REVIEW

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Transanal hemorrhoidal dearterialization (THD) versus stapled hemorrhoidopexy (SH) in treatment of internal hemorrhoids: a systematic review and meta-analysis of randomized clinical trials

Sameh Hany Emile[1] (iD) · Hossam Elfeki[1,2] · Ahmad Sakr[1,3] · Mostafa Shalaby[1]

Abstract

Background Although conventional hemorrhoidectomy proved effective in treatment of hemorrhoidal disease, postoperative pain remains a vexing problem. Alternatives to conventional hemorrhoidectomy as transanal hemorrhoidal dearterialization (THD) and stapled hemorrhoidopexy (SH) were described. The present meta-analysis aimed to review the randomized trials that compared THD and SH to determine which technique is superior in terms of recurrence of hemorrhoids, complications, and postoperative pain.

Methods Electronic databases were searched for randomized trials that compared THD and SH for internal hemorrhoids. The PRISMA guidelines were followed when reporting this meta-analysis. The primary endpoint of the analysis was persistence or recurrence of hemorrhoidal disease. Secondary endpoints were postoperative pain, complications, readmission, return to work, and patients' satisfaction.

Results Six randomized trials including 554 patients (THD = 280; SH = 274) were included. The mean postoperative pain score of THD was significantly lower than SH (2.9 ± 1.5 versus 3.3 ± 1.6). 13.2% of patients experienced persistent or recurrent hemorrhoids after THD versus 6.9% after SH (OR = 1.93, 95%CI = 1.07–3.51, $p = 0.029$). Complications were recorded in 17.1% of patients who underwent THD and 23.3% of patients who underwent SH (OR = 0.68, 95%CI 0.43–1.05, $p = 0.08$). The average duration to return to work after THD was 7.3 ± 5.2 versus 7.7 ± 4.8 days after SH ($p = 0.34$). Grade IV hemorrhoids was significantly associated with persistence or recurrence of hemorrhoidal disease after both procedures.

Conclusion THD had significantly higher persistence/recurrence rate compared to SH whereas complication and readmission rates, hospital stay, return to work, and patients' satisfaction were similar in both groups.

Keywords Transanal hemorrhoidal dearterialization · Stapled hemorrhoidopexy · Hemorrhoids · Meta-analysis · Randomized clinical trials

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Introduction

Hemorrhoids are one of the most common anorectal conditions with an estimated prevalence of 4.4% in the general population. Hemorrhoids commonly affect young and middle-aged individuals with no specific sex predilection. The most common presentation of hemorrhoidal disease is rectal bleeding, pain, pruritus, or prolapse; however, these symptoms are non-specific and can be seen in other anorectal conditions [1].

Treatment of hemorrhoidal disease varies according to the type of hemorrhoids and the grade of internal hemorrhoids. Guidelines for treatment of hemorrhoidal disease have been devised by the American Gastroenterological Association [2] and the American Society of Colon and Rectal Surgeons [3]. For grade I internal hemorrhoids, the treatment of choice is conservative treatment that includes high fiber diet, stool

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softeners, adequate fluid intake and phlebotonic medications. Grade II and grade III hemorrhoids are usually treated with non-surgical procedures including rubber band ligation and injection sclerotherapy, whereas grade IV and large symptomatic grade III hemorrhoids require surgical hemorrhoidectomy [4].

Although conventional hemorrhoidectomy remains highly effective in the treatment of hemorrhoidal disease, postoperative pain is a common sequel and still represents a challenging problem in the early postoperative period. Therefore, alternatives to excisional hemorrhoidectomy were described in the literature, including stapled hemorrhoidopexy (SH) or procedure for prolapsing hemorrhoids (PPH) [5], **Doppler**-guided transanal hemorrhoidal dearterialization (THD) [6], and hemorrhoidal artery ligation and rectoanal repair (HAL-RAR) [7].

Longo [8] first described the PPH/SH technique which involves circumferential resection of the mucosa and submucosa above the hemorrhoids using a circular stapler device resulting in hemorrhoidopexy. SH has been reported to be a safe alternative for surgical hemorrhoidectomy that confers the advantages of less postoperative pain, shorter hospital stay, and greater patient satisfaction. However, SH carries a significantly higher risk of recurrence and requirement for additional procedures compared with excisional hemorrhoidectomy according to a meta-analysis [9].

THD has emerged as a viable alternative that achieves far less postoperative pain than conventional hemorrhoidectomy. The technique involves the identification and suture ligation of the hemorrhoidal arteries with possible mucopexy for redundant mucosa using specially designed proctoscope under the guidance of **Doppler** transducer [10]. THD addresses the imbalance in blood flow of the hemorrhoidal plexus by reducing the arterial inflow which subsequently diminishes the size of hemorrhoidal plexus, leading to shrinkage of the hemorrhoids. Several studies have assessed the efficacy and safety of THD and reported encouraging results in terms of minimal complications, mild postoperative pain, and low recurrence rates [6, 11, 12].

