Surgical outcomes after colorectal surgery for endometriosis: Systematic Review and Meta-Analysis

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PRECIS

Rectal shaving is less associated with postoperative complication. Disc excision appears to be the technique of choice for large bowel infiltration compared to segmental colorectal resection.

ABSTRACT

Objective: To assess the impact of type of surgery for colorectal endometriosis – rectal shaving, discoid or colorectal segmental resection– on complications and surgical outcomes.

Data Sources: We performed a systematic review of all English and French language full-text articles addressing surgical management of colorectal endometriosis and compared the postoperative complications according to surgical technique by meta-analysis. The PubMed, Clinical Trials.gov Cochrane Library and Web of Science databases were searched for relevant studies published before March 27, 2020. The search strategy used the following MeSH terms: ("bowel endometriosis" or "colorectal endometriosis") AND ("surgery for endometriosis" or "conservative management" or "radical management" or "colorectal resection" or "shaving" or "full thickness resection" or "disc excision") AND ("treatment", "outcomes", "long term results" and "complications").

Methods of Study Selection: Two authors conducted the literature search and independently screened abstracts for inclusion, with resolution of any difference by three other authors. Studies were included when data on surgical management (shaving, disc excision and/ or segmental resection) were provided and when postoperative outcomes were detailed with at least the number of complications. The risk of bias was assessed according to the Cochrane recommendations.

Tabulation, Integration, and Results: Of the168 full-text articles assessed for eligibility, 60 were included in the qualitative synthesis. Seventeen of these were included in the meta-analysis on rectovaginal fistula, 10 on anastomotic leakage, five on anastomotic stenosis, and nine on voiding dysfunction <30 days. The mean complication rate according to shaving, discoid excision and segmental resection were 2.2%, 9.7% and 9.9%, respectively. Rectal shaving was less associated with rectovaginal fistula than discoid excision (OR=0.19; 95% CI [0.10-0.36], p<0.00001, I^2=33%) and segmental colorectal resection (OR=0.26, 95% IC [0.15-0.44], p<0.00001, I^2=0%). No difference was found in the occurrence of rectovaginal fistula between discoid excision and segmental colorectal resection (OR=1.07, 95%CI [0.70-1.63], p=0.76, I^2=0%). Rectal shaving was less associated with leakage than disc excision (OR=0.22, 95% IC [0.06-0.73], p=0.01, I^2=86%). No difference was found in the occurrence of leakage between rectal shaving and segmental colorectal resection (OR=0.32, 95% IC [0.10-1.01], p=0.05, I^2=71%) or between disc excision and segmental colorectal resection (OR=0.32, 95% IC [0.30-1.58], p=0.38, I^2=0%). Disc excision was less associated with anastomotic stenosis than segmental resection (OR=0.15, 95% IC [0.05-0.48], p=0.001, I^2=59%). Disc excision was associated with more voiding dysfunction <30 days than rectal shaving (OR=12.9, 95% IC [1.40-119.34], p=0.02, I^2=0%). No difference was found in the occurrence of voiding dysfunction <30 days between segmental resection and rectal shaving (OR=3.05, 95% IC [0.55-16.87], p=0.20, I^2=0%) or between segmental colorectal and discoid resection (OR=0.99, 95% IC [0.54-1.85], p=0.99, I^2=71%).

Conclusion: Colorectal surgery for endometriosis exposes patients to a risk of severe complications such as rectovaginal fistula, anastomotic leakage, anastomotic stenosis and voiding dysfunction. Rectal shaving appears to be less associated with postoperative complications than disc excision and segmental colorectal resection. However, this technique is not suitable in all patients with large bowel infiltration. Compared to segmental colorectal resection, disc excision has several advantages including shorter operating time, shorter hospital stay and lower risk of postoperative bowel stenosis.

Registration of Systematic Reviews: PROSPERO ID:

Keywords: colorectal endometriosis / disc excision / postoperative complications / rectal shaving / segmental resection

Introduction

The estimated incidence of colorectal endometriosis in patients with deep endometriosis (DE) varies from 5.3% to 12% [1,2]. Surgical management of colorectal endometriosis is an option after failure of medical treatment in case of progressive lesions or in patients with impaired sexual and/or reproductive functions which results in poor quality of life [3,4].

Several laparoscopic surgical techniques have been described for colorectal endometriosis such as (i) rectal shaving, (ii) discoid excision, and (iii) segmental resection. This variety of techniques highlights the considerable heterogeneity of management between authors especially concerning the choice of the most appropriate technique which also depends on different factors related to patient's characteristics (age, desire to preserve fertility, nodule location) but also on surgeon experience.

In the last decade, advocates of surgery have demonstrated favorable results in terms of quality of life (HRQOL) and pain improvement [5]. However, the reported benefits are counterbalanced by an abundancy of literature underlining major per- and postoperative complications estimated to affect an average of 1% and 18.5% of patients, respectively [6–8]. More precisely, the rates of rectovaginal fistula and anastomotic leakage, the most severe complications impacting quality of life [9,10] and fertility [11], have been reported to represent 1.3%, 3.6%, 4.5% for rectovaginal fistula and 0%, 0%, 1,9% for anastomotic leakage after shaving, disc excision and segmental colorectal resection, respectively [12].

Since the publication of previous systematic reviews [6–8], there has been a surge (>30%) in the number of studies assessing the feasibility of disc excision for both small lesions and large nodules infiltrating the mid- or lower rectum (>50mm) [10,11].

To supplement the debate, we performed a systematic review and meta-analysis to compare surgical outcomes and complications of colorectal surgery by rectal shaving, disc excision and segmental resection.

METHODS

Protocol and registration

We conducted a systematic review and meta-analysis in accordance with the Preferred Reported Items for Systematic Reviews and Meta-analyses guidelines (PRISMA) guidelines [13] and with the recommendations from the Cochrane Collaboration [14]. The review was registered *a priori* (International Prospective Register of Systematic Reviews PROSPERO ID: number pending following delays due to the COVID pandemic lockdown).

Sources and search strategy

The PubMed, Clinical Trials.gov, Cochrane Library, and Web of Science databases were searched for relevant studies published before March 27, 2020. The search strategy consisted of specific vocabulary and the National Library of Medicine's MeSH (Medical Subject Headings) terms. The major search terms that were used were ("bowel endometriosis" or "colorectal endometriosis") AND ("surgery for endometriosis" or "conservative management" or "radical surgery" or "colorectal resection" or "shaving" or "full thickness resection" or "disc excision" or "discoid resection") AND ("treatment", "outcomes", "long term results" and "complications"). The search was supplemented with a comprehensive evaluation of the references of relevant articles and reviews and was not restricted by date but was limited to the English and French language. The latest search was performed in May 14, 2020.

Data collection process and Outcome Measures

For systematic review

Two authors (AP and EV) independently performed the initial search to evaluate the eligibility criteria. The data were extracted by one author (AP) and checked by the others (SB, EV, GM, ED, HR).

Studies were included when data on (i) surgical management (shaving, disc excision and/or segmental resection) and (ii) postoperative outcomes were detailed. The following data were extracted and summarized: author, year of publication, number of patients, type of study, surgical technique, mean size of the nodule, operating time, hospital stay, number and percentage of bowel perforation, hemorrhage, ureteral injury, rectovaginal fistula, anastomotic leakage, late bowel perforation, voiding dysfunction (< and > 30 days) and ureteral fistula according to colorectal management, mean or median follow-up period, number and percentage of recurrence of pain and reoperations. We did not include recurrence in the surgical outcomes (primary endpoint of another recent meta-analysis [15]), or delayed bowel functional outcomes.

