Meta-analysis of Short-term Outcomes of Randomized Controlled Trials of LigaSure vs Conventional Hemorrhoidectomy

Emile K. Tan, MBBS, MRCS; Julie Cornish, MBBS, MRCS; Ara W. Darzi, MD, FRCS, KBE; Savas Papagrigoriadis, MD, FRCS; Paris P. Tekkis, MD, FRCS

Objective: To evaluate the short-term outcomes of hemorrhoidectomy performed using the LigaSure vessel sealing device (Valleylab, Boulder, Colorado) or the conventional approach.

Data Sources: MEDLINE, EMBASE, Ovid, and Cochrane databases for studies published between 2002 and 2006.

Study Selection: Randomized controlled trials published between 2002 and 2006 comparing short-term outcomes for LigaSure vs conventional hemorrhoidectomy.

Data Extraction: Operative parameters, short-term complications, and postoperative recovery. Trials were assessed using a modified Jadad score. Random-effects meta-analytical techniques were used in the analysis.

Data Synthesis: Nine randomized controlled trials with matched selection criteria reporting on 525 patients, of whom 266 (50.7%) underwent LigaSure and 259 (49.3%) underwent conventional hemorrhoidectomy. Operative time (weighted mean difference [WMD], –8.67 minutes; 95% confidence interval [CI], –15.34 to –2.00 minutes), blood loss (WMD, –23.08 mL; 95% CI, –27.24 to –18.92 mL), and pain the day after the operation measured by the visual analog scale (WMD, –2.31; 95% CI, –3.37 to –1.26) were significantly reduced following LigaSure hemorrhoidectomy. There was a decrease in time taken to return to work or normal activity (WMD, –3.49 days; 95% CI, –7.40 to 0.43), which was of marginal significance (P=.08). Incidence of postoperative hemorrhage was comparable as was incidence of anal stenosis and fecal and flatus incontinence between the 2 groups.

Conclusions: LigaSure hemorrhoidectomy results in a significant reduction in operative time and blood loss, but it may not confer any advantage over the conventional operation in terms of postoperative pain, length of hospital stay, or time taken to return to work or normal activity. The expediency of the device must be weighed against its additional cost. Long-term evaluation of outcomes and morbidity are still needed.

Arch Surg. 2007;142(12):1209-1218

Author Affiliations:
Department of Biosurgery and Surgical Technology, St Mary's Hospital, Imperial College (Drs Tan, Cornish, Darzi, and Tekkis), and Department of Surgery, King's College Hospital (Dr Papagrigoriadis), London, England.

HEMORRHOIDS IS ONE OF THE most common anorectal conditions. They may present with anal bleeding, pain, and mass at the anus. Hemorrhoidectomy is the definitive treatment for grade 3 and 4 hemorrhoids.[1]

Conventional diathermy hemorrhoidectomy has already been shown to be associated with less bleeding, shorter operative time, and a lower postoperative analgesic requirement[2,3] compared with scissors excision. Two well-established methods of surgical ablation of grade 3 or 4 hemorrhoids are popular: the "open" Milligan Morgan excision[4] and the "closed" Ferguson[5] method. Surgical ablation is still regarded, however, as a procedure with significant postoperative discomfort. This has led to modifications in technique, with perioperative treatments such as antibiotics[6] as well as use of modern surgical instruments. These include laser ablation,[7] ultrasonic scalpel excision,[8] and stapled hemorrhoidopexy.[9]

See Invited Critique at end of article

Recent advances in instrumental technology have provided alternatives in hemorrhoidectomy. The LigaSure device (Valleylab, Boulder, Colorado) was originally designed to seal vessels in abdominal operations. In recent years, it has been applied to achieve sutureless closed hemorrhoidectomy. The LigaSure vessel sealing generator is an isolated output electrosurgical generator that provides power for vessel sealing and bipolar operations. It can be

used on isolated arteries and veins up to 7 mm in diameter and on tissue bundles. This system provides precise energy delivery and electrode pressure to vessels for a controlled period to achieve complete and permanent fusion of the vessel lumen. LigaSure produces minimal sticking, charring, or thermal injury to adjacent tissue.[10,11]

The aim of our study was to evaluate operative and postoperative parameters and adverse outcomes in patients undergoing LigaSure vs conventional hemorrhoidectomy. Meta-analytical techniques and sensitivity analyses were used to assess the potential advantages of each technique and explain differences between the study methodologies and selection criteria.

METHODS

STUDY SELECTION

A MEDLINE, EMBASE, Ovid, and Cochrane database search was performed between 2002 and 2006 on all randomized controlled trials comparing LigaSure hemorrhoidectomy with conventional hemorrhoidectomy. The following MeSH search headings were used: *LigaSure*, *hemorrhoidectomy*, *comparative study*, and *treatment outcome*. These terms and their combinations were also searched as individual words as were *conventional hemorrhoidectomy*, *open*, and *closed*. The Related Articles function was used to broaden the search, and all scanned abstracts, studies, and citations were reviewed. References of the articles acquired were also searched by hand. No language restrictions were made. The latest date of this search was May 30, 2006.

DATA EXTRACTION

Two reviewers (E.K.T. and J.C.) independently extracted the following information from each study: first author, year of publication, study population characteristics, study design, inclusion and exclusion criteria, matching criteria, number of subjects operated on with each technique, operative parameters, complications, and postoperative recovery. There was 100% agreement between the 2 reviewers.

INCLUSION AND EXCLUSION CRITERIA

To be included in the analysis, studies had to (1) compare LigaSure with conventional hemorrhoidectomy (including scissors and diathermy techniques), (2) report on at least one of the outcome measures, (3) clearly document the operative technique as *LigaSure*, *conventional*, or *open/closed hemorrhoidectomy*, and (4) clearly report the indications for operation for each of the LigaSure and conventional hemorrhoidectomy groups. Studies were excluded from the analysis if (1) the outcomes of interest were not clearly reported for the 2 techniques and (2) it was impossible to extract or calculate the appropriate data from the published results.

OUTCOME MEASURES

The following outcomes were used to compare LigaSure hemorrhoidectomy with conventional hemorrhoidectomy:

1. Operative parameters, including operative time and operative blood loss.
2. Complications, assessed up to 6 months, including postoperative hemorrhage, fecal and flatus incontinence, constipation, poor wound healing and/or dehiscence, anal stenosis, and urinary retention.
3. Postoperative parameters comprising length of postoperative hospital stay and return to normal activity.

