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Standardisation of polypectomy technique

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A B S T R A C T

There are several approaches to polypectomy for sessile polyps <20 mm and for pedunculated polyps. Recent evidence is leading towards standardisation of polypectomy technique. Key recent polypectomy developments include: 1. Use of cold snare polypectomy (CSP) for sessile polyps <10 mm; 2. Use of hot snare polypectomy (HSP) following submucosal injection for sessile polyps sized 10–19 mm; 3. Piecemeal cold snare polypectomy (PCSP), with or without prior submucosal injection, for select sessile polyps sized 10–19 mm, where the potential risk for an adverse event is increased (e.g. polyps in the caecum or ascending colon, or patients with increased risk of post-polypectomy bleeding), and where the risk of submucosal invasion is low; 4. Avoidance of hot biopsy forceps (HBF); 5. Limiting the use of cold biopsy forceps (CBF) to the smallest of diminutive polyps, where CSP is not feasible; 6. Mechanical haemostasis prior to polypectomy for large pedunculated polyps with head ≥20 mm or stalk ≥10 mm.

Introduction

Polypectomy is a fundamental skill for all endoscopists who perform colonoscopy. Large prospective studies have established that effective colonoscopic polypectomy reduces the incidence of colorectal cancer (CRC) [1] and prevents mortality due to CRC [2]. Indeed, a large case–control study from the USA showed that having a colonoscopy for any indication was associated with a significantly reduced long-term risk of developing CRC [3]. However, colonoscopy is not completely protective against CRC [4]. The degree of protection conferred by colonoscopy is largely dependent on the technical skill of the endoscopist in identifying and effectively removing polyps that are precursor lesions to CRC [5]. Studies have shown that there is significant variation between endoscopists for detection rates of precursor lesions such as conventional adenomas [6] and sessile serrated adenomas (SSA) [7]. Furthermore, there is significant variability in the effectiveness of polypectomy between endoscopists [8].

Polypectomy techniques have continued to evolve over time. Many different techniques are used, each with its own merits. The polypectomy technique practiced by individual colonoscopists frequently reflects the polypectomy technique of their colonoscopy teachers or mentors. Although this apprenticeship model has served us well, there is now significant evidence to suggest that many colonoscopists practice with suboptimal skill or technique, as evidenced by low detection rates for adenomas or sessile serrated adenomas compared with their peers. Furthermore, there is increasing recognition of the pervasive problem of incomplete polypectomy [8].

Fortunately, we now have a greater understanding of how to achieve effective and safe polypectomy. Based on a significant body of emerging international evidence, there is now increasing consensus regarding standardizing polypectomy technique. Recently the European Society of Gastrointestinal Endoscopy (ESGE) brought together leading European and international experts to formulate an evidence and consensus based guideline for colonoscopic polypectomy and Endoscopic Mucosal Resection (EMR) [9]. Many of the concepts described in this chapter are based on those guidelines, with the addition of practical insights gleaned from our own polypectomy experience.

The increasing availability of High-Definition White Light Endoscopy (HD-WLE) and access to advanced endoscopic imaging modalities such as Narrow Band Imaging (NBI) have greatly enhanced our ability to inspect polyps and distinguish between those that are clearly not malignant and are therefore endoscopically resectable; those that are clearly malignant with likely at least deep submucosal invasion and are therefore not endoscopically resectable; and those with suspected early or superficial submucosal invasion that may be amenable to expert advanced endoscopic resection techniques such as EMR or ESD (Endoscopic

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Submucosal Dissection), or alternatively surgery, depending on local availability and experience. There is increasing recognition of the critical role that this careful visual inspection plays in determining the appropriate therapeutic intervention. This is because the approach to polypectomy varies significantly depending on the conclusions reached during inspection. While many of us still struggle to confidently make definitive optical diagnoses, we should all endeavour to enhance our knowledge and understanding of visual polyp assessment to enable us to classify the polyps we encounter into one of these three categories.

Lesions that clearly contain deep, invasive malignancy, as evidenced by ulceration, excavation and deep demarcated depression should not be attempted for polypectomy, because staging for metastatic disease is required, prior to determining the appropriate therapy. Where there are no signs of metastases, surgical therapy is required for polyps with deep invasion. Surgery is the only modality that enables removal of the surrounding draining lymph nodes in addition to the primary lesion, which is necessary if the therapy is to be curative. Lesions with suspected early or superficial submucosal invasion are generally recommended to be referred to expert centres.

