

# Safety of endoscopic mucosal resection of large colonic polyps in elderly patients: a systematic review and meta-analysis

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## Abstract

**Background** Endoscopic mucosal resection (EMR) is a procedure commonly used for large sessile and flat polyps. However, it may cause bleeding, perforation, and complications related to anesthesia. There are limited data on the safety and efficacy of EMR in the elderly. Therefore, we conducted a comprehensive review and meta-analysis to assess EMR safety in elderly patients.

**Methods** We searched MEDLINE, Embase, Cochrane Central Register of Controlled Trials, and Web of Science Core Collection for studies evaluating EMR for large colorectal lesions (>20 mm) in older patients (75+ years). Our primary result was post-polypectomy bleeding and perforation, while our secondary outcome was recurrence or residual polyp.

**Results** The meta-analysis included 6 studies with 2903 patients. The rate of post-polypectomy bleeding was 5.3% (95% confidence interval [CI] 2.3-11.7%),  $I^2=73.7\%$ ; and perforation was 1.9% (95%CI 0.9-3.8%),  $I^2=0\%$ , in patients over 75 years old. The pooled risk of post-polypectomy bleeding was 2.4%, 95%CI 1.2-4.8%,  $I^2=0\%$ ; and perforation was 2.1%, 95%CI 0.7-5.8%,  $I^2=8.6\%$ , in patients over 80 years old. The risk of post-polypectomy bleeding (odds ratio [OR] 0.922, 95%CI 0.359-2.367,  $I^2=0\%$ ); and perforation (OR 1.066, 95%CI 0.188-6.031,  $I^2=0\%$ ) did not differ significantly between patients aged over 80 and younger patients. The pooled rate of residual or recurrence of polyps in patients aged over 80 was significantly higher (25%, 95%CI 17-35.3%,  $I^2=59.5\%$ ) vs. younger patients (OR 2.234, 95%CI 1.549-3.223,  $I^2=0\%$ ).

**Conclusion** EMR is as safe for the elderly as it is for younger patients, and is not associated with a greater risk of bleeding or perforation.

**Keywords** Colorectal cancer, endoscopic mucosal resection, polypectomy, elderly

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## Introduction

Colorectal cancer (CRC) is the most common cancer of the gastrointestinal tract. In the year 2020, it was estimated

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that there were more than 1.9 million new cases of CRC occurring globally, while 935,000 deaths were attributed to CRC, representing about 1 in 10 cancer cases and deaths. Overall, CRC ranked third in terms of cancer incidence, but second in terms of cancer mortality in 2020 [1]. The incidence of CRC increases rapidly with age, with rates of 90.2 per 100,000 population in individuals aged 60-64 years, 121.4 per 100,000 population in people aged between 65 and 69, while for those aged 85 years and older, the rate is as high as 258.8 per 100,000 population [2]. Most commonly, CRC arises from pre-cancerous polyps that transform into CRC over time [3]. The prevalence of adenomas also increases with age [4], and the transformation of adenomas to CRC occurs more rapidly in elderly patients [5], probably secondary to accumulated mutations. The size of the polyps is an independent predictive factor for dysplasia, with larger polyps having a higher risk of advanced dysplasia and CRC [6]. Therefore, elderly people with large size polyps are a population that has a high risk of developing CRC.

Early colorectal polyp detection and resection are necessary to improve the CRC survival rate [7]. Small adenomas can be completely removed using biopsy forceps, but larger adenomas require snare resection (with or without electrocautery) or advanced endoscopic resection techniques, such as endoscopic mucosal resection (EMR) or endoscopic submucosal dissection (ESD) [8]. Although EMR has been widely used for removing large polyps, there are limited studies regarding its safety in very elderly patients with large polyps. We conducted a systematic review and meta-analysis of the available literature to evaluate the safety and efficacy of EMR in large colorectal lesions (>20 mm) in elderly patients over 75 years of age.

## Materials and methods

We searched the following databases from inception to August 4<sup>th</sup>, 2021: MEDLINE (PubMed), Embase (Embase.com), Cochrane Central Register of Controlled Trials (Wiley Cochrane Library), and Web of Science Core Collection (Clarivate Web of Science). A search strategy combining truncated keyword and subject terminology for endoscopic mucosal resection of large polyps in the elderly was developed for Embase by an experienced health science librarian (WL-S) and the vocabulary and syntax were translated for the remaining databases. We defined a large polyp as  $\geq 20$  mm in size. Database age filters were used when present, and exclusively non-human studies were eliminated. Publication and study type limits were used to exclude editorial materials, commentaries, reviews, guidelines, case reports, and previous systematic reviews and meta-analyses, in order to locate only clinical studies. No language or publication date limits were imposed. Full search terms are available in the Supplementary material. Results were exported to EndNote 20 (Clarivate) and were deduplicated by software algorithms with visual inspection. Data was abstracted by 2 authors (UI and AN) independently. Quality assessment of the studies was performed using the Newcastle-Ottawa quality assessment score, also by 2 authors independently. The quality of the study did not interfere with its inclusion in the meta-analysis. Our primary outcome was to evaluate the risk of polypectomy bleeding and perforation. This meta-analysis was performed in accordance with PRISMA guidelines [9].