STATISTICAL ANALYSIS

Meta-analysis was performed in line with recommendations from the Cochrane Collaboration and the Quality of Reporting of Meta-analyses guidelines.[12,13] Statistical analysis of dichotomous variables was carried out using odds ratios (ORs) as the summary statistic, while continuous variables, such as operative time or length of stay, were analyzed using the weighted mean difference (WMD)[14]; both were reported with 95% confidence intervals (CIs). Odds ratios represent the odds of an adverse event occurring in the LigaSure hemorrhoidectomy compared with the conventional hemorrhoidectomy group, while WMDs summarize the differences between the 2 groups with respect to continuous variables, accounting for sample size. For studies that presented continuous data as means and range values, the SDs were calculated using statistical algorithms and checked using bootstrap resampling techniques. Thus, all continuous data were standardized for analysis. An OR of less than 1 favored the LigaSure hemorrhoidectomy group and the point estimate of the OR was considered statistically significant at $P < .05$ if the 95% CI did not include the value 1.

The Mantel-Haenszel method was used to combine the OR for the outcomes of interest using a random-effects meta-analytical model. In a random-effects model, it is assumed that there is natural variation between studies and the calculated OR, which as a result, has a more conservative value.[15,16] The random-effects model is preferable when meta-analytical techniques are used in surgical research, because for a given surgical technique each center has its own patient selection criteria and these patients have different risk profiles. The Yates correction was used for studies that contained a zero in one cell for the number of events of interest in 1 of the 2 groups.[17] These zero cells created problems with the computation of ratio measure and its SE of the treatment effect. This was resolved by adding the value 0.5 in each cell of the 2×2 table for the study in question; if there were no events for either group, the study was discarded from the meta-analysis of that outcome.

The quality of the studies was assessed by using the Jadad core with some modifications to match the needs of this study.[18] The studies' quality was evaluated by examining 3 factors: patient selection, comparability of the study groups, and assessment of outcome. Studies achieving 3 or more stars (of a maximum of 5) were considered to be of higher quality.

Heterogeneity was assessed by 2 methods. First, graphic exploration with funnel plots was used to evaluate publication bias.[19,20] Second, sensitivity analysis was undertaken using the following subgroups: studies of higher quality, those comparing LigaSure vs open hemorrhoidectomy, and those comparing LigaSure vs closed hemorrhoidectomy. Analysis was conducted by using the statistical Review Manager, version 4.2 (Cochrane Collaboration, Oxford, England).

RESULTS

ELIGIBLE STUDIES

In our literature search, we identified 9 studies comparing the results of LigaSure hemorrhoidectomy with conventional hemorrhoidectomy for patients with grade 3 or 4 hemorrhoids. These studies, published between 2002 and 2006, had matched selection criteria and were included in the analysis.[21-30] These 9 studies reported on 525 patients, of whom 266 (50.7%) underwent LigaSure hemorrhoidec-

Table 1. Characteristics of Studies Comparing LigaSure[a] Hemorrhoidectomy (LH) and Conventional Hemorrhoidectomy (CH)

Source	No. of Patients		Matched Characteristics	Exclusion Criteria[b]	Mean Age, y		Mean No. of Resected Hemorrhoids per Patient		Type of Conventional Hemorrhoidectomy	Quality Rating[c]
	LH	CH			LH	CH	LH	CH		
Franklin,[24] 2003	17	17	Age, sex, grade 3 or 4 hemorrhoids, duration of hemorrhoids, disease symptoms	Coexisting anorectal disease, previous anorectal operation, thrombosed hemorrhoids	NA	NA	NA	NA	Closed (diathermy)	4
Wang,[30] 2006	42	42	Sex, grade 3 or 4 hemorrhoids, disease symptoms	Coexisting anorectal disease, previous anorectal operation, anticoagulation, hematologic disorder	47.1	47.5	3.10	3.05	Closed (diathermy)	3
Chung CC,[22] 2002	30	27	Grade 3 or 4 hemorrhoids, disease symptoms	Previous anorectal operation, thrombosed hemorrhoids, inflammatory bowel disease, anesthetically unfit, unable to get informed consent, hematologic disorder	44.7	50.7	NA	NA	Open (scissors)	4
Thorbeck,[29] 2002	56	56	Grade 3 or 4 hemorrhoids, disease symptoms	NA	50.0	50.0	2.44	2.44	Open (diathermy)	1
Milito,[26] 2002	29	27	Grade 3 or 4 hemorrhoids, disease symptoms	Coexisting anorectal disease, previous anorectal operation, anticoagulation	52.0	48.2	NA	NA	Open (diathermy)	4
Chung YC,[23] 2003	30	31	Grade 3 or 4 hemorrhoids, disease symptoms	NA	44.9	47.1	3.10	3.27	Closed (diathermy)	3
Pattana-Arun,[28] 2006	24	23	Age, sex, grade 3 or 4 hemorrhoids, disease symptoms	Coexisting anorectal disease, previous anorectal operation, thrombosed hemorrhoids, anesthetically unfit, anticoagulation	41.0	45.7	2.9	2.2	Closed (scissors)	4
Jayne,[25] 2002	20	20	Grade 3 or 4 hemorrhoids, disease symptoms	Anesthetically unfit, unable to get informed consent, anticoagulation, hematologic disorder	48	43	2.8	2.9	Open (diathermy)	4
Palazzo,[27] 2002	18	16	Grade 3 or 4 hemorrhoids, disease symptoms	Previous anorectal operation, anticoagulation	44	49	NA	NA	Open (diathermy)	4

Abbreviation: NA, not applicable.
[a] A vessel sealing device manufactured by Valleylab, Boulder, Colorado.
[b] All studies had the same inclusion criteria, grade 3 or 4 hemorrhoids.
[c] Maximum score of 5.

tomy and 259 (49.3%) underwent the conventional operation. Of the 259 patients who underwent conventional hemorrhoidectomy, 209 from 7 studies[23-27,29,30] had it performed with diathermy, while 50 patients from 2 studies[22,28] had it performed with scissors excision.

The study characteristics and patients' demographic details are presented in **Table 1**. The operations were performed under general, spinal, or epidural anesthesia. All the studies in the analysis were randomized controlled trials.[22-30] All studies matched patients for disease symptoms as well as having grade 3 or 4 hemorrhoids. Two studies matched patients for age and sex.[24,28] All patients in both the LigaSure and conventional hemorrhoidectomy arms of the analysis had a mixture of internal and external hemorrhoidal components treated at the time of operation.