The present meta-analysis aimed to review and analyze the randomized controlled trials (RCTs) that compared THD and SH in treatment of internal hemorrhoids in regard **to** recurrence or persistence of hemorrhoidal disease, postoperative pain, surgical complications, return to daily activities, and patients' satisfaction.

Methods

Registration

The protocol of the present meta-analysis has been registered a priori at the PROSPERO website under the registration number of *CRD42018097157*.

Search strategy

A systematic search of the current literature for RCTs comparing THD with SH was undertaken independently by two investigators (S.E. & H.E.). The screening guidelines established by the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) were followed when reporting the outcome of the present review (Fig. 1) [13].

We searched electronic databases including PubMed/Medline, Scopus, Embase, and Cochrane Central Register of Controlled Trials for published and ahead-of-publication trails starting from January 2000 through May 2018. Using the "related articles," PubMed function further publications were retrieved and screened. A parallel internet-based search was also conducted using the Google Scholar service.

Keywords used in the search process included "transanal hemorrhoidal dearterialization,," "THD," "stapled hemorrhoidopexy," "SH," "stapled anopexy," "procedure for prolapse and hemorrhoids," "PPH," "stapler," "internal hemorrhoids," "hemorrhoids," "hemorrhoidal disease," "randomized," "randomised," "controlled trials," and "clinical trials". In addition, medical subject heading (MeSH) terms: (hemorrhoids), (surgical stapler), (hemorrhoidal dearterialization), and (randomized controlled trial) were used

The reference section of each publication was manually searched for relevant articles. The search process was conducted systematically starting with title screen then abstract screen, and finally, the full-text versions of the selected articles were reviewed independently by four reviewers (S.E., H.E., M.S., and A.S.) to check for eligibility

Study selection

This meta-analysis included studies with the following inclusion criteria: (1) all original RCTs; (2) the treatment group underwent THD for internal hemorrhoids; (3) a parallel control group underwent SH for internal hemorrhoids; and (4) only articles in English language were selected for this review.

We excluded animal studies, non-randomized controlled trials, single cohort observational studies, irrelevant articles, editorials, case reports, reviews, and meta-analyses. RCTs comparing only one of the study arms with another comparator were excluded. Duplicate reports and conference abstracts without full-text articles were identified and excluded from this review.

Assessment of methodological quality within the included studies

The risk of bias in the trials included to this meta-analysis was assessed by the Cochrane Collaboration's tool for assessing
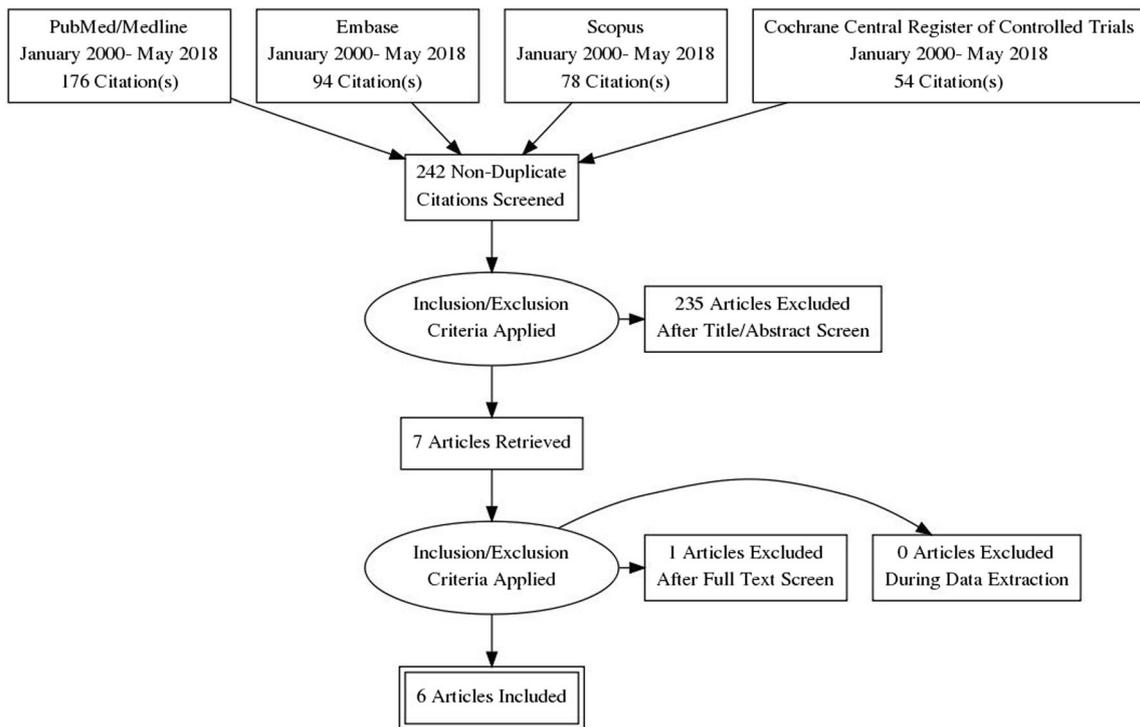
Fig. 1 PRISMA flow diagram illustrating literature search and article selection

RCTs devised by Higgins and colleagues [14]. Two reviewers (S.E and H.E) independently assessed the risk of bias in each study, and any discrepancies in interpretation were resolved by consultation of a third reviewer (M.S.) (Fig. 2).

