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ORIGINAL ARTICLE

Comparison of short- and long-term outcomes of diode laser vs. crystallized phenol treatment for pilonidal sinus disease: A propensity score-matched multicentre study

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Abstract

Aim: Pilonidal sinus disease (PSD) primarily affects young adults; rapid recovery is essential and yet lacks a standardized treatment approach. While excisional techniques delay recovery, minimally invasive options like laser ablation and phenol application are gaining interest, yet comparative long-term evidence is scarce. This study compared short- and long-term outcomes of laser versus phenol treatment in PSD.

Method: In this multicentre retrospective cohort study (Nov. 2017–Sep. 2024), patients treated with laser or phenol were included. 1:3 propensity score matching using the nearest neighbour algorithm was performed based on age, gender, prior surgical history and year of operation. Categorical variables were analysed using chi-squared or Fisher's exact tests, whereas continuous variables were compared using Student's *t*-test or Mann–Whitney *U* test depending on distribution normality.

Results: Out of 897 eligible patients, 644 were included (median age: 26 years, body mass index [BMI]: 26.2 kg/m^2, male-to-female ratio: 4:1). The number of sinuses/pits was 2–3 in both groups. Operating time was significantly longer in the laser group. Complications occurred in 6.8% of laser patients, whereas none were reported in the phenol group. Pain scores were higher in the laser group (2 [1–3] vs. 1 [0–2]). Median follow-up was 45 months (laser) and 40 months (phenol). Return to daily activities was delayed in the laser group, whereas complete healing was slower in the phenol group. Readmission, recurrence and recovery rates were comparable (85%–86%).

Conclusion: Both treatments demonstrated low complication and recurrence rates with high recovery rates. Laser favoured faster healing and fewer sessions, whereas phenol allowed for shorter procedures and earlier return to daily life.

KEYWORDS
laser ablation, minimally invasive surgery, phenol application, pilonidal sinus disease

INTRODUCTION

Pilonidal sinus disease (PSD) is a chronic condition predominantly affecting young adults and carries a notable socio-economic burden due to time lost from work [1, 2]. Despite numerous surgical strategies, ranging from wide excision to flap-based procedures, no standardized treatment exists [1, 3]. Current literature indicates that most patients still undergo major excisional surgery, which delays healing, increases complications and carries substantial recurrence risk [1, 4, 5].

In recent years, minimally invasive approaches, such as pit-picking, laser ablation and phenol application, have gained attention as alternatives to wide excision [2, 3, 6, 7]. These methods aim to reduce operative trauma, improve cosmesis and accelerate return to daily activities. However, their use remains limited, and long-term efficacy is controversial [2, 5, 8]. For instance, the multicentre PITSTOP trial further underscored this debate, reporting that pit-picking, although less invasive, resulted in higher recurrence compared with flap procedures [7].

Among non-excisional techniques, phenol application and laser ablation are the most studied. Phenol is safe, inexpensive and effective in selected patients, with favourable recurrence rates [4, 9]. Laser therapy, on the other hand, offers minimally invasive ablation with promising short-term outcomes, though data remain heterogeneous [3, 10]. Despite these advances, the current European Society of Coloproctology (ESCP) guidelines highlight that both laser and phenol treatments are supported by low-to-moderate levels of evidence, primarily due to limited comparative studies and short follow-up [5].

Thus, large-scale, long-term comparative studies are needed to better define the relative benefits of these techniques. This multicentre study provides robust data from a large cohort comparing laser and phenol using propensity score-matched analysis from tertiary care centres.

What does this paper add to the literature?

This study shows the benefits of two applicable minimally invasive approaches in pilonidal sinus disease, laser and phenol, which have gained substantial interest in recent years. This is the first multicentre study comparing these techniques with the largest sample size and propensity score matching.

METHOD

Study design

This multicentre, retrospective cohort study included patients with PSD who underwent laser or phenol treatment between November 2017 and September 2024 at Acibadem Maslak, Acibadem Altunizade and Konya State Hospitals. Ethical approval was obtained from Acıbadem Mehmet Ali Aydınlar University (ID: 2025-01/43), and all patients gave written informed consent. The phenol technique was applied in public hospitals, and laser in private hospital settings. All procedures in both groups were performed by consultant colorectal surgeons experienced in minimally invasive PSD surgery. Standardized operative protocols were applied in both centres to minimize inter-surgeon variability.

A 1:3 propensity score match was performed using age, gender, prior surgery and year of operation to compare laser and phenol groups. Demographic and clinical variables included body mass index (BMI), American Society of Anaesthesiologists (ASA) score, smoking history, previous abscess drainage, operating time, endoscopic camera use, 24-h postoperative pain, hospital stay, complications, 30-day readmission, number of treatment sessions, time to return to daily activities, complete healing, recurrence, satisfaction, overall success and follow-up duration.

Primary outcomes were complete healing time and recurrence; secondary outcomes were operating time, pain, complications, hospital stay, return to daily life and satisfaction. Recurrence was monitored through routine follow-up and physical examination.

Definitions

Previous surgery included any excisional or minimally invasive procedure except abscess drainage. Postoperative pain was recorded in the first 24 h after the procedure using the Numerical Rating Scale (1–10) and categorized as mild (1–4), moderate (5–7) or severe (8–10) [11]. Complications were events within 90 days (bleeding, infection, seroma and wound discharge). Satisfaction was rated on a 10-point modified Likert scale via telephone follow-up [12]. Complete healing was full epithelialization without discharge, sinus or infection; recurrence was non-healing beyond 3 months, persistent/recurrent discharge or new sinus/abscess formation [13, 14].