## Statistical analysis

The statistical analysis was conducted utilizing Comprehensive meta-analysis software. We used a random-effects model for this meta-analysis, with point estimates,

variance and weights for each study based on the size of the study and the number of events. Pooled rates and odds ratios (OR) with 95% confidence intervals (CI) were calculated for primary and secondary outcomes. The  $I^2$  test was used to evaluate the heterogeneity of the studies. A value of  $I^2$  in the range 0-25% represented insignificant heterogeneity, while >75% represented considerable heterogeneity.

## Results

Our initial search identified 1060 articles, of which 6 observational studies with 2903 patients were included in the meta-analysis [10-15]. Fig. 1 elaborates the systematic literature search of our study. Baseline characteristic of patients, including the size of polyps, their location and histological findings, are reported in Table 1. All studies were rated as good quality. There were 2 studies that compared outcomes of EMR between patients older and younger than 80 years [11,12]. One study reported the outcomes of EMR in patients over 75 years of age, and one reported outcomes in patients over 80 years of age without a comparative group [10,14]. Two studies compared outcomes in patients older and younger than 75 years [13,15].

In patients over 75 years of age, pooled rates (95%CI) for post-polypectomy bleeding were 5.3% (2.3-11.7%),  $I^2=73.7%$ ; and perforation was 1.9% (0.9-3.8%),  $I^2=0%$  (Fig. 2,3). In a subgroup analysis including patients over 80 years of age, the pooled rate (95%CI) of post-polypectomy bleeding was 2.4% (1.2-4.8%),  $I^2=0%$ ; and perforation was 2.1% (0.7-5.8%),  $I^2=18.6%$ . There was no statistically significant difference in the risk of post-polypectomy bleeding (OR 0.922, 95%CI 0.359-2.367,  $I^2=0%$ ) and perforation (OR 1.066, 95%CI 0.188-6.031,  $I^2=0%$ ) between patients over 80 years of age and younger patients. Among patients over 80 years of age who underwent follow-up colonoscopy for surveillance, the pooled rate (95%CI) of residual polyps or recurrent polyps was 25% (17-35.3%),  $I^2=59.5%$ . Rates of residual or recurrent polyps were significantly higher in patients over 80 years of age compared to younger patients (OR 2.234, 95%CI 1.549-3.223,  $I^2=0%$ ). There were 14 deaths reported in the included studies. None was reported to be directly secondary to the procedural complications. Among the reported causes of death, 2 patients under 80 years of age died of colorectal cancer during a median follow up of 32.5 months, while 2 patients died of cardiac causes. There was no publication bias as assessed by funnel plot diagram (Fig. 4).

## Discussion

It is established that endoscopic screening and resections of colorectal polyps decrease the incidence of CRC, and there is a large body of evidence to support the utility of colonoscopy in elderly patients [7,16-18]. Large polyps have a greater risk of harboring invasive carcinoma [6,19]. Resection of large polyps during endoscopy raises a few concerns, including the adverse events related to the procedure and the possibility of inadequate

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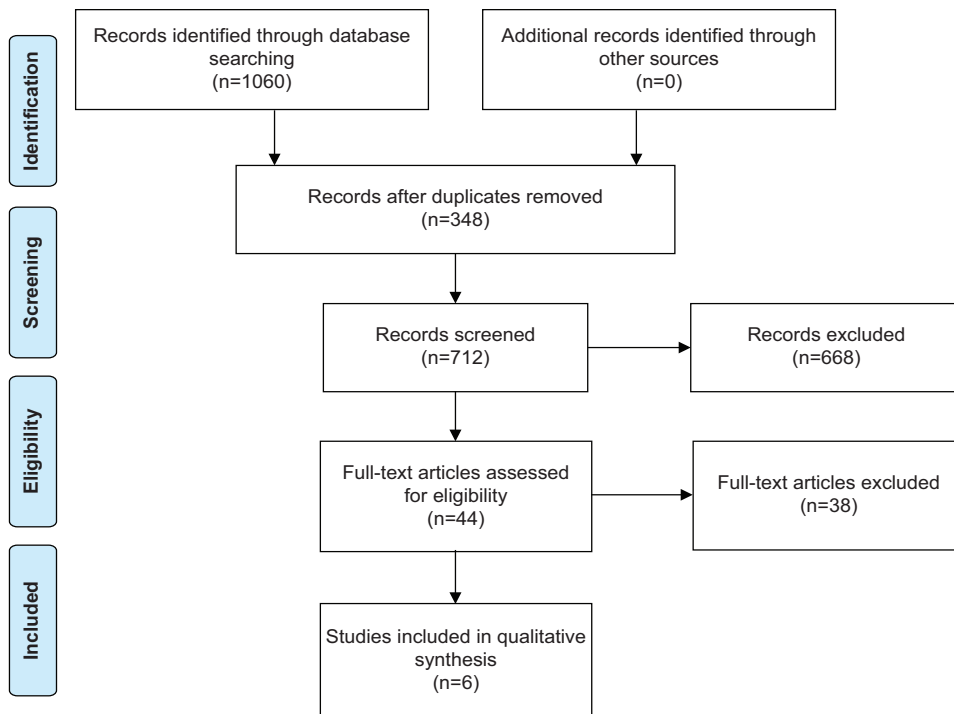