Assessment of publication bias across the included studies

A funnel plot of the standard error of the recurrence/persistence rates against the recurrence/persistence rates of the studies included was used to assess the publication bias across the studies of this review. The straight vertical line in the plot indicates the zone in which 95% of studies should exist if there was no publication bias (Fig. 3).

The Begg and Mazumdar Rank Correlation Test and the Egger regression test were also used to assess publication bias across the studies included.

Data extraction and synthesis

We extracted the following information from each study:

- Duration and country of the study
- Patients' characteristics including the number in each group, mean age, gender distribution, and grade of hemorrhoids
- Details of the randomization method used
- Technical details and operation time of each procedure

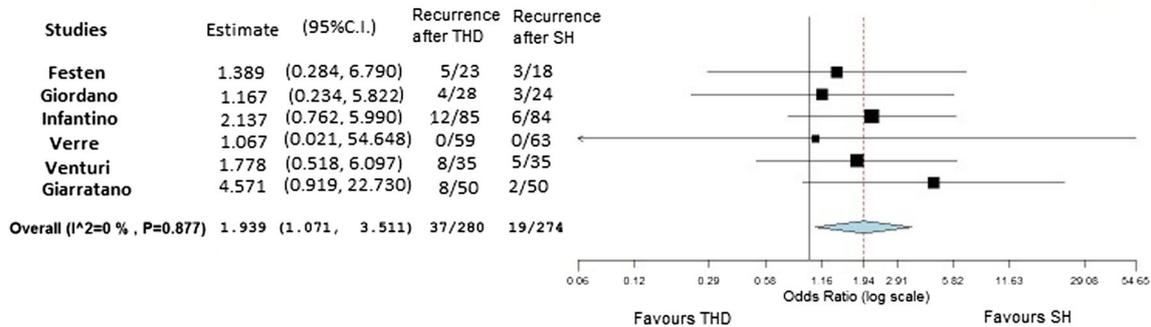**Fig. 2** Assessment of bias across the studies by Cochrane tool
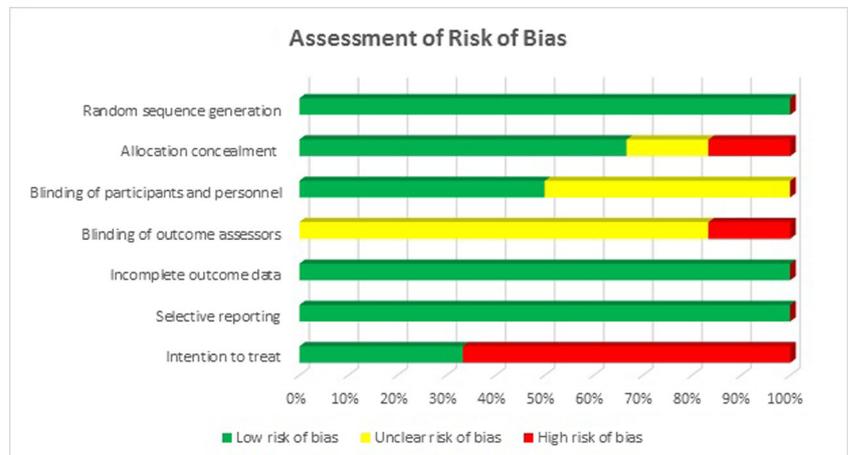
Fig. 3 Forest plot of persistence or recurrence of hemorrhoids after each technique

- Failure of the technique in terms of recurrence or persistence of hemorrhoids
- Early postoperative pain (within 24 h postoperatively) as assessed by visual analogue scale (VAS) from 0 to 10
- Postoperative complications
- Re-admission to the hospital for management of complications or residual or recurrent hemorrhoids
- Follow-up duration and time to return to normal activities

Endpoints of the review

The primary endpoint was the incidence of failure of each procedure which was defined as persistence or recurrence of hemorrhoids on follow-up. Recurrence was diagnosed clinically by physical examination. Secondary endpoints included operation time, hospital stay, complication rate, postoperative pain, patients' satisfaction, time to return to normal activities, and hospital readmission. Postoperative complications were defined as any deviation from the normal postoperative course whether early (within 30 days of the operation) or late (beyond 30 days).

Statistical analysis

Data were extracted from the original articles into fields of Excel spreadsheet (Microsoft Windows). Variables were expressed as mean or median, normal range, and percentage of patients reported in each variable. Statistical analysis of data was performed using SPSS version 23 (IBM Corp, Chicago, USA). Student's t test was used for analysis of continuous variables, and chi-square or Fisher exact tests were used for analysis of categorical variables.