Two reviewers (AP and EV) independently assessed the quality of each included study, discrepancies were discussed and, if consensus was not reached, a third reviewer was consulted (SB, ED, GM, HR).

Leakage was defined as a postoperative complication involving the bowel opening into the abdomen, leading to pelvic abscess or peritonitis, without communication with the vagina (this criterion excludes rectovaginal fistula from the leakage group). This definition includes bowel wall necrosis following shaving, leakage of rectal suture following disc excision, and anastomotic leakage following colorectal resection.

For meta-analysis

When data were available allowing the comparison of rectovaginal fistula, leakage, anastomotic stenosis and voiding dysfunction <30 days outcomes, we performed a random effects meta-analysis. The mean, standard deviation, median, interquartile range, and confidence interval of each study were assessed [16,17].

Risk of Bias

The quality of included studies was assessed by the Study Quality Assessment Tools (https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools). Studies were rated as "good" when at least 70% out of 9, 12 or 14 assessment criteria were fulfilled, "fair" when at least 50%, and poor when less than 50% of the criteria were fulfilled. Conflicts regarding study quality were resolved with four authors (SB, GM, ED, HR).

Statistical Analysis

For meta-analysis, odd ratios (OR) were derived from each study and the corresponding 95% confidence intervals (CI) were also extracted. Dichotomous data were reported as ORs, and continuous data were reported as mean difference, each with a corresponding 95% CI. Pooled response means (estimating overall mean difference with 95% CI) are expressed on Forest Plots. A p-value <0.05 was considered significant for pooled response means. Statistical heterogeneity among the studies was determined by Cochran's Q test and I2 index, in which I2 <50% or p-values of <0.1 indicated that significant heterogeneity did not exist. The fixed-effects model was applied if heterogeneity was not observed among the studies; otherwise, the random-effects model was adopted for pooled estimates.

All statistical analysis was performed with Review Manager (RevMan, IOS, version (5.3), Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2011).

RESULTS

Study selection (Figure 1 – PRISMA flow chart)

One thousand one hundred and ninety-one studies were identified through the database searches. After screening by title and abstract and removing duplicate papers, a total of 168 full-text articles were assessed for eligibility. One hundred and eight were excluded: 46 because of missing data, 31 related to case reports, guidelines, review or surgical techniques, 71 because of an unclear surgical management or the exclusion of one technique, four studies were video articles, three articles were not in French or English, three articles because of unreported data, two studies only reported quality of life, and two articles reported previously published data.

Among the 60 articles included in the review (Table 1), 35 were excluded from the meta-analysis because all the patients in the study underwent the same surgical technique. For the meta-analysis: 17 studies were included on rectovaginal fistula, 10 on anastomotic leakage, five on anastomotic stenosis and nine on voiding dysfunction <30 days.

Study characteristics – Descriptive analysis

Twenty-four studies were prospective [9,18–40], one was a randomized controlled trial [41] and 35 were retrospective [10,42–75]. The 60 studies included in the review enrolled a total of 17,495 patients: 9,673 (55.3%) underwent rectal shaving; 1,510 (8.6%) disc excision; and 6,312 (36.1%) segmental resection. Table 1 summarizes the study characteristics, intraoperative events and postoperative outcomes according to the surgical technique of the 60 studies included in the review.

The 17 studies retained for the meta-analysis on rectovaginal fistula [10,19,24,26,28,34,42,44,45,49,59,60,63,64,69,74,75] included 7,585 patients (4,500 shavings, 978 disc excisions and 2,107 segmental resections).

The 10 studies retained for the meta-analysis on anastomotic leakage [19,24,26,28,44,45,47,49,56,64] included 4,767 patients (3,416 shavings, 450 disc excisions and 901 segmental resections).

The five studies retained for the meta-analysis on anastomotic stenosis [26,42,44,60,74] included 1,446 patients (470 shavings, 366 disc excisions and 610 segmental resections).

Finally, the nine studies retained for the meta-analysis on voiding dysfunction <30 days [10,26,34,44,45,49,50,56,64] included 792 patients (231 shavings, 262 disc excisions and 299 segmental resections).

Surgical procedures

In this systematic review more than 98% of the patients were managed laparoscopically which is a good reflection of the practices of the last 20 years in surgery.

Rectal shaving

Rectal shaving, first described in 1991, consists in the separation of the nodule from the anterior part of the rectum to reach the cleavage plan. However, the surgical technique of shaving seems to be unique to each team. Indeed, in this systematic review, some authors defined shaving as the excision of endometriotic nodule reaching at most the rectal muscularis without sutures [42,47,55,68], while others include in rectal shaving the resection of the nodule beyond the muscularis and up to the opening of the lumen of the digestive tract followed by a manual suture. [29,39,44,48,51,59,60,64]

Disc excision.

In this systematic review, two main techniques were used for disc excision : the use of stapler [10,24–27,30,32,35,42–44,47,49,56,58,60,73,74] and disc excision with scissors and free hand suture. [28,34,45,59,76]

Systematic review

Overall

The overall complication rate ranged from 2.2% to 9.9%. The mean complication rate was 5.7%: 2.2% after shaving, 9.7% after disc excision and 9.9% after segmental resection.

Bowel perforation requiring colostomy

The overall rate of late bowel perforation requiring colostomy was 0.2% (11/6134) and was observed after shaving, disc excision and segmental resection in 0.1%, 0.4% and 0.7% respectively.

Rectovaginal fistula

The overall rate of rectovaginal fistula was 1.5% (235/15660) and was observed after shaving, disc excision and segmental resection in 0.3%, 2.7% and 3.3%, respectively.

Leakage

The overall rate of leakage was 1.2% (102/8470) and was observed after shaving, disc excision and segmental resection in 0.2%, 1.0% and 1.9%, respectively.

Intraoperative hemorrhage requiring blood transfusion

The overall rate of intraoperative hemorrhage requiring blood transfusion was 0.7% (18/2,429) and was observed after shaving, disc excision and segmental resection in 0.1%, 1.1% and 1.0%, respectively.

Voiding dysfunction <30 days

The overall rate of voiding dysfunction < 30 days was 2.2% (144/6,405) and was observed after shaving, disc excision and segmental resection in 0.7%, 7.8% and 6.2%, respectively.

Voiding dysfunction> 30 days

The overall rate of voiding dysfunction >30 days was 2.6% (203/7,931) and was observed after shaving, disc excision and segmental resection in 0.4%, 4.1% and 6.6%, respectively.

Ureteral injury

The overall ureteral injury rate was 0.1% (9/6,714) and was observed after shaving, disc excision and segmental resection in 0.1%, 0.4% and 0.07%, respectively.

Anastomotic stenosis

The overall anastomotic stenosis rate was 2.3% (33/1,446) and was observed after shaving, disc excision and segmental resection in 0%, 0.3% and 5.2%, respectively.

Meta-analysis

Rectovaginal fistula

Rectal shaving was less associated with rectovaginal fistula than disc excision (OR=0.19; 95% CI [0.10-0.36], p<0.00001, I^2=33%) (Figure 2) and segmental resection (OR=0.26, 95% IC [0.15-0.44], p< 0.00001, I^2=0%) (Figure 3).

No difference was found in the occurrence of rectovaginal fistula between disc excision and segmental resection (OR=1.07, 95%CI [0.70-1.63], p=0.76, I^2=0%) (Figure 4).

Leakage

Rectal shaving was less associated with leakage than disc excision (OR=0.22, 95% IC [0.06-0.73], p=0.01, I^2=86%) (Figure 5).

No difference was found in the occurrence of leakage between rectal shaving and segmental resection (OR=0.32, 95% IC [0.10-1.01], p=0.05, I^2=71%), (Figure 6) or between disc excision and segmental resection (OR=0.32, 95% IC [0.30-1.58], p=0.38, I^2=0%) (Figure 7).

