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REVIEW

A network meta-analysis of surgical treatments of complete rectal prolapse

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Abstract

Purpose Surgical treatment of complete rectal prolapse can be undertaken via an abdominal or a perineal approach. The present network meta-analysis aimed to compare the outcomes of different abdominal and perineal procedures for rectal prolapse in terms of recurrence, complications, and improvement in fecal incontinence (FI).

Methods A PRISMA-compliant systematic review of PubMed, Scopus, and Web of Science was conducted. Randomized clinical trials comparing two or more procedures for the treatment of complete rectal prolapse were included. The risk of bias was assessed using the ROB-2 tool. The main outcomes were recurrence of full-thickness rectal prolapse, complications, operation time, and improvement in FI.

Results Nine randomized controlled trials with 728 patients were included. The follow-up ranged between 12 and 47 months. Posterior mesh rectopexy had significantly lower odds of recurrence than did the Altemeier procedure (logOR, − 12.75; 95% credible intervals, − 40.91, − 1.75), Delorme procedure (− 13.10; − 41.26, − 2.09), resection rectopexy (− 11.98; − 41.36, − 0.19), sponge rectopexy (− 13.19; − 42.87, − 0.54), and sutured rectopexy (− 13.12; − 42.58, − 1.50), but similar odds to ventral mesh rectopexy (− 12.09; − 41.7, 0.03). Differences among the procedures in complications, operation time, and improvement in FI were not significant.

Conclusions Posterior mesh rectopexy ranked best with the lowest recurrence while perineal procedures ranked worst with the highest recurrence rates.

Keywords Rectal prolapse · Surgical treatment · Network · Meta-analysis

Introduction

Rectal prolapse is the protrusion of rectal tissue into or through the anal canal. Rectal prolapse can be classified as either full-thickness or mucosal prolapse and internal or external prolapse [1]. The clinical presentation of rectal prolapse includes the feeling of a mass protruding through the anus during straining, pain in up to 25% of patients, fecal incontinence (FI) in 28–88%, and constipation in 15–65% [2].

Treatment of rectal prolapse in adults is surgical. Surgical methods used for the treatment of rectal prolapse are broadly classified into two main approaches: the abdominal and

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perineal approaches [3, 4]. Perineal resectional procedures include the Altemeier procedure, Delorme procedure, and perineal stapled prolapse repair and are usually selected for elderly patients with medical comorbidities that may further increase the risk of an abdominal procedure. A recent systematic review of 39 studies [5] reported the median recurrence rate of prolapse after the three procedures to be 11.4% after the Altemeier procedure, 14.4% after the Delorme procedure, and 13.9% after stapled repair.

Conversely, abdominal rectopexy may provide a better alternative for fit patients who can tolerate abdominal procedures. Abdominal rectopexy mainly involves three types: sutured, resection, and mesh rectopexy. Ventral mesh rectopexy (VMR) described by professor D'Hoore and colleagues [6] has gained great momentum as it has conferred excellent short- and long-term outcomes. The weighted mean rate of recurrence of internal rectal prolapse after abdominal rectopexy is less than 6% according to a recent meta-analysis [7]. Another meta-analysis of 1242 patients who underwent VMR revealed low pooled rates of complications (12.4%) and recurrence (2.8%) of full-thickness rectal prolapse [8].

Although previous studies and meta-analyses have assessed different surgical treatments of rectal prolapse, there has been no previous collective evidence comparing all of the available procedures directly to determine which procedure would attain the best outcomes. Network meta-analysis is a technique used to simultaneously compare more than two procedures in one analysis by combining both direct and indirect evidence across a network of studies. The present network meta-analysis aimed to assess and compare the outcomes of different abdominal and perineal procedures for rectal prolapse in terms of recurrence, complications, and improvements in constipation and FI.

Methods

Registration and reporting

The reporting of the present systematic review and meta-analysis followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) [9]. The protocol of this systematic review was registered in the prospective register of systematic reviews (PROSPERO) under the special identifier CRD42022304299. There was no deviation from the registered protocol when reporting this review.

Literature search

Three authors (S.E., S.K., N.H.) independently conducted a systematic search of the current literature looking for randomized clinical trials (RCTs) that compared two different surgical procedures or two approaches of the same procedure used for the treatment of rectal prolapse. The authors cross-checked the articles retrieved and conflicts about article selection were addressed by mutual agreement. The process of literature search and article selection was under the supervision of the senior author (S.D.W.).

Electronic databases including PubMed, Scopus, and Web of Science were searched from their inception through January 2022. The clinicaltrials.gov registry was screened for ongoing trials. However, non-peer-reviewed gray literature was not included in the search process to ensure the inclusion of verified and robust evidence only. The PubMed function "related articles" was activated and the bibliography section of each article was manually reviewed to identify further eligible RCTs.

We excluded conference abstracts that did not have a full text and duplicate reports. The remaining articles were screened by title/abstract followed by full-text screening. One of two authors (S.E., S.K.) reviewed the full text of the articles to ascertain their eligibility for inclusion. The senior author (S.D.W.) reviewed the results of the initial and final search and the preliminary and final lists of articles before approving them.