A meta-analysis was conducted using open-source, cross-platform software for advanced meta-analysis "openMeta [Analyst]™" version 12.11.14. Differences between the two groups with regard to recurrence and complication rates were expressed as odds ratio (OR) with the 95% confidence interval (CI). Statistical heterogeneity was determined by the p value

of the Cochrane Q test for heterogeneity and the inconsistency (I^2) statistics. Heterogeneity was considered low if $I^2 < 25\%$ and high if $I^2 > 75\%$. If no significant statistical heterogeneity was present, a fixed-effects model was used to pool data, whereas in the case of significant ($p < 0.1$) statistical heterogeneity, the binary random-effects model was utilized for pooling of data.

A random-effects meta-regression model was used weighing the studies by their within-study variance and the degree of heterogeneity to determine the predictors of persistence or recurrence of hemorrhoids after each technique. The heterogeneity between the studies was explored in relation to differences in patients' age, gender, grade of hemorrhoids, and development of complications. The statistical significance of each examined variable was examined using slope regression coefficient (SE) which is the estimated increase in the log odds of the outcome per unit increase in the value of the exposure, 95%CI, and p value.

Results

Patient and study characteristics

Six randomized clinical trials [15–20] comprising 554 patients were included in the current meta-analysis. Five trials were conducted in Italy and one in the Netherlands. Patients were 314 (56.7%) male and 240 (43.3%) female of a median age of 49.5 (range, 47–56) years. Thirty-one (5.6%) patients presented with grade II hemorrhoids, 385 (69.5%) patients with grade III hemorrhoids, and 138 (24.9%) with grade IV hemorrhoids. The median follow-up period across the studies was 25.3 (range, 1.5–38) months (Table 1).

Three trials [15, 17, 19] reported the method of randomization clearly whereas the other three trials did not report how randomization was achieved. Only two trials [15, 17] used intention-to-treat analysis of the results of each technique. The assessment of the methodologic quality of the trials is illustrated in Fig. 2.

Table 1 Characteristics of the studies reviewed

Study	Country	Duration	Randomization method	Blinding	Number	Males (%)	Grade of hemorrhoids	Follow-up in months
Festen et al. 2009 [15]	The Netherlands	December 2006–November 2007	Opaque envelope	Not reported	41	29 (70.7)	36 (III) 5 (IV)	1.5
Giordano et al. 2011 [16]	Italy	September 2004–December 2005	Not reported	Single	52	36 (69.2)	31 (II) 21 (III)	38
Infantino et al. 2012 [17]	Italy	Not reported	Computer-generated	Single	169	116 (68.60)	169 (III)	17
Verre et al. 2013 [18]	Italy	January 2010–June 2012	Not reported	Not reported	122	46 (37.7)	52 (III) 70 (IV)	3
Venturi et al. 2016 [19]	Italy	January 2011–December 2012	Sealed envelope	single	70	35 (50)	40 (III) 30 (IV)	36
Giarratano et al. 2018 [20]	Italy	January 2013–December 2014	Not reported	Not reported	100	52 (52)	67 (III) 33 (IV)	33.7

Patients' characteristics and technical details of THD and SH groups

The THD group included 280 patients (161 (57.5%) male and 119 (42.5%) female) of a median age of 48.7 (range; 39–56) years. The SH group included 274 patients (153 (55.8%) male and 121 (44.2%) female) of a median age of 47.9 (range, 35–56) years. There were no significant differences between the two groups regarding patients' age and gender ($p = 0.75$).

Sixteen patients with grade II hemorrhoids, 196 with grade III hemorrhoids, and 68 with grade IV hemorrhoids underwent THD. Fifteen patients with grade II hemorrhoids, 189 with grade III hemorrhoids, and 70 with grade IV hemorrhoids underwent SH. There was no significant difference between the two groups regarding the grade of hemorrhoids treated with each technique ($p = 0.9$) (Table 2).

The studies performed SH using a circular stapling device (PPH 01 or PPH 03 stapler, Ethicon Endo-Surgery™) and performed THD using a specifically designed proctoscope (THD, THD Lab™, Correggio, Italy) that includes a side-sensing Doppler probe and a window beyond this for suturing. All studies combined the THD procedure with mucopexy with absorbable sutures. The average operation time for THD was longer than SH (30.7 ± 4.4 versus 28 ± 5 min, $p < 0.0001$).

Outcomes after THD and SH

Early postoperative pain

The mean VAS of early postoperative pain after THD was significantly lower than SH (2.9 ± 1.5 versus 3.3 ± 1.6, $p = 0.002$). Details about the number of patients who required analgesia after each procedure were not clarified in the trials included except the study by Infantino et al. [17] in which 46 (54.1%) of 85 patients in the THD group and 52 (61.9%) of 84 patients in the SH group required postoperative analgesia.

Hospital stay

Both procedures were conducted as day-case surgery except in two trials, the first study [17] reported a mean stay of 1.14 ± 0.5 days after THD versus 1.36 ± 0.6 days after SH ($p = 0.03$) and the second study [19] reported a mean stay of 2.1 ± 0.5 days after THD versus 2.2 ± 0.6 days after SH ($p = 0.45$).

