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Knives in Third Space

Roy J. Mukkada[1] Pradeep G. Mathew[1]

[1] Department of Gastroenterology, VPS Lakeshore Hospital, Kochi, Kerala, India

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Address for correspondence Pradeep G. Mathew, MD, Department of Gastroenterology, VPS Lakeshore Hospital, Kochi, Kerala 682040, India (e-mail: pgmathew1@gmail.com).

Abstract

Endoscopic mucosal resection (EMR) has always been done with a snare. The maximum diameter of the snare is usually 2 cm and the largest lesion that can be removed in one piece is usually maximum of 2 cm. In EMR, after the elevation of the submucosa, snares are used for the resection of the mucosal lesion; however, for endoscopic submucosal dissection (ESD), special knives are required, which have various uses in different areas of the gastrointestinal tract. ESD knives have developed and evolved over the past 30 years allowing it to be performed safely. It allows very precise cutting of the mucosa as well as dissection of the submucosal tissue planes. This review discusses some of the more commonly used knives.

Keywords
- dual knife
- endoscopy knives
- ESD
- IT knife
- TT knife

Introduction

Endoscopic mucosal resection (EMR) is a technique for removing gastrointestinal mucosal lesions. It involves the submucosal injection of a solution to lift the lesion away from the muscularis propria, and then a snare is used to resect lesions up to 20 mm as a whole or larger lesion in a piecemeal fashion. The maximum diameter of the standard snare is 2 cm, although larger snares are available. Therefore, the largest diameter of the lesion that can be removed in one piece with a snare is usually maximum of 2 cm. There are various modifications of EMR, such as cap-assisted EMR and band-ligation-assisted EMR. Endoscopic submucosal dissection (ESD) differs from EMR as special knives are used to dissect the lesion. ESD knives have developed and evolved over the past 30 years, allowing them to perform procedures safely. It allows precise cutting of the mucosa and dissection of the submucosal tissue planes. Solutions for injection, elevation, and expansion of the submucosal layer have also evolved and improved, which have added to longer-lasting elevation to become an efficient and relatively safe procedure.[1] In 1999, Yamamoto et al[2] developed a new technique of making a safe mucosal incision with a sharp needle knife. They used sodium hyaluronate to create a thick submucosal fluid cushion. Yahagi et al[3] developed a new knife, using a slightly protruded tip of a thin type of snare, called the flex knife.

Several ESD knives are available (►**Fig. 1**). The choice of knife depends on the location of lesion, severity and extent of submucosal fibrosis, and the axis of the knife in relation to the dissection plane—parallel or vertical. These knives are divided into three basic types. Needle-type or tip-type knives have a needle-knife extremity that can be used for marking, cutting, dissection, and hemostasis. The blunt-tip knives consist of an insulated tip (IT), usually ceramic, that prevents coagulation of the muscle layer. The ceramic tip at the distal end limits the current at the knife tip and allows controlled dissection using the knife shaft. They are not suitable for marking, but submucosal dissection tends to be faster with these blunt knives. The most recent addition to the armamentarium are the scissor-type knives. They can be used for all the steps of ESD and at all the locations.[4] Knives from different manufacturers are elaborated and summarized in ►**Fig. 1.**[5]

