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RESEARCH ARTICLE

LigaSure Hemorrhoidectomy versus Non-Doppler Artery Ligation with Mucopexy for Grade IV Hemorrhoids: Short-Term Outcomes of a Retrospective Cohort Study

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ABSTRACT

Aim: The present study was designed to evaluate early surgical outcomes, recurrence rates, and exploratory patient-reported outcome measures between LigaSure excisional hemorrhoidectomy and non-Doppler-guided hemorrhoidal artery ligation with mucopexy in patients with Grade IV hemorrhoidal disease.

Method: A retrospective cohort study was performed involving 92 consecutively included patients treated for Grade IV hemorrhoidal disease in a single high-volume center between January 2021 and July 2024. Participants were allocated to either LigaSure hemorrhoidectomy (n=46) or non-Doppler-guided hemorrhoidal artery ligation with mucopexy (n=46). Postoperative pain, complications, recurrence, and patient-reported outcomes were assessed, with follow-up at 6 months.

Results: Early postoperative pain and complication rates did not differ significantly across groups. However, recurrence at 6 months was significantly higher in the non-Doppler ligation with mucopexy group than in the LigaSure group (30.4% vs. 10.9%, p=0.018). Exploratory patient-reported outcomes at 6 months favored LigaSure hemorrhoidectomy in terms of daily activity, comfort, social functioning, and psychological well-being.

Conclusion: In patients with Grade IV hemorrhoidal disease, non-Doppler-guided hemorrhoidal artery ligation with mucopexy was associated with higher short-term recurrence rates without demonstrating clear advantages in early postoperative or patient-reported outcomes compared with LigaSure hemorrhoidectomy. Exploratory patient-reported outcome findings should be interpreted cautiously due to the absence of validated assessment tools and preoperative baseline measurements. Careful patient selection is warranted, and extended follow-up is needed to confirm the present observations.

Keywords: Hemorrhoidal disease, hemorrhoidectomy, hemorrhoidal artery ligation, mucopexy, recurrence, patient-reported outcome scores, short-term follow-up

Introduction

Hemorrhoidal disease is a frequently encountered benign anorectal condition that can significantly affect quality of life due to manifestations such as rectal bleeding, mucosal prolapse, perianal discomfort, and pruritus ani.[1] Although early-stage disease is usually managed conservatively, advanced cases—particularly Grade IV—often require surgical intervention.[2]

Excisional hemorrhoidectomy is widely accepted as a definitive treatment for advanced (Grade III-IV) disease due to its durability and low recurrence rates.[3] The introduction of energy-based vessel-sealing devices, such as LigaSure™, has aimed to reduce intraoperative blood loss and postoperative pain while maintaining the long-term effectiveness of conventional excisional techniques.[4] However, excisional surgery is still associated with postoperative discomfort and wound-related morbidity.

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In contrast, tissue-sparing techniques such as hemorrhoidal artery ligation combined with mucopexy have gained popularity due to their potential to reduce postoperative pain and accelerate recovery.[5] By avoiding excision of anoderm and minimizing tissue trauma, these approaches are thought to preserve anal anatomy and function. Although Doppler-guided hemorrhoidal artery ligation has been widely studied, non-Doppler-guided ligation with mucopexy represents a simpler and more accessible alternative.[6] Nevertheless, concerns remain regarding its durability, particularly in patients with advanced (Grade IV) hemorrhoidal disease.

Data comparing excisional energy-based hemorrhoidectomy with non-Doppler artery ligation and mucopexy specifically in Grade IV hemorrhoids are limited. Furthermore, the balance between recurrence risk and postoperative patient-reported outcomes in this patient population remains unclear.

The purpose of this study is to evaluate early postoperative outcomes, recurrence rates, and patient-reported outcome measures of LigaSure excisional hemorrhoidectomy and non-Doppler-assisted hemorrhoidal artery ligation with mucopexy among individuals with Grade IV hemorrhoidal disease. We hypothesized that non-Doppler-assisted hemorrhoidal artery ligation with mucopexy would yield comparable early postsurgical outcomes but may be associated with higher recurrence rates than LigaSure excisional hemorrhoidectomy.