Search keywords

The following keywords were used in the database search: "rectal prolapse," "full-thickness prolapse," "complete rectal prolapse," "internal rectal prolapse," "rectoanal intussusception," "rectopexy," "ventral mesh rectopexy," "resection rectopexy," "suture rectopexy," "Delorme," "Altemeier," "stapled," "surgical treatment," "surgery," "outcome". In addition, we used the following Medical Subject Headings (MeSH) terms: (rectal prolapse), (surgical procedure), (outcome), and (randomized controlled trial). A summary of the search strategy and keywords syntax used is shown in Supplementary file 1.

The following syntax combination was used for literature search: (Full-thickness rectal prolapse OR complete rectal prolapse OR internal rectal prolapse OR external rectal prolapse) AND (Ventral mesh rectopexy OR resection rectopexy OR suture rectopexy OR Delorme OR Altemeier OR stapled prolapse repair) AND (outcome OR recurrence OR complications).

Article selection criteria

Only RCTs comparing two or more procedures for rectal prolapse with full-text English language publications were considered for inclusion. We excluded non-randomized cohort studies, case reports, and case series entailing fewer than ten patients, animal studies, editorials, previous

reviews, and meta-analyses. On reviewing overlapping RCTs that included the same cohort of patients within similar time periods, we included only the most recent and complete RCT.

The studies had to fulfill the following PICO criteria to be included in this network meta-analysis:

- P (*Patients*): Patients with full-thickness complete rectal prolapse
- I (*Intervention*): Any abdominal (open, laparoscopic, robotic) or perineal procedure for the treatment of rectal prolapse
- C (*Comparator*): Any abdominal (open, laparoscopic, robotic) or perineal procedure for the treatment of rectal prolapse
- O (*Outcome*): Recurrence of full-thickness rectal prolapse, complications, operation time, and improvement in bowel symptoms

Assessment of risk of bias and certainty of the evidence

Two authors (S.E. & Z.G.) independently assessed the risk of bias in the studies using the ROB-2 tool for assessing RCTs [10]. Any conflicts of interpretation of the results were resolved by consulting a third author (S.E.). The certainty of the evidence was assessed by the CINeMA approach for assessing confidence in the results of a network meta-analysis [11].

Data extraction

Three authors (Z.G., E.S., N.H.) extracted the following information from each study into an Excel sheet template:

- Authors, duration, country, and design of the study; the total number of patients and numbers in each group
- Type of rectal prolapse included and previous surgery for rectal prolapse
- Type and approach of the procedures
- Outcome of each procedure in terms of recurrence of prolapse, complications, operation time, improvement in constipation and FI
- Follow-up duration in months

Review outcomes

The primary outcome of this review was recurrence of rectal prolapse, defined as full-thickness recurrence; mucosal prolapse was not considered as recurrence. The secondary outcomes included complications, operation time in minutes, and improvement in constipation and FI after each procedure.

Statistical analysis

A network meta-analysis with a Bayesian framework was conducted in R version 4.1.2 and RStudio version 2021.09.2 using the gemtc package. The logarithms of the odds ratio (OR) for dichotomous data and mean difference outputs (MD) for continuous data were presented with their respective 95% credible intervals (CrI). The mean and standard deviation estimates were derived from the median and ranges using a previously published method [12]. A graphical summary of the direct and indirect comparisons was reported in the form of network maps, where the line thickness correlates with the number of studies and the node size with the population available for comparison. Comparisons between operations were made by analysis of NMA outputs (odds ratios and mean differences) [13].

The relative rankings on plotted rankograms, odds ratios, and mean differences were compared for each operation in the NMA output, and any statistically significant differences or consistently higher operation-specific odds ratios or mean differences were identified. Network meta-analysis was conducted using the following parameters in R software (number of chains, 4; no. of tuning iterations, 7000; simulation iterations, 50,000; thinning interval, 10. Model random). We used Brooks–Gelman–Rubin method and the potential scale reduction factor (PSRF) to assess the convergence of models, with PSRF values less than 1.2 being deemed acceptable and values close to 1 representing good convergence. The probability of a surgical method being best for a particular outcome was assessed using Rankograms, with rank 1 being the best rank and rank Nth being the worst rank.

The consistency and transitivity of the network meta-analysis were examined. Consistency implies similar effect sizes derived from the indirect and direct comparisons. A random-effect standard deviation was calculated to make a heterogeneity assessment, and a node-splitting analysis was conducted to determine inconsistency in the indirect comparison outputs. Transitivity implies equal distribution of the potential modifiers of treatment effect sizes across all trials. The fitness of the model was assessed by deviance information criteria (DIC) using gemtc as smaller values of DIC signified a better model.

Results

Study characteristics and outcomes

The initial search returned 878 records; after exclusion of duplicates and irrelevant studies, 12 randomized trials were reviewed. Three trials [14–16] had disconnected networks and were not included in the network meta-analysis to reduce heterogeneity as the inclusion of these disconnected

networks could significantly increase bias in the analysis (Fig. 1). Screening the clinical trials registry revealed one active RCT comparing anterior and posterior rectopexy (NCT03026738) whereas two RCTs were prematurely terminated because of slow recruitment (NCT04893642) and (NCT01595412).

Nine randomized control trials [17–25], published between 1992 and 2022, were included in network meta-analysis. Three studies were from the UK, two from Egypt, and one each from Sweden, Denmark, Finland, and Scotland. According to ROB-2, three studies had a low risk of bias, five had some concern of bias, and one had a high risk of bias (Appendix Table 1). The certainty of evidence assessment showed low confidence in the results of recurrence and very low confidence in complications for most comparisons (Appendix Tables 2, 3). A total of 728 patients with a median age of 76 (range, 8–76) years were included, 88.5% of whom were female. All patients had complete full-thickness rectal prolapse and follow-up duration ranged between 12 and 47 months (Table 1). The incontinence scores used and technical variations among the studies in the surgical approach, type of prosthesis, type of anastomosis, and use of levatorplasty are shown in Table 2.

