

Fluoroscopic removal of retrievable self-expandable metal stents in patients with malignant oesophageal strictures: Experience with a non-endoscopic removal system

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Abstract

Objectives To evaluate clinical outcomes of fluoroscopic removal of retrievable self-expandable metal stents (SEMSs) for malignant oesophageal strictures, to compare clinical outcomes of three different removal techniques, and to identify predictive factors of successful removal by the standard technique (primary technical success).

Methods A total of 137 stents were removed from 128 patients with malignant oesophageal strictures. Primary overall technical success and removal-related complications were evaluated. Logistic regression models were constructed to identify predictive factors of primary technical success.

Results Primary technical success rate was 78.8 % (108/137). Complications occurred in six (4.4 %) cases. Stent location in the upper oesophagus ($P=0.004$), stricture length over 8 cm

($P=0.030$), and proximal granulation tissue ($P<0.001$) were negative predictive factors of primary technical success. If granulation tissue was present at the proximal end, eversion technique was more frequently required ($P=0.002$).

Conclusions Fluoroscopic removal of retrievable SEMSs for malignant oesophageal strictures using three different removal techniques appeared to be safe and easy. The standard technique is safe and effective in the majority of patients. The presence of proximal granulation tissue, stent location in the upper oesophagus, and stricture length over 8 cm were negative predictive factors for primary technical success by standard extraction and may require a modified removal technique.

Key Points

- Fluoroscopic retrievable SEMS removal is safe and effective.
- Standard removal technique by traction is effective in the majority of patients.
- Three negative predictive factors of primary technical success were identified.
- Caution should be exercised during the removal in those situations.
- Eversion technique is effective in cases of proximal granulation tissue.

Keywords Oesophageal neoplasms · Stents · Self-expandable metallic stents · Fluoroscopy · Device removal

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Abbreviations

SEMS	self-expandable metal stent
CCRT	concurrent chemo-radiation therapy
SIR	Society of Interventional Radiology
CI	confidence interval

Introduction

Placement of self-expandable metal stents (SEMSs) is safe, easy, and effective for the palliative treatment of dysphagia induced by malignant oesophageal strictures [1–7]. However, a number of complications can occur with the placement of SEMSs including migration, severe pain, tumour overgrowth, food impaction, oesophagorespiratory fistula, and bleeding [3–6, 8]. Overall complication rates of 24–40 % have been reported in studies including 119–645 patients [4, 6, 8]. If stent-induced complications occur, stent removal should be considered. However, nonsurgical removal is difficult, and sometimes impossible with traditional SEMSs. To overcome this problem, Song et al developed a retrievable SEMS in 1997 [2]. Most of the stent-induced complications of a retrievable SEMS can be managed without difficulty, with a reported success rate of 97.1 % [6].

A retrievable SEMS can also be temporarily placed to relieve dysphagia when palliative radiation or concurrent chemo-radiation therapy (CCRT) is planned for unresectable oesophageal cancer. Elective removal following stent placement has some advantages. Firstly, stent placement can provide immediate relief of dysphagia. Although CCRT is highly effective in palliating dysphagia, symptomatic improvement usually takes 4–6 weeks [9]. During this period, stents can be an effective palliative tool. Secondly, stent removal after that period avoids numerous delayed complications and increases overall survival rates [5, 10].

Since the situations in which stents should be removed are common, retrievable SEMSs have been widely used recently. However, to our knowledge, all reports of oesophageal stent removal have investigated a small number of patients with limited clinical outcomes, and almost exclusively by an endoscopic approach. Non-endoscopic removal with a dedicated retrieval hook, which allows capture of the stent at three different points (purse string extraction, engagement of proximal stent mesh, and stent eversion) has not been described in detail. Stent removal by purse string extraction is referred to as the standard technique, as this removal system is primarily aimed at extraction from a proximal purse string. The remaining two methods are considered to be modified techniques since these are attempted if the standard technique fails. Since the outcomes of non-endoscopic removal using those techniques have been reported in only few case series [3, 11], further studies on a large scale are required to evaluate the comprehensive outcomes.

Therefore, the purpose of the present study was to (a) evaluate the safety and efficacy of fluoroscopic removal of retrievable SEMS using three different removal techniques (standard, proximal mesh, and eversion technique) in patients with malignant oesophageal strictures, (b) compare clinical outcomes of those removal techniques, and (c) identify predictive factors of the technical success of the standard technique.

Materials and methods

Patients

Informed consent for stent placement and removal was obtained from each patient. This retrospective study was approved by our Institutional Review Board.

Between January 2001 and April 2014, 155 retrievable SEMSs were removed under fluoroscopic guidance from 145 patients with malignant oesophageal strictures. Inclusion criteria for the study were as follows: (a) documented malignancy causing symptomatic obstruction of the oesophagus and anastomotic sites, (b) placement of a retrievable SEMS due to a malignancy, and (c) fluoroscopic removal of a retrievable SEMS. The exclusion criterion was complete migration of the stent to the stomach or intestine.