Anastomotic stenosis

Disc excision was less associated with anastomotic stenosis than segmental resection (OR=0.15, 95% IC [0.05-0.48], p=0.001, I^2=59%) (Figure 8).

Voiding dysfunction <30 days

Disc excision was associated with more voiding dysfunction <30 days than rectal shaving (OR=12.9, 95% IC [1.40-119.34], p=0.02, I^2=0%) (Figure 9).

No statistical was found in the occurrence of voiding dysfunction <30 days between segmental resection and rectal shaving (OR=3.05, 95% IC [0.55-16.87], p=0.20, I^2=0%) (Figure 10), or between segmental colorectal and discoid resection (OR=0.99, 95% IC [0.54-1.85], p=0.99, I^2=71%) (Figure 11).

DISCUSSION

We report a systematic review and meta-analysis focusing on—postoperative outcomes following surgery for DE infiltrating the colon and the rectum. Our meta-analysis shows that removing DE by rectal shaving is associated with a lower risk of rectovaginal fistula, bowel leakage and bladder dysfunction than disc excision or segmental resection, while no statistically significant differences were found between the latter two techniques. However, disc excision for colorectal endometriosis significantly reduces the risk of bowel stenosis –which requires additional endoscopic or surgical procedures–compared to segmental resection.

Colorectal surgery for endometriosis has been a matter of debate for several years especially concerning the risk of major complications such as rectovaginal fistula and leakage. In this setting, a previous systematic review from Meuleman et al. in 2011 [6] reported that rates of rectovaginal fistula and anastomotic leakage were 2.7% and 1.5 %, respectively. Similarly, in 2017 Donnez and Roman [7] reported rates of 0.25%, 2.8% and 4.3% for the risk of rectovaginal fistula after rectal shaving, disc excision and segmental resection, respectively. The rate of bowel leakage after disc excision was 0% and after segmental resection 3.7%. More recently in 2018, Balla et al [8] observed a rate of rectovaginal fistula and anastomotic leakage of 2.4% and 2.1%, respectively. In the present study, the reported rates of major complications tended to be lower than in previous reviews. This apparent discrepancy can be explained by: (i) the higher number of publications over the last 3 years reporting patients managed by disc excision which is less radical than segmental resection [41] and associated with favorable outcomes [41,43,56]; and (ii) the lack of individual patient data in our review (and meta-analysis) which is a source of overestimation of the number of cases and complications. Illustratively, compared to 2017, the present systematic review analyzed 9322 vs 6491 patients for rectal shaving, 1091 vs 455 patients for disc excision and 5652 vs 3902 patients for segmental resection. On one hand, this spectacular increase (>30%) may have resulted in a more precise estimate of the prevalence of postoperative complications, but it also increases the risk of an overlap of patients between studies: the largest published studies are from the same teams throughout the world which may represent a bias due to the high expertise of those authors and may limit the extrapolation of the results.

Rectal shaving would appear to be associated with a lower postoperative complication rate than disc excision and segmental resection. Our results confirmed that the overall risk of major complications after segmental resection is generally less than 10%. In addition, the mean operation time was 203 and 258.7 minutes for disc excision and segmental resection, respectively, and the mean hospital stay was 5 and 7 days, respectively. In our study, we also observed an advantage of disc excision over segmental resection in terms of operating time, hospital stay and voiding dysfunction > and <30 days. However, in meta-analysis no statistical differences were observed between segmental resection and disc excision (OR=0.99, 95% IC [0.54-1.85], p=0.99, I^2=71%), (Figure 11). More interestingly, Braund et al. [74] also recently showed the advantage of disc excision over segmental resection in terms of the risk of stenosis. In the present systematic review, the overall anastomotic stenosis rate was 2.3% and was observed after rectal shaving, disc excision and segmental resection in 0%, 0.3% and 5.2%, respectively. Disc excision was statistically less associated with anastomotic stenosis than segmental resection (OR=0.15, 95% IC [0.05-0.48], p=0.001, I^2=59%). Till today, the major technical limitation of disc excision is the size of lesion which can be resected. Using a transanal end-to-end anastomosis (EEA) circular stapler, most experienced authors have found that 30 mm / 90° is the maximum size for disc excision [77]. However, a recent pilot study by Namazov et al. reported that both double disc excision and the Rouen technique are suitable for excising larger nodules infiltrating the middle or lower rectum and is associated with a low rate of severe complications with good functional outcomes [77]. Similarly, Jayot et al. underlined its feasibility with a prevalence rate of double disc excision of 6.5% [27]. This raises the issue of preoperative imaging and the role of MRI and rectal endoscopic ultrasound to select good candidates for single or double disc excision [24,27,28,30,35,45,53,58]. However, the low accuracy of imaging and discrepancy between the two techniques and surgical findings explain the failure rate disc excision which is probably <3.2% requiring segmental resection and/or double-disc excision [27].

Multidisciplinary management of postoperative outcomes is crucial for optimal patient care, especially after colorectal surgery. The impact of hospital and surgeon case volume on morbidity, especially for colorectal endometriosis, has been clearly demonstrated [78]. Hence, it is reasonable to recommend that colorectal surgery be performed in high-volume hospitals to improve the quality of care: the occurrence of rectovaginal fistula and anastomotic leakage for centers performing more than 40 procedures per year has been reported as 2.77% and 0.92% compared to 4.95% and 1.98% in centers performing fewer than 10 procedures [78]. However, although knowledge about the type of center and the surgeon's expertise is important when comparing studies to facilitate interpretability, this information was lacking in the vast majority of studies included in the current review. This underlines the importance of developing quality and care indicators in the field of endometriosis.

While a meta-analysis would appear to be an appropriate tool to answer several questions which remain unresolved by analysis of conventional retrospective and prospective series, this methodology may be also a source of misinterpretation. Our meta-analysis clearly shows an inflation in the number of rectal shaving and disc resection procedures over a limited period. Unlike for disc excision and segmental resection, there is no histological evidence to confirm which kind of rectal shaving was performed. As pointed out by Meuleman et al, the concept of shaving varies from author to author consisting in the removal of rectal serosa for some and including resection of the bowel muscularis requiring digestive suturing for others [78]. It stands to reason that rectal shaving involving simple excision of the rectal serosa can only be associated with a low risk of complications. Conversely, postoperative complications such as leakage or rectovaginal fistula can occur when the rectal shaving involves incision deep into the internal muscular or submucosal layer requiring suturing. However, details about the type of rectal shaving are missing in the various series analyzed. From a medico-legal point of view, this has many implications because rectal shaving with intestinal suture requires a qualification in digestive surgery while published studies are mainly by gynecologic teams without information about involvement of a digestive surgeon. In addition, on the medico-economic level, reimbursement by the health care system of superficial rectal shaving without suturing artificially leads to an increase in costs compared to a classic excision of the Douglas pouch. Overall, the nomenclature of colorectal procedures deserves to be reviewed. If the term rectal shaving were reserved exclusively for procedures involving removal of the rectal muscularis with suturing, true comparison with disc excision and segmental resection would be feasible. It is obvious that rectal shaving reduces the risk of postoperative complications when compared to disc excision and segmental resection. However, in patients with severe DE massively infiltrating the colon and rectum shaving may no longer be suitable, and in this setting the risk of postoperative complications is counterbalanced by the expected improvement in pain and quality of life, as well as lower risk of recurrence [15].