The sensitivity analysis included 9 studies that scored 4 or more stars on the modified Jadad Scale,[22,24-28] 5 studies that compared LigaSure with open hemorrhoidectomy,[22,25-27,29] 4 that compared LigaSure with closed hemorrhoidectomy,[23,24,28,30] 7 that compared LigaSure with diathermy hemorrhoidectomy,[23-27,29,30] and 2 that compared LigaSure with scissors hemorrhoidectomy.[22,28]

Results of operative and postoperative parameters and complications for LigaSure hemorrhoidectomy vs conventional hemorrhoidectomy groups are summarized in **Table 2**. The table displays the number of studies reporting on each outcome, the total number of patients in both LigaSure hemorrhoidectomy and conventional hemorrhoidectomy groups, the summary statistic, 95% CIs, a test of heterogeneity between the studies, and the calculated *P* values. **Figure 1** and **Figure 2** display the results of

Table 2. Results of Meta-analysis Comparing LigaSure[a] With Conventional Hemorrhoidectomy

Outcome	No. of Studies	No. of Patients	WMD (95% CI)	*P* Value	HG χ^2	HG *P* Value
Operative characteristic						
Operative time, min	9	525	−8.67 (−15.34 to −2.00)	.01[b]	1860.73	<.001[b]
Blood loss, mL	4	293	−23.08 (−27.24 to −18.92)	<.001[b]	4.95	.08[b]
Postoperative characteristic						
Pain day 1[c]	7	444	−2.31 (−3.37 to −1.26)	<.001[b]	335.89	<.001[b]
Length of stay, d	6	332	−0.22 (−0.90 to 0.47)	.53	1209.30	<.001[b]
Time to return to work/normal activity, d	4	258	−3.49 (−7.40 to 0.43)	.08[b]	47.00	<.001[b]

Complication	No. of Studies	No. of Patients	OR (95% CI)	*P* Value	HG χ^2	HG *P* Value
Postoperative hemorrhage	8	491	0.70 (0.24 to 2.04)	.51	1.36	.85
Fecal/flatus incontinence	7	444	0.33 (0.01 to 8.22)	.50		
Constipation	4	313	0.54 (0.19 to 1.56)	.25	2.72	.44
Poor wound healing/dehiscence	5	289	0.99 (0.35 to 2.77)	.98	0.65	.88
Anal stenosis	6	404	0.92 (0.13 to 6.44)	.93	0.71	.40
Urinary retention	8	491	0.52 (0.21 to 1.33)	.17	1.67	.95

Abbreviations: CI, confidence interval; OR, odds ratio; HG, heterogeneity; WMD, weighted mean difference.
[a] A vessel sealing device manufactured by Valleylab, Boulder, Colorado.
[b] Statistically significant.
[c] Measured by the visual analog scale (0-10); 0 represents no pain, 10 represents the worst pain.

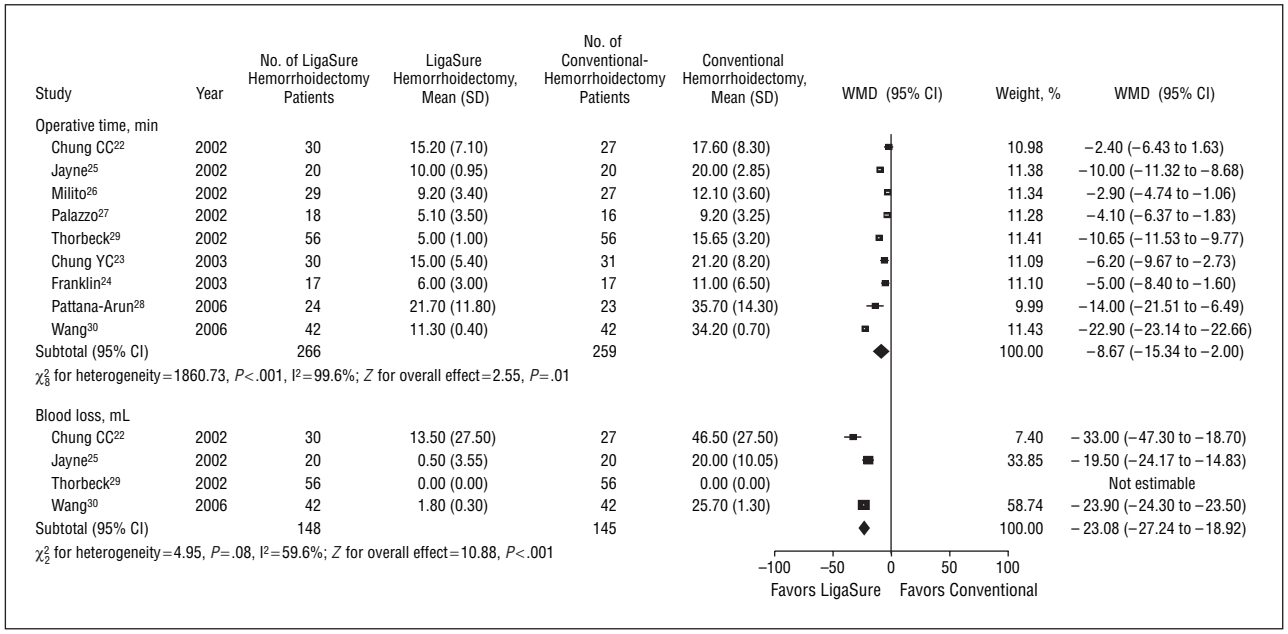

Figure 1. Forest plot for operative time and blood loss. Squares indicate the point estimates of the treatment effect (weighted mean difference [WMD]) with 95% confidence intervals (CIs) indicated by horizontal bars. Diamonds represent the summary estimate from the pooled studies with 95% CIs. LigaSure is a vessel sealing device manufactured by Valleylab, Boulder, Colorado.

the analysis for operative time, operative blood loss, pain on postoperative day 1, length of hospital stay, and time to return to work or normal activity following LigaSure hemorrhoidectomy vs conventional hemorrhoidectomy.

HEMORRHOIDECTOMY PROCEDURES

Patients were put in the lithotomy position. LigaSure hemorrhoidectomy was performed with an Eisenhammer retractor. The internal and external components of each hemorrhoidal complex were first grasped and elevated using artery forceps or Allis clamps. The LigaSure device was applied along the curvature of the artery forceps with its own curvature facing into the lumen of the anal canal to minimize potential injury to the sphincter muscles. The clamplike electrode was first positioned beneath the external component and activated. The feedback-controlled sensor signaled the completion of coagulation and the coagulated tissue was transected along the line of coagulation. The device was subsequently applied along the sealed tissue line into the anal canal, now comprising the internal hemorrhoid and inferior hem-

