grade 2 dysphagia. He had previously had two radiological balloon dilatations, which only gave short-term relief, with recurrence of symptoms within 1 month.

Fluoroscopy demonstrated a 1-cm tight peptic stricture above a small sliding hiatus hernia (Fig. 2a). A therapeutic dilatation to 18 mm was performed using a high-pressure ‘Atlas’ angioplasty balloon (Bard, Crawley, UK). Following this a 6-cm SX Ella-BD stent was inserted (Fig. 2b) and expansion confirmed by injection of contrast through the catheter (Fig. 2c). Six hours after stent placement the patient described an episode of lower central chest pain. Unfortunately a water-soluble contrast swallow the following day demonstrated stent migration into the stomach, but the peptic stricture appeared well dilated. The patient had relief of symptoms that lasted 4 months; the stent was left in-situ. Over the next 4 weeks the patient experienced intermittent symptoms of nausea, but no evidence of gastric or intestinal obstruction as the stent dissolved.

Case 2—malignant stricture

An 80-year-old male patient presented with a 3-month history of dysphagia to solids from a T3 N0 M0 carcinoma at the gastro-oesophageal junction (GOJ). Due to cardiovascular co-morbidities radical radiotherapy was offered rather than surgery.

At the beginning of treatment the patient started to struggle with semi-solids but refused tube feeding. After discussion with relatives, it was decided to place a biodegradable stent instead of undertaking a gastrostomy. Written informed consent for “off-label” use was given.

The stricture was pre-dilated to 12 mm. A 6-cm Ella-BD stent unfortunately did not sufficiently cover the proximal end of the stricture, and a second stent was placed more proximally with 50% overlap and an excellent technical result.

Initial problems with gastro-oesophageal reflux and delayed gastric emptying were overcome through the use of proton pump inhibitors and metoclopramide. The patient gained 2 kg in the first 4 weeks but developed severe radiation oesophagitis and anorexia. He subsequently continued to lose weight and was later admitted for nasogastric feeding. The stents were shown repeatedly to be widely patent in follow-up examinations (Fig. 3), but the patient died 3 months following stent placement.

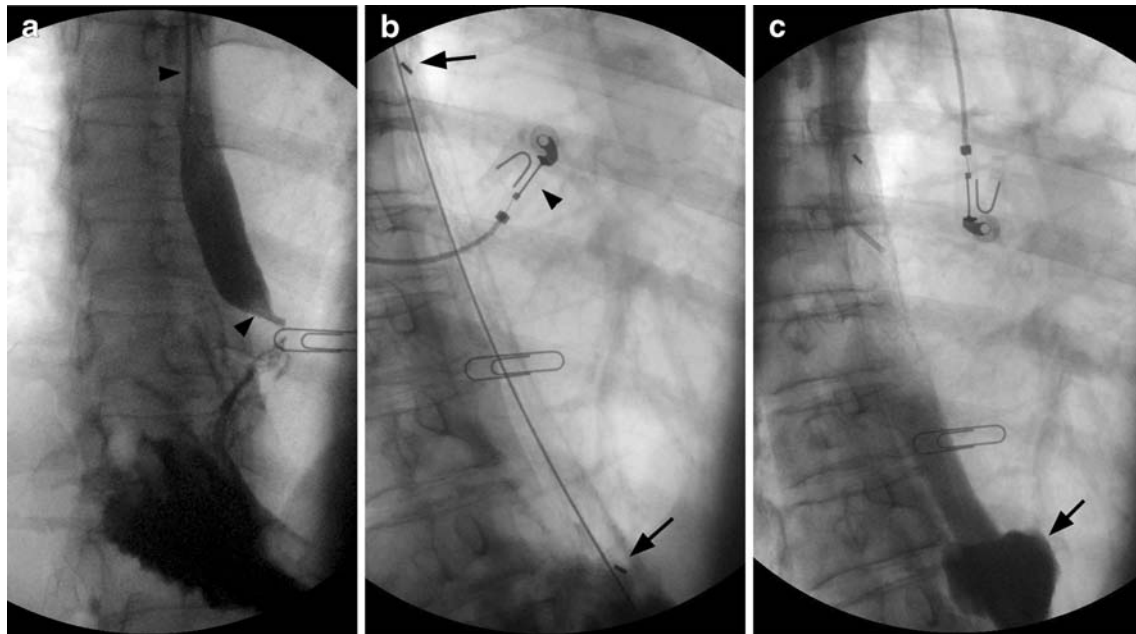


Fig. 2 **a** Injection of contrast through a Headhunter catheter (*arrowheads*) shows a tight 1-cm peptic stricture above a hiatus hernia, indicated by a paperclip on the patient's skin (patient 1). **b** Positioning of the stent delivery system after therapeutic dilatation.