Fortunately, most polyps are small and not malignant, and are therefore amenable to polypectomy by all colonoscopists. In this chapter, we discuss a standardized approach to polypectomy. In particular, we will focus on sessile polyps sized <20 mm and pedunculated polyps. We will not address polypectomy for sessile polyps sized ≥20 mm, as these generally require EMR for complete and safe excision. EMR is discussed in the following chapter of this issue.

The key trends in contemporary polypectomy practice are:

- the use of cold snare polypectomy (CSP) for sessile polyps sized <10 mm
- the use of hot snare polypectomy (HSP) following submucosal injection for sessile polyps sized 10–19 mm
- the use of piecemeal cold snare polypectomy (PCSP), with or without prior submucosal injection, for select sessile polyps sized 10–19 mm, where the potential risk for an adverse event is thought to be high (e.g. polyps in the caecum or ascending colon, or patients with increased risk of post-polypectomy bleeding) and where the risk of submucosal invasion is thought to be low, on polyp assessment
- avoidance of hot biopsy forceps (HBF)
- limiting the use of cold biopsy forceps (CBF) to only the very smallest of diminutive polyps in circumstances where snare resection is not feasible.
- mechanical haemostasis prior to polypectomy for large pedunculated polyps

Diminutive sessile polyps (sized ≤5 mm)

Diminutive polyps are defined as being 1–5 mm in size, and represent the majority of colorectal polyps. 90% of polyps encountered during colonoscopy are sized <10 mm, and of these, 10% are sized 6–9 mm, with the remaining 90% being diminutive [10,11]. Effectively, this means that approximately 80% of all polyps encountered during colonoscopy are within the diminutive size range. Cold snare polypectomy (CSP) en-bloc is now the preferred technique for the removal of diminutive polyps. It is exceedingly uncommon for polyps in this diminutive size range to contain malignancy. CSP has the advantages of achieving complete polypectomy, combined with very low rates of adverse events. When performed correctly, there is no risk of perforation, nor of post-polypectomy syndrome. Minor ooze of blood following CSP is frequently apparent, but nearly always ceases spontaneously within seconds, and does not require intervention. In our experience, the requirement for intervention for intra-procedural bleeding following CSP is exceedingly rare. Studies have shown that the rate of delayed bleeding following CSP is significantly lower than following hot snare polypectomy (HSP) [12]. In our experience, post-procedural bleeding following CSP is also exceedingly rare.

Wherever possible, CSP should be performed with a dedicated cold snare. This type of snare is usually characterised by a stiff, thin, monofilament wire that facilitates transection through the tissue. It is important to orient the polyp in the 6 o'clock position whenever possible. The snare is pushed down firmly onto the mucosa, taking care to deliberately grasp a clear rim of normal tissue circumferentially around the polyp. Air may be suctioned while closing the snare, to enhance tissue capture. Polyps in this diminutive size range will usually be completely and easily resected by a cold snare.

Once the polyp has been completely excised, it is important to retrieve the polyp for histological analysis. Some dedicated cold snares have the additional advantage of being sufficiently narrow within the working channel of the colonoscope, such that there is room for the resected polyp to be suctioned through the scope, alongside the snare, for retrieval. This leads to significant efficiency gains, because there is no need to remove the snare after each polypectomy to enable polyp retrieval. The combination of a high prevalence of diminutive polyps and the safety benefits of CSP, has resulted in very high rates of cold snare use in our colonoscopy practice. In fact, we now often complete entire colonoscopy lists where CSP was the only modality used.

Cold Biopsy Forceps (CBF) are a safe method for removal of diminutive polyps, but can no longer be recommended due to high rates of incomplete polypectomy. In a prospective study of 52 patients with diminutive polyps that were removed by CBF until no residual polyp tissue was visible, the polypectomy sites were then excised by EMR. The EMR histology showed that only 39% of the polyps were completely resected using CBF [13]. In comparison with CBF, CSP has high rates of complete resection, adequate tissue sampling for histology and low complication rates [9]. In a randomised controlled trial (RCT) that included 117 diminutive polyps sized <5 mm in 52 consecutive patients, the rate of histologic eradication was significantly higher in the CSP group than in the cold biopsy forceps (CBF) group (93% vs. 76%, P=0.009). Furthermore, the time taken for polypectomy was significantly shorter in the CSP group (14 s vs. 22 s, $P < 0.001$) [14]. In another RCT of 145 polyps sized <7 mm, the complete resection rate for adenomatous polyps was significantly higher in the CSP group compared with the CBF group (96.6% vs 82.6%; $P = 0.01$) [15].