Figure 1 Literature review process

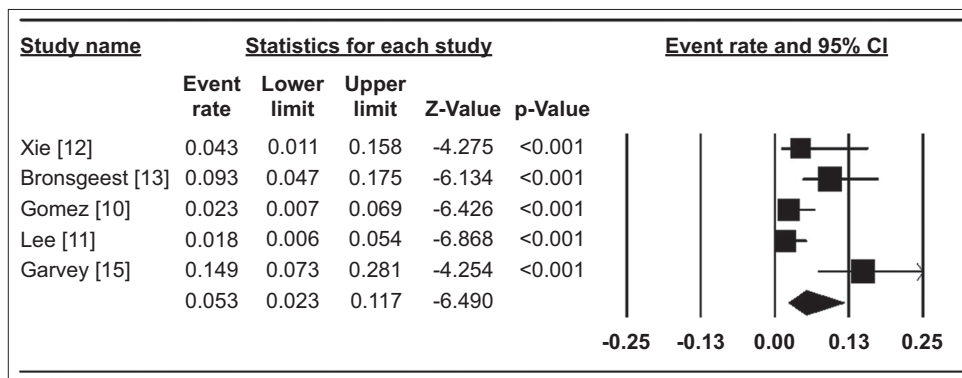


Figure 2 Pooled rate of post-polypectomy bleeding in patients over 75 years of age

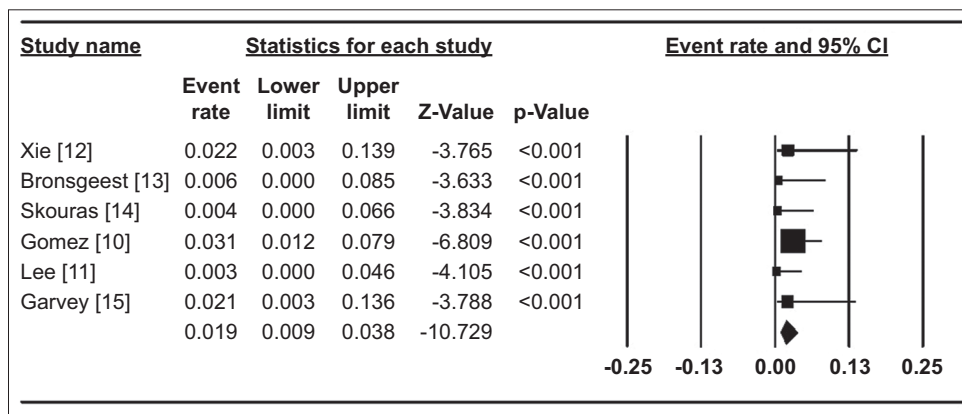


Figure 3 Pooled rate of perforation in patients over 75 years of age

**Table 1** Baseline characteristic of the included studies

Study, year [ref.]	Sample size	Demographics	Polyp size	Pathology	Location of polyps	Adverse events
Gomez <i>et al</i> 2014 [10]	Total=99  >80 years=99	Mean age=84 years (Range: 80-93)  Sex: Male=59 Female=40	Mean size=3.3 cm (range: 2-12.5 cm)	Adenoma/tubulovillous=72.5% Hyperplastic=11.5% Adenocarcinoma=7.6% Hyperplastic serrated/sessile serrated/traditional serrated Adenoma=5.3% Others=3.1%	Right colon=72% Left colon=28%	Bleeding=2.3% Perforation=3.0% Chest pain=1 patient
Xie <i>et al</i> 2016 [12]	Total=339 >80 years=46  <80 years=293	>80 years group Median age=83.5 years (80-91)  Sex: Male=26 Female=20  <80 years group Median age=66 years (26-79)  Sex: Male=160 Female=133	>80 years Median size: 32.5 mm (20-110)  <80 years Median size: 30 mm (20-120)	>80 years Adenoma=64.6% Intramucosal cancer=21.5%  <80 years Submucosal cancer=13.8% Adenoma=71.6% Intramucosal cancer=21.9% Submucosal cancer=6.5%	>80 years Ascending=29.2% Transverse=7.7% Descending=12.3% Sigmoid=38.5% Rectum=12.3%  <80 years Ascending=33.4% Transverse=9% Descending=10.2% Sigmoid=39.2% Rectum=8.2%	>80 years group Delayed bleeding=4.3%  Perforation=2.2%  <80 years group Delayed bleeding=3.1% Perforation=1.7%
Bronsgest <i>et al</i> 2017 [13]	Total=343  >75 years=80  <75 years=263	Mean age=67.4±8.3 years  Sex: Male=201 Female=142	Mean size=32.3±13	Tubular adenoma=372% Tubulovillous adenoma=43.1% Villous adenoma=2.6% Sessile serrated=12.8% Other=4.4% No dysplasia=12.4% Low-grade dysplasia=73.1% High-grade dysplasia=7.3% Intramucosal carcinoma=2.7% Invasive carcinoma=4.4%	Ileocecal valve=2.7% Cecum=13.1% Ascending colon=20.4% Hepatic flexure=9.0% Transverse colon=12.4% Splenic flexure=6.3% Descending colon=3.2% Sigmoid=13.3% Rectosigmoid=3.6% Rectum=16.0%	>75 years group Bleeding: 9.3% Perforations: 0  <75 years group Bleeding: 6.2% Perforation: 1.5%
Skouras <i>et al</i> 2021 [14]	Total=206  >75 years=206 (114 had polyp>20 mm)	Median age=80 years (78-83)  Sex: Male=114 Female=92		Low-grade Dysplasia=71% High-grade=18% Malignancy=7% Hyperplastic=4%	Not reported	Perforation: 0  2 patients died with cardiac causes within 2 months