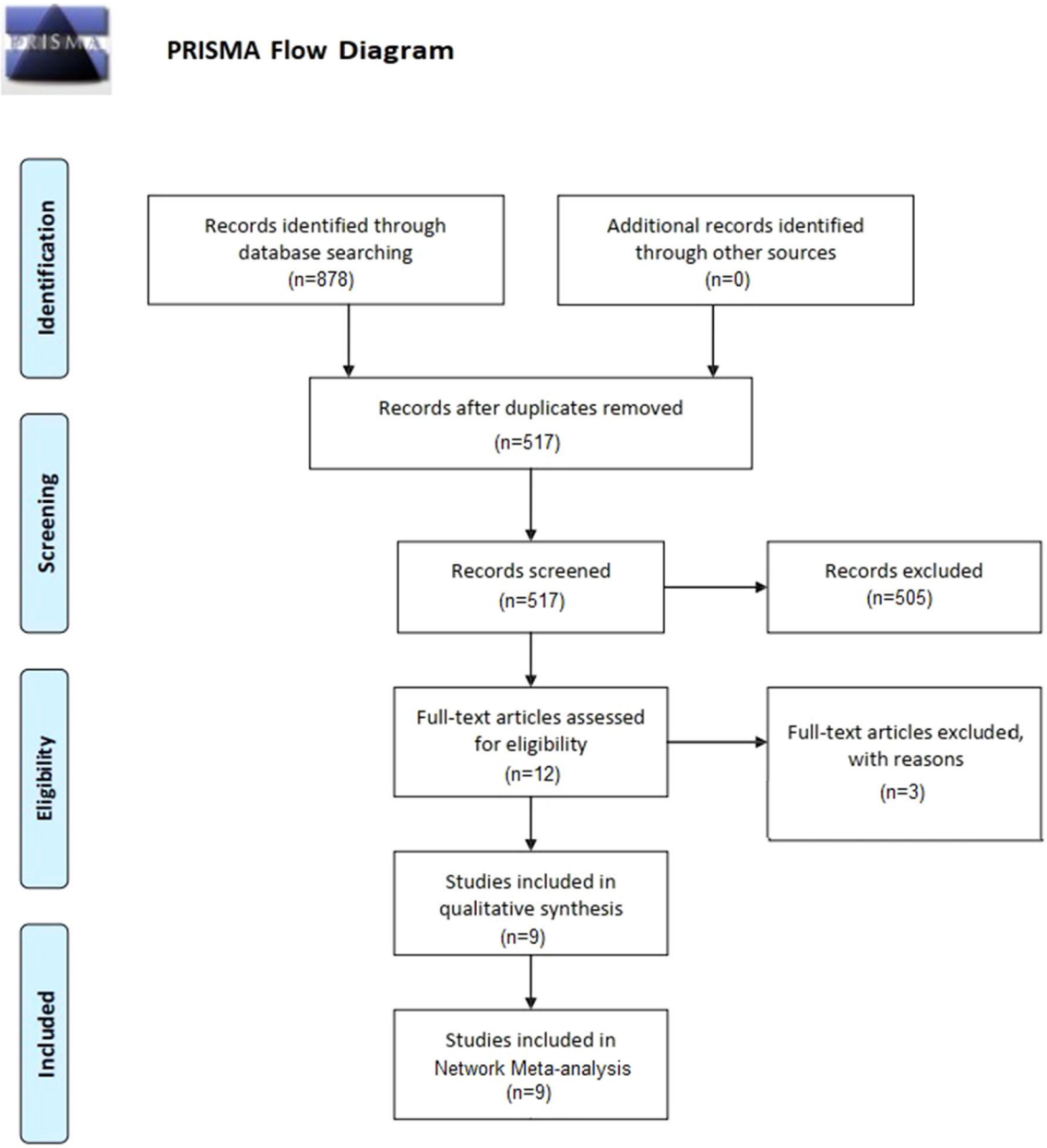

Fig. 1 PRISMA flow diagram for study selection

Table 1 Characteristic of patients and studies

Study	Duration	Country	Number	Male	Mean age (years)	Procedures assessed	Follow-up (months)
Smedberg et al. [17]	March 2000–May 2009	Sweden	122	7	71.3	Delorme (36), Altemeier (34), suture rectopexy (27), resection rectopexy (25)	31.2
Yehya et al. [18]	Feb 2010–Jan 2015	Egypt	58	36	8	Posterior mesh rectopexy (30), suture rectopexy (28)	36
Lundby et al. [19]	Nov 2006–Jan 2014	Denmark	75	7	60	Ventral mesh rectopexy (38), sutured rectopexy (37)	12
Emile et al. [20]	Jan 2012–Jan 2014	Egypt	50	19	39.7	Ventral mesh rectopexy (25), Delorme (25)	18
Senapati et al. [21]	Feb 2001–April 2008	UK	293	8	58–73	Suture rectopexy (38), resection rectopexy (40), Delorme (107), Altemeier (106)	36
Novell et al. [22]	1983–1991	UK	63	1	76	Sponge rectopexy (31), suture rectopexy (32)	47
Deen et al. [23]	NR	UK	20	0	68	Resection rectopexy (10), Altemeier (10)	17
Luukkonen et al. [24]	Oct 1988–May 1990	Finland	30	2	66	Resection rectopexy (15), posterior mesh rectopexy (15)	25.2
McKee et al. [25]	Jan 1988–June 1989	Scotland	17	4	70	Resection rectopexy (9), suture rectopexy (8)	20