The strengths of this review include the use of an exhaustive search strategy applied to four different databases. In addition, it seems to be the first meta-analysis that reports postoperative complications according to the three surgical approaches for DE with colorectal involvement. Nonetheless, some limitations have to be underlined. According to Cochrane guidelines we should estimate the risk of bias. However, as our systematic review included only one randomized controlled trial, estimating the risk of bias seemed inappropriate. In addition, heterogeneity between some studies may limit the accuracy and the validity of the results. Similarly, other complications such as bowel stenosis after surgery were not systematically reported. In this setting, it has been reported that bowel stenosis occurs in patients who undergo segmental resection, most of them with a diverting stoma, with no cases reported in patients undergoing disc excision, with or without stoma [74]. Finally, the high heterogeneity of reporting results limits the feasibility of metanalysis of other criteria.

CONCLUSION

This systematic review and meta-analysis confirm that colorectal surgery for endometriosis is a major procedure exposing patients to a relatively high risk of severe complications such as rectovaginal fistula and anastomotic leakage. When feasible, disc excision appears to be associated with fewer postoperative complications than segmental colorectal resection.

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FIGURES LEGENDS

Figure 1: PRISMA flow diagram

Figure 2: Forest plot of the occurrence of rectovaginal fistula comparing rectal shaving and discoid resection.

Figure 3: Forest plot of the occurrence of rectovaginal fistula comparing rectal shaving and segmental colorectal resection.

Figure 4: Forest plot of the occurrence of rectovaginal fistula comparing rectal discoid and segmental colorectal resection.

Figure 5: Forest plot of the occurrence of anastomotic leakage comparing rectal shaving and discoid resection.

Figure 6: Forest plot of the occurrence of anastomotic leakage comparing rectal shaving and segmental colorectal resection.

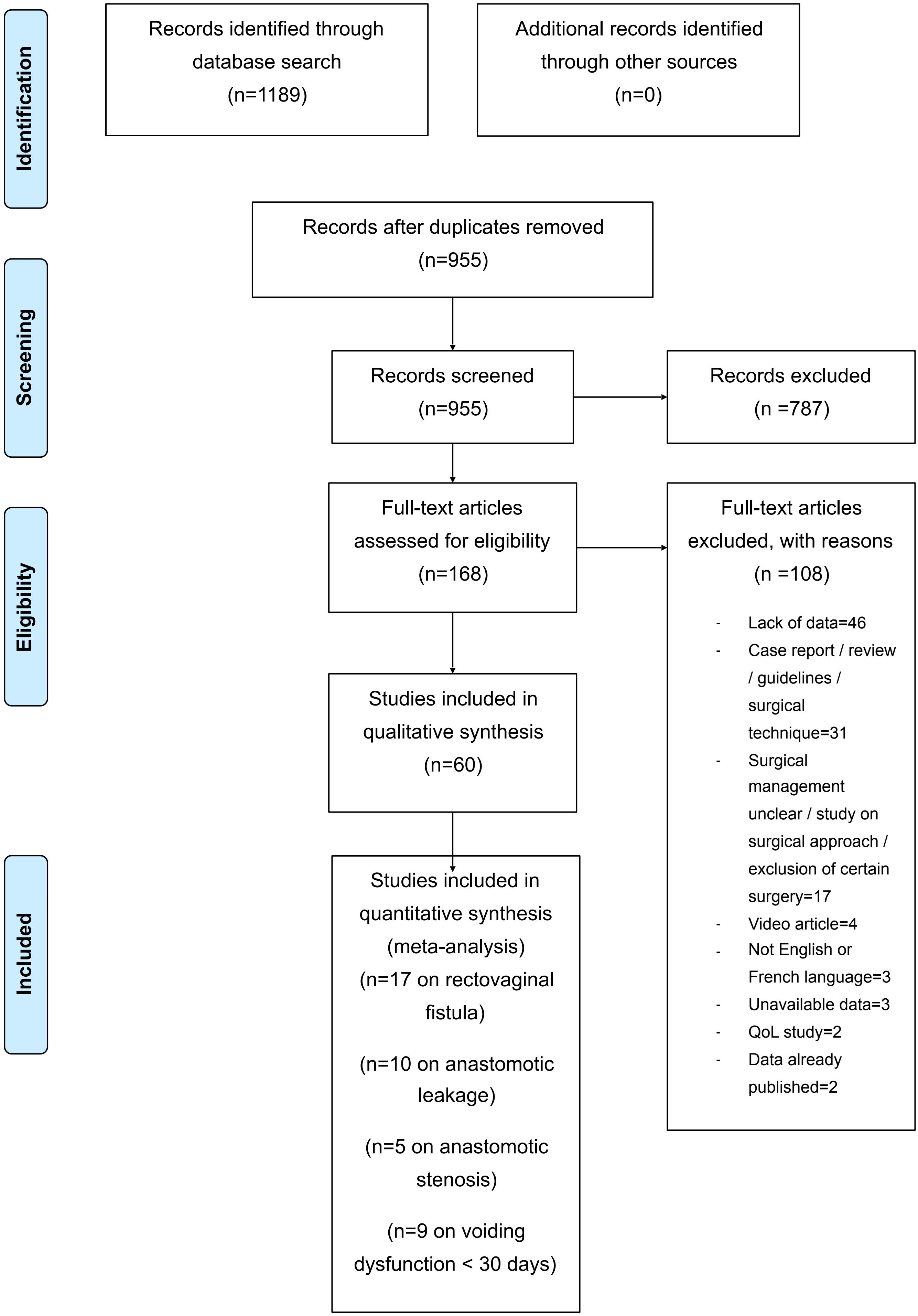
Figure 7: Forest plot of the occurrence of anastomotic leakage comparing rectal discoid and segmental colorectal resection.

Figure 8: Forest plot of the occurrence of anastomotic stenosis comparing rectal discoid and segmental colorectal resection.

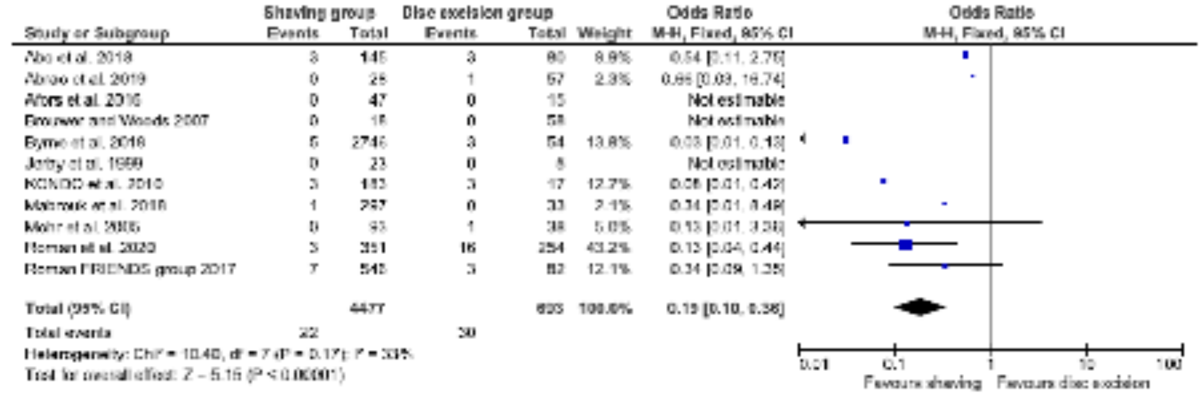
Figure 9: Forest plot of the occurrence of voiding dysfunction < 30 days comparing discoid resection and rectal shaving.

Figure 10: Forest plot of the occurrence of voiding dysfunction < 30 days comparing segmental resection and rectal shaving.