The use of CBF for polypectomy should be limited to cases where attempts at CSP have been unsuccessful or thought to be unsuitable. In our experience, this occasionally occurs when the polyp is located at the 9–11 o'clock position, and the colonic anatomy is such that it is not possible to re-orientate the polyp to the 6 o'clock position for snare resection. In these cases, CBF may be used as a last resort. However, careful attention will be required to ensure that there is no residual polyp at the conclusion of the procedure. Studies have suggested that complete polyp resection is possible using CBF, for the smallest of diminutive polyps, i.e. polyps sized 1–3 mm [16]. In a study of CBF excision of 86 diminutive polyps, the complete resection rate was 92% for all diminutive adenomas (95%CI 85.8–98.8%) and 100% for 1–3 mm adenomas (95%CI 81.5–100%) [16].

Hot biopsy forceps (HBF) were previously popular at many centres for removal of polyps in this diminutive size range. However, in our opinion, the use of HBF should be disallowed for standard polypectomy. The reasons for this are high rates of

incomplete resection, inadequate tissue sampling for histology and unacceptably high risks of adverse events such as deep thermal injury and delayed bleeding, in comparison with snare excision [9]. Studies show incomplete resection rates ranging between 10 and 17% with HBF used for diminutive adenomas [17,18]. Furthermore, the overall diagnostic quality of specimens removed by HBF was shown to be inferior to those removed by jumbo CBF in a prospective study (80% vs 96%; $p < 0.001$). Of the HBF specimens in this study, 92% demonstrated cautery damage or crush artefact [19]. In a retrospective study of 1964 diminutive polyps, the risk of significant haemorrhage with HBF was 0.4% overall, with the risk highest in the right colon (1.3% in caecum and 1.0% in the ascending colon) [20]. High rates (32%–44%) of transmural colonic injury were demonstrated with HBF in animal studies [21,22].

Small polyps sized 6–9 mm

En-bloc snare polypectomy is the technique of choice for small polyps sized 6–9 mm. CSP has a superior safety profile compared with HSP, therefore, it is increasingly preferred over HSP [9]. This is despite a lack of evidence for greater efficacy of CSP compared to HSP. The safety advantages of CSP over HSP are due to the absence of electrocautery during polypectomy, resulting in reduced risks of clinically significant bleeding, perforation or post-polypectomy syndrome. In a prospective multi-centre study that included 193 polyps sized 6–9 mm that were resected via CSP, there were no instances of delayed post-polypectomy bleeding [23]. A randomised trial of HSP vs CSP for polyps up to 10 mm in size in 70 anticoagulated patients found that HSP had significantly higher rates of intra-procedural bleeding (23% vs. 5.7%, $p = 0.042$) and post-procedural bleeding requiring haemostasis (14% vs. 0%; $p = 0.027$) [12]. Although CSP may result in higher rates of intra-procedural bleeding compared to HSP [24], in our experience the bleeding is nearly always a minor ooze of blood from the polypectomy that settles spontaneously within seconds, and is therefore of no clinical significance. A randomised study of 80 patients with polyp size $\leq$8 mm, showed that neither CSP nor HSP resulted in bleeding requiring haemostasis measures, however, post-procedure abdominal symptoms were more common in the HSP group (20.0% vs. 2.5%; $p = 0.029$) [25]. Furthermore, studies have shown that CSP confers a significantly shorter procedure time compared with HSP [25]. CSP has also been shown to achieve equivalent rates of complete polyp retrieval compared with HSP [12]. Therefore, when CSP is used with the appropriate technique as previously described (placing the snare firmly down onto the mucosa while ensuring a rim of normal tissue), high rates of complete polyp resection and retrieval can be safely achieved.