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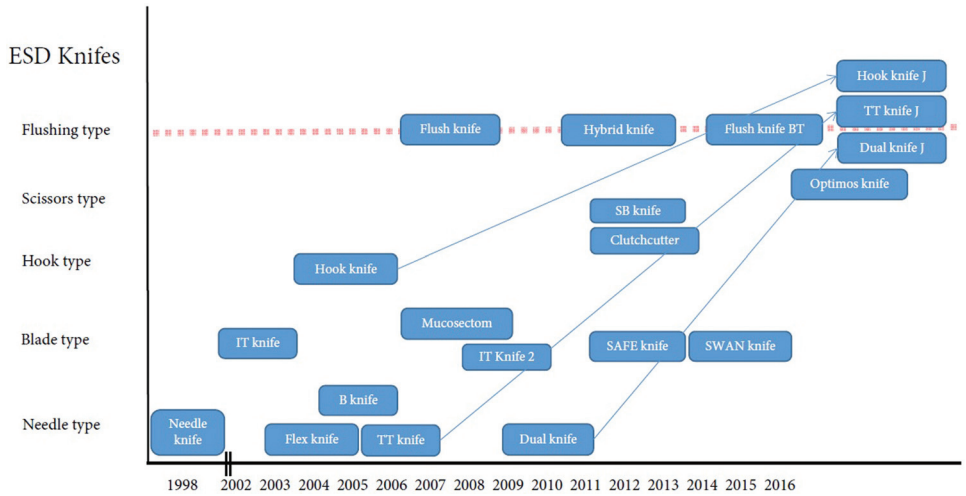

Fig. 1 Endoscopic submucosal dissection (ESD) knives. Each knife for gastrointestinal ESD, and its release year. Adapted from Koh et al.[1]

Needle-Type Knife (Dual Knife, Hook Knife)[6]

The needle knife was initially used by Yamamoto[6] to conduct ESD procedures. A newer development was the dual knife (Olympus, Tokyo, Japan; ►**Fig. 2A**), which was developed by Yahagi et al in 2004.[3] It has a tiny noninsulated dome-shaped electrode at the tip of the knife of 1.5 mm (for the esophagus and colon) or 2 mm (for stomach), with two different working lengths of 1.6 or 2.3 m. The knife length can be fixed in two positions: retracted or extended. In the retracted position, the length of the exposed tip measures 0.3 mm. The short length of the closed knife can be used for both marking and coagulation (with the retracted tip), as well as cutting, and dissection with the tip extended. Another commonly used knife, especially in fibrotic lesions, is the hook knife (Olympus America, Center Valley, Pennsylvania, United States; ►**Fig. 2A**). The distal L-shaped hook is fully rotatable in all directions. It is used for incision and dissection. It can also be used to grasp tissue and apply traction on fibrotic areas, which helps to reduce collateral burns.

The type of approach and procedure while using the hook knife depends on the orientation of the lesion. If the lesion needs to be approached tangentially, the hook part