Materials and Methods

Study Design and Patients

This retrospective cohort study included patients who underwent surgical treatment for Grade IV hemorrhoidal disease between January 2021 and July 2024 at a single tertiary referral center. Eligibility criteria included age ≥18 years, symptomatic Grade IV hemorrhoidal disease (irreducible prolapse according to the Goligher classification), and elective surgical treatment. Exclusion criteria included prior hemorrhoidal surgery, concurrent anorectal pathology (anal fissure, fistula, perianal abscess, or rectal prolapse), inflammatory bowel disease, pregnancy, anticoagulant therapy, or incomplete follow-up data at 6 months. Overall, 108 patients were assessed for eligibility throughout the enrollment period; 16 were not included [5 were lost to follow-up, 4 had a history of prior hemorrhoidal surgery, 4 had concurrent anorectal pathology (3 anal fissure, 1 anal fistula), and 3 declined to participate], leaving 92 patients in the study cohort (Figure 1). The study population was separated into two groups according to the surgical technique performed: LigaSure excisional hemorrhoidectomy (Group 1, n=46) and non-Doppler-assisted hemorrhoidal artery ligation combined with mucopexy (Group 2, n=46). The operations were carried out by two senior colorectal surgeons, each with >5 years of experience in proctological surgery. Surgeon A predominantly performed LigaSure hemorrhoidectomy, and Surgeon B predominantly performed non-Doppler artery ligation with mucopexy. The allocation of patients to a particular surgical technique was primarily determined by which surgeon the patient was referred to in the outpatient clinic, rather than a deliberate selection based on disease severity or clinical characteristics. Both surgeons had completed their learning curves for their respective techniques prior to the study period. The equal group size of 46 patients was coincidental and resulted from the consecutive inclusion of patients meeting the eligibility criteria. All procedures were performed under spinal anesthesia. Ethical clearance was granted by the University of Health Sciences Türkiye, Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital Scientific Research Ethics Committee (approval no.: 297, dated: 27.08.2025). The study was conducted in accordance with the principles of the Declaration of Helsinki.

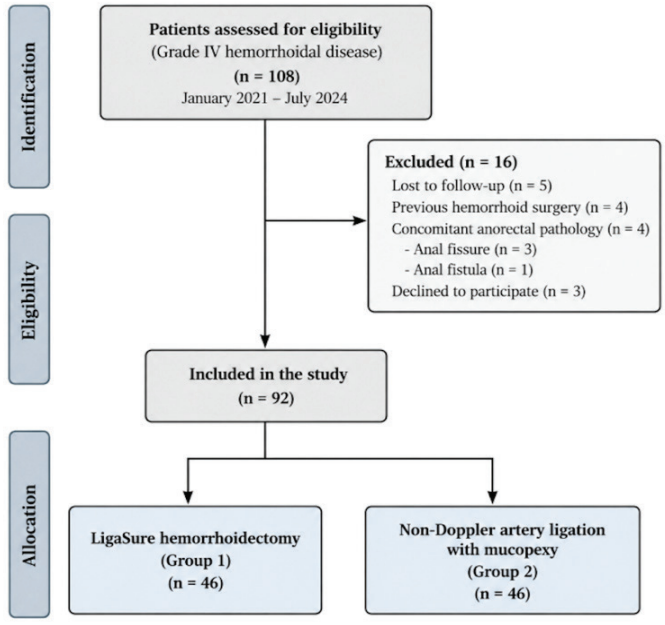

Figure 1. Flow diagram of patient selection and allocation according to surgical technique

Surgical Techniques

In Group 1, excisional hemorrhoidectomy was performed using a bipolar vessel-sealing instrument (LigaSure™ Small Jaw Open Sealer/Divider; Medtronic, Minneapolis, MN, USA). Hemorrhoidal pedicles were sealed and divided at their vascular origin while preserving mucocutaneous bridges. Hemostasis was achieved with the same device, and the wounds were left open.