With increasing polyp size (approaching 8–9 mm), the colonoscopist may encounter difficulty in quickly transecting through the polyp base with a single closure of the cold snare. This is because the cold snare may stall on the "bunched-up" or contracted submucosa beneath the polyp. This should not be a cause for concern, as a number of techniques may be safely used to overcome this obstacle. Usually, keeping the snare closed and placing the snare device under mild tension while completely straightening the snare sheath outside the scope (i.e. between the scope channel and the assistant's hand) is helpful. This is achieved by the assistant pulling back on the still-closed snare handle, while the colonoscopist secures the snare at the entry point to the working channel of the colonoscope. This technique frequently provides the additional mechanical advantage for the snare to cut through the remaining submucosal tissue. If this is not effective, we then gently pull the still-closed snare into the colonoscope working channel, which usually results in transection through the remaining submucosa. If this is still not effective, we then open the snare and reposition it slightly higher on the "pseudostalk" that has formed from the contracted submucosa, before closing the snare again. In the uncommon scenario where these measures are not successful, the snare may be opened and released from the polyp, and then polypectomy performed in two pieces. This sequence of strategies is ultimately always successful. Therefore, we recommend against changing over to HSP, as there is a risk of causing deep mural injury and perforation if electrocautery is used to resect through the condensed submucosa.

It is important for colonoscopists to appreciate the significance of the residual "pseudostalk" that is sometimes evident after CSP. The pseudostalk has also been termed a cold snare defect protrusion (CSDP) and was associated with polyps sized $\geq$6 mm in a prospective study [26]. Systematic biopsies of the CSDP proved that this tissue contained bland submucosa or muscularis mucosa only and does not represent vascular structures nor residual polyp [26]. Therefore, there is no need to attempt resection of this residual CSDP tissue.

Sessile polyps sized 10–19 mm

All polyps sized >10 mm should be carefully inspected with advanced endoscopic imaging, if available, to assess for features suggestive of malignancy/submucosal invasion as detailed earlier in this article. This is significantly more important in this size range compared with smaller polyps, as the risk of malignancy is higher. The current standard of care for polypectomy in this size range is HSP. However, there is limited data comparing HSP to other techniques in this setting. The advantage of HSP in this size range is that en-bloc resection can be achieved, whereas this is usually not possible with CSP in this size range. The possibility of achieving en bloc complete resection is also enhanced if submucosal injection is used prior to HSP. A randomised study of polypectomy for sessile polyps sized 10–25 mm found that the rate of complete resection was significantly higher with submucosal injection followed by HSP in comparison to HSP alone (89% vs 73%, $p = 0.002$) [27]. Further subgroup analysis found that complete resection rates were similar between the two groups for polyps sized up to 14 mm (93% vs 90%). However, polyps sized $\geq$15 mm had higher rates of complete resection when submucosal injection was used prior to HSP (90% vs 76%) [27]. Although current evidence only supports submucosal injection prior to HSP for polyps sized $\geq$15 mm, in order to standardise our polypectomy practice, we prefer to use submucosal injection prior to HSP for polyps in the 10–14 mm size range as well. As a result, since we resect sessile polyps sized <10 mm with CSP, and sessile polyps $\geq$10 mm by submucosal injection followed by HSP, it is very uncommon for any sessile polyps to be resected by HSP without prior submucosal injection in our colonoscopy practice.

It is worth noting that the terms EMR and "lift-polypectomy" refer to the same technique, which is submucosal injection followed by snare resection. We generally find that colonoscopists use the term "EMR" when describing resection of large polyps (e.g. sized $\geq$20 mm) and the term "lift-polypectomy" when describing smaller polyps. However, the distinction is arbitrary, and many authors use "EMR" to describe submucosal injection followed by snare resection, even for smaller polyps that are <20 mm in size.

There are multiple advantages to the use of submucosal injection that require explanation:

1. Submucosal injection provides a safety cushion that protects against electrocautery injury to the underlying muscularis propria layer. Therefore, this cushion potentially reduces the risk of immediate or delayed perforation or post-polypectomy syndrome.