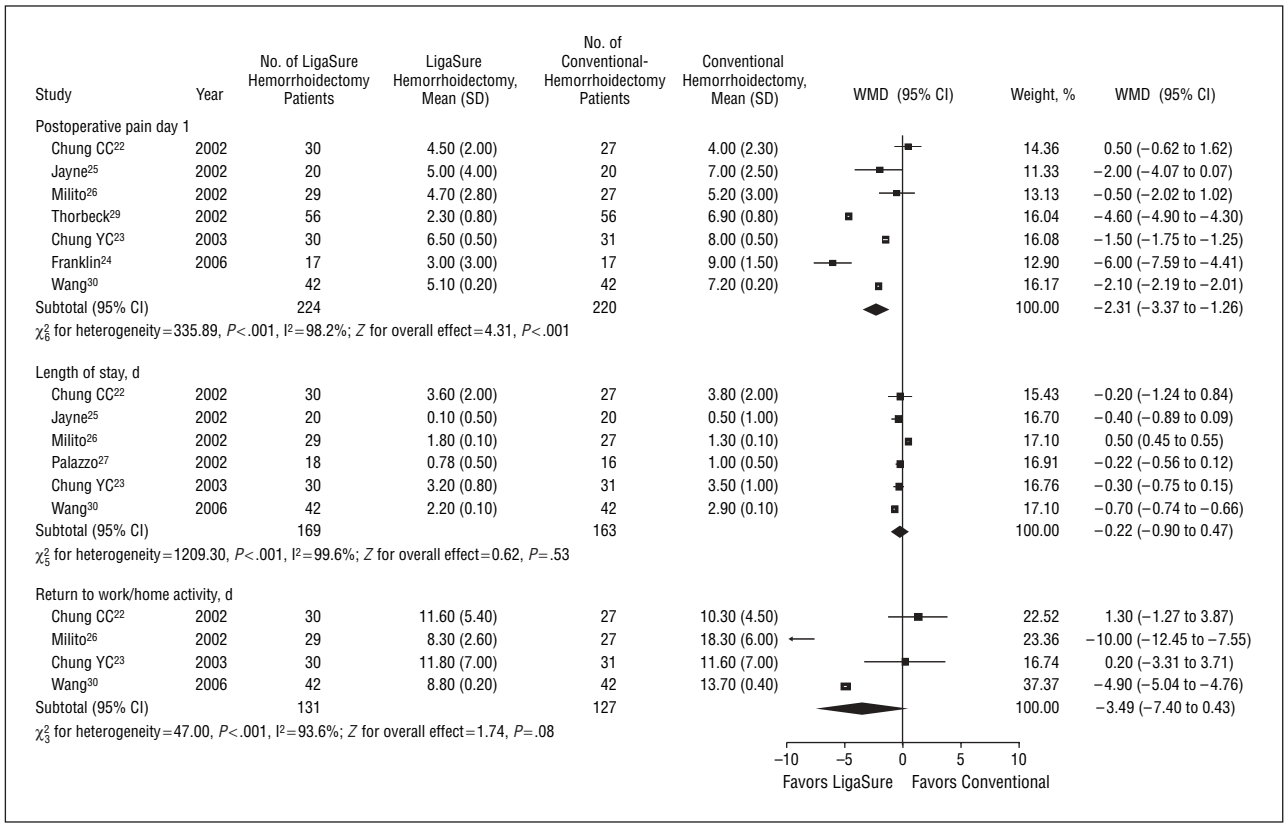

Figure 2. Forest plot for day 1 postoperative pain (measured by the visual analog scale [0-10]; 0 represents no pain, 10 represents the worst pain), length of hospital stay, and time to return to normal life or work. Squares indicate the point estimates of the treatment effect (weighted mean difference [WMD]) with 95% confidence intervals (CIs) indicated by horizontal bars. Diamonds represent the summary estimate from the pooled studies with 95% CIs. LigaSure is a vessel sealing device manufactured by Valleylab, Boulder, Colorado.

orrhoidal vascular pedicle. In larger hemorrhoids, further application of the LigaSure device may be repeated. The pedicle was finally coagulated by a further delivery of bipolar energy and then divided. The naked area was then inspected with an Eisenhammer retractor to ensure complete hemostasis. In the presence of bleeding, sutures may be applied as necessary. In all 9 studies, the LigaSure hemorrhoidectomy procedure followed the same initial incision and dissection of internal and external hemorrhoidal components as the conventional procedure, except that the LigaSure bipolar cautery device made the transection instead.

Conventional hemorrhoidectomy was carried out either with scissors or monopolar diathermy. Local anesthetic and adrenaline was first infiltrated into the subcutaneous and submucosal planes to elevate the hemorrhoidal pedicles from the underlying anal sphincter muscle. Submucosal dissection of the hemorrhoidal tissue from the internal sphincter was performed. Hemorrhoidal pedicles were transfixed in some studies but not in others, with care to maintain 6- to 8-mm skin bridges between each excision. Patients were subsequently given a mixture of oral and parenteral analgesia, as necessary.

META-ANALYSIS OF OPERATIVE AND POSTOPERATIVE PARAMETERS

Nine studies[22-30] reported on operative time, which was found to be significantly shorter in the LigaSure group compared with the conventional hemorrhoidectomy group (−8.67 minutes; 95% CI, −15.34 to −2.00; P = .01). There was significant heterogeneity in this result. Four studies[22,25,29,30] reported on operative blood loss, which was significantly lower in the LigaSure group (−23.08 mL; 95% CI, −27.24 to −18.92 mL; P < .001).

Seven studies[22-26,29,30] reported data regarding pain on postoperative day 1, measured by the Visual Analogue Scale (VAS). A score of 0 represents no pain, while a score of 10 represents the worst pain. Patients undergoing LigaSure hemorrhoidectomy were found to have significantly less pain on postoperative day 1 (WMD, −2.31; 95% CI, −3.37 to −1.26; P < .001). Chung and Wu[23] also charted pain scores at days 2 and 7. On day 2, mean VAS scores were lower for patients who underwent LigaSure hemorrhoidectomy (6.5) compared with those who underwent conventional hemorrhoidectomy (7.5; P < .001). On day 7, mean VAS scores were 4.0 in patients who underwent LigaSure hemorrhoidectomy vs 4.5 for those who had a conventional hemorrhoidectomy. This was of marginal significance (P = .06). Three studies described mean VAS scores at day 14[23,24,28]; there was no significant difference in scores between LigaSure hemorrhoidectomy and conventional hemorrhoidectomy patients at this point.

There was also no significant difference in length of stay in the 6 studies that reported it.[22,23,25-27,30] Time to return to work or normal activity was reported by 4 studies[22,23,26,30] and was shorter by 3.49 days in the LigaSure

groups (95% CI, −7.40 to 0.43). This was of marginal significance ($P=.08$). There was significant heterogeneity in all the results.

META-ANALYSIS OF ALL COMPLICATIONS

No significant differences were found between the 2 surgical approaches when rates of the following operative and postoperative complications were compared: postoperative hemorrhage (OR, 0.70; 95% CI, 0.24-2.04; $P=.51$); fecal and/or flatus incontinence (OR, 0.33; 95% CI, 0.01-8.22; $P=.50$); constipation (OR, 0.54; 95% CI, 0.19-1.56; $P=.25$); poor wound healing and/or dehiscence (OR, 0.99; 95% CI, 0.35-2.77; $P=.98$); anal stenosis (OR,0.92; 95% CI, 0.13-6.44; $P=.93$); or urinary retention (OR,0.52; 95% CI, 0.21-1.33; $P=.17$). No deaths were reported.

SENSITIVITY ANALYSIS

Analysis of the high-quality studies (>3 stars)[22,24-28] and of the subgroup LigaSure vs open hemorrhoidectomy[22,25-27,29] showed similar results for operative time and blood loss, with reduction in statistical heterogeneity (**Table 3**). However, there was no significant difference in pain on postoperative day 1, length of stay, or return to work or normal life. Analysis of LigaSure vs closed hemorrhoidectomy[23,24,28,30] mimicked the overall results, with a great reduction in statistical heterogeneity, except in return to work or normal life, which now showed no significant difference.