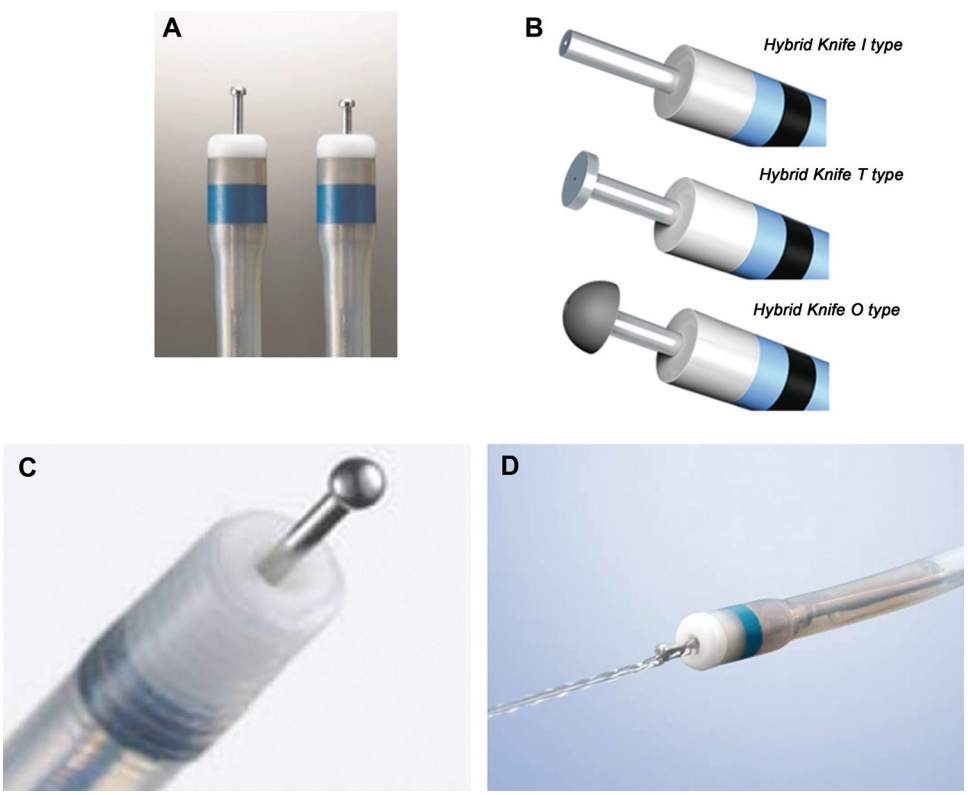

Fig. 2 (A) Dual knife (Olympus, Tokyo, Japan). **(B)** Hybrid knife (ERBE, Erlangen, Germany). **(C)** Flush knife (Fujifilm, Tokyo, Japan). **(D)** Dual knife J (Olympus, Tokyo, Japan).

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can be turned parallel to the muscularis propria. The hook knife can then be inserted into the submucosal layer and manipulated parallel with the muscularis propria, enabling efficient incision and dissection. Since esophageal lesions are always approached tangentially, incision or dissection using the arm part of the hook knife is particularly useful. Compared with knives that can perform sequential incision and dissection, hook knife may be disadvantageous in some situations in terms of speed. However, where the lesion orientation is favorable, providing traction to the tissue using the tip attachment may enable efficient dissection by utilizing the long 4.5-mm arm part of the hook knife. The inclusion of injection function at the tip of the knife, a newer innovation, allows the endoscopist to do all the above functions and inject saline or sodium hyaluronate into the submucosal space with the help of a foot pedal. This helps save valuable time, as the exchange of accessories can be avoided. The knives with the water-jet function that are currently available include the hybrid knife (►**Fig. 2B**; ERBE USA, Marietta, Georgia, United States), the flush knife (►**Fig. 2C**; Fujifilm America, Valhalla, New York, United States), the dual knife J type (►**Fig. 2D**; Olympus America, Center Valley, Pennsylvania, United States), and the triangle-tip J (TTJ) knife.

Triangle-Tip Knife

Inoue et al developed the triangle-tip (TT) knife[7] (►**Fig. 3A**). It became popular with Per Oral Endoscopic Myotomy (POEM) procedure's introduction since it facilitates grasping and dissection of muscular fibers. However, it is less commonly used for ESD procedures due to the larger size of the tip. We use the TT knife mainly for POEM procedure and very rarely in ESD. The tip of the knife has a triangular plate. It has three angulations that allow spraying of energy toward a larger area. The submucosal dissection is performed with the knife without touching the tissue. It can also be used for submucosal tunneling and myotomy. The newer iteration of the