2. The submucosal cushion facilitates en-bloc resection by elevating the sessile polyp into a more favourable morphology for the snare to grip below the adenomatous tissue.
3. Dyes such as indigo carmine or methylene blue may be added to the submucosal injectate, which has two benefits:
   a) It facilitates identification of the margins of subtle lesions, such as non-granular polyps or sessile serrated adenomas (SSA). This makes it more likely that complete resection will be achieved. We know from the "CARE" study that the rates of incomplete resection with HSP are significantly higher for polyps sized 10–20 mm compared to smaller polyps (17.3% vs 6.8%; P = 0.003) [8]. This issue is magnified when assessing the rates of incomplete resection of SSAs, for which the rates of incomplete resection were as high as 47.6% for SSAs sized 10–20 mm in the CARE study [8]. A recent study showed that this outcome can be significantly improved by using submucosal injection followed by HSP (i.e. EMR technique) [28]. A total of 199 patients were studied, with a median size of SSA/P of 15 mm. The recurrence rate was only 3.6% when this approach was used [28], making a strong argument that this should be adopted as the standard of care.
   b) The dye is taken up by the submucosal layer, so that any area of non-uptake of dye that is seen after HSP, may potentially indicate the presence of a "mirror target sign". This suggests that there is a "target sign" on the underside of the resected polyp specimen, which indicates at least partial resection of the muscularis propria layer [29]. It is critical to identify this defect and close it with endoscopic clips to prevent progression to complete perforation. Without the dye, this subtle injury is much harder to identify and repair.
4. Dilute adrenaline (epinephrine) may also be added to the submucosal injectate. We use a concentration of 1:100,000. Although this will not prevent delayed post-polypectomy bleeding, it can help reduce the risk of intra-procedural bleeding during polypectomy. The absence of bleeding at the polypectomy site may facilitate more comprehensive inspection of the polypectomy margins for completeness of resection. We know from the large, prospective, multicentre Australian Colonic EMR (ACE) study of sessile polyps sized ≥20 mm that intra-procedural bleeding is a risk factor for polyp recurrence at surveillance colonoscopy [30]. Since bleeding was always successfully managed endoscopically in the EMR cases, we postulated that the mechanism for recurrence was unrecognised residual adenoma at the index resection due to visual interference caused by the intra-procedural bleeding [30]. Although there is no such evidence yet for this phenomenon in polyps sized 10–19 mm, there is little downside to the inclusion of inexpensive dilute adrenaline in the submucosal injectate. Furthermore, this serves to standardise our approach when using colonic submucosal injection, as dilute adrenaline at this same concentration is used in our submucosal injectate for EMR of large sessile polyps sized ≥20 mm. Having a standardised preparation minimises the potential for errors. However, in the absence of evidence in this size range, we recognise that the use of adrenaline in the injectate is at the discretion of the colonoscopist.

There is not yet definitive evidence for the optimal choice for the main constituent of submucosal injectate for polypectomy [31]. We use succinylated gelatin (Gelofusine) based on our own studies, where it was associated with better outcomes than normal saline in EMR of polyps sized ≥20 mm [32,33]. Other commonly used injectates include normal saline, sodium hyaluronate and hydroxyethyl starch [31]. The choice of submucosal injection used may influence outcomes of HSP, even for polyps of this size. In a RCT, 196 patients with polyps sized <20 mm were randomised to undergo EMR following submucosal injection with either hyaluronic acid (HA) or normal saline (NS). Complete resection was achieved in 79.5% of polyps in the HA group and 65.6% of polyps in the NS group ($p < 0.05$) [34].

Although en-bloc resection is usually not possible with CSP for polyps sized 10–19 mm, piecemeal cold snare polypectomy (PCSP) may have an increasingly valuable role in this setting. In a retrospective study that evaluated PCSP outcomes in sessile polyps sized >10 mm, 30 sessile polyps sized ≥10 mm were analysed, of which 15 were sized between 10 and 20 mm. There were no adverse events (delayed bleeding, post-polypectomy syndrome nor perforation), and the polyps were all retrieved [35]. The safety of PCSP was evaluated in a prospective study of 124 patients, where 43 of the 171 sessile polyps excised were sized between 10 and 19 mm. There were no adverse events in the entire cohort [36].

PCSP has therefore been shown to be safe, likely due to the absence of electrocautery from the polypectomy process. However, further prospective studies are required to more thoroughly determine the efficacy of PCSP for completeness of resection and recurrence rates. In our experience, PCSP is particularly effective for resection of sessile serrated adenomas (SSA) in this size range, as these polyps are usually non-dysplastic, flat, non-bulky and therefore are particularly suited to effective resection by PCSP. SSA are often very subtle and the distinction between SSA and normal surrounding mucosa is not always easy to determine. Since PCSP is safe, it lends itself to the ability to widely excise the margins of the polypectomy site, to ensure complete resection (see Fig. 1).

However, during PCSP, there is a tendency to attempt to grasp larger pieces of tissue to reduce the total number of resections required, and therefore make the polypectomy more efficient. Unfortunately, this may result in the opposite effect, with the snare stalling on the bunched-up submucosa. To avoid this, using submucosal (SM) injection prior to PCSP can be very helpful. In our experience, SM injection expands the submucosa, reducing its density, and thereby facilitates cold snare resection through larger specimens without stalling. This is an additional benefit of SM injection beyond the multiple advantages of the use of SM injection outlined previously in this article. Prospective or randomised studies are required to determine if there is truly a benefit of SM injection for PCSP within this size range.