(Contd...)

Table 1 (Continued)

Study, year [ref.]	Sample size	Demographics	Polyp size	Pathology	Location of polyps	Adverse events
Lee <i>et al</i> 2021 [11]	Total=1853 >80 years=167 <80 years=1686	>80 years group Mean age=83.3±2.7 years Sex: Male=76 Female=91 <80 years group Mean age=63.8±9.1 years Sex: Male=875 Female=811	All polyp s>20 mm in size	>80 years Adenomatous=81.4% Sessile serrated=12.9% Hyperplastic=5.7% <80 years Adenomatous=74.3% Sessile serrated=21.2% Hyperplastic=4.5%	>80 years Left colon=15.2% Transverse colon=27.1% Right colon=57.6% <80 years Left colon=17.3% Transverse colon=21.6% Right colon=61.1%	> 80 years group: Bleeding: 1.8% Perforation: 0 <80 years group Bleeding: 2.5% Perforations: 0.3%
Garvey <i>et al</i> 2021 [15]	Total=155>75 years=108<75 years=47	Not reported	All polyp s>20 mm in size	Not reported	Not reported	>75 years group Bleeding: 14.8% Perforations: 2.1% <75 years group Bleeding: 13.9% Perforation: 0.9%

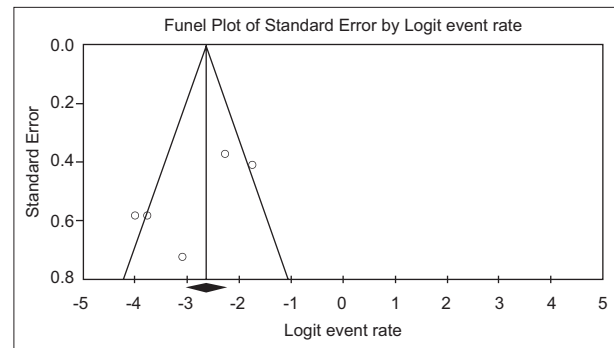


Figure 4 Funnel plot for post-polypectomy bleeding over 75 years of age

resection. Nevertheless, EMR is an effective technique for resection of polyps. It is imperative to consider the safety of EMR in elderly patients with large polyps, as this population has a greater incidence, as well as a higher transformation rate of polyps to dysplasia, but there is also concern regarding adverse events related to the procedure, due to comorbidities, and potential longevity [4,5].

The 2 major complications related to the endoscopic removal of large colon polyps are delayed bleeding and perforation. Studies have reported bleeding rates following EMR of large polyps in the range 2-11% [20-26]. In our meta-analysis, we found that the pooled risk for post-polypectomy bleeding was 5.3% (95%CI 2.3-11.7%) in patients over the age of 75, while the pooled risk for post-polypectomy bleeding in patients over 80 years of age was 2.4% (95%CI 1.2-4.8%). We found no statistically significant difference in post-polypectomy bleeding in patients over 80 years of age compared to the younger population. Bronsgeest *et al* did not find significantly more bleeding complications in elderly patients over 75 years of age, but observed that bleeding complications were more frequently observed when antithrombotic drugs were used, especially in patients who were on dual antiplatelet therapy [13]. Perforation is also one of the most dreaded complications of EMR, as it can result in peritonitis and morbidity. EMR-related perforation has been reported with a rate between 0% and 3% in earlier studies [22,25,27-29]. In our meta-analysis, we found that, in patients over the age of 75, the pooled risk for perforation was 1.9%, whereas in patients over 80 years of age it was 2.1%; again there was no statistically significant difference in the risk of perforation between patients over 80 years of age and the younger population.

The residual polyp or recurrence rate after EMR has been reported in the literature to be between 4% and 40% [20,22,30-35]. In our study this rate was 25% (95%CI 17-35.3%) in patients over 80 years of age. The biggest risk factor for recurrence after EMR is piecemeal resection. It is well documented that *en bloc* resection is associated with a lower residual rate compared to piecemeal resection. Follow-up examination after endoscopic removal of large polyps is essential to decrease recurrence and to detect residual tissue [35-38]. The follow-up timeline is based on the histology and resection method. After piecemeal resection, follow up is usually recommended after 6 months [8]. Gomez *et al* reported



residual polyps in 22 of 70 patients who underwent follow-up colonoscopy. A piecemeal technique was utilized in 20 of 22 patients who had residual polypoid tissue. ESD is associated with a lower rate of recurrence as compared to EMR, but ESD is a labor-intensive and technically difficult procedure associated with a higher perforation rate [39].