Protocols for stent placement and removal

Stent placement was indicated if the patient had severe dysphagia to liquid or a soft diet caused by neoplasms involving the oesophagus. Contraindications of stent placement were as follows: (a) patients with a presumed life expectancy of less than a month, (b) evidence of multiple small bowel obstructions, and (c) patients with severe vocal cord palsy. Elective removal was considered in all patients undergoing palliative CCRT. A study to estimate the effectiveness of elective removal after CCRT was conducted in 2005 [5]. Compared to permanent stent placement, temporary stent placement (4 weeks) exhibited a significantly reduced complication rate (33.3 % vs. 65.2 %, $P=0.042$), longer dysphagia progression free survival (median, 11 vs. 10 weeks, $P=0.005$) and overall survival rates (median, 31 vs. 14 weeks, $P=0.001$). Stents were electively removed 4–6 weeks after starting radiation therapy, consistent with the protocol outlined by Park et al [10]. In that study, compared to removal within 4–6 weeks, early removal (<4 weeks) exhibited higher recurrent obstruction rate, and delayed removal (>6 weeks) was associated with a higher incidence of esophagorespiratory fistulae.

Stents were non-electively removed if the patient could not tolerate stent-induced complications. Reasons for non-elective removal were as follows: stent migration ($n=22$), severe pain ($n=10$), recurrent aspiration ($n=6$), formation of a new stricture ($n=4$), or incomplete expansion of the stent ($n=2$). Of six stents removed due to recurrent aspiration, two stents were placed across the esophagogastric junction (Table 1).

Concurrent chemoradiation therapy

Treatment protocol and regimen for CCRT were described in a previous study [10]. Cisplatin/5-fluorouracil, cisplatin/capecitabine, or oxaliplatin/fluoropyrimidine regimen was used for chemotherapy. Induction chemotherapy (cisplatin/

Table 1 Basic characteristics of the study population

Characteristics	Number (%)
Total number of patients	128
Total number of procedures	137
Sex	
Male	114 (89.1)
Female	14 (10.9)
Mean age (years)	61.8 ± 9.9
Site of obstruction (number of patients)	
Upper oesophagus	26 (20.3)
Middle oesophagus	57 (44.5)
Lower oesophagus	39 (30.5)
Oesophagogastric junction	5 (3.9)
Anastomotic site	1 (0.8)
Aetiology (number of patients)	
Oesophageal cancer	112 (87.5)
Gastric cancer	7 (5.5)
Lung cancer	7 (5.5)
Hypopharyngeal cancer	1 (0.8)
LAP due to cervical cancer	1 (0.8)
Indications for the removal (number of procedures)	
Elective removal	93 (67.9)
Non-elective removal	44 (32.1)
Stent migration	22 (50.0)
Severe pain	10 (22.7)
Recurrent aspiration	6 (13.6)
New stricture	4 (9.1)
Incomplete expansion	2 (4.5)

LAP, lymphadenopathy

capecitabine or oxaliplatin/fluoropyrimidine, 2-week schedule) was added prior to CCRT, depending on the severity of dysphagia at the time of diagnosis.

Patients were treated once daily up to a total dose of 3800–4600 cGy in 180- to 200-cGy fractions (4-week schedule). Total dose was determined according to the cord tolerance dose. Radiation therapy was performed with 15 MV linear accelerators (Clinac 1800; Varian, Palo Alto, CA, USA). The radiation field included the gross tumour volume defined by endoscopy, oesophagography and chest CT with at least 7 cm longitudinal margins and 2 cm radial margins. Supraclavicular lymph nodes were included if any lesion were detected above the level of the carina or the celiac nodes in distal oesophageal lesions. A dose was delivered in both anterior and posterior directions.

Stent construction and retrieval set

In the present study, 7th (Niti-S; Taewoong, Ilsan, Korea) [6] or 8th generation (EGIS; S&G Biotech Inc., Seongnam,

Korea) retrievable SEMSs were used (Fig. 1). A Niti-S stent was woven from a single 0.2 mm nitinol wire thread in a tubular configuration in a simple braided construction of crossing wires. It was internally covered with polytetrafluoroethylene (PTFE) membrane. The stent was subsequently bonded to the external surface of the covering membrane using a polyurethane solution (Taewoong, Ilsan, Korea). The stent consisted of three parts: the upper head, the body, and the lower head. Both head parts were 24 mm in diameter and 20 mm long when fully expanded. The body part was 16 or 18 mm in diameter and 60–120 mm long when full expanded. To prevent migration, both head parts were