In Group 2, non-Doppler-assisted hemorrhoidal artery ligation with mucopexy was undertaken. Absorbable sutures

(2-0 polyglactin 910, Vicryl™; Ethicon, Somerville, NJ, USA) were inserted approximately 2-3 cm above the dentate line. Six ligation sutures were applied at six standard clock-face positions (1, 3, 5, 7, 9, and 11 o'clock) using a figure-of-eight technique. Mucopexy was then performed at the same levels to correct mucosal prolapse. No excision of hemorrhoidal tissue was undertaken in this group.

Postoperative Care

A standardized postoperative care protocol was applied to both groups. Postoperative analgesia was standardized for all patients. Paracetamol (1 g, intravenous or oral) was administered every 8 hours in combination with a nonsteroidal anti-inflammatory drug, either dexketoprofen (50 mg, intravenous) or diclofenac (75 mg, intramuscular), given at regular intervals. Tramadol (100 mg, intravenous) was used as rescue analgesia in cases of insufficient pain control, defined as a visual analog scale (VAS) score >5. The same analgesic protocol was applied to both study groups. Laxatives (lactulose or fiber supplementation) were prescribed to all patients to prevent constipation and straining. Patients were instructed to perform sitz baths two to three times daily and to maintain local wound hygiene. Dietary advice included a high-fiber diet with adequate fluid intake. Patients were discharged on postoperative day 1 once they tolerated oral intake, had voided, and pain was adequately controlled. Follow-up visits were scheduled at postoperative week 1 and at months 1, 3, and 6.

Data Collection and Follow-up

Demographic and clinical information was retrieved from the institutional electronic health records. Recorded baseline parameters encompassed age, sex, body mass index (BMI), comorbid conditions, and previous hemorrhoidal treatments. Previous treatment was categorized as (a) none (no prior treatment), (b) conservative only (dietary and lifestyle modifications, including fiber-rich diet, adequate hydration, and avoidance of excessive straining), or (c) conservative combined with medical treatment (the above measures plus topical or oral pharmacological agents, such as flavonoids, topical analgesics, or corticosteroid preparations). Intraoperative complications were documented.

Postoperative outcomes encompassed VAS pain ratings, postoperative bleeding, tenesmus, surgical site infection, fecal incontinence, flatus incontinence, anal stenosis, and recurrence. The VAS pain rating was assessed using a standard 0-10 scale at two time points: postoperative day 1 (approximately 24 hours after surgery, assessed at rest before discharge) and at the postoperative week 1 follow-up visit.

The analgesic protocol was standardized across both groups (see postoperative care). Postoperative bleeding was classified as (a) minor/self-limiting (requiring no intervention), (b) requiring outpatient treatment (e.g., local hemostatic measures), (c) requiring readmission, or (d) requiring reoperation. Recurrence was defined as the reappearance of prolapsing hemorrhoidal tissue (Grade II or higher according to the Goligher classification) and/or the recurrence of hemorrhoid-related symptoms (bleeding, prolapse) at clinical examination during follow-up. Anal stenosis was defined as difficulty in digital rectal examination or patient-reported symptoms of obstructed defecation. Return to normal activity was defined as resumption of daily activities without restriction as reported by the patient.

All patients were followed up at postoperative week 1 and at months 1, 3, and 6. Follow-up evaluations were conducted in the outpatient clinic by the operating surgeon or a trained surgical team member who was not involved in the procedure. Clinical assessment included postoperative pain (VAS), complications, and recurrence. Recurrence was assessed by clinical examination including inspection and digital rectal examination. Functional outcomes, including flatus incontinence, fecal incontinence, and anal stenosis, were re-evaluated at 6 months postoperatively. Postoperative patient-reported outcome scores were evaluated at 6 months using an author-designed, non-validated 5-domain 0-10 scale assessing general health status, ability to perform daily activities, life comfort, social relationships, and psychological well-being. No preoperative baseline scores were available. This scale has not been psychometrically validated, and the results should therefore be interpreted as exploratory.