Analysis of the subgroup LigaSure vs diathermy hemorrhoidectomy[23-27,29,30] showed results that were almost identical to the overall analysis, with significantly shorter operative times, less blood loss, less pain on postoperative day 1, and significantly earlier return to normal activity and work in the LigaSure group. The subgroup LigaSure vs scissor hemorrhoidectomy contained only 2 of the studies and we were thus unable to include it in the meta-analysis.[22,28]

OTHER OUTCOMES

Three studies[22,26,30] compared the postoperative need for parenteral analgesia between the LigaSure hemorrhoidectomy and conventional hemorrhoidectomy groups. Wang et al[30] reported that LigaSure hemorrhoidectomy patients required 12 injections of parenteral analgesia (unspecified) compared with 32 patients in the conventional hemorrhoidectomy group during a 2- to 3-day hospital stay. Chung et al[22] reported that LigaSure hemorrhoidectomy patients required a mean 0.7 injections of pethidine compared with 1.2 in the conventional hemorrhoidectomy group during a 3- to 4-day hospital stay. Milito et al[26] reported no requirement for parenteral analgesia in either group.

Two studies[28,29] reported on pain scores immediately postoperatively. Thorbeck and Montes[29] reported mean scores of 4.9 in the LigaSure hemorrhoidectomy group vs 7.8 in the conventional hemorrhoidectomy group, while Pattana-Arun et al[28] reported scores of 6.0 vs 4.8, respectively. One study[23] reported mean pain scores during a 2-week postoperative period in the LigaSure vs the conventional hemorrhoidectomy groups, respectively: 6.5 vs 8.0 at day 1, 6.5 vs 7.5 at day 2, 4.0 vs 4.5 at day 7, and 0.5 for both groups at day 14. Two further studies[24,28] reported on pain at day 14, with similar scores for LigaSure hemorrhoidectomy and conventional hemorrhoidectomy groups.

Three studies[23,26,28] also reported on the time taken for complete wound healing. According to Milito et al,[26] patients in the LigaSure hemorrhoidectomy group healed significantly faster than those in the conventional hemorrhoidectomy group (16.3 vs 37.5 days). Chung and Wu[23] and Pattana-Arun et al[28] reported similar time to complete wound healing. Two studies[31,32] reported longer-term follow-up data from 2 of the studies in the meta-analysis.[25,27]

Lawes et al[31] reported on patients 1 year posthemorrhoidectomy. Patients were contacted by telephone and sent a questionnaire to assess their symptoms and their level of satisfaction (very happy, happy, disappointed, or unhappy) with the outcome of the operation. They were also sent the Continence Grading Scale[33] to evaluate fecal continence. At 1 year postoperatively, 13 of 16 patients (81%) in the conventional hemorrhoidectomy group and 17 of 18 patients (94%) in the LigaSure hemorrhoidectomy group responded. One patient who underwent conventional hemorrhoidectomy developed flatus incontinence daily and another developed liquid stool incontinence (rarely requiring the use of pads). In the LigaSure hemorrhoidectomy group, 5 patients developed occasional flatus incontinence. This was not regarded as statistically significant because of the small numbers. Two of 16 patients (12.5%) who underwent conventional hemorrhoidectomy and 1 of 18 patients (5.5%) who underwent LigaSure hemorrhoidectomy were dissatisfied, complaining of continuing pain on defecation and recurrent bleeding.

Peters et al[32] reported follow-up data on patients at 36 months posthemorrhoidectomy. Fourteen of 20 (70%) conventional hemorrhoidectomy patients and 16 of 20 (80%) LigaSure hemorrhoidectomy patients responded. Patients were assessed using the Cleveland Clinic Incontinence Score[33] and self-reported satisfaction levels. Ten patients in each group agreed to undergo detailed physical examination, including rectal manometry. Recurrent bleeding was reported by 5 of 16 (31%) patients in the conventional hemorrhoidectomy group but by no patients in the LigaSure hemorrhoidectomy group. This was not regarded as statistically significant because of the small numbers. No episodes of fecal incontinence were reported. Cleveland Clinic Incontinence Scores were similar in both groups and there was no difference in satisfaction levels. In the 10 patients who underwent further examination and rectal manometry, 3 patients in the conventional hemorrhoidectomy group and 1 in the LigaSure hemorrhoidectomy group had residual skin tags on examination. None of these were symptomatic. There was no significant difference between the 2 groups in resting anal pressure, maximal squeeze pressure, or functional sphincter length. External sphincter thickness was similar in both groups, but internal sphincter thickness was significantly decreased in the conventional hemorrhoidectomy group ($P=.005$).

Table 3. Sensitivity Analysis of LigaSure[a] vs Conventional Hemorrhoidectomy Groups