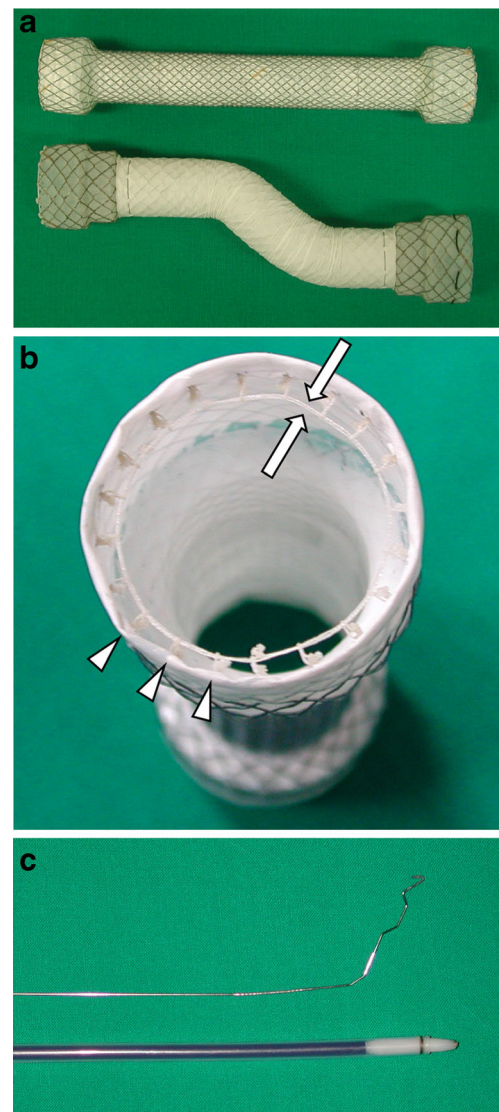


Fig. 1 (a) Photograph shows polytetrafluoroethylene (PTFE)-covered retrievable SEMSs we used in this study (top, Niti-S stent; bottom, EGIS stent). (b) Photograph of the proximal end of a Niti-S stent shows purse strings (arrows) and nylon loops (arrowheads) attached to its upper inner margin. Purse strings are passed through each of the nylon loops to form larger loops that fill the circumference of the inside of the proximal part. (c) Photograph shows a hook wire (top) and retrieval set (bottom)

connected at right angles to the body part. To facilitate stent removal, purse strings were attached to the upper inner margin of the stent. Nylon loops (diameter, 2 mm) were hooked inside of each bend of the upper end of the stent and secured with sutures. Purse strings were passed through each of the nylon loops to form larger loops that filled the circumference of the inside of the proximal part. Conversely, the EGIS stent consisted of a knitted construction of interlinked wires, and covered with 12 % polyurethane solution (Chronoflex; Cardiotech International, Woburn, MA, USA) via a dipping method. It was also partially covered with PTFE membrane on the external surface of the stent. Both head parts were double-stepped, 20–24 mm in diameter and 7 mm long for a smaller rim and 24–28 mm in diameter and 13 mm long for a larger rim when fully expanded. The body part was 16–20 mm in diameter and 40–120 mm long when fully expanded. Purse strings were attached to the upper and lower inner margin of the stent. Valved stents were not used in this study.

Stent retrieval set consisted of a 13 French sheath, a 10 French dilator, a hook wire (Taewoong, Ilsan, Korea) and a 0.035-inch hydrophilic guidewire (Radiofocus M; Terumo, Tokyo, Japan). The distal end of the hook wire was constructed in a question-mark configuration to capture the purse string of the stent, and the distal portion of the hook wire was positioned at approximately a 30° angle to the axis. Both the retrievable stents (Niti-S and EGIS) and the retrieval set were CE marked.

Stent removal techniques and follow-up after stent removal

Topical anaesthesia was routinely administered to the pharynx performed with an aerosol spray. Sedative agents were not used. Each stent was removed using a retrieval set under fluoroscopic guidance with the patient in the supine position. Details of the stent removal techniques are also provided in the previous studies [2, 11, 12]. In brief, three types of removal techniques were used in the present study: standard, proximal mesh, and eversion techniques. Proximal mesh or eversion technique is also called modified technique. In the standard technique, a sheath with a dilator is passed over a guide wire into the proximal stent lumen, and a hook wire is subsequently introduced to capture the proximal purse string. When this is achieved, the hook wire is withdrawn through the sheath to collapse the proximal end of the stent. After that, the sheath, hook wire, and the stent are pulled out of the oesophagus (Fig. 2). When the hook wire fails to capture the proximal purse string and instead inadvertently captures the proximal third of the mesh of the stent through the covering membrane by making a hole, the stent is removed by pulling it out in its expanded state (proximal mesh technique). If the hook fails to capture the proximal purse string or proximal mesh of the stent, the lower shoulder or the distal purse string is captured

and pulled out from the oesophagus. The stent invaginates upon itself and is removed in an everted state (eversion technique).