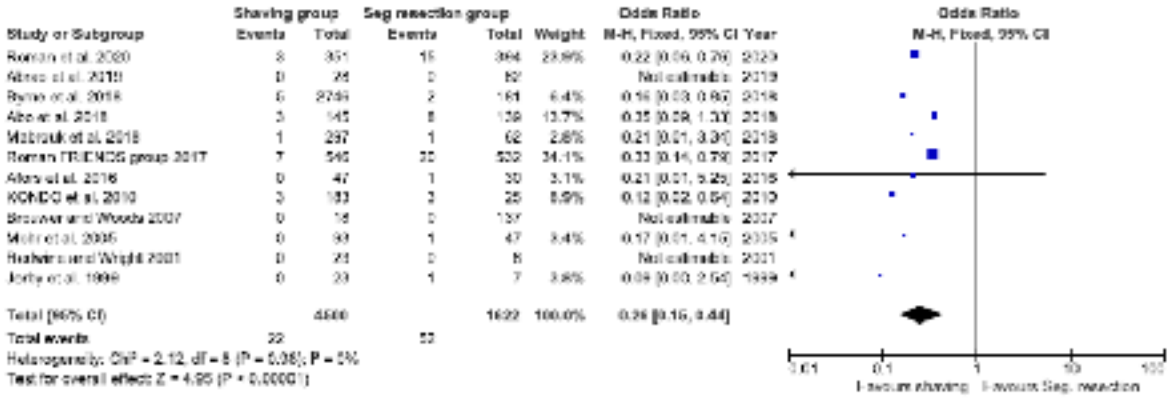
Figure 11: Forest plot of the occurrence of voiding dysfunction < 30 days comparing segmental and discoid resection.



Identification
Screening
Eligibility
Included
Records identified through database search (n=1189)
Additional records identified through other sources (n=0)
Records after duplicates removed (n=955)
Records screened (n=955)
Records excluded (n =787)
Full-text articles assessed for eligibility (n=168)
Full-text articles excluded, with reasons (n =108)
- Lack of data=46
- Case report / review / guidelines / surgical technique=31
- Surgical management unclear / study on surgical approach / exclusion of certain surgery=17
- Video article=4
- Not English or French language=3
- Unavailable data=3
- QoL study=2
- Data already published=2
Studies included in qualitative synthesis (n=60)
Studies included in quantitative synthesis (meta-analysis)
(n=17 on rectovaginal fistula)
(n=10 on anastomotic leakage)
(n=5 on anastomotic stenosis)
(n=9 on voiding dysfunction < 30 days)



CI: confidence interval



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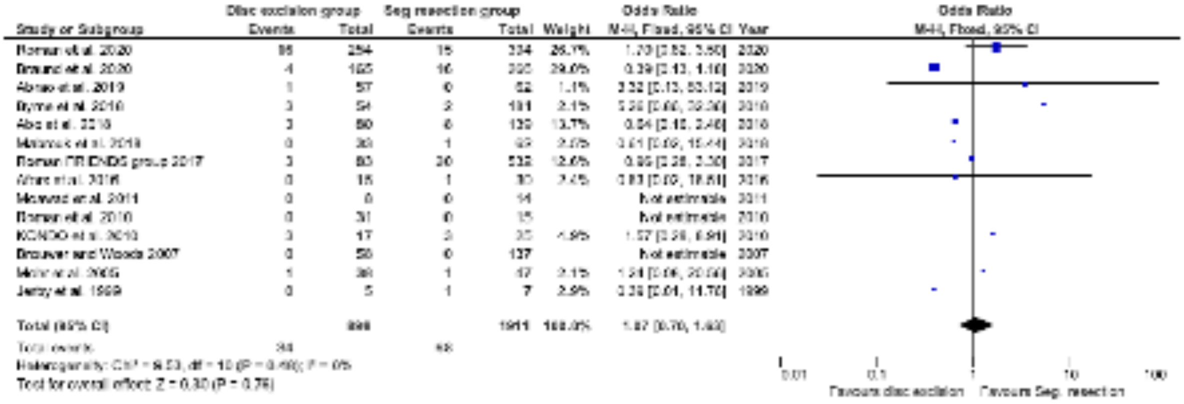

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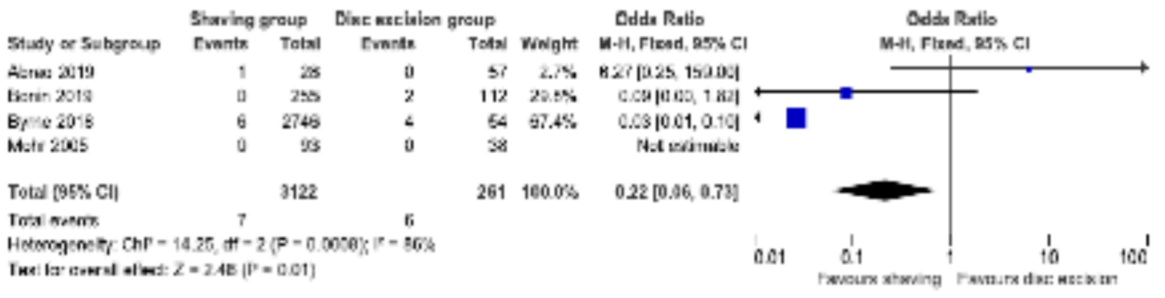
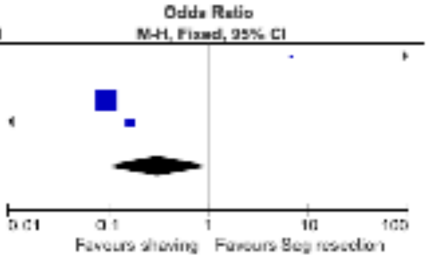


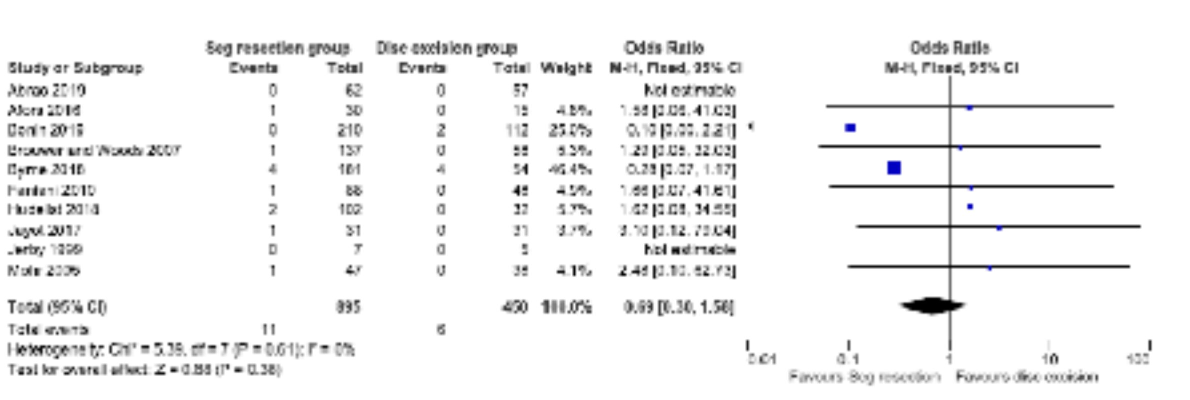
CI: confidence interval

Study or Subgroup	Shaving group Events	Shaving group Total	Seg resection group Events	Seg resection group Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Abrao 2019	1	28	0	62	3.1%	6.82 [0.27, 172.69]
Bonin 2019	0	255	0	210		Not estimable
Byrne 2018	6	2746	4	181	76.7%	0.10 [0.03, 0.35]
Mehr 2005	0	93	1	47	20.2%	0.17 [0.01, 4.15]
Total (95% CI)		3122		500	100.0%	0.32 [0.10, 1.01]
Total events	7		5			

