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Snare devices with thinner loop wire may provide higher performance for cold snare polypectomy in an experimental model

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ABSTRACT

Background and study aims Snare devices play an important role in treatment of intestinal polyps. However, there are no objective measurements for the characteristics of the various types of snare devices.

Materials and methods Seven types of snare devices from four manufacturers were evaluated based on original measurements. The evaluated factors were stiffness, cutting quality, and change in force required for cutting depending on sheath shape. The latter two factors were evaluated by measuring the force required to cut 20 % gelatin cylinders, which simulated intestinal polyps. The cutting sharpness was evaluated by observing the sectional surface of cut gelatin cylinders using a stereomicroscope. The correlations between these measurements and characteristics of the snare devices were investigated.

Results A strong positive correlation, with an R^2 value of 0.863, was shown between the force required to cut gelatin cylinders and loop wire diameter. Loop wire diameter also had a strong correlation, with an R^2 value of 0.7997, with the change in force required for cutting gelatin cylinders depending on sheath shape. No correlations were detected between loop stiffness and characteristics of snare devices. The edge-enhanced image revealed that the rougher surfaces of the gelatin cylinders were cut by snares with a thicker diameter.

Conclusions Thinner loop wire may provide higher performance in cold snare polypectomy in an experimental model.

Introduction

Endoscopic treatments, including endoscopic submucosal dissection, have been accepted as reliable and less invasive treatment even for large intestinal lesions [1–3]. Among them, cold snare polypectomy without high-frequency generators recently has been accepted as an easy and simple way to resect precancerous lesions < 10 mm in diameter, especially in periodic colonoscopy after a patient's colon is disease-free [4–8]. It enables resection of polyps with less damage to residual tissue surrounding the resected lesion. Specifically, cold snare polypectomy has been reported to prevent bleeding and perforations compared to conventional endoscopic resection using electrical hot wire [9, 10]. Recently, besides its use for colon polyps, cold snare polypectomy has been reported to be effective for duodenal polyps [11–13]. Cold snare polypectomy, however, has not been used in conjunction with electrocautery, which ablates possible residual tumor tissue surrounding a resected lesion. The stiffness and cutting quality of snare devices as well as their technical maneuverability are gaining increased in-

▶ **Table 1** Summary of characteristics of snare devices.

Snare devices	Longitudinal diameter of loop (mm)	Transverse diameter of loop (mm)	Diameter of loop wire (mm)	Diameter of main wire (mm)	Internal diameter of sheath (mm)	External diameter of sheath (mm)	Clearance
A: Stella Cold	26.00	11.08	0.24	0.93	1.58	2.40	0.65
B: Hot Snare Oval	32.33	15.48	0.48	0.81	1.59	2.38	0.78
C: Hot Snare Hexagon	34.31	15.03	0.45	0.81	1.59	2.38	0.78
D: Exacto	21.13	7.00	0.31	0.79	1.70	2.35	0.91
E: Snare Master Plus	19.27	9.80	0.31	0.91	1.56	2.38	0.65
F: Captivator Cold	19.82	7.04	0.33	0.69	1.64	2.40	0.95
G: Pentax Prototype Snare	26.62	10.10	0.37	0.91	1.58	2.40	0.67

▶ **Table 2** Summary of measurements of snare devices.

Snares devices	Stiffness (g)	Force required to cut gelatin cylinders			
		Direct cutting (N)	Straight position (N)	Bending position (N)	Gap of bending-straight (N)
A: Stella Cold	3.35 ± 0.87	2.63 ± 0.40	3.30 ± 0.29	3.6 ± 0.29	0.3
B: Hot Snare Oval	7.96 ± 0.82	3.59 ± 0.40	3.13 ± 0.36	5.62 ± 0.82	2.49
C: Hot Snare Hexagon	15.95 ± 1.79	3.86 ± 0.56	4.54 ± 0.76	6.65 ± 1.07	2.11
D: Exacto	8.32 ± 1.38	2.92 ± 0.25	2.64 ± 0.45	3.33 ± 0.85	0.69
E: Snare Master Plus	3.02 ± 0.58	2.89 ± 0.44	3.55 ± 0.42	4.53 ± 0.45	0.98
F: Captivator Cold	15.66 ± 1.52	2.73 ± 0.37	4.05 ± 0.45	4.06 ± 0.35	0.01
G: Pentax Prototype Snare	3.80 ± 0.33	3.22 ± 0.57	3.62 ± 0.26	5.17 ± 0.45	1.55

terest. There are few reports, however, concerning these characteristics, despite the number of snares available.