Esophagography was performed before and after the procedure to detect any complications or granulation tissues at both ends of the stent. If complications were not observed, patients were administered a liquid or soft diet for 1–3 days, followed by a regular diet. All patients underwent barium esophagography 1 month after stent removal to evaluate the recurrence of stricture. Patients were subsequently followed up at monthly intervals in the outpatient clinic; if this was not practical, they or their families were contacted by telephone. Thereafter, barium esophagography was performed only for patients with recurrent dysphagia or coughing.

Definition and analysis of data

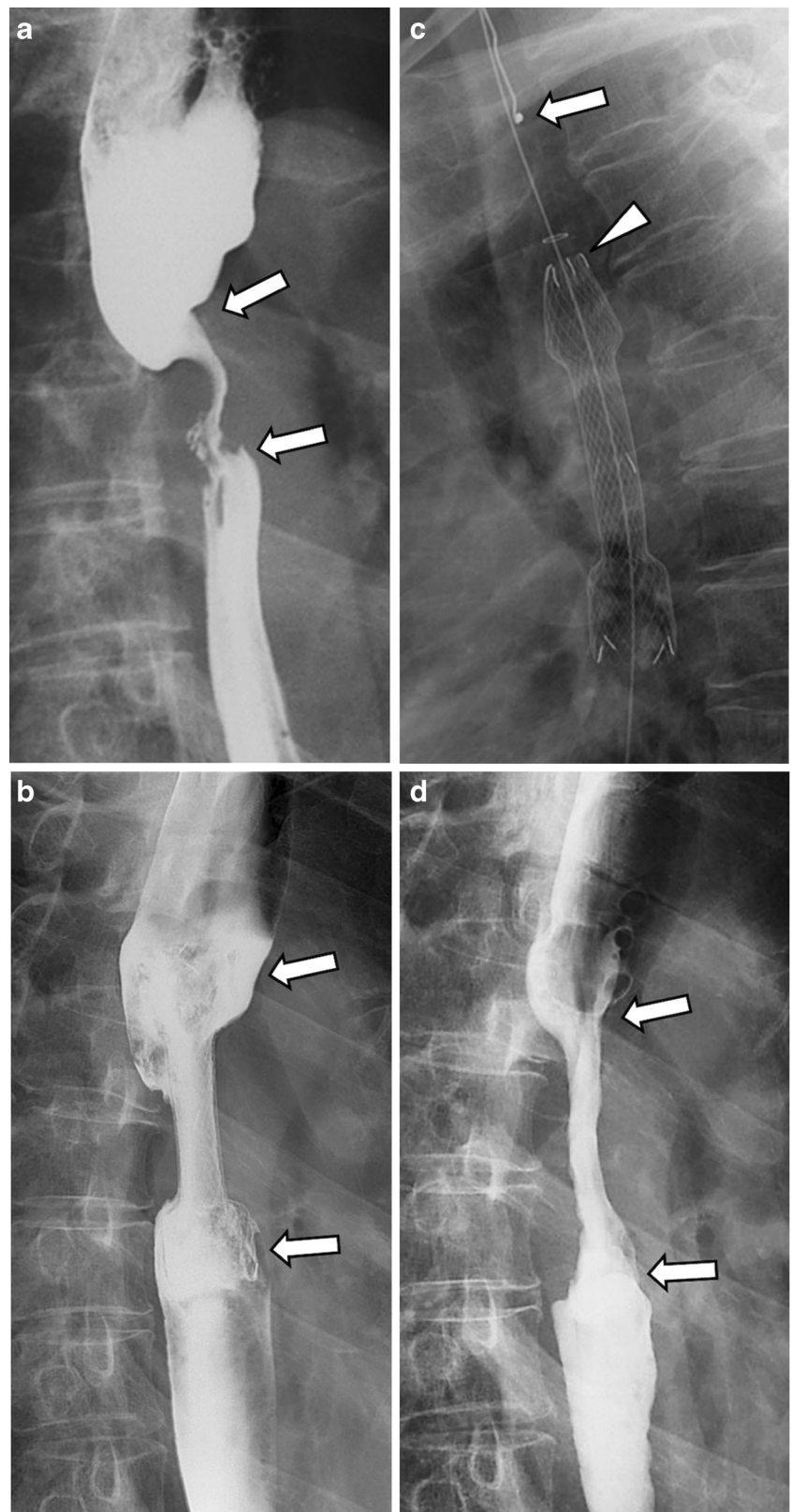
Granulation tissue was defined as a circumferential or eccentric filling defect accompanied by luminal narrowing at the proximal or distal end of the stent as seen on esophagography. Complications were classified as minor or major, according to the Society of Interventional Radiology reporting standards [13]. Primary technical success was defined as complete stent removal under fluoroscopic guidance using the standard technique. Secondary technical success was defined as complete stent removal under fluoroscopic guidance using the modified removal technique. Minor bleeding was defined as a blood stained stent or bleeding out of the mouth that resolved spontaneously without treatment. Major bleeding was defined as bleeding that required treatment. To identify predictive factors for primary technical success, univariate and multivariate logistic regression models were constructed. Only variables with a *P*-value of < 0.20 following univariate analysis were subjected to the multivariate logistic regression test. A *P*-value of < 0.05 was considered to indicate a statistically significant difference.