NR not reported

Table 2 Technical detail of the procedures used in the studies

Study	Incontinence score used	Use of levatorplasty in perineal procedures	Abdominal rectopexy			
			Approach	Type of prosthesis	Type of anastomosis	Division of lateral stalks
Smedberg et al. [17]	Wexner/Cleveland Clinic Florida	Optional	Open or laparoscopic	Not Not available	Surgeon's preference	No
Yehya et al. [18]	Wexner/Cleveland Clinic Florida	Not available	Laparoscopic	Polypropylene mesh	Not available	No
Lundby et al. [19]	Wexner/Cleveland Clinic Florida	Not available	Laparoscopic	Polypropylene mesh	Not available	No
Emile et al. [20]	Wexner/Cleveland Clinic Florida	No	Laparoscopic	Polypropylene mesh	Not available	No
Senapati et al. [21]	Vaizey	Optional	Open or laparoscopic	Not applicable	Optional	Optional
Novell et al. [22]	None	Not available	Open	Ivalon sponge	Not available	Yes
Deen et al. [23]	Grade A–D	No	Open	Not available	Not reported	No
Luukkonen et al. [24]	Grade 0–3	Not available	Open	Polyglycolic acid mesh	Not reported	No
McKee et al. [25]	None	Not available	Open	Not available	Hand-sewn	Yes

Outcome of the network meta-analysis

Pooled analysis of nine studies (Fig. 2) showed that posterior mesh rectopexy had significantly lower odds of recurrence than did the Altemeier procedure (log odds ratio, − 12.75; 95% credible intervals − 40.91, − 1.75), the Delorme procedure (− 13.01; − 41.26, − 2.09), resection rectopexy (− 11.98; − 41.36, − 0.19), sponge rectopexy (− 13.19; − 42.87, − 0.54), and sutured rectopexy (− 13.12; − 42.58, − 1.50), but similar odds to ventral mesh rectopexy (− 12.09; − 41.70, 0.03) (Table 3).

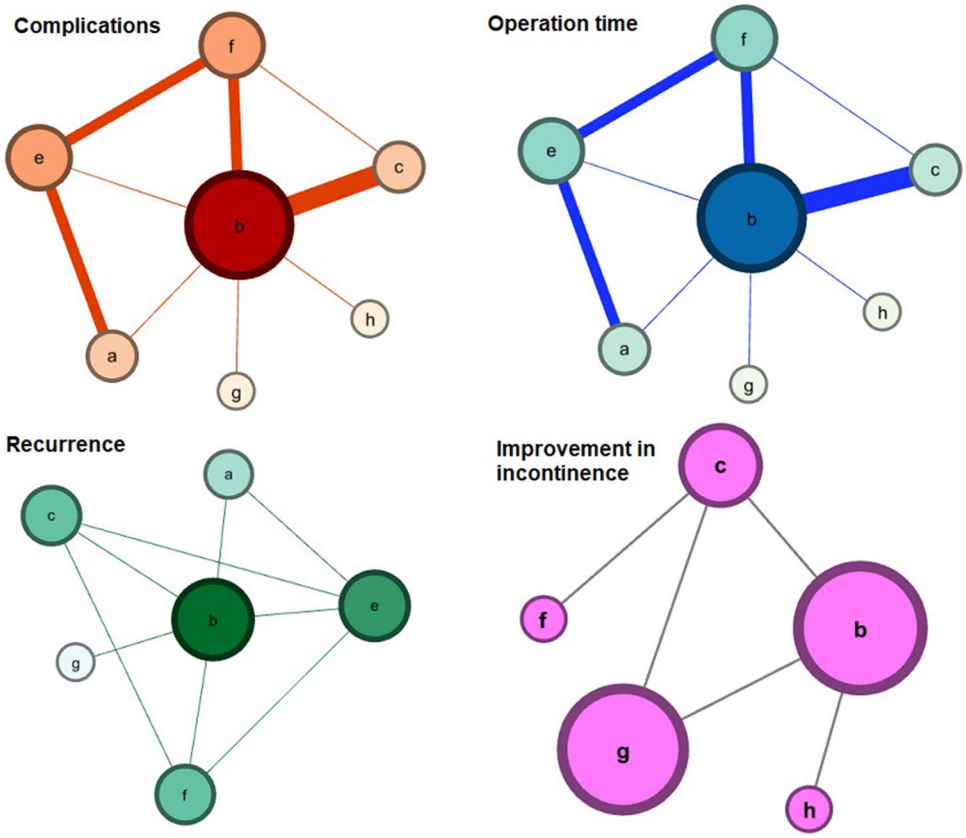

Fig. 2 Network maps of the main outcomes. The size of the node represents the total number of patients and width of the edge represents number of studies that compared the procedures. **a** Ventral mesh rectopexy, **b** sutured rectopexy, **c** resection rectopexy, **e** Delorme, **f** Altemeier, **g** posterior mesh rectopexy, **h** sponge rectopexy