Outcome	No. of Studies	No. of Patients	WMD (95% CI)	OR (95% CI)	*P* Value	HG χ^2	HG *P* Value
High-quality Studies (>3 of 5 Stars)							
Operative characteristic							
Operative time, min	6	268	−5.92 (−9.35 to −2.50)		<.001[b]	54.56	<.001[b]
Blood loss, mL	2	97	−24.49 (−37.26 to −11.72)		<.001[b]	3.09	.08
Complication							
Postoperative hemorrhage	5	234		0.44 (0.09 to 2.16)	.31	0.75	.69
Constipation	1	56		1.93 (0.16 to 22.55)			
Poor wound healing	3	144		0.98 (0.29 to 3.28)	.98	0.65	.72
Anal stenosis	3	144		2.80 (0.11 to 71.59)	.53		
Urinary retention	5	234		0.64 (0.18 to 2.22)	.48	1.41	.84
Postoperative characteristic							
Pain day 1[c]	4	187	−1.97 (−4.92 to 0.97)		.19	44.60	<.001[b]
Length of stay, d	4	187	−0.04 (−0.61 to 0.53)		.90	31.09	<.001[b]
Time to return to work/normal activity, d	2	113	−4.36 (−15.43 to 6.72)		.44	38.83	<.001[b]
LigaSure Hemorrhoidectomy vs Open Hemorrhoidectomy							
Operative characteristic							
Operative time, min	5	299	−6.23 (−9.64 to −2.82)		<.001[b]	86.01	<.001[b]
Blood loss, mL	3	209	−24.49 (−37.26 to −11.72)		<.001[b]	3.09	.08
Complication							
Postoperative hemorrhage	5	299		0.44 (0.09to 2.16)	.31	0.75	.69
Constipation	2	168		0.44 (0.02 to 10.42)	.61	2.76	.10
Poor wound healing	2	97		0.58 (0.07 to 4.95)	.62	0.32	.57
Anal stenosis	4	259		2.80 (0.11 to 71.59)	.53		
Urinary retention	5	299		0.72 (0.17 to 3.04)	.65	1.31	.73
Postoperative details							
Pain day 1[c]	4	265	−1.68 (−4.77 to 1.42)		.29	100.64	<.001
Length of stay, d	4	187	−0.04 (−0.61 to 0.53)		.90	31.09	<.001[b]
Time to return to work/normal activity, d	2	113	−4.36 (−15.43 to 6.72)		.44	38.83	<.001[b]
LigaSure Hemorrhoidectomy vs Closed Hemorrhoidectomy							
Operative characteristic							
Operative time, min	4	226	−12.05 (−23.73 to −0.37)		.04[b]	198.31	<.001[b]
Blood loss, mL	1	84	−23.90 (−24.30 to −23.50)		<.001[b]		
Complication							
Postoperative hemorrhage	3	192		1.03 (0.24 to 4.36)	.97	0.00	.98
Fecal/flatus incontinence	2	145		0.33 (0.01 to 8.22)	.50		
Constipation	2	145		0.55 (0.15 to 1.98)	.36	0.01	.93
Poor wound healing	3	192		1.16 (0.36 to 3.77)	.81	0.03	.86
Anal stenosis	2	145		0.49 (0.04 to 5.59)	.56		
Postoperative characteristic							
Pain day 1[c]	3	179	−2.46 (−3.24 to −1.67)		<.001[b]	43.33	<.001[b]
Length of stay, d	2	145	−0.57 (−0.94 to −0.20)		.003[b]	2.96	.09
Time to return to work/normal activity, d	2	145	−2.66 (−7.62 to 2.30)		.29	8.08	.004
LigaSure Hemorrhoidectomy vs Diathermy Hemorrhoidectomy							
Operative characteristic							
Operative time, min	7	421	−8.86 (−16.31 to −1.42)		.02[b]	1775.49	<.001[b]
Blood loss, mL	3	236	−22.34 (−26.47 to −18.22)		<.001[b]	3.38	.07[b]
Complication							
Postoperative hemorrhage	6	387		0.70 (0.24 to 2.04)	.51	1.36	.85
Fecal/flatus incontinence	6	387		0.33 (0.01 to 8.22)	.50		
Constipation	4	313		0.54 (0.19 to 1.56)	.25	2.72	.44
Poor wound healing	3	185		1.00 (0.19 to 5.16)	>.99	0.00	>.99
Anal stenosis	5	347		0.49 (0.04 to 5.59)	.56		
Urinary retention	6	387		0.56 (0.19 to 1.68)	.30	1.62	.81
Postoperative characteristic							
Pain day 1[c]	6	387	−2.78 (−3.90 to −1.67)		<.001[b]	313.53	<.001[b]
Length of stay, d	5	275	−0.22 (−0.96 to 0.52)		.56	1209.30	<.001
Time to return to work/normal activity, d	3	201	−5.08 (−9.23 to −0.93)		.02[b]	24.68	<.001[b]

Abbreviations: CI, confidence interval; HG, heterogeneity; OR, odds ratio; WMD, weighted mean difference.
[a] A vessel sealing device manufactured by Valleylab (Boulder, Colorado).
[b] Statistically significant.
[c] Measured by the visual analog scale (0-10); 0 represents no pain, 10 represents the worst pain.

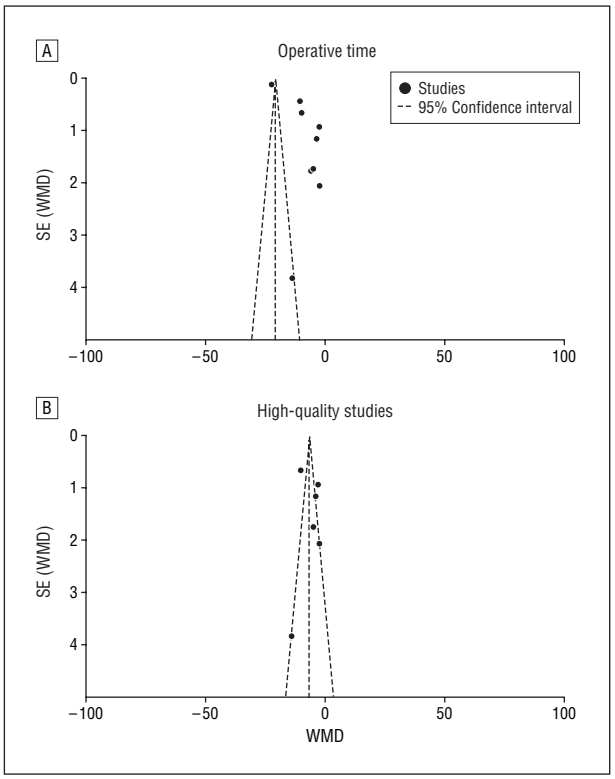

Figure 3. Funnel plot illustrating overall analysis of operative time (A) and effect of subgroup analysis of high-quality studies (>3 of 5 stars) (B). Standard error (SE) (effect estimate) vs effect estimate for each study under the outcome. WMD indicates weighted mean difference.

PUBLICATION BIAS

A funnel plot of the studies used in this meta-analysis reporting on operative time in LigaSure hemorrhoidectomy vs conventional hemorrhoidectomy is shown in **Figure 3**A. This is a scatterplot of the treatment effects estimated from individual studies plotted on the horizontal axis (WMD) against the SE of the estimate shown on the vertical axis (SE [WMD]). Seven studies[22-27,29] lie outside the 95% CIs, with most studies lying to the right of the vertical. When only studies matched for quality (>3 stars) were considered (Figure 3B), most studies lie within the 95% CIs and are distributed evenly about the vertical, showing less evidence of publication bias.

COMMENT

The results of this meta-analysis suggest that LigaSure hemorrhoidectomy is a safe, effective, and fast alternative to the conventional operation. There was comparable morbidity in terms of postoperative hemorrhage, fecal or flatus incontinence, constipation, poor wound healing, anal stenosis, or urinary retention. LigaSure hemorrhoidectomy was associated with shorter operative times (8.67 minutes shorter) and significantly less blood loss (23.08 mL less) compared with conventional hemorrhoidectomy. The reduced operative time associated with LigaSure is likely related to better hemostatic control and not needing to ligate the pedicles.

Patients had significantly less pain on postoperative day 1 in the LigaSure group. This was evidenced also by the lower amount of analgesia, parenteral or oral, used by patients postoperatively. The measurements for analgesic use were nonuniform and therefore we could not include it in the meta-analysis. While no significant difference was found in length of hospital stay, patients in the LigaSure group returned to work and regular activities 3.5 days sooner ($P = .08$).