Persistence or recurrence of hemorrhoids

Thirty-seven (13.2%) patients experienced persistent or recurrent hemorrhoids after THD and 19 (6.9%) patients experienced persistent or recurrent hemorrhoids after SH ($p = 0.02$) (Table 3). THD had significantly higher odds for postoperative persistence or recurrence of hemorrhoids compared to SH ($OR = 1.93$, 95%CI = 1.07–3.51, $p = 0.029$, $I^2 = 0$) (Fig. 3).

Table 2 Characteristics of patients in THD and SH groups

Study	Number in THD group	Number in SH group	Male/female in THD group	Male/female in SH group	Mean age in THD group	Mean age in SH group	Grade of hemorrhoids in THD group	Grade of hemorrhoids in SH group
Festen et al. 2009 [15]	23	18	16/7	13/5	39	35	19 (III) 4 (IV)	17 (III) 1 (IV)
Giordano et al. 2011 [16]	28	24	20/8	16/8	54	48	16 (II) 12 (III)	15 (II) 9 (III)
Infantino et al. 2012 [17]	85	84	58/27	58/26	47.6	46.2	85 (III)	84 (III)
Verre et al. 2013 [18]	59	63	22/37	24/39	48.9	47.8	27 (III) 32 (IV)	25 (III) 38 (IV)
Venturi et al. 2016 [19]	35	35	18/17	17/18	48.5	49.5	20 (III) 15 (IV)	20 (III) 15 (IV)
Giarratano et al. 2018 [20]	50	50	27/23	25/25	56	56	33 (III) 17 (IV)	34 (III) 16 (IV)
Total number	280	274	161/119	153/121	48.7	47.9	16 (II) 196 (III) 68 (IV)	15 (II) 189 (III) 70 (IV)

THD, transanal hemorrhoidal dearterialization; *SH*, stapled hemorrhoidopexy

Table 3 Outcomes of THD and SH groups

Study	Persistence or recurrence after THD (%)	Persistence or recurrence after SH (%)	Complications after THD (%)	Complications after SH (%)	Readmission after THD (%)	Readmission after SH (%)	Return to work in days after THD	Return to work in days after SH
Festen et al. 2009 [15]	5 (21.7)	3 (16.6)	2 (8.7)	3 (16.6)	1 (4.3)	2 (11.1)	NA	NA
Giordano et al. 2011 [16]	4 (14.2)	3 (12.5)	4 (14.2)	6 (25)	0	3 (12.5)	3.2	6.3
Infantino et a. 2012 [17]	12 (14.1)	6 (7.1)	28 (32.9)	31 (36.9)	10 (11.7)	6 (7.1)	NA	NA
Verre et al. 2013 [18]	0	0	8 (13.5)	9 (14.2)	0	0	3.5	5.5
Venturi et al. 2016 [19]	8 (22.8)	5 (14.2)	3 (8.5)	4 (11.4)	5 (14.2)	1 (2.8)	10.8	12.9
Giarratano et al. 2018 [20]	8 (16)	2 (4)	3 (6)	11 (22)	0	0	11.8	6.12
Total number	37 (13.2)	19 (6.9)	48 (17.1)	64 (23.3)	16 (5.7)	12 (4.3)	7.3 ± 5.2	7.7 ± 4.8

THD, transanal hemorrhoidal dearterialization; *SH*, stapled hemorrhoidopexy; *NA* not available

Complications

Forty-eight (17.1%) patients developed complications after THD and 64 (23.3%) patients developed complications after SH ($p = 0.08$) (Table 3). The type of complications recorded after each procedure is illustrated in Table 4. There were no significant differences between the two procedures with regard complication rate (OR = 0.68, 95%CI 0.43–1.05, $p = 0.08$, $I^2 = 0$) (Fig. 4).

Return to work and patients' satisfaction

The average duration to return to work and daily activities after THD was 7.3 ± 5.2 versus 7.7 ± 4.8 days after SH ($p = 0.34$). Three trials [16, 19, 20] reported patients' satisfaction with each procedure. Overall, 100 (88.5%) of 113 patients who underwent THD were satisfied with the outcome of the procedure compared to 103 (94.5%) of 109 patients who underwent SH ($p = 0.17$).

Re-admission

One (0.35%) patient required readmission after THD for management of complications versus 5 (1.8%) patients after SH. Fifteen (5.3%) patients required readmission after THD for management of persistent or recurrent hemorrhoids versus 7 (2.5%) patients after SH. Overall, 16 (5.7%) patients required hospital readmission after THD versus 12 (4.3%) patients after SH ($p = 0.6$) (Table 3). There was no significant difference in re-admission rates between THD and SH (OR = 1.24, 95%CI 0.48–3.24, $p = 0.65$, $I^2 = 11.47$) (Fig. 5).