Therefore, this study aimed to establish a method for objective evaluation of characteristic features of snare devices, such as stiffness, cutting quality, and maneuverability.

Materials and methods

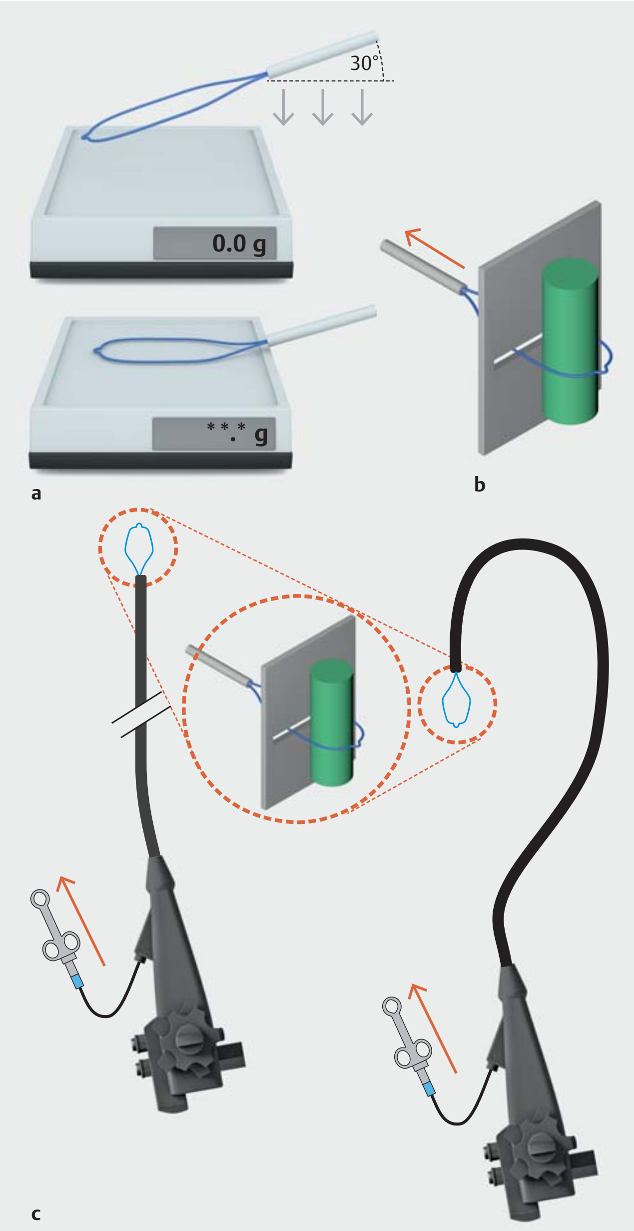
Seven types of snare devices (A: Stella Cold, B: Hot Snare Oval, C: Hot Snare Hexagon, D: Exacto, E: Snare Master Plus, F: Captivator Cold, and G: Pentax Prototype Snare) from four manufactures (Hoya Corp., Tokyo, Japan; United States Endoscopy Group Inc., Ohio, United States; Olympus Corp., Tokyo, Japan; and Boston Scientific Corp., Massachusetts, United States) were evaluated. Their characteristics, including loop wire diameter, main wire diameter, sheath inner diameter, sheath outer diameter, and clearance, were measured and are summarized in ▶ **Table 1**. Clearance was defined as the ratio of main wire diameter to sheath inner diameter.

Loop stiffness

The forces required to bend the loops at 30 degrees were measured as follows. A fully opened loop at the tip of the sheath at an angle of −30 degrees to a horizontal surface was gradually pressed on the top of the electro weigh scale (HL-100; A&D Co., Ltd., Tokyo, Japan) until the opened snare was bent to become completely horizontal (▶ **Fig. 1a**). The measurements were repeated 10 times for each snare and the mean value of the force shown on the electro weigh scale was calculated.