When taking into account the sensitivity analysis, studies rated as higher quality (>3 stars) and studies of LigaSure hemorrhoidectomy vs open hemorrhoidectomy showed similar benefits in shortened operative time and blood loss. There were no differences noted in morbidity, pain on postoperative day 1, length of stay, or return to normal activity. This was different in studies only comparing LigaSure hemorrhoidectomy with closed hemorrhoidectomy, which showed similar benefits of LigaSure hemorrhoidectomy, with shortened operative time, decreased blood loss, significantly less pain, and shorter hospital stays, but no difference in the time to return to work.

There were no unexpected complications reported in any of the studies analyzed. This contrasts with circular stapled hemorrhoidopexy, about which exist reports of serious complications, such as pelvic sepsis[34] and anastomotic stenosis.[35]

When comparing LigaSure with circular stapled hemorrhoidectomy, patients undergoing LigaSure hemorrhoidectomy were found to have significantly less intraoperative and postoperative bleeding.[36] Patients in the LigaSure group also experienced slightly more postoperative pain initially and on defecation. Circular stapling also has the drawback of occasional failure to deal with large external hemorrhoidal components and skin tags, with higher levels of recurrence of hemorrhoidal prolapse.[37] In a recent comparison of harmonic scalpel excision of hemorrhoids with LigaSure hemorrhoidectomy and conventional hemorrhoidectomy,[22] the harmonic scalpel was associated with less pain, shorter hospital stays, earlier return to work, and increased patient satisfaction.

The LigaSure system is an excellent method for achieving bloodless dissection of vascular tissues.[38] The combination of localized coagulation with minimal collateral thermal spread makes it seem like an ideal instrument for hemorrhoidectomy. Improved hemostasis may also offer better visibility and therefore a more accurate dissection. The lack of thermal spread and consequently decreased tissue necrosis from the LigaSure device may also contribute to lower postoperative pain. The cost of each single-use device is about $156. Coupled with potential time saving, decreased blood loss, and decreased postoperative pain, LigaSure may also produce a cost benefit, though this assessment was not performed in any of the studies analyzed.

As with any operation involving the anal canal, preservation of sphincter structure and function is of paramount importance. With the use of adequate tissue retraction and submucosal infiltration, the hemorrhoidal plexus can be readily elevated off the underlying anal sphincter, allowing for safe application of the diathermy forceps.

Sphincter stretching should also be minimized during the operative procedure to avoid injury. By decreasing operative time and simplifying the procedure, Liga-

Sure hemorrhoidectomy could help prevent sphincter injury.

It is important to mention the limitations of this meta-analysis. None of the studies reported on hemorrhoid recurrence. There was heterogeneity in some results, which we tried successfully to account for by sensitivity analysis. Also, as mentioned earlier, none of the studies reported on long-term success rates. The study also has its strengths, with large numbers of patients being analyzed at once, which would have been difficult to gather in one primary randomized clinical trial.

CONCLUSIONS

Meta-analysis has shown that LigaSure hemorrhoidectomy can provide a safe, fast, low-morbidity alternative to conventional hemorrhoidectomy. There are significant benefits of LigaSure hemorrhoidectomy: reduced operative time and blood loss, as well as reduced postoperative pain, analgesic requirement, and time to return to work or normal activity. Further randomized controlled trials are required to assess long-term success rates of the technique.

Accepted for Publication: June 24, 2006.
Correspondence: Paris P. Tekkis, MD, FRCS, Department of Biosurgery and Surgical Technology, Imperial College London, St Mary's Hospital, 10th Floor QEQM Wing, Praed Street, London W2 1NY, England (p.tekkis@imperial.ac.uk).
Author Contributions: *Study concept and design:* Tan, Darzi, Papagrigoriadis, and Tekkis. *Acquisition of data:* Tan and Cornish. *Analysis and interpretation of data:* Tan and Tekkis. *Drafting of the manuscript:* Tan, Cornish, and Papagrigoriadis. *Critical revision of the manuscript for important intellectual content:* Tan, Darzi, and Tekkis. *Statistical analysis:* Tan and Tekkis. *Administrative, technical, and material support:* Tekkis. *Study supervision:* Tekkis.
Financial Disclosure: None reported.