Global life expectancy is increasing, and the aging population and the increased implementation of screening programs will lead to a higher rate of detection of large polyps in the elderly population. Surgical removal of adenoma in this population is associated with significant morbidity and mortality [40]. EMR appears to be a safer option, as it is less invasive, usually does not require general anesthesia, and is conducted in an outpatient setting. EMR in the elderly population with large polyps is also not associated with an increased risk of bleeding or perforation. Efforts should be made towards increased surveillance and resection of polyps in the elderly, as it will decrease CRC morbidity and mortality. The role of distal attachment devices has recently attracted growing interest as a means to improve the detection of colonic adenomas. A recent network meta-analysis showed only a modest increase in the rate of detection of colonic adenomas with the use of distal attachment devices, with no device showing any advantage over another [41].

To our knowledge, this is the first systematic review and meta-analysis conducted to evaluate the safety of EMR in elderly patients. There are several strengths to our study. We included all the current studies to date that focused on evaluating the safety of EMR for resection of colonic polyps >20 mm in patients over 75 years of age, and the number of patients included in the final meta-analysis was reasonable to evaluate differences in outcomes. We performed further subgroup analyses to evaluate differences in outcomes in patients over 80 years of age compared to the younger population. However, there are some limitations to our meta-analysis results. All the included studies are non-randomized observational studies that might have included bias in the study results; therefore, large prospective trials are needed to evaluate the safety of EMR in elderly patients. One study was in abstract form and has not yet been published in full [15]. Given the lack of data reporting in all studies, we unable to evaluate differences in the rate of *en bloc* resection in the elderly population compared to younger patients, or to assess differences in all-cause mortality.

In summary, EMR is safe in elderly patients and is not associated with a greater risk of complications compared to the younger population. Our study revealed higher odds of residual polyp in patients over 80 years of age. Therefore, efforts should be made to carry out adequate surveillance of polyps with colonoscopy in these elderly patients, to decrease the morbidity and mortality associated with colorectal cancer. Further larger prospective trials are needed to evaluate the safety of EMR in very elderly patients.

## References

1. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for

## Summary Box

### What is already known:

- The incidence of colorectal cancer (CRC) increases rapidly with age
- Most of the time, CRC arises from precancerous polyps that transform into CRC over time
- The size of the polyps is an independent predictive factor for dysplasia, with larger polyps having a higher risk of advanced dysplasia and CRC
- Endoscopic mucosal resection (EMR) is widely used for removing large polyps

### What the new findings are:

- EMR is safe in older patients for larger colonic polyps
- EMR is not associated with an increased risk of complications of bleeding and perforation in patients >75 years of age compared to younger patients for larger colonic polyps
- There is an increased risk of residual polyps in patients aged over 80 years, which should prompt more comprehensive screening in this patient population

36 cancers in 185 countries. *CA Cancer J Clin* 2021;**71**:209-249.

2. Siegel RL, Miller KD, Goding Sauer A, et al. Colorectal cancer statistics, 2020. *CA Cancer J Clin* 2020;**70**:145-164.
3. Grady WM, Markowitz SD. The molecular pathogenesis of colorectal cancer and its potential application to colorectal cancer screening. *Dig Dis Sci* 2015;**60**:762-772.
4. Corley DA, Jensen CD, Marks AR, et al. Variation of adenoma prevalence by age, sex, race, and colon location in a large population: implications for screening and quality programs. *Clin Gastroenterol Hepatol* 2013;**11**:172-180.
5. Brenner H, Hoffmeister M, Stegmaier C, Brenner G, Altenhofen L, Haug U. Risk of progression of advanced adenomas to colorectal cancer by age and sex: estimates based on 840,149 screening colonoscopies. *Gut* 2007;**56**:1585-1589.
6. Bretagne JF, Manfredi S, Piette C, Hamonic S, Durand G, Riou F. Yield of high-grade dysplasia based on polyp size detected at colonoscopy: a series of 2295 examinations following a positive fecal occult blood test in a population-based study. *Dis Colon Rectum* 2010;**53**:339-345.
7. Winawer SJ, Zauber AG, Ho MN, et al. Prevention of colorectal cancer by colonoscopic polypectomy. The National Polyp Study Workgroup. *N Engl J Med* 1993;**329**:1977-1981.
8. Kaltenbach T, Anderson JC, Burke CA, et al. Endoscopic removal of colorectal lesions-recommendations by the US multi-society task force on colorectal cancer. *Gastrointest Endosc* 2020;**91**:486-519.
9. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med* 2009;**151**:264-269, W64.
10. Gomez V, Racho RG, Woodward TA, et al. Colonic endoscopic mucosal resection of large polyps: Is it safe in the very elderly? *Dig Liver Dis* 2014;**46**:701-705.