Heterogeneity: Chi² = 6.94, df = 2 (P = 0.03); I² = 71%
Test for overall effect: Z = 1.96 (P = 0.05)



CI: confidence interval



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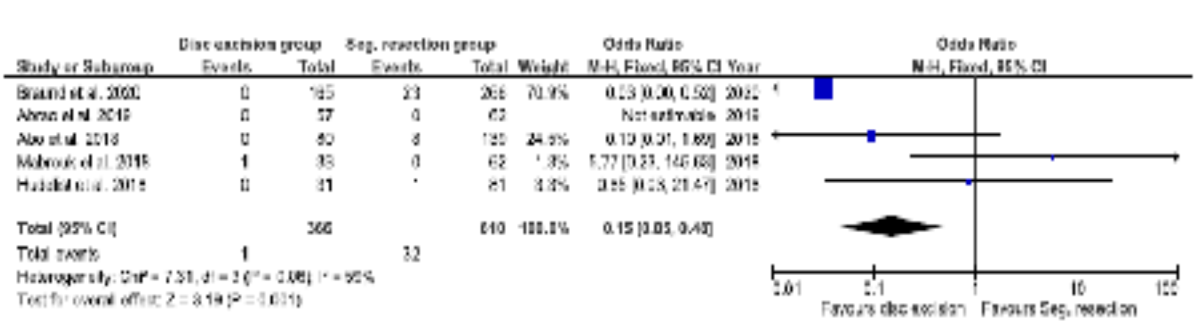

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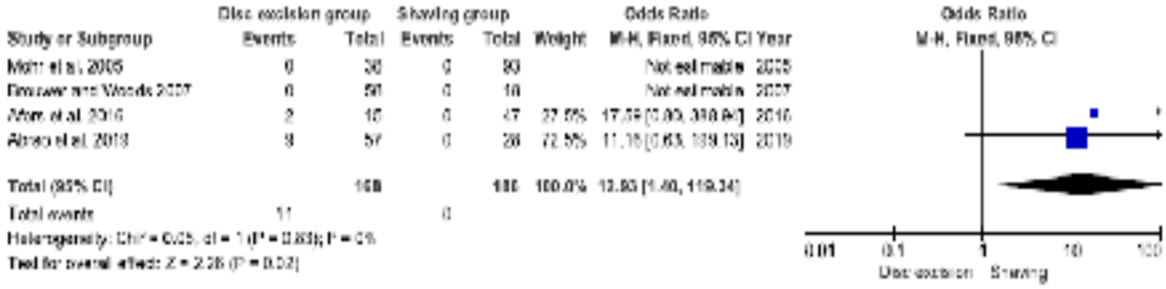
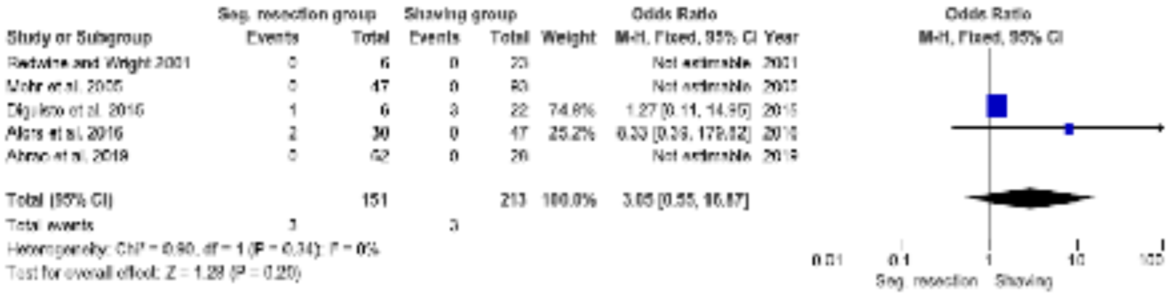
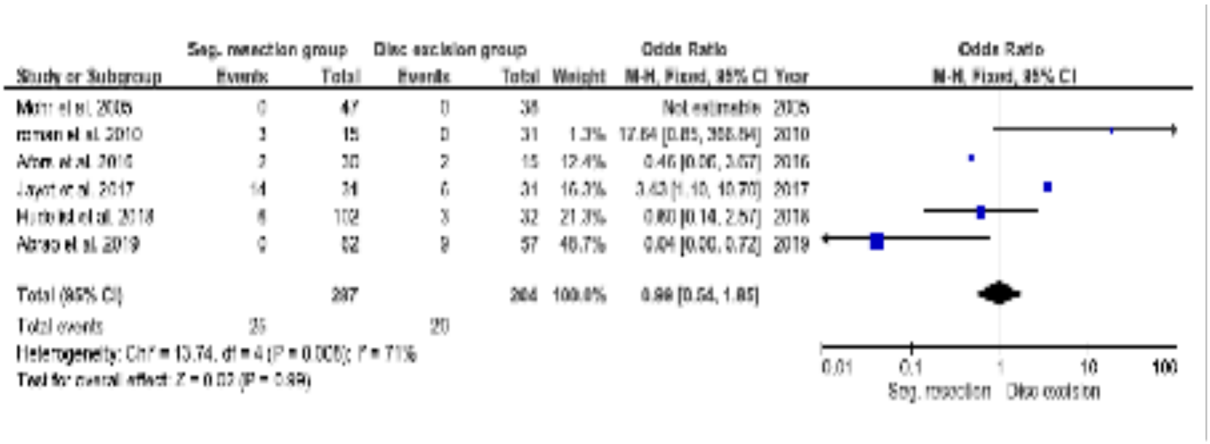


CI: confidence interval



CI: confidence interval



CI: confidence interval

Table 1: Study characteristics, intraoperative events and postoperative outcomes according to surgical approach of the 58 studies included in the review.

Authors	Type	N	Mean size of the nodule (cm)	Mean operating time (min)	Length of stay (days)	Bowel perforation N (%)	Late bowel perforation requiring colostomy N (%)	Late bowel perforation not requiring colostomy N (%)	Rectovaginal fistula N (%)	Anastomotic leakage N (%)	Intraoperative hemorrhage N (%)	Delayed hemorrhage N (%)	Voiding dysfunction < 30 d N (%)	Voiding dysfunction > 30 d N (%)	Ureteral injury N (%)	Ureteral fistula N (%)	Anastomotic stenosis N (%)	Follow-up (months)	Recurrence pain N (%)	Reoperation N (%)	Pregnancy N (%)
Shaving Total Shaving		**9673**	**3**	**150**	**2**	**88/7574 (1.2)**	**6/5127 (0.1)**	**4/4919 (0.1)**	**26/9032 (0.3)**	**7/3122 (0.2)**	**1/772 (0.1)**	**3/1755 (1.7)**	**33/4763 (0.7)**	**17/4858 (0.4)**	**6/4783 (0.1)**	**26/5080 (0.5)**	**0/470 (0)**	**490.6**	**105/1385 (7.6)**	**91/4410 (2.1)**	**818/1242 (65.9)**
Reich et al. 1991[66]	Retro	100		178															11 (11)		70 (70)
Donnez et al. 1995[51]	Retro	231				3 (1.29)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)	3 (1.29)	0 (0)	0 (0)	0 (0)					
Koninckx et al. 1996[29]	Pro	225		120	1	14 (6.3)	4 (1.8)	3 (1.3)	0 (0)			0 (0)	0	0 (0)	1 (0.4)	0 (0)					
Jerby et al. 1999[28]	Pro	23		110	1	0 (0)	0 (0)	0 (0)	0 (0)						0 (0)	0 (0)		10			
Redwine and Wright 2001[34]	Pro	23				0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					
Duepree et al. 2002[53]	Retro	26		168	1.2																
Mohr et al. 2005[64]	Retro	93			1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		24		13 (14)	33 (36)
Brouwer and Woods 2007[49]	Retro	18	< 2			0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		68	4 (22.2)		
Donnez and Squifflet 2010[21]	Pro	500	3.4	78		7 (1.4)	0 (0)	0 (0)	0 (0)			0 (0)	4 (0.8)	0 (0)	0 (0)	4 (0.8)		37,2	39 (7.8)	12 (2.4)	420 (84)