Statistical Analysis

Statistical computations were performed with IBM SPSS Statistics, version 29.0 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed with the Kolmogorov-Smirnov test. Based on the distribution pattern, continuous variables were presented as mean±standard deviation or median (interquartile range) and analyzed with Student's t-test or the Mann-Whitney U test, respectively. Categorical data were expressed as frequencies and percentages and evaluated by the chi-square test or Fisher's exact test where applicable. Statistical significance was defined as a two-tailed p-value of <0.05. Although multivariable logistic regression analysis was initially planned for the primary outcome of recurrence, the small number of observed recurrences (n=19) did not allow for reliable model construction in accordance with the recommended minimum of 10 events per predictor variable.

Results

Baseline Characteristics

Ninety-two patients with Grade IV hemorrhoidal disease were included, with 46 patients in each group. The mean age was 43.19±11.97 years in the LigaSure group and 46.48±11.14

years in the non-Doppler ligation with mucopexy group. The mean BMI was 27.38±4.35 kg/m² in Group 1 and 26.57±3.73 kg/m² in Group 2. There were no significant differences across groups in terms of age, BMI, sex ratio, comorbid conditions, or previous treatment history (Table 1). No intraoperative complications were observed in either group.

Early Postoperative Outcomes

Initial postoperative findings are detailed in Table 2. Postoperative pain scores were comparable between the two groups. The mean VAS pain score on postoperative day 1 was 5.38±2.21 in the LigaSure group and 5.00±2.97 in the non-Doppler ligation with mucopexy group (p=0.483). At postoperative week 1, the mean VAS pain score decreased to 1.94±1.62 and 1.76±1.66, respectively (p=0.608).

No statistically meaningful differences were detected across groups regarding postoperative bleeding (19.6% vs. 17.4%, p=0.788), tenesmus (10.9% vs. 6.5%, p=0.487), flatus incontinence (10.9% vs. 8.7%, p=0.739), fecal incontinence (4.3% vs. 0%, p=0.496), or anal stenosis (2.2% vs. 0%, p=1.000). No surgical site infections were recorded in either group.

The mean time to return to normal activity was 3.91±2.60 days in the LigaSure group and 3.26±1.61 days in the non-Doppler group, without reaching statistical significance (p=0.149).

Table 1. Baseline characteristics of the study population

Variable	Group 1 (LigaSure) n=46	Group 2 (non-Doppler + Mucopexy) n=46	p-value
Age (years), mean±SD	**43.19±11.97**	46.48±11.14	0.176
BMI (kg/m²), mean±SD	27.38±4.35	26.57±3.73	0.339
Male sex, n (%)	29 (63.0%)	31 (67.4%)	0.662
Female sex, n (%)	17 (37.0%)	15 (32.6%)	0.662
Diabetes mellitus, n (%)	3 (6.5%)	6 (13.0%)	0.293
Hypertension, n (%)	6 (13.0%)	8 (17.4%)	0.562
Cardiovascular disease, n (%)	3 (6.5%)	4 (8.7%)	0.694
COPD, n (%)	0 (0%)	3 (6.5%)	0.242
Malignancy, n (%)	1 (2.2%)	0 (0%)	1.000
Previous treatment, n (%)			0.096
None	15 (32.6%)	22 (47.8%)	
Conservative only	29 (63.0%)	19 (41.3%)	
Conservative + medical	2 (4.3%)	5 (10.9%)	
Intraoperative complications, n (%)	0 (0%)	0 (0%)	1.000

Values are presented as mean±standard deviation (SD) or number (percentage)