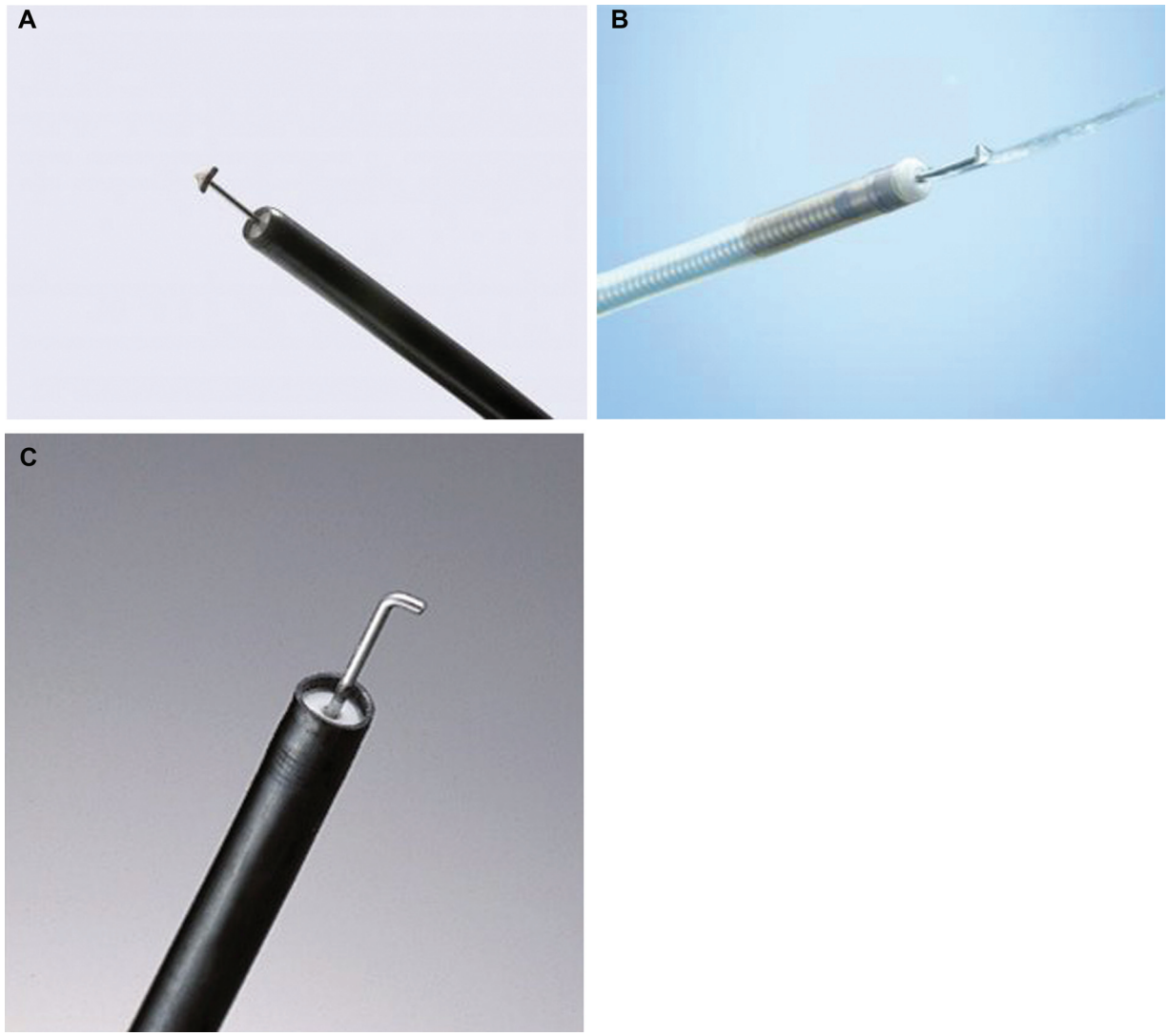

Fig. 3 Tip-cutting endoscopic submucosal dissection knives. **(A)** Triangle-tip (TT) knife (Olympus, Tokyo, Japan). **(B)** TT knife J (Olympus, Tokyo, Japan). **(C)** Hook knife (Olympus, Tokyo, Japan).