Results

Incidence and characteristics of stent removal

A total of 137 stents were removed from 128 patients (Fig. 3), either electively (*n*=93) or non-electively (*n*=44). Stent removal was not difficult in any of the patients. Overall technical success rate was 100 %. Primary technical success rate was 78.8 % (108/137), and secondary technical success rate was 100 % (29/29). Of 29 stents removed by secondary technique, 14 were removed by the proximal mesh technique, and the remainder was removed by the eversion technique. After the removal, additional stents were required due to stent migration (13/22; 59 %), severe pain (3/10; 30 %), recurrent aspiration (1/6; 17 %), newly formed strictures (3/4; 75 %), and incomplete expansion of the stent (2/2; 100 %). Gastrostomy was

Fig. 2 Stent removal in a 63-year-old man with oesophageal cancer. The Niti-S stent (diameter, 16 mm; length, 6 cm) was electively removed 6 weeks after placement. **(a)** An oesophagogram obtained before the placement shows a short segmental stricture (*arrow*) in the upper oesophagus. **(b)** An oesophagogram obtained before stent removal shows the patent stent (*arrow*). **(c)** An oesophagogram obtained during stent removal shows the hook wire (*arrow*) engaged in the purse string of the stent being pulled out to collapse the head of the stent (*arrowhead*). Of note, the hook wire was within the sheath. **(d)** An oesophagogram taken immediately after stent removal shows a patent oesophageal lumen (*arrow*)



required in patients with stent migration (1/22; 4.5 %), severe pain (3/10; 30 %), and recurrent aspiration (2/6; 33 %). The remaining cases did not require re-intervention. Granulation

tissue was detected at the proximal end (n=11), distal end (n=6), or both ends (n=1), 19–137 days (median, 31.5 days) after stent placement.

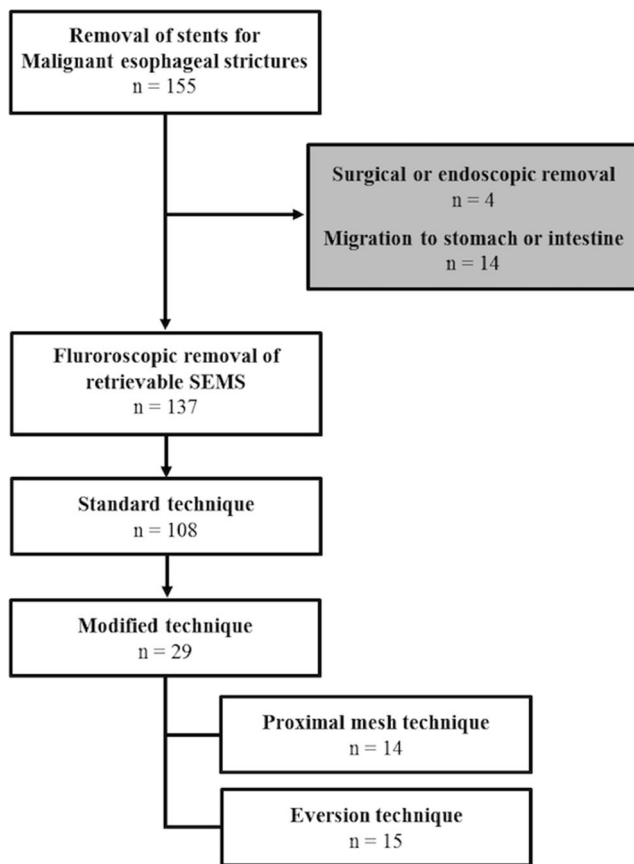


Fig. 3 Flow chart showing the selection process and procedural outcomes. SEMS, self-expandable metal stent

Complications

Complications occurred in six (4.4 %) cases, including minor bleeding (n=5) and intramural perforation (n=1). Detailed information is summarized in Table 2. Five stents were blood stained after removal; however, there was no evidence of further bleeding. The patient with intramural perforation was discharged after an observation period of 30 min, according to our institution's protocol (Fig. 4) [14, 15]. All six stents were electively removed by the standard technique. Median

dwelling time of these stents was 37 days (range, 28–40 days) and the mean length of the strictures was 5.4 cm (range, 2–6 cm). However, there was no correlation between the complication rate and either CCRT ($P=0.180$), removal techniques ($P=0.220$), stricture length ($P=0.340$), or the presence of granulation tissue ($P=1.000$).

Predictive factors of primary technical success

Age, stricture length ≥ 8 cm, proximal granulation tissue, and stent location showed P -values < 0.2 for primary technical success in univariate analysis. Therefore, those factors were subjected to the multivariate logistic regression model.