BMI: Body mass index, COPD: Chronic obstructive pulmonary disease

Table 2. Early postoperative outcomes

Parameter	Group 1 (LigaSure) n=46	Group 2 (non-Doppler + Mucopexy) n=46	p-value
VAS pain score (postoperative day 1), mean±SD	5.38±2.21	5.00±2.97	0.483
VAS pain score (postoperative week 1), mean±SD	1.94±1.62	1.76±1.66	0.608
Postoperative bleeding, n (%)	9 (19.6%)	8 (17.4%)	0.788
Tenesmus, n (%)	5 (10.9%)	3 (6.5%)	0.487
Surgical site infection, n (%)	0 (0%)	0 (0%)	1.000
Flatus incontinence, n (%)	5 (10.9%)	4 (8.7%)	0.739
Fecal incontinence, n (%)	2 (4.3%)	0 (0%)	0.496
Anal stenosis, n (%)	1 (2.2%)	0 (0%)	1.000
Time to return to normal activity (days), mean±SD	3.91±2.60	3.26±1.61	0.149

Values are presented as mean±standard deviation (SD) or number (percentage)

VAS: Visual analogue scale

Six-Month Postoperative Outcomes

At 6 months postoperatively, recurrence was significantly more frequent in the non-Doppler ligation with mucopexy group than in the LigaSure group (30.4% vs. 10.9%, p=0.018) (Table 3). All early postoperative functional complications, including flatus incontinence, fecal incontinence, and anal stenosis, had resolved completely in both groups by the 6-month follow-up visit.

Regarding exploratory patient-reported outcome scores assessed with a non-validated author-designed scale, most domains appeared to favor the LigaSure group at 6-month follow-up. The mean general health score was 9.57±1.23 in the LigaSure group and 8.91±2.01 in the non-Doppler group, approaching statistical significance (p=0.059). Notable differences emerged in the ability to perform daily activities (9.57±1.23 vs. 8.80±2.15, p=0.037), life comfort (9.49±1.38 vs. 8.48±2.27, p=0.011), social relationships (9.49±1.38 vs. 8.57±2.23, p=0.019), and psychological well-being (9.60±1.17 vs. 8.59±2.46, p=0.013), all favoring the LigaSure group.

Discussion

This study compared LigaSure-based excisional hemorrhoidectomy with non-Doppler-guided hemorrhoidal artery ligation combined with mucopexy in patients with Grade IV hemorrhoidal disease. The key findings were as follows: early postoperative outcomes, including pain and complication rates, were similar between the two techniques; recurrence at 6 months was higher in the ligation with mucopexy group; and patient-reported outcomes tended to favor the excisional approach. However, these findings warrant cautious interpretation given the use of a non-validated instrument and the absence of preoperative baseline data.

Excisional hemorrhoidectomy remains the reference standard for advanced hemorrhoidal disease, primarily due to its durability and low recurrence rates.[7] In the present study, the recurrence rate after LigaSure hemorrhoidectomy was 10.9%, which aligns with previously published data demonstrating low recurrence rates after excisional hemorrhoidectomy in advanced hemorrhoidal disease.[8] These findings reinforce the established role of excisional surgery, particularly in Grade IV hemorrhoids, where irreversible prolapse and a frequently prominent external component may limit the long-term effectiveness of non-excisional techniques.

In contrast, tissue-sparing approaches such as hemorrhoidal artery ligation with mucopexy have gained popularity due to the perceived advantages of reduced postoperative pain and faster recovery.[9,10] By preserving anoderm and minimizing tissue trauma, these techniques aim to reduce wound-related morbidity and functional impairment. However, most published data on artery ligation techniques involve Doppler-guided procedures and predominantly include Grade II-III disease. Evidence specifically addressing non-Doppler-guided ligation with mucopexy in Grade IV hemorrhoids remains limited.[11]