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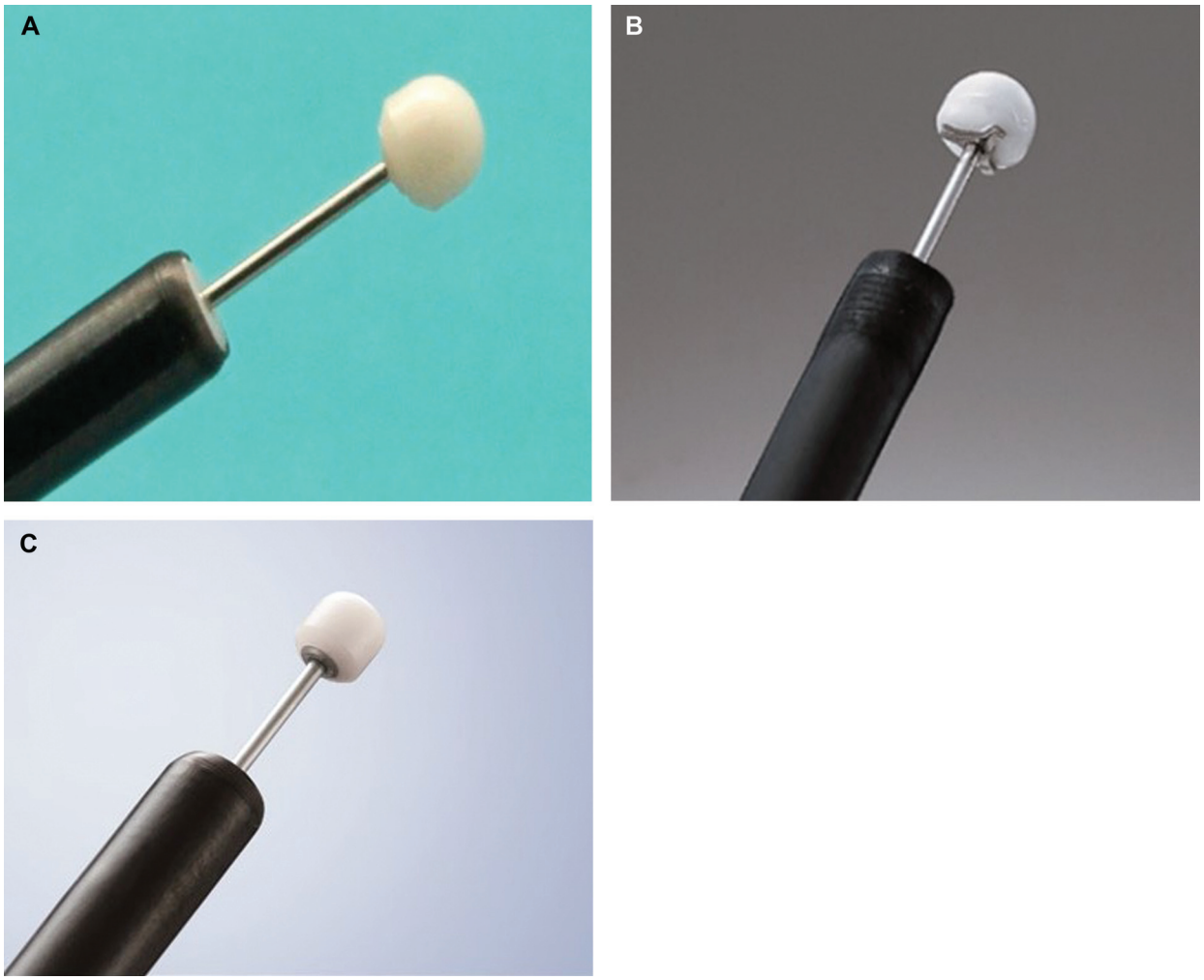

Fig. 4 Blunt-tip endoscopic submucosal dissection knives. **(A)** Insulated-tip (IT) knife (Olympus, Tokyo, Japan). **(B)** IT knife 2 (Olympus, Tokyo, Japan). **(C)** IT knife nano (Olympus, Tokyo, Japan).

knife called TTJ knife (►**Fig. 3B**) comes with a water-jet function that allows for fluid injection without exchanging accessories.[8]

Insulated-Tip (IT) Knives

Hosokawa and Yoshida developed the IT knife (►**Fig. 4A**) to completely remove a large lesion during EMR in a single piece with good results.[9] The IT knives have a ceramic tip at the end of the metal needle, which is nonconducting and makes it less likely to perforate the mucosa. The cutting is done using the shaft of the IT knife. The usage of IT knives is, however, different from needle knives. IT knives use the pull technique or drag technique rather than the controlled push movements, which are used for the needle-type knives such as dual knife and TT knife.[10]

The IT knife 2 (IT2) was developed by Ono et al in 2008.[11] The IT2 (►**Fig. 4B**) has a triangular electrode behind the ceramic tip. This triangular electrode helps incise the mucosa as well as dissect the submucosa. However, the IT2 knife's use is usually limited to the stomach as only the stomach has enough space to maneuver the knife and the muscle layer is thicker. These knives can be potentially dangerous in the esophagus or the colon.