Table 4 Complications recorded after THD and SH

Complication	THD ($n = 280$)	SH ($n = 274$)	P value
Bleeding	9	20	0.049*
Hematoma	6	6	0.97
Thrombosis	6	5	0.78
Urine retention	12	16	0.52
Dysuria	5	4	1
Bladder dysfunction	0	1	0.49
Fecal soiling	1	0	1
Fecal urgency	0	3	0.12
Anal stenosis	0	1	0.49
Obstructed defecation	0	1	0.49
Perianal abscess	0	2	0.24
Severe pain	0	2	0.24
Technical failure	3	2	1
Other complications	6	1	0.12
Total	48	64	0.08

THD, transanal hemorrhoidal dearterialization; *SH*, stapled hemorrhoidopexy

* Significant p value < 0.05

Assessment of publications bias

No publication bias was detected on using the funnel plot (Fig. 6) which was symmetrical with all studies located near the straight vertical line of the plot. Also, on performing the Begg and Mazumdar rank correlation test, the Kendall's tau-b (corrected for ties) was -0.3, with a one-tailed P value of 0.23 and a two-tailed P value of 0.46. The Egger's regression test revealed an intercept (B0) of -0.2 (95%CI -5.9–5.5), with $t = 0.11$ and 3 degrees of freedom. The one-tailed P value was 0.45 and the two-tailed P value was 0.91 indicating no significant publication bias among the studies included.

Predictors for persistence or recurrence of hemorrhoids after THD and SH

The potential effect of clinical confounders on failure of each procedure was investigated using the random effect meta-regression model.

Grade IV hemorrhoids was the only variable that was significantly associated with persistence or recurrence of hemorrhoids after THD (SE = -0.005, 95%CI -0.007–-0.003, $p < 0.001$) and after SH (SE = -0.002, 95%CI -0.003–-0.001, $p = 0.001$).

Factors that were not associated with persistence or recurrence of hemorrhoids after THD and SH were:

- Patients' age: THD: (SE = -0.002, 95%CI -0.017–0.012, $p = 0.75$), SH: (SE = -0.004, 95%CI -0.013–0.005, $p = 0.35$).
- Male gender: THD: (SE = 0.0001, 95%CI -0.005–0.005, $p = 0.99$), SH: (SE = -0.000, 95%CI -0.003–0.002, $p = 0.83$)
- Development of complications: THD: (SE = -0.0001, 95%CI -0.008–0.006, $p = 0.76$), SH: (SE = -0.000, 95%CI -0.005–0.004, $p = 0.85$)

Discussion

The optimal treatment of hemorrhoids should not only achieve low recurrence rate, but also minimal postoperative pain and complications. Although conventional hemorrhoidectomy confers excellent results in terms of recurrence of hemorrhoidal disease postoperatively [21], anal pain after the procedure still represents a challenging problem. Different methods were described to relieve posthemorrhoidectomy pain including topical agents that induce chemical sphincterotomy [22] and surgical internal anal sphincterotomy [23]; however, the impact of these methods on postoperative pain is variable and inconsistent.

Forest Plot for complications

Studies	Estimate	(95%C.I.)	Complications after THD	Complications after SH
Festen	0.476	(0.071, 3.209)	2/23	3/18
Giordano	0.500	(0.123, 2.038)	4.28	6/24
Infantino	0.840	(0.446, 1.582)	28/85	31/84
Verre	0.941	(0.337, 2.627)	8/59	9/63
Venturi	0.727	(0.150, 3.515)	3/35	4/35
Giarratano	0.226	(0.059, 0.869)	3/50	11/50
Overall (I^2=0 % , P=0.592)	0.680	(0.438, 1.055)	48/280	64/274

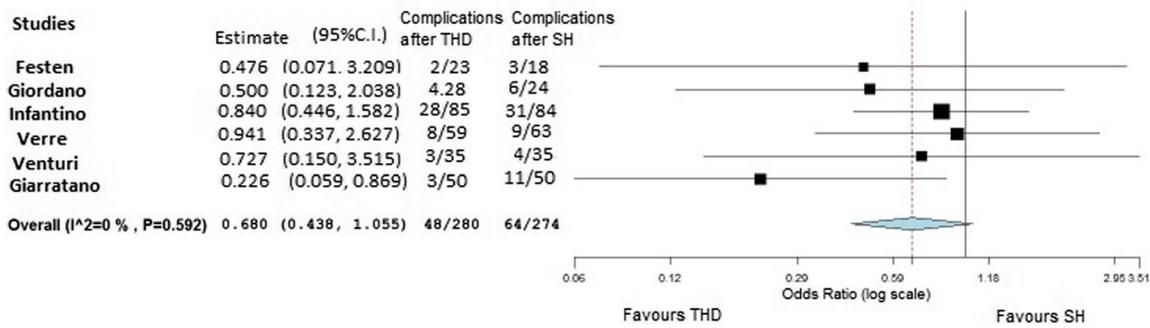Odds Ratio (log scale) — Favours THD / Favours SH

Fig. 4 Forest plot of complications after each technique

Alternatives to conventional hemorrhoidectomy were advocated with the intent to avoid or reduce the severity of postoperative anal pain and accelerate recovery after surgery. These alternatives include SH using circular stapler, HAL-RAR, laser hemorrhoidoplasty, and THD. According to the present literature, conventional hemorrhoidectomy proved to achieve significantly better outcome than SH [24] and similar outcome to THD [25] in terms of recurrence rates. We opt to conduct the present meta-analysis to compare THD and SH to determine if one technique is superior to the other regarding recurrence, complications, postoperative pain, and patients' recovery and satisfaction.