Arrows Gold stent markers, *arrowhead* External ECG lead. **c** Stent deployed with the lower end in the hiatus hernia (*arrow*). Patency confirmed by injection of contrast

Discussion

Biodegradable stents have one major advantage over removable metal or plastic stents for temporary stenting: they do not need to be removed, either from their original position or if they have migrated, avoiding the cost of a second procedure and the potential trauma to the oesophagus.

In benign strictures, stents should allow a near-normal diet while the stent is in place and potentially offer maintained relief beyond the lifetime of the stent. What the recurrence rate of benign strictures is remains to be seen, but patients are likely to prefer two to three BD stent insertions per year over monthly dilatation.

Stent migration in malignancy occurs in up to 20% with conventional covered stents, depending on the site of the stricture and the stent used [10], but can be much higher in benign strictures [11]. It is possible that the smoother mucosa in a benign stricture is less able to fix the stent in position than tumour tissue.

The risk of intestinal obstruction and perforation from migrated metal stents is low, but wherever possible a migrated stent should be retrieved. In contrast a migrated BDS can be left as it will dissolve within the gastric acid, which accelerates hydrolysis. This was seen in our first patient where the only symptoms were transient nausea.

The manufacturer's instructions recommend pre-dilatation of the stricture as the radial force of the BD stent is lower than that of nitinol stents. However in our experience the expansion force is certainly adequate for malignant strictures, and obliterating the stricture prior to stent placement

increases the risk of displacement. We suggest that—in keeping with standard stents—pre-dilatation should be avoided and only performed if the delivery system cannot be passed. The gentle dilatation by the gradual expansion of the stent must cause less trauma to the stricture than forced mechanical dilatation and probably reduces the risk of re-stenosis in benign disease. Post-dilatation can always be performed if the patient does not have a satisfactory clinical result after several days.

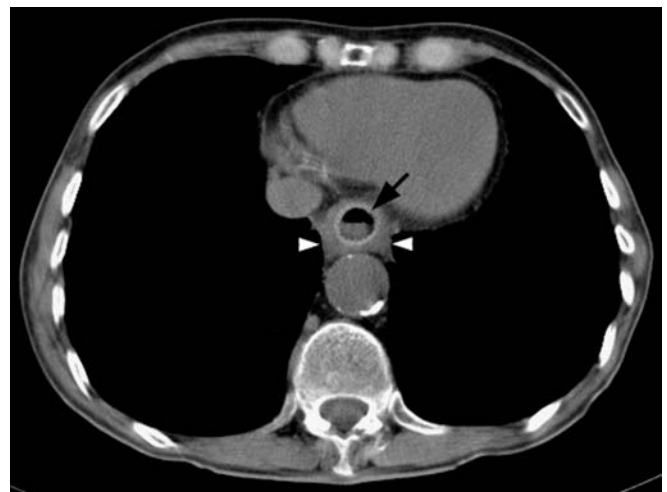


Fig. 3 CT scan on day +5 (patient 2). The stent has fully expanded and its faint outline is clearly seen (*arrow*) as it maintains the oesophageal lumen through the tumour (*arrowheads*)

If deployed across the gastro-oesophageal junction, an unvalved stent predisposes the patient to regurgitation of gastric content. In case of a peptic stricture this may increase the risk of recurrence and it will certainly increase the rate of degradation due to exposure of the stent to gastric acid.

Routine addition of proton pump inhibitors is important, and valved stents may become available in the future.

The role of BD stents in the treatment of oesophageal cancer needs to be explored in more detail. Improved outcome from a combination of radiotherapy and stenting has been demonstrated, if stents are removed within 4 weeks [12, 13]. In contrast stenting *following* chemoradiotherapy has been found to have a higher risk of complications [14, 15].

Courses of radiotherapy coincide with the reported stent integrity of 6–8 weeks. There are several reservations from radiation oncologists about stenting during curative radiotherapy. Stents change the tumour anatomy and expand the tumour volume, there may be altered interaction of radiotherapy with the additional air/soft tissue interface

within the stent lumen and there is an increased theoretical risk of perforation.

The benefits are that the patient may continue to eat, thus avoiding social exclusion, the cost of enteral feeding and the potential complications from gastrostomy including stoma metastases [16, 17]. Our second patient, however, illustrated the fact that a patent stent does not guarantee adequate nutrition.

Biodegradable stents may also aid radiotherapy planning in difficult cases. Small tumours can be hard to identify on radiotherapy planning CT, and in these cases the stent could act as a target map.

In summary we suggest that patients with benign strictures should be considered for BD stent insertion if conventional dilatation has had no significant improvement or the result was short-lived.

Patients with dysphagia from curable oesophageal cancer may have BD stent insertion as an alternative to gastrostomy during neo-adjuvant or radical chemo/radiotherapy, but a number of questions need to be answered before this can translate into routine practice.

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