The IT knife nano (►**Fig. 4C**; Olympus America, Center Valley, Pennsylvania, United States) was developed specifically to address this difficulty. It has a much smaller ceramic tip of 1.7 mm, while the IT2 has a tip of 2.2 mm. The IT knife nano has a disk-shaped electrode, while the IT2 has a triangular one. However, an initial incision with a needle knife is still required to enter the submucosal space.

Flex Knife

Flex knife (►**Fig. 5**; Olympus, Tokyo, Japan) was developed by Kodashima et al from Olympus, Tokyo, Japan.[12] It featured a braided 0.8 mm cutting knife with a looped tip adjusted to different lengths, suitable for marking, incision, and dissection. The distal end of the sheath, which functions as a stopper, was designed to prevent perforation by allowing better control of the cutting depth. The dual knife and the dual knife J were further refinements to the flex knife.

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Fig. 5 Flex knife (Olympus Tokyo, Japan).

Flush Knife

Flush knife (►**Fig. 2C**; Fujifilm, Japan) was developed by Toyonaga et al.[13,14] There are 13 combinations and variations of the flush knife depending on the length of the needle knife (1, 1.5, 2, 2.5, or 3 mm). There are even variations with a ball tip and length of the catheter (1.8 and 2.3 m). As the name suggests, the main advantage of this knife is the water-jet capability (thus the name "flush"). This flush capability has been designed to clean the field of operation during endoscopic dissection. It can also be used to clean the tip of the knife and, most importantly, can inject saline or viscous substances such as hydroxyethyl starch 6%.[13,14] The narrower ESD knife (flush knife BT-S 2.0 mm; diameter, 2.2 mm; Fujifilm Co., Tokyo, Japan) has a slim design, but it has a 3 cm thick part at the front (2.6 mm), which anchors the knife and ensures the stability of the knife during submucosal dissection. The flush knife BT-S is 200 mm longer than the flush knife BT, making it suitable for the longer colonoscopes used in the West.[15]

Hybrid Knife (ERBE; ►Fig. 2B)

The hybrid knife is a multifunction knife capable of injecting, marking, incision, and submucosal dissection. An ultrafine 120 lumens water-jet injection feature is foot-pedal-activated and functions as a water-jet unit with the ERBE JET System, which is computer-controlled (ERBE JET 2 System, ERBE). There are three types of hybrid knife: the I-type (needle type with adjustable length), the T-type (with a disk-shaped non-IT), and the O-type (with an insulated dome-like tip similar to the IT2).

Fig. 6 Clutch cutter (Fujifilm Japan).

Scissor-Type Knives

Akahoshi et al developed the clutch cutter knife (Fujifilm; ►**Fig. 6**). This is a scissor-like electrosurgical knife with the ability to grasp, pull, coagulate, and incise the targeted tissue using electrosurgical current. It is 0.4 mm wide and 3.5 mm or 5 mm long, has monopolar blades, and a serrated cutting edge to facilitate grasping tissue, and the outside of this knife is insulated for preventing coagulation of the muscle layer.[16,17] The standard approach with scissor-type knives involves first grabbing the tissue and then incising or dissecting it.[16]

SB Knife (►Fig. 7; Sumitomo Bakelite, Japan). This knife incorporates a centrally positioned 1.2 mm electrode, surrounded by an electrically insulated coating. The curved tip of the knife allows for dissecting the proper layer and prevents unexpected muscle layer injury. Three versions are available: one with a 7 mm blade for the stomach (standard type), a 6 mm blade for the esophagus knife (short type), and an even smaller version for colorectal applications (Jr type).[18]