The vast majority of the trials included were conducted in Italy, perhaps because the procedures were originally devised by Italian surgeons [8]. On collective analysis, both groups were balanced in terms of patients' age and gender and grade of hemorrhoids included which confirms proper randomization of patients to each group and absence of selection bias in the trials.

Anal pain after surgery for hemorrhoids represents a dreadful adverse event of the procedure that may make some patients opt to postpone surgery to avoid it. Compared to excisional hemorrhoidectomy, THD and SH are followed by minimal postoperative pain which is logical since THD and SH

are performed above the sensitive anoderm as Giordano and colleagues [16] implied.

The results of this review imply that THD was associated with significantly lower pain scores than SH. While the explanation of this finding is not completely clear, we can assume that pain after SH was greater since it involves a blind excision of the rectal wall whereas THD is essentially a non-excisional procedure.

Early pain after SH can be attributed to impingement of the staple line on the sensitive squamous epithelium of the anoderm, inclusion of smooth muscle in the doughnut, and induction of a staple line inflammatory response in the rectal ampulla [26, 27]. Persistent pain after SH may be attributed to fixation of the external component of hemorrhoids leading to excessive tension on the sensitive anoderm and resulting in persistent anal pain [28]. Other factors that may contribute to prolonged pain after SH include sphincter or rectal spasm, elevated anal resting pressures, retained staples, fibrosis around the staple line, wound dehiscence, and sepsis [29, 30].

Failure of each technique was defined as persistence of recurrence of hemorrhoids postoperatively. The failure rate of THD (13%) was significantly higher than SH (6.9%) which was paralleled by a significantly higher odds ratio in the meta-analysis. A plausible explanation
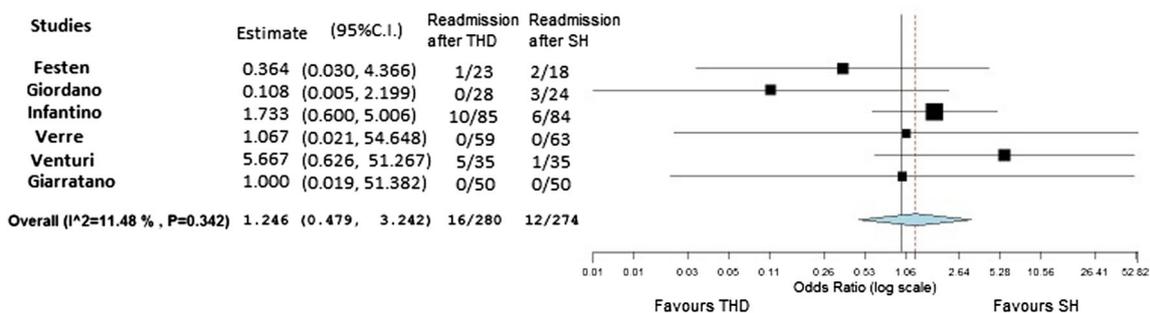
Forest Plot for readmission

Studies	Estimate	(95%C.I.)	Readmission after THD	Readmission after SH
Festen	0.364	(0.030, 4.366)	1/23	2/18
Giordano	0.108	(0.005, 2.199)	0/28	3/24
Infantino	1.733	(0.600, 5.006)	10/85	6/84
Verre	1.067	(0.021, 54.648)	0/59	0/63
Venturi	5.667	(0.626, 51.267)	5/35	1/35
Giarratano	1.000	(0.019, 51.382)	0/50	0/50
Overall (I^2=11.48 % , P=0.342)	1.246	(0.479, 3.242)	16/280	12/274