In our study, early postoperative pain scores and complication rates were similar across the two study arms. Notably, no significant differences were observed in VAS scores on postoperative day 1 or at week 1, nor in rates of bleeding, tenesmus, incontinence, anal stenosis, or interval to resumption of routine activity. The absence of a pain advantage in the artery ligation group deserves particular attention, as reduced postoperative pain is considered one of the principal benefits of tissue-sparing techniques in current guidelines. However, most studies demonstrating a pain advantage of artery ligation have compared it with conventional (cold-knife or scissors) excisional hemorrhoidectomy. Therefore, the lack of a notable pain disparity in our study may reflect the already favorable pain profile of the LigaSure technique rather than a failure of the artery ligation approach. LigaSure hemorrhoidectomy has previously been associated with lower postoperative pain

Table 3. Six-month postoperative outcomes

Parameter	Group 1 (LigaSure) n=46	Group 2 (non-Doppler + Mucopexy) n=46	p-value
Recurrence, n (%)	5 (10.9%)	14 (30.4%)	0.018
Flatus incontinence, n (%)	0 (0%)	0 (0%)	1.000
Fecal incontinence, n (%)	0 (0%)	0 (0%)	1.000
Anal stenosis, n (%)	0 (0%)	0 (0%)	1.000
General health status, mean±SD	9.57±1.23	8.91±2.01	0.059
Ability to perform daily activities, mean±SD	9.57±1.23	8.80±2.15	0.037
Life comfort, mean±SD	9.49±1.38	8.48±2.27	0.011
Social relationships, mean±SD	9.49±1.38	8.57±2.23	0.019
Psychological well-being, mean±SD	9.60±1.17	8.59±2.46	0.013

Quality-of-life parameters were assessed using a 5-domain 0-10 patient-reported scale. Higher scores indicate better perceived quality of life. Values are presented as mean±standard deviation (SD) or number (percentage)

compared with conventional excisional hemorrhoidectomy due to reduced lateral thermal injury and improved vessel sealing.[4] Therefore, the expected pain advantage of tissue-sparing approaches may have been attenuated in the present comparison. Nevertheless, we cannot fully exclude the possibility that technical factors or surgeon experience may have contributed to this finding. The single case of early postoperative anal stenosis observed in the LigaSure group was mild and transient in nature, likely related to postoperative edema and sphincter spasm rather than fixed fibrotic narrowing, and was resolved with conservative management during follow-up. These results suggest that, in experienced hands, excisional hemorrhoidectomy using a modern energy device may not necessarily be associated with increased early morbidity compared with tissue-sparing techniques, even in advanced disease.

The most clinically relevant finding of this study was the significantly higher recurrence rate observed in the non-Doppler ligation with mucopexy group (30.4% vs. 10.9%). This approximately threefold increase in recurrence highlights the potential limitations of a non-excisional approach in the setting of Grade IV hemorrhoidal disease. Advanced hemorrhoidal disease is characterized by persistent prolapse and structural changes that may not be fully corrected by arterial ligation and mucosal suspension alone. In this context, excision of redundant tissue may provide more definitive anatomical correction and durable symptom control.[12]

Several factors related to the non-Doppler technique itself may have contributed to the higher recurrence rate. Without Doppler guidance, the identification and ligation of hemorrhoidal arterial branches relies entirely on standard anatomical positions. However, the number and distribution of hemorrhoidal arteries show considerable anatomical variability, and non-guided ligation may result in incomplete arterial interruption or missed branches.[13] Schuurman et al.[6] demonstrated comparable results between Doppler-guided and non-Doppler ligation in Grade II-III hemorrhoids; however, in Grade IV disease, the greater tissue redundancy and vascular complexity may make Doppler guidance more relevant.[6] Additionally, the mucopexy component alone may be insufficient to address the degree of prolapse and external component frequently seen in Grade IV disease, where permanent structural changes in the hemorrhoidal cushions have occurred.