Cutting quality

Cylinders with a diameter of 8 mm were made from 20 % food-grade gelatin (Cook Gelatin; Morinaga & Co., Ltd., Tokyo, Japan) to simulate intestinal polyps. To remove the effect of the stiffness of the sheaths or the shape of the loop, the opened loop was inserted through a slit of a metallic plate, and the gelatin cylinder was inserted through the opened loop (▶ **Fig. 1b**). The tensile force required to cut the gelatin cylinder was measured with a digital force gauge (ZP-100N; IMADA Co., Ltd., Aichi, Japan) directly connected to the loop wire. The evaluations were repeated 10 times for each snare and the mean value of the force was calculated. In addition, cutting sharpness was evaluated by observing the sectional surface of cut gelatin cylinders using a stereomicroscope.



▶ **Fig. 1** Scheme of measurements. **a** Evaluation of loop stiffness. **b** Cutting a gelatin cylinder through a slit of metallic plate. **c** Evaluation of change in force required for cutting depending on sheath shape.

Change in force required to cut between straight and bent positions

Each snare device was inserted through the channel of a straight fixed scope (EC34-i10M; Hoya Corp.) and the force required to cut the gelatin cylinders was measured with a digital force gauge (ZP-100N) directly connected to the handle of the snare device (▶ **Fig. 1c**). Then, the force required to cut the gelatin cylinder through a channel of a scope shaped as a question mark to simulate insertion into the cecum was measured. The gelatin cylinders were cut through a slit in the metallic plate similar to the procedure previously described. The evaluations were repeated 10 times for each snare and the mean value of the force was calculated.

Scatter plotting and calculation of the value of coefficient of determination (R^2) were done using EXCEL software (Microsoft Corp., Seattle, Washington, United States).

Results

Results of the measurements are summarized in ▶ **Table 2**.

Loop stiffness

▶ **Fig. 2a** is a scatter plot of loop stiffness vs. loop wire diameter and longitudinal length of loop. Both were poorly correlated with snare stiffness.

Cutting quality

▶ **Fig. 2b** is a scatter dimensional plot of the force required to cut the gelatin cylinders vs. loop wire diameter, transverse length, and longitudinal length of loop. It shows a strong positive correlation, with an R^2 value of 0.863, between the force required to cut the gelatin cylinders and loop wire diameter. The other two factors were poorly correlated with force required to cut the gelatin cylinders. ▶ **Fig. 3** shows the sectional surfaces of cut gelatin cylinders. The edge-enhanced image revealed that the rougher surfaces of the gelatin cylinders were cut by snares with a thicker diameter, including B and C. The sectional surface of gelatin cylinders cut by thinner snares showed a relatively smooth surface with equally spaced traces.

Change in force required for cutting depending on sheath shape

▶ **Fig. 2c** is a scatter plot of the change in force required to cut the gelatin cylinders depending on sheath shape *vs*. loop wire diameter, transverse length, longitudinal length of loop, main wire diameter, internal sheath diameter, and clearance. Among them, only loop wire diameter was strongly correlated with the gap in force required to cut the gelatin cylinders between the wire and sheath in the bent position. The value of R^2 was 0.7997.