Multivariate analysis identified (1) proximal granulation tissue (odds ratio: 0.047, 95 % CI: 0.010–0.228, $P<0.001$), (2) stent location in the upper oesophagus (odds ratio: 0.155, 95 % CI: 0.043–0.557, $P=0.004$), and (3) stricture length ≥ 8 cm (odds ratio: 0.292, 95 % CI: 0.096–0.889, $P=0.030$) as independent predictive factors for primary technical success. Detailed information is provided in Table 3.

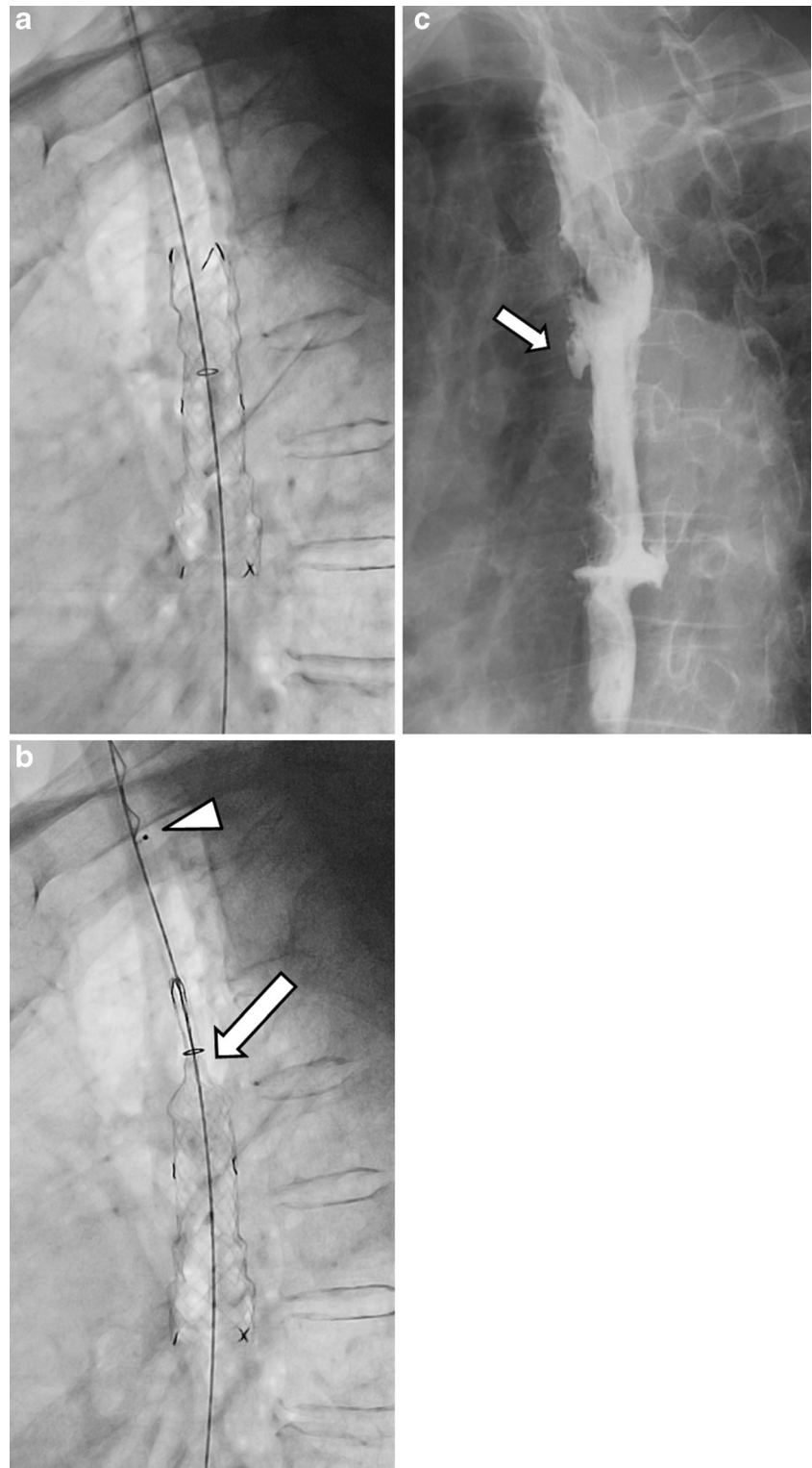
In cases of proximal granulation tissue (proximal end, 11 stents; both ends, one stent), primary technical success rate was only 25 % (3/12). Two of these 12 stents (16.7 %) were removed by the proximal mesh technique, and seven stents (58.3 %) were removed by the eversion technique. The eversion technique was more frequently performed in cases of proximal granulation tissue, compared to the other situations ($P=0.002$). Of 28 stents located in the oesophagus, 17 stents (60.7 %) were removed by the standard technique. Five of 24 stents (17.9 %) were removed by the proximal mesh technique, and the rest (21.4 %) were removed by the eversion technique. Of 25 stents placed at the stricture longer than 8 cm, 16 stents (64.0 %) were removed by the standard technique. Four of 25 stents (16.0 %) were removed by the proximal mesh technique, and the remaining five stents (20.0 %) were removed by the eversion technique. Of 82 stents without any predictive factors, primary technical success reached 92.3 % (Table 4).