Kondo et al. 2011 [59]	Retro	183	2.9	182	3.2	0 (0)	0 (0)	0 (0)	3 (1.6)												
Donnez et al. 2013[52]	Retro	3298	2.8	70	2.7	42 (1.3)	1 (0.03)	0 (0)	2 (0.06)			3 (0.09)	21 (0.64)	0 (0)	4 (0.12)	6 (0.18)				27 (0.8)	
Diguisto et al. 2015[50]	Retro	22		165	4								3 (13.6)							0 (0)	
Seracchioli et al. 2015[39]	Pro	19	3.3			1 (5.3)												92,4			
Afors et al. 2016[45]	Retro	47		130		3 (6.4)		1 (2.1)	0 (0)		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.1)		24		13 (27.6)	
Roman et al. 2016 [67]	Retro	46	3			0 (0)	1 (2.2)	0 (0)	0 (0)		0 (0)	0 (0)	0 (0)	1 (2.2)	0 (0)	1 (2.2)		60	4 (8.7)	4 (8.7)	
Roman et al. 2016[68]	Retro	122	≥ 3	162		0 (0)	0 (0)	0 (0)	1 (0.8)		0 (0)	0 (0)	0 (0)	8 (6.6)	0 (0)	10 (0.8)		36	5 (4)	6 (4.9)	80 (65.4)
Bourdel et al. 2017[48]	Retro	172	≥ 2															60		13 (7.6)	126 (73)
Roman, 2017[35]	Pro	110	< 3				0 (0)	0 (0)	1 (0.9)				2 (1.8)	0 (0)	0 (0)	0 (0)		36	1 (0.9)	3 (2.7)	32 (29.1)
Roman, FRIENDS group. 2017[69]	Retro	546							7 (1.3)												
Abo et al. 2018[42]	Retro	145		152					3 (2.1)		0 (0)	0 (0)		8 (5.5)			0 (0)		0 (0)		57 (39.3)
Byrne et al. 2018[19]	Pro	2746				18 (0.7)			5 (0.2)	6 (0.2)											
Mabrouk et al. 2018[60]	Retro	297		147	5.4				1 (0.3)							4 (1.3)	0 (0)	43	35 (11.8)		
Abrão et al. 2019[44]	Retro	28	1.1	164	3.8				0 (0)	1 (3.3)			0 (0)				0 (0)				
Bonin et al. 2019[47]	Retro	255		240			0 (0)			0 (0)		0 (0)									

Guttierez et al. 2019[55]	Retro	47	1.79	195							1 (2.1)	0 (0)			1 (2.1)	0 (0)		46.4	6 (12.7)		
Roman et al 2020[75]	Retro	351							3 (0.8)												
Disc excision Total Disc excision		**1510**	**3**	**203**	**5**	**5/494 (1.0)**	**2/552 (0.4)**	**0/440 (0)**	**37/1378 (2.7)**	**8/819 (1.0)**	**6/530 (1.1)**	**16/768 (2.1)**	**42/536 (7.8)**	**29/701 (4.1)**	**2/461 (0.4)**	**0/600 (0)**	**1/366 (0.3)**	**53.6**	**9/106 (8.5)**	**8/65 (12.3)**	**148/263 (56.3)**
Jerby et al. 1999[28]	Pro	5		120	3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0 (0)	0 (0)		10			
Duepree et al. 2002[53]	Retro	5		382	1.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					
Woods et al. 2003[73]	Retro	30	< 2			0 (0)	0 (0)	0 (0)	1 (3.3)	0 (0)	0 (0)	1 (3.3)		0 (0)	0 (0)	0 (0)				1 (3.3)	
Mohr et al. 2005[64]	Retro	38			3	0 (0)	0 (0)	0 (0)	1 (3.0)	0 (0)	0 (0)	0 (0)	0 (0)					24		9 (24)	17 (44)
Brouwer and Woods 2007[49]	Retro	58				0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		68	3 (5.2)		
Landi et al. 2008[30]	Pro	35	< 2,5	230	5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)	0 (0)	0 (0)				2 (5.7)	
Fanfani et al. 2010[24]	Pro	48	1.1	200	7	0 (0)	0 (0)	0 (0)	1 (2.1)	0 (0)		5 (10.4)		0 (0)	0 (0)	0 (0)		33	6 (13.8)	2 (4.2)	13 (27,3)
Kondo et al. 2010[59]	Retro	17	3	215.3	6.6				3 (17.6)												
Roman et al. 2010[10]	Retro	31							0 (0)			1 (3)	0 (0)								
Moawad et al. 2011[63]	Retro	8	2.875	236.4	3.5				0 (0)									41.27			

Koh et al. 2012[58]	Retro	65		209	5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.2)	0 (0)				0 (0)		16		5 (7.7)	30 (46,4)
Afors et al. 2016[45]	Retro	15	3.5	132	4.5	1 (6.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (13.4)	0 (0)	0 (0)	0 (0)		23		2 (13.3)	
Jayot et al. 2017[56]	Retro	31		155	7					0 (0)	1 (3.2)		6 (19)	0 (0)	1 (3.2)			275			
Roman, FRIENDS group. 2017[69]	Retro	83							3 (3.6)												
Abo et al. 2018[42]	Retro	80	4.5	213					3 (3.7)		3 (3.7)	1 (1.2)		16 (20)			0 (0)				64 (80)
Byrne et al. 2018[19]	Pro	54				4 (7.4)			3 (5.6)	4 (7.4)											
Hudelist et al. 2018[26]	Pro	32		199	6.8				0 (0)	0 (0)	0 (0)	1 (3.1)	3 (9.4)				0 (0)	34.3	2 (6.2)		24 (63,6)
Mabrouk et al. 2018[60]	Retro	33		186	7.2				0 (0)							0 (0)	1 (3.0)	46	4 (12.1)		
Abo et al. 2019[43]	Retro	141	≥ 3	176		0 (0)	0 (0)	0 (0)	1 (0.7)	2 (1.4)	1 (0.7)	3 (2.1)	11 (7.8)	5 (3.5)	0 (0)	0 (0)		21			
Abrão et al. 2019[44]	Retro	57	2.1	164	4.6				1 (1.8)	0 (0)			9 (1.5)				0 (0)				
Bonin et al. 2019[47]	Retro	112		240	5.7		2 (1.7)			2 (1.8)		2 (1.8)									
Guttierez et al. 2019[55]	Retro	20	2.4	285								1 (5.0)						42.2	1 (5)		
Jayot et al. 2020[27]	Pro	93	1.5	150	7				0 (0)	0 (0)		1 (1.1)	11 (11.8)	4 (4.3)	1 (1.1)			20			
Braund et al 2020[74]	Retro	165	> 3 in 66.1%						4 (2.4)					4 (2.4)		0 (0)	0 (0)				
Roman et al 2020[75]	Retro	254							16 (6.3)												