For those who prefer not to use SM injection prior to PCSP, an alternative strategy is to make use of the foot pump controlled water jet function that is available with later model colonoscopes. After performing the first CSP without SM injection, the water jet is used to irrigate the polypectomy site. This causes expansion of the submucosa at the CSP site, and with continued irrigation, results in spread of the irrigated water beneath the lateral margins of the first CSP site. This may result in a similar effect to SM injection with the needle. Once again, the optimal approach requires further study. However, a very recent retrospective study suggests that our technique of SM injection followed by PCSP may be a very promising approach [37]. This study included 73 patients with 94 non-pedunculated colonic polyps sized >10 mm (size range 12–60 mm, median size 20 mm), that were managed by submucosal injection to lift the polyp, followed by PCSP. Residual/recurrent adenoma was detected in only 9.7% of cases at surveillance colonoscopy. There were no adverse events among all patients. The original polyp size was significantly greater in those found to have residual/recurrent adenoma (37 mm vs 19 mm, $p < 0.0001$) [37]. This implies that SM injection followed by PCSP is both safe and highly effective for sessile polyps sized 10–19 mm. These outcomes for completeness of resection exceed those described for HSP in the CARE study for 10–19 mm sized polyps [8]. Since there are significant safety advantages conferred by PCSP, it is important that

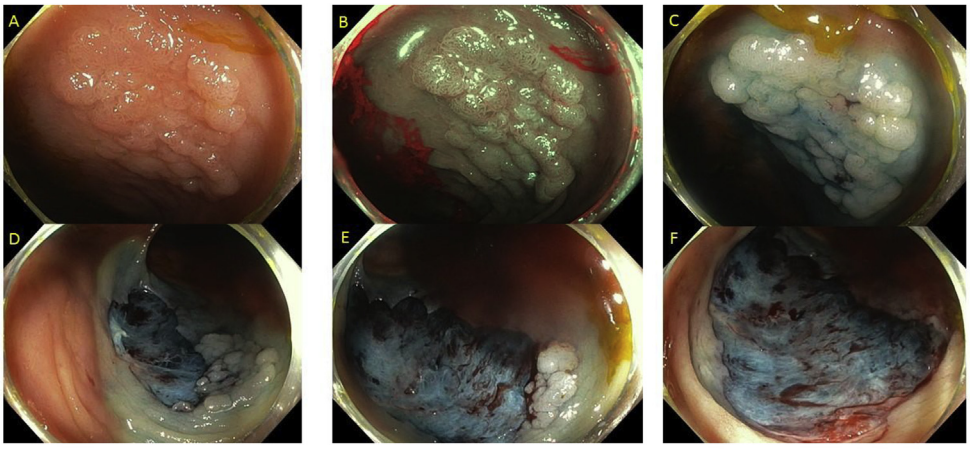

Fig. 1. This is an example of a 15 mm sized, Paris classification 0–IIa granular polyp, in the ascending colon of an elderly patient. It was successfully removed by submucosal injection followed by piecemeal cold snare polypectomy (PCSP). There was no adverse event. The histology was tubular adenoma with low grade dysplasia. A] High-Definition White Light view of ascending colon polyp B]Narrow Band Imaging (NBI) view of polyp C] polyp elevated with submucosal injection D] Appearance following partial PCSP E] Appearance following further PCSP F] Appearance following wide and complete PCSP.

future studies are designed to establish the optimal technique for sessile polyps in this size range.

Pedunculated polyps

HSP is the preferred technique for pedunculated polyps, and most pedunculated polyps are easily and safely removed with this technique. It is important to close the snare around the stalk of the polyp, taking care to ensure a clear margin from the adenomatous polyp head, to be confident of complete resection. However, it is also important not to position the snare too close to the colonic wall, so as to reduce the risk of deep thermal injury. The optimal electrocautery settings for resection of pedunculated polyps are not defined. We use the same microprocessor controlled "Endocut" setting (on our ERBE generator), that we use for resection of sessile polyps. Similar settings are available for other manufacturers. Some colonoscopists prefer to use a forced coagulation setting for resection of pedunculated polyps, in order to reduce the risk of immediate post-polypectomy bleeding (PPB). However, this does result in greater delivery of thermal energy, and therefore care must be taken to tent the closed snare away from the colonic wall prior to applying current, to reduce the risk of deep thermal injury.