Table 2 Detailed information on cases with complications

Age (years)/Sex	Aetiology	Location	Technique	Stricture length (cm)	Duration (days)	Complication	SIR classification	Treatment
53/M	Eso Ca	Lower	Standard	6	28	Minor bleeding	Minor	Observation
54/M	Eso Ca	Middle	Standard	6	31	Minor bleeding	Minor	Observation
70/M	Eso Ca	Middle	Standard	4	31	Minor bleeding	Minor	Observation
66/M	Eso Ca	Upper	Standard	4	40	Minor bleeding	Minor	Observation
82/M	Eso Ca	Middle	Standard	2	40	Minor bleeding	Minor	Observation
69/M	Eso Ca	Middle	Standard	5	37	Intramural perforation	Minor	Observation

Eso Ca, oesophageal cancer; SIR, Society of Interventional Radiology

Fig. 4 Stent removal in a 69-year-old man with oesophageal cancer. The EGIS stent (diameter, 16 mm; length, 7 cm) was electively removed 6 weeks after placement. **(a)** An oesophagogram obtained before the stent removal shows patent stent at the mid-oesophageal level. **(b)** An oesophagogram obtained during the removal shows the hook wire (*arrowhead*) captured the purse string being pulled out to collapse the head of the stent (*arrow*). **(c)** An oesophagogram obtained after the removal shows intramural perforation of the oesophagus (*arrow*). He was discharged after 30 min of observation. He did not show any fever or aggravating pain during the observation



Discussion

The present study demonstrated that fluoroscopic removal of retrievable SEMSs using three different removal techniques is safe and easy, with an overall technical success rate of 100 %

and a removal-related complication rate of 4.4 % (6/137). All complications were minor. Primary technical success rate was 78.8 %. Proximal granulation tissue, stent location in the upper oesophagus, and stricture length ≥ 8 cm were negative predictive factors of primary technical success. Eversion

Table 3 Univariate and multivariate analysis of primary technical success

	Success (n = 108)	Failure (n = 29)	Univariate analysis, <i>P</i> -value	Multivariate analysis		
				OR	95 % CI	<i>P</i> -value
Age (years)	62.8 ± 9.4	58.2 ± 11.1	0.029	1.037	0.984 – 1.093	0.177
Sex			0.734			
Male	96 (88.9)	27 (93.1)				
Female	12 (11.1)	2 (6.9)				
Stricture length			0.045	0.292	0.096 – 0.889	0.030
≥ 8 cm	16 (14.8)	9 (31.0)				
< 8 cm	92 (85.2)	20 (69.0)				
Stent dwell time (weeks)			0.364			
> 6	41 (38.0)	15 (51.7)				
4 – 6	43 (39.8)	10 (34.5)				
< 4	24 (22.2)	4 (13.8)				
Indications of removal			0.450			
Elective	75 (69.4)	33 (62.1)				
Non-elective	18 (30.6)	11 (37.9)				
Proximal GT			<0.001	0.047	0.010 – 0.228	<0.001
Present	3 (2.8)	9 (31.0)				
Absent	105 (97.2)	20 (69.0)				
Location			0.006			0.016
Upper	17 (15.7)	11 (37.9)		0.155	0.043 – 0.557	0.004
Middle	53 (49.1)	7 (24.1)		RD	RD	RD
Lower	32 (29.6)	10 (34.5)		0.433	0.126 – 1.490	0.184
EGJ	6 (5.6)	0		NA	NA	NA
Anastomotic	0	1 (3.4)		NA	NA	NA

Data are presented as the number of procedures (%); *OR*, odds ratio; *CI*, confidence interval; *GT*, granulation tissue; *EGJ*, oesophagogastric junction; *RD*, reference data; *NA*, not applicable

technique was more frequently performed in cases of proximal granulation tissue, compared to other situations ($P=0.002$).

Since the development of a retrievable SEMS in 1997, the standard technique has been considered safe and effective, with reported success rates of 85.1–100 % and complication rates of 0–4.4 % [2, 3, 11, 16]. We also observed good clinical outcomes of the standard technique in the present study. Theoretically, a purse string makes it possible to minimize mucosal injuries by means of collapsing the proximal end of the stent during removal [17]. Although all complications were the result of the standard technique, this does not mean standard technique is more invasive because the modified removal techniques were only used when the standard technique failed. Therefore, the standard technique can be performed in a safe and convenient manner in majority of patients.

However, standard technique failed in 21.2 % of retrievable SEMSs. In this context, we identified three predictive factors associated with primary technical success.