Discussion

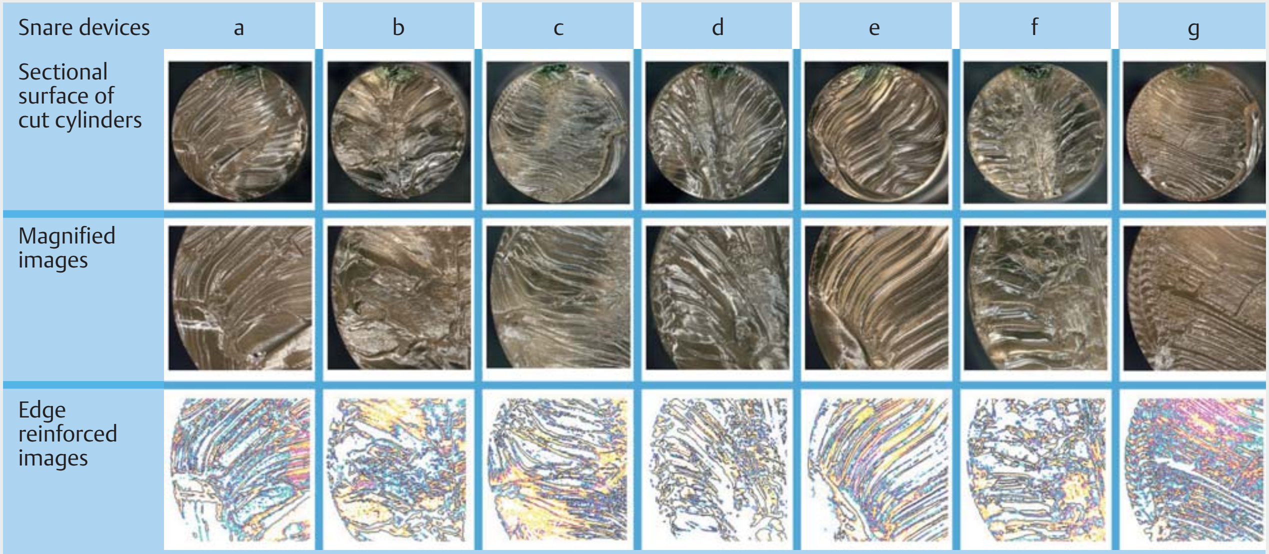
In recent decades, use of snare devices in clinical daily practice of endoscopy for gastrointestinal disease has gradually increased. Throughout this period, endoscopists have described the characteristics of an ideal snare device, including appropriate stiffness, appropriate quality for cutting, and maneuverability even in the deeper colon. In this study, we attempted to evaluate these factors objectively using original measurements.

This study showed that a snare device with a thinner loop wire required minimal force to cut gelatin cylinders. These results corroborate the experience that endoscopists have in clinical daily practice. The smoother sectional surface of cut gelatin cylinders demonstrated that a thinner wire loop minimized damage to resected tissue, especially during cold snare polypectomy without electrical coagulation. In addition, a snare device with a thinner loop wire also had a minimal change in force

► **Fig. 2** Scatter plot of measurements. **a** Loop stiffness vs. loop wire diameter and longitudinal length of loop. **b** Force required to cut gelatin cylinders versus loop wire diameter, transverse length, and longitudinal length of loop. **c** Change in force required for cutting depending on shape of sheath vs. loop wire diameter, transverse length, longitudinal length of loop, main wire diameter, internal diameter of sheath, and clearance.

required to cut the gelatin cylinders between wire and sheath in the bent position. This result suggests that a snare device with a thinner loop wire also has preferable maneuverability in the colon regardless of location.

There were no correlations between loop stiffness, loop wire diameter, and loop length. Stiffness may be determined by other factors, including the material from which a loop is made, its shape, and the knitting patterns of the loop wire. These are complex factors, which were difficult to analyze in this study. Undoubtedly, the cutting quality and change in force required for cutting between positions must be affected by various factors, including those mentioned above. However, this study revealed that the thinness of loop wire may be a non-negligible factor for high performance for cold snare polypec-



▶ **Fig. 3** Section surfaces of cut gelatin cylinders.

tomy for intestinal polyps. From this standpoint, snare devices with thinner loop wire might be ideal.

The major limitation of this study is its design as a simplified desktop experiment. Undoubtedly, other factors including the stiffness of the sheaths, the shape of snares, and the materials from which the devices are made should influence outcomes, although manufacturers may not make all of that information available to the public. In addition, the higher performance in this experimental model does not ensure higher performance in clinical daily practice. The required stiffness of snares varies depending on the existence of various conditions in a patient's intestinal tract. The speed of cutting is one of the important factors that affects cutting sharpness. Moreover, cutting sharpness in this experimental model might have resulted a higher rate of complications, including bleeding and perforation. Our results do not guarantee a clinical outcome, although this is the first study concerning the common experience that endoscopists have in clinical daily practice with snares. Future clinical trials are mandatory to support these results, especially concerning completeness of resection and complications associated with the thinner loop wire. In addition, the small number of snare devices is another limitation, as well as the lack of evaluation of other factors, as mentioned previously. The accumulation of data from other devices might reveal other factors that would make for ideal snare devices.

Conclusions

In conclusion, this study using an experimental model demonstrated the possibility that a thinner loop wire might provide higher performance for cold snare polypectomy of intestinal polyps.

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Competing interests

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