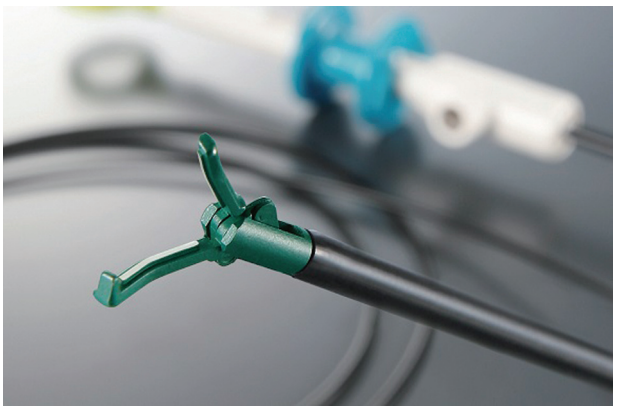

Fig. 7 SB knife (Sumitomo Bakelite, Japan).

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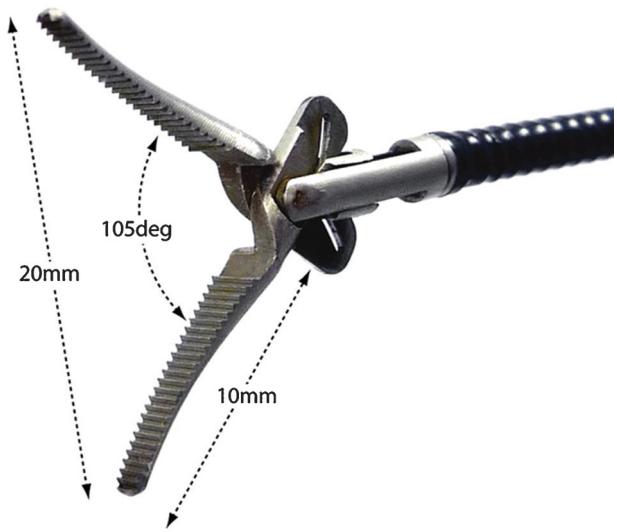

Fig. 8 Endo-Maryland dissector (Ovesco, Germany).

Fig. 9 AqaKnife (Ovesco, Germany).

Endo-Maryland Dissector (Ovesco; ►Fig. 8). Laparoscopic surgical instruments inspire the tip design. Dissection with Maryland can be performed in several ways, including dissection by opening the jaws or by grasping and pulling the submucosal tissue with or without electrocautery. It requires a biopsy channel of at least 3.2 mm.[19]

Other Less Commonly Used Knives

ESD AqaNife (Ovesco, Germany; ►Fig. 9). It is a needle-type knife with a straight needle and a ceramic sheath. The needle length is 1.5, 2, 2.5, and 3 mm. It incorporates a flushing channel for irrigation and submucosal injection.[4]

Endo FK (Kachu Technology, South Korea). Endo FK is an ESD knife that can be used for all the steps of ESD. Endo FK has two interchangeable knives. A forked knife and a fixed flexible snare like the flex knife form a single working unit. It has an inlet for injection of saline or saline irrigation during the procedure. Two switches help to change the knives during a procedure.[20]

Fig. 10 Splash M knife (Pentax Medical, Japan).

Splash M-Knife (Pentax; ►Fig. 10). This is a tip-cutting knife with a jet function. The blade contains a metal disk used to hook tissue and provide clear marking.[4]

Optimos (Taewoong, South Korea). The Optimos knife has a 1.9 mm wide and 2.5 mm long anchor-shaped tip that can be rotated with the help of a dedicated button. It has a water-jet function, and it can be used for all steps of ESD.[4]

Conclusion

Preference of one knife over the other is mostly based on personal experience and preference. We prefer the dual knife J and IT knives for most of our ESD work and the TTJ knife for POEM and Submucosal Tunelling Endoscopic Resection (STER) procedure in the esophagus. The knives used in the Third Space have improved over the past 20 years. They will continue to evolve and improve with newer, safer devices with significantly lesser complications and more precise usage, especially with advances in techniques and electrosurgical generator advances and newer and more refined endoscopic accessories and devices.

Conflict of Interest
None declared.

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