When granulation tissue was present at the proximal end of the stent, primary technical success rate was only 25 %. Notably, more than a half of the stents (58 %) were removed

by the eversion technique without any difficulties. This is because an everted stent with reduced diameter can easily pass through proximal granulation tissue. Furthermore, the stent peels away from the oesophagus during invagination, thereby minimizing the shearing force on surrounding tissues [18]. On the other hand, the standard technique may potentially cause oesophageal injuries because the distal part of the stent is still in an expanded state during the removal. Several case reports have demonstrated the safety and effectiveness of the eversion technique, particularly in proximal stenosis [18–20]. Considering our results and aforementioned reports, we recommend the eversion technique be considered if proximal granulation tissue is present at the proximal end. However, extended follow-up studies or prospective analyses are required to verify which technique is superior in these settings.

The multivariate logistic regression model also demonstrated that stent location in the upper oesophagus was associated with technical failure of the standard technique. Since the sheath is angulated at the oropharynx, it is difficult to set the angle of the hook wire to capture the proximal purse strings. In

Table 4 Removal techniques with regard to the predictive factors of primary technical success

	No factors (n = 82)	Proximal GT (n= 12)	Stricture length over 8 cm (n = 25)	Stent location in upper oesophagus (n = 28)
Standard	76 (92.3)	3 (25.0)	16 (64.0)	17 (60.7)
Proximal mesh	5 (6.1)	2 (16.7)	4 (16.0)	5 (17.9)
Eversion	1 (1.2)	7 (58.3) ^a	5 (20.0)	6 (21.4)

Data are presented as the number of procedures (%); *GT*, granulation tissue. ^a Eversion technique was more frequently performed in cases of proximal GT, compared to other situations ($P=0.002$)

these situations, endoscopic guidance may be useful as it can directly visualize the procedure.

Stricture length over 8 cm was also indicated as a negative predictive factor. Considering that a long stricture has a larger contact surface resulting in a stronger anchoring force between the oesophageal wall and the stent, it may be more difficult to remove for long strictures by the standard technique [21]. In the present study, the primary technical success rate was 64.0 % and the remainder was successfully removed by the proximal mesh or eversion technique without any complications. Therefore, sequential application of three different removal techniques seems to be effective in those cases. Nevertheless, caution should be exercised to avoid unexpected complications, such as stent fracture, bleeding, or oesophageal perforation [12].

Since radiation combined with chemotherapy induces oesophagitis, ulcer, fibrosis, or radiation-induced vasculitis, resulting in the tissue more fragile [22], CCRT may increase the risk of mucosal injury during removal. Although all complications were detected in the case of elective removal after initiating CCRT, no significant correlation was detected between CCRT and complications ($P=0.180$). This can be partly explained by the small number of complications. Larger studies are required to elucidate whether CCRT is a risk factor or not.

Although stents were removed under fluoroscopic guidance, endoscopic removal of retrievable SEMs has also shown to be safe and effective, with the complication rates of 0–11 % and overall technical success rates of 96–100 % [16, 23–27]. Endoscopic guidance can directly visualize the stricture, thereby avoiding unexpected complications. Nevertheless, fluoroscopic stent removal still has several advantages over endoscopic guidance. Firstly, fluoroscopy can provide visual control of the whole procedure in real-time. Secondly, fluoroscopic stent removal can approach a distal lesion regardless of the severity of proximal stenosis. Van Halsema et al [24] reported two cases necessitating a mini-gastrostomy for distal access when using an endoscopy due to tight proximal stenosis. To our knowledge, no study has compared fluoroscopic and endoscopic guidance for oesophageal stent removal. Therefore, further investigation may be required.

There has been some interest in biodegradable stents as a treatment option for refractory benign oesophageal strictures (RBESs) or malignant oesophageal strictures [28–30]. The major advantage of biodegradable stents is that dysphagia can be relieved without the need for removal, even following migration. However, further improvements are necessary to replace retrievable SEMs, due to a gradual decrease of expansile force due to degradation, long and variable dissolution time, and chemical dissolution increasing the risk of tissue hyperplasia [28].

A limitation of the present study was that the study design was retrospective and the study population was not randomized with respect to the removal techniques employed. Notably, the strength of our study was that the study population was larger than any previous studies focusing on removal techniques.

In conclusion, fluoroscopic removal of retrievable SEMs for malignant oesophageal strictures can be performed in a safe and convenient manner, with an overall technical success rate of 100 % and complication rate of 4.4 %. Primary technical success rate was 78.8 %. Standard technique is safe and effective in the majority of patients. Proximal granulation tissue, stricture length over 8 cm, and stent located in the upper oesophagus were the negative predictive factors of primary technical success. During removal, caution should be exercised in these situations. Eversion technique may be effective when granulation tissue is present at the proximal end of the stent, but further studies are required to confirm this.

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Methodology: retrospective, observational, performed at one institution.

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