11. Lee CJ, Vemulapalli KC, Rex DK. Colorectal EMR outcomes in octogenarians versus younger patients referred for removal of large ( $\geq 20$  mm) nonpedunculated polyps. *Gastrointest Endosc* 2021;**93**:699-703.
12. Xie HQ, Zhong WZ. Outcomes of colonic endoscopic mucosal resection for large polyps in elderly patients. *J Laparoendosc Adv Surg Tech A* 2016;**26**:707-709.
13. Bronsgeest K, Huisman JF, Langers A, et al. Safety of endoscopic mucosal resection (EMR) of large non-pedunculated colorectal adenomas in the elderly. *Int J Colorectal Dis* 2017;**32**:1711-1717.
14. Skouras T, Bond A, Gaglia A, Bonnett L, Jiang Lim M, Sarkar S. Outcomes and adverse factors for endoscopic mucosal resection (EMR) of colorectal polyps in elderly patients. *Frontline Gastroenterol* 2021;**12**:95-101.
15. Garvey T, Hadjinicolaou A, Frank M, Nadesalingam V, McDermott E. Endoscopic mucosal resection (EMR) of colonic polyps in the older patient—is it safe? *Endoscopy* 2021;**53**(Suppl 01):S97.
16. Loffeld RJ, Liberov B, Dekkers PE. Yearly diagnostic yield of colonoscopy in patients age 80 years or older, with a special interest in colorectal cancer. *Geriatr Gerontol Int* 2012;**12**:298-303.
17. Syn WK, Tandon U, Ahmed MM. Colonoscopy in the very elderly is safe and worthwhile. *Age Ageing* 2005;**34**:510-513.
18. Karajeh MA, Sanders DS, Hurlstone DP. Colonoscopy in elderly people is a safe procedure with a high diagnostic yield: a prospective comparative study of 2000 patients. *Endoscopy* 2006;**38**:226-230.
19. Walsh RM, Ackroyd FW, Shellito PC. Endoscopic resection of large sessile colorectal polyps. *Gastrointest Endosc* 1992;**38**:303-309.
20. Arebi N, Swain D, Suzuki N, Fraser C, Price A, Saunders BP. Endoscopic mucosal resection of 161 cases of large sessile or flat colorectal polyps. *Scand J Gastroenterol* 2007;**42**:859-866.
21. Brooker JC, Saunders BP, Shah SG, Thapar CJ, Suzuki N, Williams CB. Treatment with argon plasma coagulation reduces recurrence after piecemeal resection of large sessile colonic polyps: a randomized trial and recommendations. *Gastrointest Endosc* 2002;**55**:371-375.
22. Luigiano C, Consolo P, Scaffidi MG, et al. Endoscopic mucosal resection for large and giant sessile and flat colorectal polyps: a single-center experience with long-term follow-up. *Endoscopy* 2009;**41**:829-835.
23. Saito Y, Fukuzawa M, Matsuda T, et al. Clinical outcome of endoscopic submucosal dissection versus endoscopic mucosal resection of large colorectal tumors as determined by curative resection. *Surg Endosc* 2010;**24**:343-352.
24. Zlatanich J, Wayne JD, Kim PS, Baiocco PJ, Gleim GW. Large sessile colonic adenomas: use of argon plasma coagulator to supplement piecemeal snare polypectomy. *Gastrointest Endosc* 1999;**49**:731-735.
25. Conio M, Repici A, Demarquay JF, Bianchi S, Dumas R, Filiberti R. EMR of large sessile colorectal polyps. *Gastrointest Endosc* 2004;**60**:234-241.
26. Burgess NG, Metz AJ, Williams SJ, et al. Risk factors for intraprocedural and clinically significant delayed bleeding after wide-field endoscopic mucosal resection of large colonic lesions. *Clin Gastroenterol Hepatol* 2014;**12**:651-661.e1-e3.
27. De Ceglie A, Hassan C, Mangiavillano B, et al. Endoscopic mucosal resection and endoscopic submucosal dissection for colorectal lesions: A systematic review. *Crit Rev Oncol Hematol* 2016;**104**:138-155.
28. Ma MX, Bourke MJ. Complications of endoscopic polypectomy, endoscopic mucosal resection and endoscopic submucosal dissection in the colon. *Best Pract Res Clin Gastroenterol* 2016;**30**:749-767.
29. Lee EJ, Lee JB, Lee SH, Youk EG. Endoscopic treatment of large colorectal tumors: comparison of endoscopic mucosal resection, endoscopic mucosal resection-precutting, and endoscopic submucosal dissection. *Surg Endosc* 2012;**26**:2220-2230.
30. Pellise M, Burgess NG, Tutticci N, et al. Endoscopic mucosal resection for large serrated lesions in comparison with adenomas: a prospective multicentre study of 2000 lesions. *Gut* 2017;**66**:644-653.
31. Knabe M, Pohl J, Gerges C, Ell C, Neuhaus H, Schumacher B. Standardized long-term follow-up after endoscopic resection of large, nonpedunculated colorectal lesions: a prospective two-center study. *Am J Gastroenterol* 2014;**109**:183-189.
32. Moss A, Bourke MJ, Williams SJ, et al. Endoscopic mucosal resection outcomes and prediction of submucosal cancer from advanced colonic mucosal neoplasia. *Gastroenterology* 2011;**140**:1909-1918.
33. Jameel JK, Pillinger SH, Moncur P, Tsai HH, Duthie GS. Endoscopic mucosal resection (EMR) in the management of large colo-rectal polyps. *Colorectal Dis* 2006;**8**:497-500.
34. Rao AK, Soetikno R, Raju GS, et al. Large sessile serrated polyps can be safely and effectively removed by endoscopic mucosal resection. *Clin Gastroenterol Hepatol* 2016;**14**:568-574.
35. Hurlstone DP, Sanders DS, Cross SS, et al. Colonoscopic resection of lateral spreading tumours: a prospective analysis of endoscopic mucosal resection. *Gut* 2004;**53**:1334-1339.
36. Moss A, Williams SJ, Hourigan LF, et al. Long-term adenoma recurrence following wide-field endoscopic mucosal resection (WF-EMR) for advanced colonic mucosal neoplasia is infrequent: results and risk factors in 1000 cases from the Australian Colonic EMR (ACE) study. *Gut* 2015;**64**:57-65.
37. Tanaka S, Haruma K, Oka S, et al. Clinicopathologic features and endoscopic treatment of superficially spreading colorectal neoplasms larger than 20 mm. *Gastrointest Endosc* 2001;**54**:62-66.
38. Belderbos TD, Leenders M, Moons LM, Siersema PD. Local recurrence after endoscopic mucosal resection of nonpedunculated colorectal lesions: systematic review and meta-analysis. *Endoscopy* 2014;**46**:388-402.
39. Lim XC, Nistala KRY, Ng CH, et al. Endoscopic submucosal dissection vs endoscopic mucosal resection for colorectal polyps: a meta-analysis and meta-regression with single arm analysis. *World J Gastroenterol* 2021;**27**:3925-3939.
40. Peery AF, Shaheen NJ, Cools KS, et al. Morbidity and mortality after surgery for nonmalignant colorectal polyps. *Gastrointest Endosc* 2018;**87**:243-250.
41. Facciorusso A, Del Prete V, Buccino RV, et al. Comparative efficacy of colonoscope distal attachment devices in increasing rates of adenoma detection: a network meta-analysis. *Clin Gastroenterol Hepatol* 2018;**16**:1209-1219.