Table 3 Pooled analysis of recurrence across seven procedures, results are in logOR (95% credible interval)

Altemeier	0.31 (– 1.19, 1.43)	– 12.75 (– 40.91, – 1.75)	– 1.38 (– 2.93, – 0.1329)	– 0.25 (– 4.48, 4.04)	– 0.28 (– 1.58, 1.01)	– 1.32 (– 4.29, 0.84)
– 0.30 (– 1.41, 1.10)	**Delorme**	– 13.10 (– 41.26, – 2.09)	– 1.68 (– 3.11, – 0.29)	– 0.53 (– 4.71, 3.75)	– 0.58 (– 1.72, 0.86)	– 1.62 (– 4.19, 0.38)
13.39 (1.66, 42.91)	13.67 (1.91, 43.09)	**Posterior mesh rectopexy**	11.36 (0.38, 39.61)	12.65 (0.74, 41.36)	12.48 (1.62, 40.64)	11.4 (0.09, 39.58)
1.38 (0.19, 2.91)	1.68 (0.35, 3.09)	– 11.98 (– 41.36, – 0.19)	**Resection rectopexy**	1.16 (– 3.06, 5.53)	1.1 (– 0.18, 2.71)	0.06 (– 2.83, 2.38)
0.23 (– 3.77, 4.29)	0.52 (– 3.59, 4.50)	– 13.19 (– 42.87, – 0.54)	– 1.18 (– 5.32, 2.93)	**Sponge rectopexy**	– 0.025 (– 4.05, 4.02)	– 1.10 (– 6.06, 3.31)
0.25 (– 1.00, 1.55)	0.57 (– 0.87, 1.68)	– 13.12 (– 42.58, – 1.50)	– 1.13 (– 2.73, 0.18)	0.037 (– 3.89, 3.85)	**Sutured rectopexy**	– 1.04 (– 3.88, 1.0)
1.32 (– 0.77, 4.22)	1.61 (– 0.34, 4.20)	– 12.09 (– 41.70, 0.03)	– 0.066 (– 2.37, 2.76)	1.14 (– 3.23, 5.81)	1.039 (– 0.99, 3.84)	**Ventral mesh rectopexy**

Pooled analysis of nine studies showed no significant difference in complication rates among the different surgical procedures (Table 4). Pooled analysis of four studies found no significant differences in the operation times among different surgical procedures (Table 5). Pooled analysis of five studies showed no significant differences in improvement in fecal incontinence between different surgical procedures (Table 6). The calculated PSRF was 1, indicating good convergence of the model for all outcomes.

Relative ranking of surgical procedures

Rank probabilities of surgical procedures showed that:

- Posterior mesh rectopexy had the best rank with the lowest recurrence while Delorme had the worst rank with the highest recurrence.

Table 4 Network analysis of complications across seven procedures, results are expressed as logOR and 95% credible interval

Altemeier	− 1.24 (− 4.14, 0.70)	− 1.37 (− 5.53, 2.42)	− 0.41 (− 2.65, 1.49)	0.66 (− 3.70, 4.23)	− 0.26 (− 3.09, 1.77)	− 0.68 (− 4.28, 2.01)
1.26 (− 0.69, 4.06)	**Delorme**	− 0.05 (− 4.15, 4.36)	0.87 (− 1.46, 3.65)	1.94 (− 2.05, 5.89)	1.01 (− 1.36, 3.37)	0.59 (− 2.03, 3.14)
1.366 (− 2.4, 5.39)	0.07 (− 4.33, 4.11)	**Posterior mesh rectopexy**	0.95 (− 2.37, 4.42)	2.04 (− 3.41, 6.96)	1.09 (− 3.33, 5.06)	0.67 (− 4.21, 5.05)
0.41 (− 1.49, 2.65)	− 0.86 (− 3.60, 1.41)	− 0.934 (− 4.26, 2.47)	**Resection rectopexy**	1.07 (− 3.23, 4.91)	0.143 (− 2.64, 2.42)	− 0.28 (− 3.75, 2.69)
− 0.67 (− 4.21, 3.59)	− 1.94 (− 5.87, 1.93)	− 2.01 (− 7.11, 3.39)	− 1.08 (− 4.83, 3.06)	**Sponge rectopexy**	− 0.93 (− 4.14, 2.20)	− 1.33 (− 5.57, 2.71)
0.24 (− 1.65, 3.04)	− 1.0 (− 3.34, 1.30)	− 1.10 (− 5.05, 3.28)	− 0.15 (− 2.42, 2.58)	0.92 (− 2.17, 4.08)	**Sutured rectopexy**	− 0.41 (− 3.08, 2.16)
0.70 (− 2.09, 4.21)	− 0.58 (− 3.16, 1.99)	− 0.66 (− 5.09, 4.18)	0.289 (− 2.69, 3.73)	1.36 (− 2.74, 5.49)	0.43 (− 2.24, 3.09)	**Ventral mesh rectopexy**

Table 5 Pooled analysis of operation time across six procedures, results are in mean difference (95% credible interval)