It is important to note that the European Society of Coloproctology and the Italian Society of Colorectal Surgeons recommend hemorrhoidal artery ligation primarily for Grade II-III hemorrhoids and suggest excisional methods for Grade IV disease, with a high level of evidence.[14,15] Applying artery ligation in Grade IV disease therefore goes beyond the recommended indications, and the higher recurrence rate observed in our study is consistent with the concerns expressed in these guidelines. Nevertheless, several studies have reported favorable outcomes with artery ligation and mucopexy in selected Grade IV patients, suggesting that the technique may still have a role when careful patient selection criteria are applied.[16]

Exploratory patient-reported outcome scores at 6 months appeared to favor the excisional approach in most domains, including daily activities, life comfort, social relationships, and psychological well-being. However, these findings must be interpreted with considerable caution. The scale used was a non-validated, author-designed instrument, and no preoperative baseline scores were collected. Therefore, it is not possible to determine whether the observed differences reflect the direct effect of the surgical technique or are instead a consequence of the higher recurrence rate in the non-Doppler group leading to lower patient satisfaction. Future studies using validated instruments, such as the Sodergren Hemorrhoid Symptom Score[17] or EQ-5D, with preoperative baseline assessments, are needed to clarify the impact of surgical technique on patient-reported outcomes in advanced hemorrhoidal disease.

The present study has several strengths. All patients had Grade IV hemorrhoids, providing a homogeneous and clinically relevant study population. Both groups were comparable in baseline characteristics, and standardized follow-up was performed at 6 months. Furthermore, the comparison specifically addressed non-Doppler-guided ligation, a simpler and more accessible alternative to Doppler-guided techniques, which increases the practical applicability of the findings.

Study Limitations

However, certain limitations deserve mention. Foremost, the retrospective, non-randomized nature of the study introduces a risk of selection bias, as unmeasured clinical factors such as prolapse severity, external component, and symptom burden may have influenced treatment selection. In addition, the Goligher classification does not fully capture disease heterogeneity. Second, procedures were predominantly performed by two surgeons, each favoring a specific technique, introducing a potential surgeon-related confounder. Third, outcome assessors were not blinded. Fourth, follow-up extended only to 6 months, preventing conclusions about long-term outcomes. Fifth, patient-reported outcomes were assessed using a non-validated scale without preoperative baseline data, limiting interpretability. Finally, the modest sample size constrains statistical power and restricts adjustment for confounders. Therefore, these results should be regarded as preliminary and hypothesis-forming.

Despite these limitations, our results suggest that in Grade IV hemorrhoidal disease, non-Doppler-guided hemorrhoidal artery ligation carries a considerably higher short-term

recurrence rate than LigaSure excisional hemorrhoidectomy, without a clear advantage in early postoperative recovery or patient-reported outcomes. Careful patient selection is therefore essential when considering tissue-sparing approaches in advanced disease, particularly in the presence of major prolapse.

Conclusion

Well-designed prospective randomized trials with extended follow-up, validated outcome measures, and larger cohorts are required to delineate the optimal surgical strategy more precisely. Comparative studies in Grade IV disease may further clarify the role of artery ligation techniques.

Ethics

Ethics Committee Approval: Ethical clearance was granted by the University of Health Sciences Türkiye, Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital Scientific Research Ethics Committee (approval no.: 297, dated: 27.08.2025).

Informed Consent: For this type of study, formal consent is not required.

Footnotes

Authorship Contributions

Surgical and Medical Practices: H.S., İ.A., Concept: A.G., N.H.K., İ.A., Design: A.G., N.H.K., Data Collection or Processing: A.G., M.G.K., M.K.B., G.Ö., Analysis or Interpretation: A.G., H.S., N.H.K., M.G.K., Writing: A.G., N.H.K.

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Declaration Regarding the Use of AI and AI-Assisted Technologies: Artificial intelligence-assisted tools were used for language editing purposes during the preparation of this manuscript. The authors take full responsibility for the accuracy and integrity of all content.

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