## Supplementary material

Embase Search Strategy (Embase.com from Elsevier) 4 August 2021

No.	Query	Results
#1	'endoscopic mucosal resection*' OR 'emr' OR 'endoscopic aspiration mucosectom*' OR 'endoscopic mucosa resection*' OR 'endoscopic mucosectom*' OR 'endoscopic mucous membrane resection*' OR 'endoscopic mucosal resection'/exp	25748
#2	(polyp* OR adenoma*) AND (colon* OR colorect* OR rectum* OR rectal*) OR 'colonic neoplasm*' OR 'colon polyp'/exp OR 'colon adenoma'/exp	97063
#3	#1 AND #2	3303
#4	elder*:ab,kw,ti OR aged:ab,kw,ti OR older:ab,kw,ti OR 'senior citizen':ab,kw,ti OR 'senior citizens':ab,kw,ti OR retired:ab,kw,ti OR retirement:ab,kw,ti OR retiree*:ab,kw,ti OR 'social security':ab,kw,ti OR 'assisted living':ab,kw,ti OR 'nursing home':ab,kw,ti OR 'nursing homes':ab,kw,ti OR pension*:ab,kw,ti OR senil*:ab,kw,ti OR dementia:ab,kw,ti OR grandparent*:ab,kw,ti OR grandmother*:ab,kw,ti OR grandfather*:ab,kw,ti OR grandpa*:ab,kw,ti OR septuagenarian*:ab,kw,ti OR octagenarian*:ab,kw,ti OR sexagenarian*:ab,kw,ti OR nonagenarian*:ab,kw,ti OR centenarian*:ab,kw,ti OR supercentenarian*:ab,kw,ti OR geriatric*:ab,kw,ti OR gerontol*:ab,kw,ti OR medicare:ab,kw,ti OR [aged]/lim OR [very elderly]/lim	4492787
#5	#3 AND #4	983
#6	large:ab,ti,kw OR larger:ab,ti,kw OR size:ab,ti,kw OR sized:ab,ti,kw OR sizes:ab,ti,kw OR mm:ab,ti,kw OR cm:ab,ti,kw OR 20mm:ab,ti,kw	4693989
#7	#5 AND #6	678
#8	#7 NOT ([animals]/lim NOT [humans]/lim)	678
#9	#8 NOT ('editorial'/it OR 'note'/it OR 'review'/it OR 'short survey'/it)	666
#10	#9 NOT ('case report'/de OR 'meta analysis'/de OR 'practice guideline'/de OR 'systematic review'/de)	521