Altemeier	19.08 (− 49.59, 85)	41.05 (− 53.24, 139.10)	65.92 (− 4.76, 136.20)	22.41 (− 43.53, 89.3)	53.18 (− 24.41, 130)
− 19.68 (− 83.24, 47.67)	**Delorme**	21.91 (− 64.42, 114.20)	46.98 (− 19.79, 117.90)	3.11 (− 48.33, 62.74)	33.94 (− 19.73, 90.35)
− 41.4 (− 135.30, 50.03)	− 21.65 (− 113.09, 61.66)	**Posterior mesh rectopexy**	24.57 (− 69.90, 118.40)	− 18.94 (− 86.19, 48.96)	12.07 (− 77.93, 99.53)
− 66.46 (− 135.5, 4.313)	− 46.93 (− 116.4, 19.82)	− 24.5 (− 117.30, 73.85)	**Resection rectopexy**	− 43.42 (− 110, 24.37)	− 13.04 (− 91.87, 66.77)
− 22.71 (− 89.69, 41.11)	− 2.672 (− 63.07, 50.21)	19.05 (− 47.79, 87.58)	43.35 (− 26.12, 108.50)	**Sutured rectopexy**	31.11 (− 25.42, 84.63)
− 53.39 (− 129.20, 20.1)	− 33.66 (− 92.07, 19.85)	− 12.34 (− 96.85, 75.54)	12.88 (− 65.81, 89.54)	− 31.34 (− 84.23, 24.79)	**Ventral mesh rectopexy**

Table 6 Pooled analysis of improvement in fecal incontinence across seven procedures, results are in logOR (95% credible interval)

Altemeier	3.669 (− 2.84, 11.39)	1.041 (− 4.23, 6.81)	0.5257 (− 8.68, 10.36)	3.22 (− 4.03, 11.27)
− 3.704 (− 11.15, 2.87)	**Posterior mesh rectopexy**	− 2.607 (− 7.56, 1.35)	− 3.135 (− 11.20, 4.15)	− 0.44 (− 6.05, 4.45)
− 1.05 (− 6.71, 4.28)	2.602 (− 1.34, 7.56)	**Resection rectopexy**	− 0.5787 (− 7.99, 7.48)	2.09 (− 2.83, 7.93)
− 0.5831 (− 10.24, 8.41)	3.078 (− 4.06, 10.88)	0.5004 (− 7.25, 7.81)	**Sponge rectopexy**	2.63 (− 2.67, 8.16)
− 3.234 (− 11.35, 4.06)	0.3851 (− 4.49, 5.97)	− 2.129 (− 7.99, 2.73)	− 2.605 (− 8.26, 2.66)	**Sutured rectopexy**

- Posterior mesh rectopexy had the best rank with the lowest complications while sponge rectopexy had the worst rank with the highest complications.
- Altemeier procedure had the best rank with shortest operation time while resection rectopexy had the worst rank with the longest time.
- Posterior mesh rectopexy had the best rank with the greatest improvement in FI while Altemeier had the worst rank with the lowest improvement in FI (Fig. 3a–d).

Comparisons between direct and indirect evidence

The inconsistency between direct and the indirect estimates for each comparison was confirmed by the node-splitting method; a *P* value greater than 0.05 indicated that there was no inconsistency between comparisons. *P* values of complications and operation time were greater than 0.05, indicating consistency between direct and indirect evidence.