REFERENCES

1. MacRae HM, McLeod RS. Comparison of hemorrhoidal treatment modalities: a meta-analysis. *Dis Colon Rectum*. 1995;38(7):687-694.
2. Andrews BT, Layer GT, Jackson BT, Nicholls RJ. Randomized trial comparing diathermy hemorrhoidectomy with the scissor dissection Milligan-Morgan operation. *Dis Colon Rectum*. 1993;36(6):580-583.
3. Seow-Choen F, Ho YH, Ang HG, Goh HS. Prospective, randomized trial comparing pain and clinical function after conventional scissors excision/ligation vs diathermy excision without ligation for symptomatic prolapsed hemorrhoids. *Dis Colon Rectum*. 1992;35(12):1165-1169.
4. Milligan E, Morgan C. Surgical anatomy of the anal canal and operative treatment of hemorrhoids. *Lancet*. 1937;2:1119-1124.
5. Ferguson JA, Heaton JR. Closed hemorrhoidectomy. *Dis Colon Rectum*. 1959;2(2):176-179.
6. Carapeti EA, Kamm MA, McDonald PJ, Phillips RK. Double-blind randomised controlled trial of effect of metronidazole on pain after day-case hemorrhoidectomy. *Lancet*. 1998;351(9097):169-172.
7. Senagore A, Mazier WP, Luchtefeld MA, MacKeigan JM, Wengert T. Treatment of advanced hemorrhoidal disease: a prospective, randomized comparison of cold scalpel vs contact Nd:YAG laser. *Dis Colon Rectum*. 1993;36(11):1042-1049.
8. Armstrong DN, Ambroze WL, Schertzer ME, Orangio GR. Harmonic Scalpel vs. electrocautery hemorrhoidectomy: a prospective evaluation. *Dis Colon Rectum*. 2001;44(4):558-564.
9. Rowsell M, Bello M, Hemingway DM. Circumferential mucosectomy (stapled hemorrhoidectomy) versus conventional hemorrhoidectomy: randomised controlled trial. *Lancet*. 2000;355(9206):779-781.
10. Kennedy JS, Stranahan PL, Buipass SF, et al. Large vessel ligation using bipolar energy: a dynamic animal study and histological evaluation. Paper presented at: Seventh International Meeting of the Society for Minimal Invasive Therapy; September 21-23, 1995; Portland, OR.
11. Kennedy JS, Stranahan PL, Taylor KD, Chandler JG. High-burst-strength, feedback-controlled bipolar vessel sealing. *Surg Endosc*. 1998;12(6):876-878.
12. Clarke M, Horton R. Bringing it all together: Lancet-Cochrane collaborate on systematic reviews. *Lancet*. 2001;357(9270):1728.
13. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology, a proposal for reporting: Meta-analysis of Observational Studies in Epidemiology (MOOSE) group. *JAMA*. 2000;283(15):2008-2012.
14. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials*. 1986;7(3):177-188.
15. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315(7109):629-634.
16. Yusuf S, Peto R, Lewis J, Collins R, Sleight P. Beta blockade during and after myocardial infarction: an overview of the randomized trials. *Prog Cardiovasc Dis*. 1985;27(5):335-371.
17. Mantel N, Haenszel W. Statistical aspects of the analysis of data from retrospective studies of disease. *J Natl Cancer Inst*. 1959;22(4):719-748.
18. Jadad AR, Moore RA, Carroll D, et al. Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials*. 1996;17(1):1-12.
19. Cherqui D. Laparoscopic liver resection. *Br J Surg*. 2003;90(6):644-646.
20. Egger M, Smith GD. Misleading meta-analysis. *BMJ*. 1995;311(7007):753-754.
21. Altomare DF. Randomized clinical trial of Ligasure versus open hemorrhoidectomy. *Tech Coloproctol*. 2002;6(1):64.
22. Chung CC, Ha JP, Tai YP, Tsang WW, Li MK. Double-blind, randomized trial comparing Harmonic Scalpel hemorrhoidectomy, bipolar scissors hemorrhoidectomy, and scissors excision: ligation technique. *Dis Colon Rectum*. 2002;45(6):789-794.
23. Chung YC, Wu HJ. Clinical experience of sutureless closed hemorrhoidectomy with LigaSure. *Dis Colon Rectum*. 2003;46(1):87-92.
24. Franklin EJ, Seetharam S, Lowney J, Horgan PG. Randomized, clinical trial of Ligasure vs conventional diathermy in hemorrhoidectomy. *Dis Colon Rectum*. 2003;46(10):1380-1383.
25. Jayne DG, Botterill I, Ambrose NS, Brennan TG, Guillou PJ, O'Riordain DS. Randomized clinical trial of Ligasure versus conventional diathermy for day-case hemorrhoidectomy. *Br J Surg*. 2002;89(4):428-432.
26. Milito G, Gargiani M, Cortese F. Randomised trial comparing LigaSure hemorrhoidectomy with the diathermy dissection operation. *Tech Coloproctol*. 2002;6(3):171-175.
27. Palazzo FF, Francis DL, Clifton MA. Randomized clinical trial of Ligasure versus open hemorrhoidectomy. *Br J Surg*. 2002;89(2):154-157.
28. Pattana-Arun J, Sooriprasoet N, Sahakijrungruang C, Tantiphlachiva K, Rojana-sakul A. Closed vs ligasure hemorrhoidectomy: a prospective, randomized clinical trial. *J Med Assoc Thai*. 2006;89(4):453-458.
29. Thorbeck CV, Montes MF. Hemorrhoidectomy: randomised controlled clinical trial of Ligasure compared with Milligan-Morgan operation. *Eur J Surg*. 2002;168(8-9):482-484.
30. Wang JY, Lu CY, Tsai HL, et al. Randomized controlled trial of LigaSure with submucosal dissection versus Ferguson hemorrhoidectomy for prolapsed hemorrhoids. *World J Surg*. 2006;30(3):462-466.
31. Lawes DA, Palazzo FF, Francis DL, Clifton MA. One year follow up of a randomized trial comparing Ligasure with open hemorrhoidectomy. *Colorectal Dis*. 2004;6(4):233-235.
32. Peters CJ, Botterill I, Ambrose NS, Hick D, Casey J, Jayne DG. Ligasure trademark vs conventional diathermy hemorrhoidectomy: long-term follow-up of a randomised clinical trial. *Colorectal Dis*. 2005;7(4):350-353.
33. Jorge JM, Wexner SD. Etiology and management of fecal incontinence. *Dis Colon Rectum*. 1993;36(1):77-97.
34. Cheetham MJ, Mortensen NJ, Nystrom PO, Kamm MA, Phillips RK. Persistent pain and faecal urgency after stapled hemorrhoidectomy. *Lancet*. 2000;356(9231):730-733.
35. Ho YH, Cheong WK, Tsang C, et al. Stapled hemorrhoidectomy, cost and effectiveness: randomized, controlled trial including incontinence scoring, anorectal manometry, and endoanal ultrasound assessments at up to three months. *Dis Colon Rectum*. 2000;43(12):1666-1675.
36. Basdanis G, Papadopoulos VN, Michalopoulos A, Apostolidis S, Harlaftis N. Randomized clinical trial of stapled hemorrhoidectomy vs open with Ligasure for prolapsed piles. *Surg Endosc*. 2005;19(2):235-239.

37. Lan P, Wu X, Zhou X, Wang J, Zhang L. The safety and efficacy of stapled hemorrhoidectomy in the treatment of hemorrhoids: a systematic review and meta-analysis of ten randomized control trials. *Int J Colorectal Dis*. 2006;21(2):172-178.

38. Gelmini R, Romano F, Quaranta N, et al. Sutureless and stapleless laparoscopic splenectomy using radiofrequency: LigaSure device. *Surg Endosc*. 2006;20 (6):991-994.

INVITED CRITIQUE

The authors performed a meta-analysis of randomized controlled trials comparing short-term outcomes in LigaSure and conventional hemorrhoidectomy. They found that operative time, blood loss, and pain on postoperative day 1 were significantly less following LigaSure hemorrhoidectomy than conventional hemorrhoidectomy. For minor procedures, blood loss is realistically not a significant factor and the difference in operative times is also not clinically significant. Pain, however, remains an important issue.

Patients seek hemorrhoidectomy for a variety of complaints: troublesome bleeding, hemorrhoidal prolapse requiring manual reduction, and difficulties with hygiene due to large external hemorrhoidal tags, among other reasons. Each of these may require a slight modification or variation of surgical technique and therefore may be associated with differing degrees of postoperative pain. Treating the external hemorrhoidal component, by necessity, involves a cutaneous incision, which will clearly be associated with more pain than that associated with excision of the internal hemorrhoidal component alone, regardless of how this is done.

When reading the description of conventional hemorrhoidectomy trials (Table 1), one finds that closed hemorrhoidectomy was performed in only 4 of the 9 conventional hemorrhoidectomy trials, ie, the wounds were closed rather than left open. I do not believe that most US surgeons commonly perform open hemorrhoidectomy nor that they use diathermy for their dissection, especially in proximity to the anal sphincter.

Considering that there is not an adequate number of studies available to permit comparison to scissor dissection and closed hemorrhoidectomy, one can only conclude that there is less pain on day 1 with LigaSure hemorrhoidectomy compared with diathermy dissection. The authors have performed a detailed and thoughtful meta-analysis. However, I am still not certain we know which technique is superior, especially for those of us who perform closed hemorrhoidectomy using scissor dissection.

Susan Galandiuk, MD

Correspondence: Dr Galandiuk, Department of Surgery, University of Louisville School of Medicine, 550 S Jackson St, Louisville, KY 40292 (susan.galandiuk @louisville.edu).

Financial Disclosure: None reported.