MEDLINE Search Strategy (PubMed from NCBI) 4 August 2021

Search number	Query	Results
1	Endoscopic-mucosal-resection* OR "EMR" OR endoscopic-aspiration-mucosectom* OR endoscopic-mucosa-resection* OR endoscopic-mucosectom* OR Endoscopic-Mucous-Membrane-Resection* OR "Endoscopic Mucosal Resection"[Mesh]	13,550
2	((polyp* OR adenoma* OR "Intestinal Polyps"[Mesh] OR "Adenomatous Polyps"[Mesh]) AND (colon* OR colorect* OR rectum* OR rectal*)) OR colonic-neoplasm* OR "Colonic Polyps"[Mesh]	115,885
3	#1 AND #2	1,185
4	elder*[Text Word] OR aged[Text Word] OR older[Text Word] OR 'senior citizen'[Text Word] OR 'senior citizens'[Text Word] OR retired[Text Word] OR retirement[Text Word] OR retiree*[Text Word] OR 'social security'[Text Word] OR 'assisted living'[Text Word] OR 'nursing home'[Text Word] OR 'nursing homes'[Text Word] OR pension*[Text Word] OR senil*[Text Word] OR dementia[Text Word] OR grandparent*[Text Word] OR grandmother*[Text Word] OR grandfather*[Text Word] OR grandpa*[Text Word] OR septuagenarian*[Text Word] OR octagenarian*[Text Word] OR sexagenarian*[Text Word] OR nonagenarian*[Text Word] OR centenarian*[Text Word] OR supercentenarian*[Text Word] OR geriatric*[Text Word] OR gerontol*[Text Word] OR medicare[Text Word]	6,012,417
5	#3 AND #4	617
6	Large[Text Word] OR larger[Text Word] OR size[Text Word] OR sized[Text Word] OR sizes[Text Word] OR mm[Text Word] OR cm[Text Word] OR 20mm[Text Word]	3,318,782
7	#5 AND #6	349
8	#7 NOT ("animals"[mesh] NOT "humans"[mesh])	349
9	#8 NOT ("case reports"[Publication Type] OR "comment"[Publication Type] OR "editorial"[Publication Type] OR "guideline"[Publication Type] OR "introductory journal article"[Publication Type] OR "meta analysis"[Publication Type] OR "news"[Publication Type] OR "retracted publication"[Publication Type] OR "review"[Publication Type] OR "systematic review"[Publication Type])	296



Cochrane Central Register of Controlled Trials Search Strategy  
(Cochrane Library from Wiley) 4 August 2021

71 Trials matching  
 Endoscopic-mucosal-resection\* OR "EMR" OR endoscopic-  
 aspiration-mucosectom\* OR endoscopic-mucosa-resection\* OR  
 endoscopic-mucosectom\* OR Endoscopic-Mucous-Membrane-  
 Resection\* in Title Abstract Keyword  
 AND  
 ((polyp\* OR adenoma\*) AND (colon\* OR colorect\* OR rectum\*  
 OR rectal\*)) OR colonic-neoplasm\* in Title Abstract Keyword  
 AND  
 Large OR larger OR size OR sized OR sizes OR mm OR cm OR  
 20mm in Title Abstract Keyword  
 AND  
 (elder\* OR aged OR older OR 'senior citizen' OR 'senior citizens'  
 OR retired OR retirement OR retiree\* OR 'social security' OR  
 'assisted living' OR 'nursing home' OR 'nursing homes' OR pension\*  
 OR senil\* OR dementia OR grandparent\* OR grandmother\* OR  
 grandfather\* OR grandma\* OR grandpa\* OR septuagenarian\*  
 OR octagenarian\* OR sexagenarian\* OR nonagenarian\* OR  
 centenarian\* OR supercentenarian\* OR geriatric\* OR gerontol\* OR  
 medicare) in Title Abstract Keyword

Cochrane Central Register of Controlled Trials  
 Issue 8 of 12, August 2021

Web of Science Core Collection Search Strategy (Web of Science from Clarivate) 4 August 2021

Line	Search Terms	Results
1	TS=(Endoscopic-mucosal-resection* OR "EMR" OR endoscopic-aspiration-mucosectom* OR endoscopic-mucosa-resection* OR endoscopic-mucosectom* OR Endoscopic-Mucous-Membrane-Resection*)	12712
2	TS=(((polyp* OR adenoma*) AND (colon* OR colorect* OR rectum* OR rectal*)) OR colonic-neoplasm*)	57107
3	TS=(Large OR larger OR size OR sized OR sizes OR mm OR cm OR 20mm)	8589975
4	TS=((elder* OR aged OR older OR 'senior citizen' OR 'senior citizens' OR retired OR retirement OR retiree* OR 'social security' OR 'assisted living' OR 'nursing home' OR 'nursing homes' OR pension* OR senil* OR dementia OR grandparent* OR grandmother* OR grandfather* OR grandma* OR grandpa* OR septuagenarian* OR octagenarian* OR sexagenarian* OR nonagenarian* OR centenarian* OR supercentenarian* OR geriatric* OR gerontol* OR medicare))	4942154
5	#1 AND #2 AND #3 AND #4	187
6	#1 AND #2 AND #3 AND #4 and Review Articles or Editorial Materials (Exclude - Document Types)	172