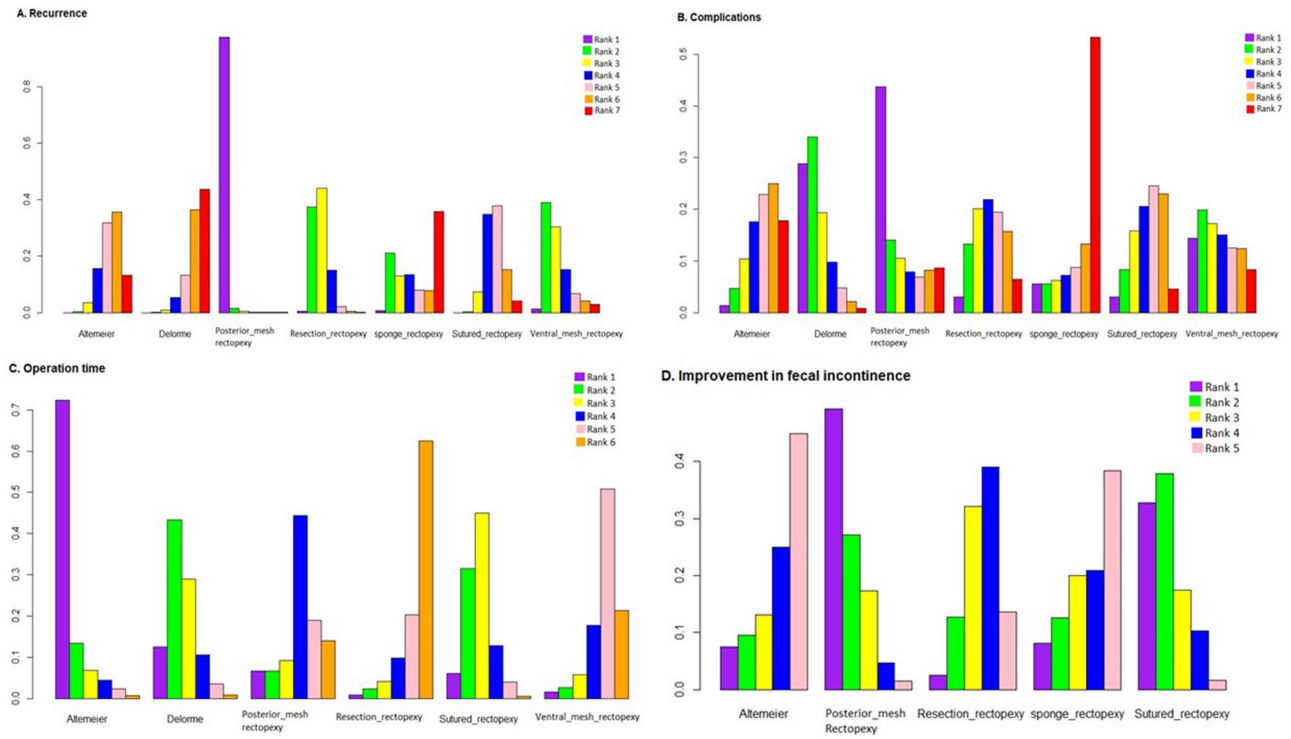

Fig. 3 Rank probabilities of best surgical procedure for **a** recurrence, rank 1 is the lowest and rank 7 is the highest; **b** complications, rank 1 is the lowest and rank 7 is the highest; **c** operation time, rank 1 is the shortest and rank 7 is longest; **d** improvement in fecal incontinence, rank 1 is the greatest and rank 7 is the lowest

In regards to recurrence, the comparison between sutured rectopexy vs posterior mesh rectopexy, resection rectopexy vs posterior mesh rectopexy, sutured rectopexy vs Altemeier, and resection rectopexy vs Delorme showed *P* values greater than 0.05. *P* values for improvement in fecal incontinence were less than 0.05, indicating an inconsistency between direct and indirect evidence (Supplementary Figs. 1–4).

Transitivity analysis

The demographics of patients randomized to each procedure varied among the trials. The mean age of patients ranged from 37.4 to 74.8 years, the proportion of male patients ranged from 8.3% to 44.4%, and the mean follow-up varied across the procedures from 15 to 47 months (Appendix Table 4).

Analysis of transitivity assumption based on differences in age of patients who underwent the same procedure showed that the skewness shape was potentially symmetrical

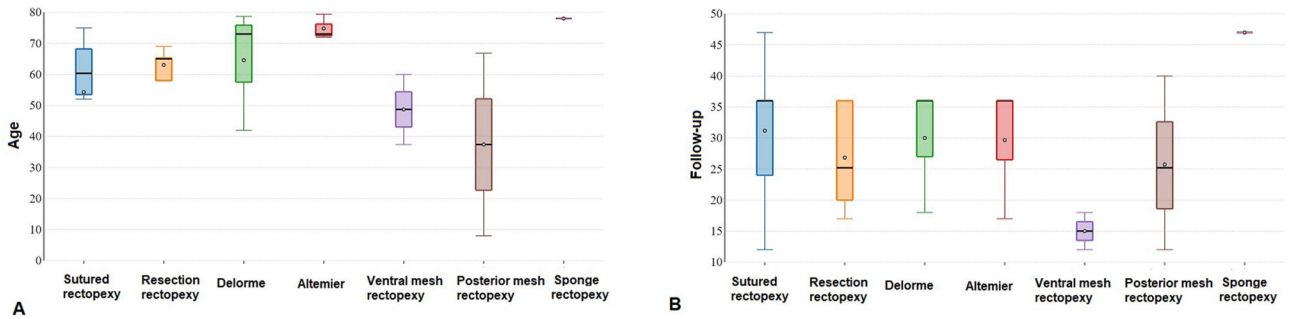

Fig. 4 Analysis of transitivity for different surgical treatments in patients with rectal prolapse. Whisker box plot showing the variation in **a** patients' age and **b** follow-up

for sutured rectopexy (0.0361, $P=0.968$), resection rectopexy (−0.116, $P=0.898$), Delorme procedure (−1.571, $P=0.2$), Altemeier's procedure (1.612, $P=0.188$), and posterior mesh rectopexy (1.639, $P=0.181$) (Fig. 4a).

The proportion of male patients varied across the studies from 8.3% of patients who underwent resection rectopexy to 44.4% of patients who underwent posterior mesh rectopexy. The proportion of male patients who underwent posterior mesh rectopexy showed a wide 95% confidence interval.

Analysis of transitivity assumption based on differences in follow-up across the trials showed that the skewness shape is potentially symmetrical for sutured rectopexy (0.592, $P=0.532$), resection rectopexy (0.669, $P=0.311$), Delorme procedure (−1.73, $P=0.157$), Altemeier's procedure (−1.732, $P=0.157$), and posterior mesh rectopexy (0.679, $P=0.456$) (Fig. 4b).

Model fitness

The fitness of the model was assessed using DIC for each outcome. The DIC was 31.8 for recurrence, 33.8 for complications, 20.4 for FI, and 20.1 for operative time.

Discussion

A few randomized trials compared different procedures for rectal prolapse; nonetheless, there is no consensus on which procedure confers the best outcomes. This network meta-analysis was undertaken to compare the results of different abdominal and perineal procedures for the treatment of complete rectal prolapse in one pooled analysis. Posterior mesh rectopexy was followed by the lowest recurrence and complication rates and the greatest improvement in FI.

The trials analyzed in this meta-analysis included more than 700 patients, approximately 90% of whom were women. This finding was consistent with the literature that documented a strong female predominance of rectal prolapse in women, probably owing to weaker pelvic floor muscles and supporting ligaments than men, in addition to the effect of vaginal deliveries [26].