Our practice is to apply prophylactic haemostatic measures prior to HSP to reduce the risk of both immediate and delayed PPB. This is particularly relevant for large pedunculated polyps that frequently have a large blood vessel supplying the polyp head via the stalk, and therefore are at increased risk of PPB [38]. Studies have shown that polyp size >10 mm, stalk diameter >5 mm, polyp location in the right colon and the presence of malignancy within the polyp are risk factors for PPB [9,38–41]. Mechanical haemostasis with endoloop or endoscopic clips, and pharmacological intervention with injection of dilute adrenaline are effective for reducing PPB in pedunculated polyps sized >10 mm, with the greatest benefit observed in polyps sized ≥20 mm [9,42,43]. Injection of the polyp stalk with 1:10,000 adrenaline prior to polypectomy has been shown to reduce PPB compared to no intervention ($p < 0.05$) [42,44]. However, in a different randomised controlled trial of adrenaline versus normal saline injection before polypectomy for polyps sized ≥10 mm, the lower rates of bleeding with adrenaline did not reach statistical significance [45]. Mechanical prophylaxis such as endoloops or endoscopic clips may be superior to adrenaline injections in achieving haemostasis [9]. The use of mechanical devices for pre-treatment of the stalk in large pedunculated polyps sized ≥20 mm, alone or in combination with adrenaline injection, significantly decreased PPB compared to adrenaline injection alone [46,47]. Therefore, the current recommendations from the recent ESGE guidelines are that dilute adrenaline injection and/or mechanical haemostasis should be used for prophylaxis of PPB for pedunculated colorectal polyps with head ≥2 cm or stalk ≥1 cm in diameter [9].

It is possible to apply these treatments either before or after HSP, and multiple approaches can legitimately be used. The options include:

1. Place an endoloop tightly around the base of the stalk prior to HSP. The advantages of this approach are that haemostasis can be confidently assured, and the endoloop falls off spontaneously in the days or weeks following polypectomy, leaving a clean based resection site that can be easily inspected at surveillance colonoscopy. This is in contrast to clips, that often remain in-situ or leave behind mucosal clip induced artefacts. Clip induced artefacts must be carefully inspected to distinguish them from residual adenoma. One disadvantage of this endoloop approach is that the endoloop is floppy and therefore sometimes difficult to manoeuvre over the head of a large polyp, and to secure at the stalk base. It also requires a thorough understanding by the endoscopist and the assistant as to how the endoloop is operated and deployed, to prevent mal-deployment. The most common error is for the endoloop to be deployed loosely, such that haemostasis is not actually achieved. If the endoloop is applied correctly, the polyp head will very quickly be rendered ischaemic and this is visible as a change in polyp colour to dark purple. Once the endoloop is applied and the polyp is observed to become ischaemic, care must be taken to position the snare above the closed endoloop, but below the adenomatous polyp head. This ensures complete resection without disrupting the haemostatic measure. The application of endoloops prior to HSP is our preferred approach for very large pedunculated polyps.
2. Apply one or more endoscopic clips at the base of the stalk prior to polypectomy. The main advantage of this approach is that endoscopic clips are usually easy to deploy. The disadvantages of this approach include multiple clips often being required to achieve haemostasis of large stalks, and indeed may not be feasible for some particularly large polyps, as the endoscopic clips may not be of a sufficient size to secure the stalk, even when multiple clips are applied. Other disadvantages include

retained clips and the need to distinguish between clip related artefact and residual polyp at surveillance colonoscopy.

3. Inject the stalk base with 1:10,000 adrenaline. This shrinks the polyp, and reduces blood flow to the polyp head, and may then be followed by HSP. A variation of this approach, which is our practice, is to use our standardised SM injectate instead of adrenaline alone. This continues our theme of reduction of error by standardising the injectate across all polyps where SM injection is used, and also has the benefit of expanding the stalk base, thereby providing a safety cushion for HSP. Even though this is less critical for pedunculated polyps compared with sessile polyps, in our experience it does increase the likelihood of a complete resection that is well clear of the adenomatous polyp head, but does not risk electrocautery injury to the colonic wall. This approach is particularly helpful for pedunculated polyps with thick, but short, polyp stalks. Following HSP, clips may then be applied to the resected base to prevent PPB.
4. HSP followed by clip deployment at the base of the resected polyp. This is a very straightforward approach, but is associated with a risk of immediate intra-procedural bleeding that can occasionally be difficult to control. This is particularly the case for large pedunculated polyps where immediate PPB may quickly fill the colonic lumen with blood, and vision may be lost, especially in parts of the sigmoid colon where the lumen may be narrow and angulated. This is our least preferred option, as we believe that the other measures that achieve haemostasis before HSP, involve less risk.