Odds Ratio (log scale) — Favours THD / Favours SH

Fig. 5 Forest plot of readmission after each technique

Fig. 6 Funnel plot demonstrating publication bias in the studies included

Funnel Plot of Standard Error by Recurrence Odds Ratio
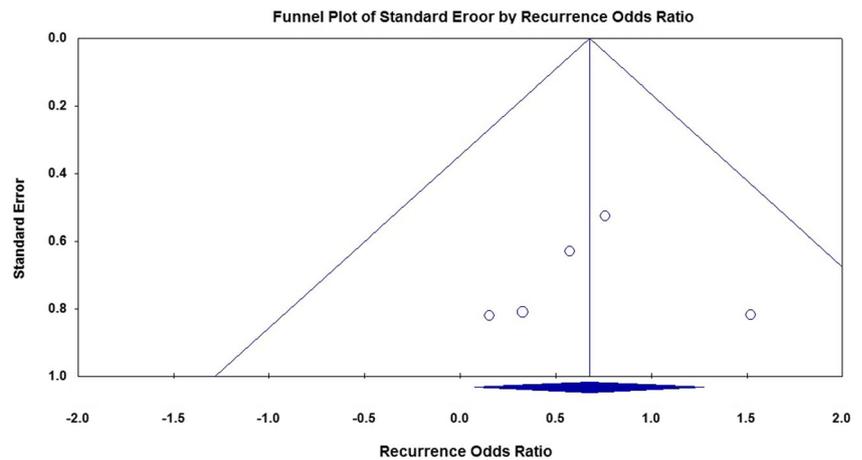
of the higher failure rate after THD was proposed by Giarratano et al. [20] who postulated that "hemorrhoidal prolapse beyond the anal verge is caused by a mucous or full-thickness prolapse originating inside the rectum and it sometimes reaches the hemorrhoidal cushion beyond the anal verge." Therefore, SH achieved lower recurrence rate as the circular stapler tends to remove the prolapsed tissue and the rectal wall if necessary which offers a drastic resolution of the hemorrhoidal disease compared to THD that does not involve any tissue excision.

The overall complication rates after SH and THD were comparable with no significant differences. The most common complication in both groups was urine retention which was recorded in 25% of patients. Urine retention is known to be one of the most common complications after surgery for benign anorectal conditions with an incidence reaching 32% after conventional hemorrhoidectomy [31]. Retention of urine after hemorrhoidectomy is mostly attributed to a dysfunction of the detrusor muscle or the trigone in response to pain or to distention of the anal canal or perineum [32].

Postoperative anal bleeding was significantly higher in patients who underwent SH (31%), than patients who underwent THD (18%). Bleeding after both procedures might be attributed to inadequate hemostasis or to the anti-platelet effect of postoperatively prescribed non-steroidal anti-inflammatory drugs on the staple line as Festen and associates [15] highlighted. Technical failure was reported in 6% of patients after THD and 3% of patients after SH which emphasizes the importance of adequate training on both procedures before they are employed in routine practice.

Other complications such as anal stenosis, obstructed defecation, and fecal urgency were encountered after SH only, probably related to the excisional nature of the procedure as aforementioned. It is worthy to note that more severe complications such as sigmoid intramural hematoma with hemoperitoneum [33] and rectal pocket syndrome [34] have been reported after SH though not reported in the studies included in this meta-analysis.

In addition to minimal postoperative pain, further advantages of SH and THD were demonstrated as being day-case surgeries and the short operation time. The duration required to return to work after both procedures was comparable as patients took approximately 1 week to resume their daily activities after THD and SH compared to 3 weeks after conventional hemorrhoidectomy [25, 35]. It has been shown that early return to work within enhanced recovery after surgery program is cost-effective because it reduces caregiver burden without compromising patients' quality of life [36]. Furthermore, patients' satisfaction and readmission rates were similar after both procedures. Around 5% of patients in each group required readmission. Interestingly, most readmissions after THD were for management of persistent or recurrent hemorrhoids whereas more readmissions after SH were for treatment of complications.

On meta-regression analysis of the risk factors for failure of each technique, only advanced grade of hemorrhoids (grade IV) was significantly associated with persistence or recurrence of hemorrhoids postoperatively. Festen and colleagues [15] suggested that advanced grade of hemorrhoids could be responsible for recurrence after THD. They also explained that the atrophy induced by ligating the vessels takes more time to reduce the prolapse in grade IV hemorrhoids. Similarly, other studies found that SH seems to present a high long-term recurrence rate particularly in grade IV hemorrhoids [37, 38].

Although not discussed in the majority of the trials included, the treatment cost of THD is lower than SH due to the difference in the cost of the two devices used which is approximately €700 for PPH01/03 device and approximately €500 for the THD device [17]. On the other hand, conventional hemorrhoidectomy costs far less than THD and SH; hence, the relatively high cost of both procedures maybe prohibitive for resource-limited communities.

Limitations of the present study include the small number and average quality of the trials included. The vast majority of the studies were undertaken in one country which may affect the external validity of the results. The short-term follow-up in

some trials is another important limitation although the median follow-up period exceeded 24 months.

Conclusion

THD had significantly higher persistence/recurrence rate compared to SH whereas complication and readmission rates, hospital stay, return to work, and patients' satisfaction were similar in both groups. Grade IV hemorrhoids was the only significant predictor for persistence or recurrence of hemorrhoids after both techniques; hence, THD and SH may provide better outcome when used for lower grades (II/III) of hemorrhoids.

Author contribution Sameh Hany Emile designed the review. Sameh Hany Emile, Hossam Elfeki, Mostafa Shalaby, and Ahmad Sakr participated in data collection and analysis, writing, and drafting of the manuscript. All authors read and approved the final version of the manuscript.

Compliance with ethical standards

Conflict of interests   The authors declare that they have no conflict of interest.

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