Segmental resection Total Segmental resection		**6312**	**3.3**	**258.7**	**7**	**6/310 (1.9)**	**3/455 (0.7)**	**5/657 (0.8)**	**172/5250 (3.3)**	**87/4529 (1.9)**	**11/1127 (1.0)**	**105/3782 (2.8)**	**69/1106 (6.2)**	**157/2372 (6.6)**	**1/1470 (0.07)**	**12/3113 (0.4)**	**32/610 (5.2%)**	**45.9**	**248/2025 (12.2)**	**50/799 (6.3)**	**506/1831 (27.6)**
Verspyck et al. 1997[72]	Retro	6			9.2	0 (0)	0 (0)	0 (0)	1 (16.7)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		36	0 (0)	1 (16.6)	
Jerby et al. 1999[28]	Pro	7		240	5				1 (14.2)	0 (0)				0 (0)	0 (0)	0 (0)		10			
Possover et al. 2000[65]	Retro	34	> 2	185,6					0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		16	0 (0)	0 (0)	18 (53.3)
Redwine and Wright 2001 [34]	Pro	6							0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)				0 (0)	
Duepree et al. 2002[53]	Retro	18		200	4																
Daraï et al. 2005[9]	Pro	40	2.4	378					3 (7.5)	0 (0)	0 (0)	6 (15.0)			0 (0)	0 (0)		15			
Fleisch et al. 2005[54]	Retro	23		343	12,7				0 (0)	1 (4.3)		2 (8.7)			0 (0)	0 (0)		45.2	8 (34.8)		5 (23.5)
Keckstein and Wiesinger 2005[57]	Retro	202		180					0 (0)	6 (3.0)		1 (0.5)				0 (0)					10 (50.0)
Mohr et al. 2005[64]	Retro	47			4	0 (0)	0 (0)	0 (0)	1 (2)	1 (2.0)	0 (0)	1 (2.0)	1 (2.0)	0 (0)	0 (0)			24		16 (34.0)	8 (18.0)
Dubernard et al. 2006[23]	Pro	58							6 (10.3)	0 (0)		1 (1.7)				1 (1.7)		22.5			
Brouwer and Woods 2007[49]	Retro	137						1 (0.7)	0 (0)	1 (0.7)	0 (0)	3 (2.1)		2 (1.4)	0 (0)	0 (0)		68	3 (2.2)		

Daraï et al. 2007[20]	Pro	71	3	366					6 (8.4)	0 (0)	6 (8.4)	10 (14.1)				0 (0)		24.4			
Mereu et al. 2007[31]	Pro	192	5% < 2% - 95% > 2	326,7	9,4		1 (0.5)		5 (2.7)	9 (4.7)	2 (1.0)	4 (2.0)		9 (4.7)	1 (0.5)	2 (1)		> 36			
Seracchioli et al. 2007[38]	Pro	22	3,6	192,8	8			1 (4.5)	0 (0)	1 (4.5)		1 (4.5)	5 (22.7)	3 (13.6)	0 (0)	0 (0)		42	0 (0)	0 (0)	
Ferrero et al. 2009[25]	Pro	46	≥ 3						10 (2.2)	1 (2.2)		5 (10.8)		2 (4.3)	0 (0)	0 (0)		49.9			20 (42.9)
Minelli et al. 2009[33]	Pro	357		300				2 (0.6)	14 (3.9)	4 (1.1)		36 (10.1)	34 (9.5)	15 (4.2)	0 (0)			19.6	30 (8.4)	14 (3.9)	149 (41.6)
Tarjanne et al 2009[71]	Retro	54		145	5				1 (1.9)			1 (1.9)									
Dousset et al. 2010[22]	Pro	100	2,6	320					4 (4.0)	2 (2.0)	0 (0)	2 (2.0)		16 (16)		2 (2)		78	6 (6)	7 (7.0)	
Fanfani et al. 2010[24]	Pro	88	1.5	300	8			1 (1.1)	3 (3,4)	1 (1.1)		5 (5.7)		13 (14.7)		1 (1.1)		30		4 (4.5)	
Kondo et al. 2010[59]	Retro	25	4	371.4	11.9				3 (12.0)	1 (4.0)											
Roman et al. 2010[10]	Retro	15							0 (0)	1 (6.0)			3 (20.0)								
Ruffo et al. 2010[36]	Pro	436							14 (3.2)	9 (2.1)		14 (3.2)		71 (16.3)		0 (0)					
Meuleman et al. 2011[78]	Retro	45		420	7				0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.2)	0 (0)	0 (0)		36	5 (11.1)	5 (11.1)	21 (46.0)
Moawad et al. 2011[63]	Retro	14	3.517	426	5.07				0 (0)									41.27			
Wolthuis et al. 2011[40]	Pro	21		90	6				0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		18			
Ruffo et al. 2012[37]	Pro	750		255	8				16 (2.0)	21 (3.0)		4 (0.5)				3 (0.4)					

Belghiti et al. 2014[18]	Pro	198	3				9 (4.5)	6 (3.0)		0 (0)			0 (0)	0 (0)					
Ruffo et al. 2014[70]	Retro	774														54	119 (15.4)		128 (16.5)
Akladios et al. 2015[46]	Retro	41	> 3	210	8		1 (2.4)	1 (2.4)	1 (2.4)	2 (4.8)	0 (0)	0 (0)	0 (0)	1 (2.4)		18		1 (2.4)	
Diguisto et al. 2015[50]	Retro	6		281	8						1 (16.7)						0 (0)		3 (50.0)
Milone et al. 2015[32]	Pro	90		206			0 (0)	2 (2.2)											
Afors et al. 2016[45]	Retro	30	4	184.2	5.4		1 (3.3)	1 (3.3)			2 (6.7)					24.6		2 (6.7)	
Malzoni et al. 2016[61]	Retro	248		169,88	7,6		6 (2.4)	4 (1.6)	0 (0)	1 (0.4)	0 (0)	0 (0)	0 (0)	0 (0)		12	57 (22.9)		
Bourdel et al. 2017[48]	Retro	23	≥ 2													67		0 (0)	16 (69.0)
Jayot et al. 2017[56]	Retro	31		180	8			1 (3.2)			14 (45.0)	7 (22.0)				198			
Roman, FRIENDS group. 2017[69]	Retro	532					20 (3.9)	4 (0.8)								< 15			
Abo et al. 2018[42]	Retro	139		263			8 (5.8)		2 (1.4)	0 (0)		6 (4.3)			8 (5.7)				40 (29.0)
Byrne et al. 2018[19]	Pro	181				4 (2.2)	2 (1.1)	4 (2.2)											
Hudelist et al. 2018[26]	Pro	102		210.5	7,6		1 (1.0)	2 (1.9)		3 (2.9)	6 (5.9)				1 (1.2)	36.5	0 (0)		65 (64.0)
Mabrouk et al. 2018[60]	Retro	62		207	9.3		1 (1.6)								0 (0)	46	4 (6.5)		
Roman et al. 2018[41]	RCT	33	3	270			0 (0)			1 (3.0)	3 (9.1)	1 (3.6)				58,9	15 (45.0)		23 (71.0)

Abrão et al. 2019[44]	Retro	62	4.2	188	5.3			0 (0)	0 (0)		0 (0)			0 (0)		
Bonin et al. 2019[47]	Retro	210		293	5.9		2 (1.1)		0 (0)	0 (0)						
Guttierez et al. 2019[55]	Retro	76	3.2	309		2 (2.6)		4 (5.2)	3 (3.9)	2 (2.6)		4 (5.2)	1 (1.3)		46.4	1 (1.3)
Braund et al 2020[74]	Retro	266	> 3 in 73.3 %					16 (6.3)				7 (2.6)	1 (0.4)	23 (8.6)		
Roman et al 2020 [75]	Retro	394						15 (3.8)								

Retro: Retrospective study, Pro: Prospective study, RCT: Randomized control trial