It is also important to identify patients at high risk of PPB, even when the polyp would not be deemed particularly high risk, based on polyp criteria alone. For example, patients on anticoagulation or requiring prompt recommencement of anticoagulation, patients with coagulopathy, chronic liver disease, renal impairment or thrombocytopenia may benefit from prophylactic mechanical haemostasis. This should be considered for individual patients on a case-by-case basis, independent of the size of the resected polyp.

Conclusions

The goals of polypectomy are to achieve complete and safe polyp resection, and retrieval of the resected polyp for histological analysis. Unfortunately, achieving these outcomes is not always straightforward. There are a wide variety of approaches to polypectomy as a result of our apprenticeship style training model for colonoscopy and polypectomy. This has resulted in colonoscopy and polypectomy often being less effective than desired, with incomplete polypectomy remaining a significant concern. Fortunately, we are now able to move towards a standardised approach towards polypectomy technique, based on the emerging body of international evidence in this field. We now have a far better understanding of the advantages and disadvantages of the various polypectomy techniques, and have achieved greater clarity regarding how they may be applied to achieve safe and effective polypectomy for the range of polyp sizes and morphologies.

In this chapter, we discussed a standardised approach towards polypectomy for sessile polyps sized up to 19 mm, as well as for pedunculated polyps. In addition, we offered practical insights from our own colonoscopy experience, that may help colonoscopists to successfully negotiate commonly encountered challenges during polypectomy. In our opinion, the main principles of modern standardised polypectomy technique are the use of CSP for diminutive (1–5 mm) and small (6–9 mm) sessile polyps, the use of HSP (ideally with prior SM injection) for intermediate sized (10–19 mm) sessile polyps, the avoidance of hot biopsy forceps, limiting the use of cold biopsy forceps to only the smallest of diminutive polyps where snare polypectomy is not feasible, and the use of prophylactic haemostatic measures prior to HSP for large pedunculated polyps, particularly those with a polyp head sized $\geq$20 mm or a stalk sized $\geq$10 mm. We believe that the future will herald an increasingly recognised role for piecemeal cold snare polypectomy for intermediate sized sessile polyps, and especially for resection of SSA. However, well-designed prospective or randomised trials are required to determine if the substantial safety advantages of CSP are achieved without compromising efficacy, as determined by completeness of resection and the absence of residual polyp at surveillance colonoscopy.

Conflicts of interest

None.

Practice points

Key practice points for a standardised approach to polypectomy for sessile colorectal polyps sized <20 mm and for pedunculated polyps are:

- the use of cold snare polypectomy (CSP) for sessile polyps sized <10 mm
- the use of hot snare polypectomy (HSP) following submucosal injection for sessile polyps sized 10–19 mm
- the use of piecemeal cold snare polypectomy (PCSP), with or without prior submucosal injection, for select sessile polyps sized 10–19 mm, where the potential risk for an adverse event is thought to be high (e.g. polyps in the caecum or ascending colon, or patients with increased risk of post-polypectomy bleeding) and where the risk of submucosal invasion is thought to be low, on polyp assessment.
- avoidance of hot biopsy forceps (HBF)
- limiting the use of cold biopsy forceps (CBF) to only the very smallest of diminutive polyps in circumstances where snare resection is not feasible.
- mechanical haemostasis prior to polypectomy for large pedunculated polyps

Research agenda

Potential topics for further research in the field of polypectomy for sessile polyps sized <20 mm are:

- The efficacy of piecemeal cold snare polypectomy (PCSP) for sessile polyps sized 10–19 mm. Is this technique as effective as hot snare polypectomy in terms of completeness of resection and polyp recurrence rates? Does the enhanced safety of cold snare polypectomy come at a cost of less effective polyp removal than hot snare polypectomy? Is PCSP more effective for SSA/Ps than for conventional adenomas in this size range, or equally effective for all sessile polyps?
- The role for submucosal injection prior to polypectomy of sessile polyps sized 10–19 mm. Is there a safety or efficacy benefit for submucosal injection? This question is relevant to both hot snare polypectomy and piecemeal cold snare polypectomy techniques.

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