Regarding the primary outcome of this analysis, posterior mesh rectopexy ranked first with the lowest recurrence rate. The odds of recurrence after posterior mesh rectopexy were significantly lower than after all other procedures, except ventral mesh rectopexy which ranked second as regards recurrence. This finding may imply that the use of mesh may confer better fixation of the rectum in place, probably owing to stronger fibrosis induced by the mesh. It should be noted that although mesh rectopexy may provide lower recurrence, certain mesh-related factors, such as length and type, may affect the outcome. A retrospective cohort analysis found that synthetic meshes are associated with a higher likelihood of recurrence than biologic meshes (HR = 4.24; $P=0.02$) [27]. On the other hand, a meta-analysis [8] found that mesh length of 15 cm or smaller would be associated with a higher risk of recurrence of rectal prolapse after VMR.

Perineal procedures including Delorme and Altemeier ranked worst with the highest recurrence rates, ranging from 27% to 33%. Although a systematic review [5] reported lower recurrence rates after perineal procedures, ranging from 11% to 14%, the median follow-up in this review was approximately 3 years. It is known that with a longer follow-up the recurrence rates of perineal procedures tend to increase. A study that followed patients after Delorme procedure for 88 months reported a recurrence rate of 23% [28]. The same recurrence rate was also reported by other authors after a shorter follow-up period of 46 months [29]. Similarly, long-term recurrence of rectal prolapse after Altemeier was 26.7% after a mean follow-up of 50 months [30]. The higher recurrence after perineal procedures may be attributed to the fact that these procedures do not entail fixation of the rectum in place, but only mucosal or full-thickness resection.

Posterior mesh rectopexy was also ranked first with the lowest complication rate of 4.4%; however, the difference in the odds of complications compared to other procedures was not significant. Delorme procedure ranked second in regards to lower complication rates which seems plausible since the Delorme procedure was mainly described as a relatively safe operation to treat high-risk patients with rectal prolapse. The complication rate after Delorme in this meta-analysis was about 6%, close to the rate reported by another systematic review (8.7%) [5]. Owing to the good safety profile of Delorme, and perineal procedures in general, they were recommended by the practice guidelines of American Society of Colon and Rectal Surgeons (ASCRS) for treatment of high-risk, elderly patients with comorbidities [31]. Sponge rectopexy ranked worst with a complication rate of around 20%, which may explain why this procedure has been discontinued in current practice.

Secondary outcomes included operative time and improvements in FI. While the average operation time for the perineal procedures was less than 90 min, it was 2 h or longer for VMR and resection rectopexy. This may also be another reason for choosing perineal procedures over abdominal operations for high-risk patients as they subject the patients to a shorter anesthesia and operation time which may help accelerate recovery of these high-risk patients. A longer time of abdominal procedures is expected as they entail time for mobilization of the rectum, resection of colon, anastomosis, plus the time needed for fixation to the sacral promontory.

Although there were no significant differences in the improvement in FI among the procedures, posterior mesh rectopexy ranked first with the best improvement. The use of mesh, particularly in the posterior aspect of the rectum,

was described to be associated with significant improvement in FI, up to 60% [3, 31]. Conversely, procedures entailing resection such as Altemeier and resection rectopexy were followed by the lowest improvement in FI. It has been noted that resection procedures may present concerns for patients with rectal prolapse and FI since the improvement in FI appears to be lower when sigmoid resection is done [32]. That is why sigmoid resection was recommended not to be offered to patients with low anal pressures on manometry or patients with severe baseline FI [33].

Limitations of the present review include the small numbers and average quality of the studies included. The lack of reporting on improvement in constipation after each procedure precluded doing a network meta-analysis of this outcome. Furthermore, the included trials spanned a period of 30 years during which some technical modifications of the procedures assessed may have occurred. The inclusion of English-language articles only may limit the sensitivity of our search. Differences in follow-up may affect the outcomes by affecting underlying risk; however, since such heterogeneity is expected when conducting systematic reviews, it is considered an important limitation. Furthermore, the inclusion of all eligible trials, regardless of the patients' age, may add to the heterogeneity of the results. The range of the 95% credible interval of log odds ratio was quite large for some parameters, suggesting several orders of magnitude of difference in effects and indicating substantial variability that makes direct comparison challenging. Finally, despite the non-significant *P* values for the inconsistency between direct and indirect estimates for each comparison, some of the direct and indirect estimates were markedly different which may reflect imprecision rather than no incoherence.

Conclusions

Posterior mesh rectopexy ranked best with the lowest recurrence rate while perineal procedures ranked worst with the highest recurrence rates. A significant difference among the procedures was observed only in recurrence, whereas the differences in other outcomes were not significant.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10151-023-02813-2.

Declarations

Conflict of interest None of the authors report any relevant financial disclosures. Non-relevant disclosures: Dr. Wexner reports receiving consulting fees from ARC/Corvus, Astellas, Baxter, Becton Dickinson, GI Supply, ICON Language Services, Intuitive Surgical, Leading BioSciences, Livsmed, Medtronic, Olympus Surgical, Stryker, Takeda and receiving royalties from Intuitive Surgical and Karl Storz Endoscopy America Inc. Dr. Emile reports receiving consulting fees from SafeHeal.

Ethical approval Formal ethics approval was not required because the study was a review of previously published studies.

Informed consent Informed consent is not applicable since the study is a review article.

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