In the phenol group, repeat applications were part of the intended protocol unless recurrence occurred after initial healing. Success was defined as complete healing without recurrence or unexpected further surgery during follow-up [3, 4].

Eligibility and contraindications

Patients with active abscesses were not eligible for definitive treatment until at least 2 weeks after drainage. Laser therapy was contraindicated for sinus diameter more than 1 cm (can cause wide open wound) or impaired tissue integrity. No specific contraindication noted for phenol application apart from active infection. All patients were informed preoperatively about

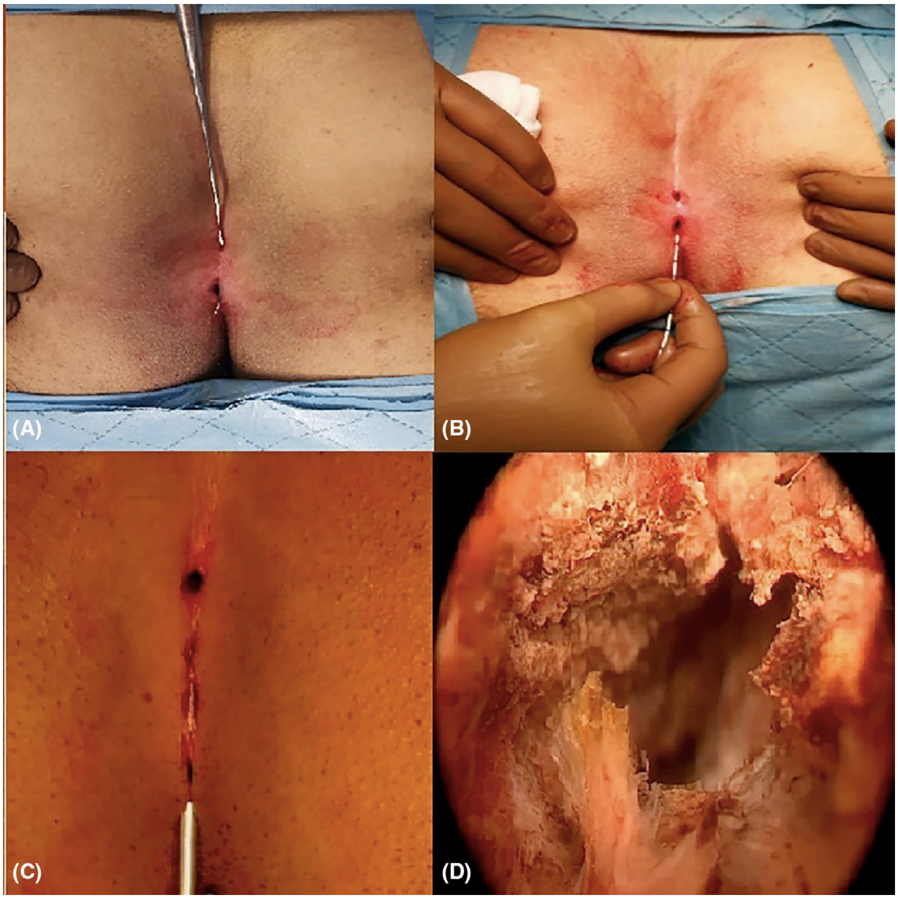

FIGURE 1 (A) Cannulation of sinuses with a fistula probe, (B) ablation of the tract cavity with a laser probe, (C) following laser ablation, checking the cavity with an endoscopic camera and (D) confirmation of the absence of hair or necrotic tissue.

treatment-related risks, benefits and recurrence rates based on literature.

Details about surgical procedures

Laser procedure

Under general anaesthesia in prone position, hair removal and antisepsis with povidone-iodine were performed. Sinuses/pits were cannulated with a fistula probe (Figure 1A), and proximal/distal pits were excised using a punch biopsy scalpel of appropriate size (3, 4, 6 or 10 mm), leaving a 1-mm skin margin around the pits. Debris and hair were removed, followed by saline irrigation. A 1470-nm diode laser (Ceralas® or Leonardo Dual45®, Biolitec GmbH, Germany) was used to ablate the sinus at 13 W power, delivering 78 J pulses at 1-cm intervals (Figure 1B). The laser probe was gradually withdrawn during ablation to ensure uniform treatment of the sinus walls. Necrotic tissue was removed, and ablation was repeated, ensuring complete tract closure within the same session. A videoendoscopic system was used based on the surgeon's preference (Figure 1C,D). An ice pack was applied for 5 min to cool the operative area. External openings were left open, and gauze dressing was applied. Patients, according to preference, were discharged on postoperative day 0 or day 1.

Phenol procedure

Phenol application was performed under local anaesthesia in an outpatient setting. After hair removal and antisepsis in the prone position, sinus tracts were debrided. Smaller sinuses/pits were gently expanded with a clamp if <3 mm (Figure 2A). Hair and necrotic tissue were mechanically removed using a clamp, and the sinus walls were debrided with a curette. A broad-spectrum local antibiotic (fusidate/nitrofurantoin-based preparation) was applied around the sinus to minimize the risk of infection and prevent irritation or dermatitis caused by phenol exposure. Crystallized phenol was applied using a clamp and left in the sinus for 2 minutes, then absorbed with gauze (Figure 2B). Phenol rapidly liquefied, filling the sinus, and induced sclerosis by destroying the sinus epithelium, facilitating sinus closure. This process was repeated 2–3 times, depending on the sinus width, taking care to avoid spread to surrounding tissues. Then, the local antibiotic was reapplied to the treated area. The site was covered with a gauze dressing.

Follow-up and outcome assessment

Patients were followed at 1, 2 and 4 weeks post-procedure, at 3 and 12 months and annually thereafter when possible. In the phenol

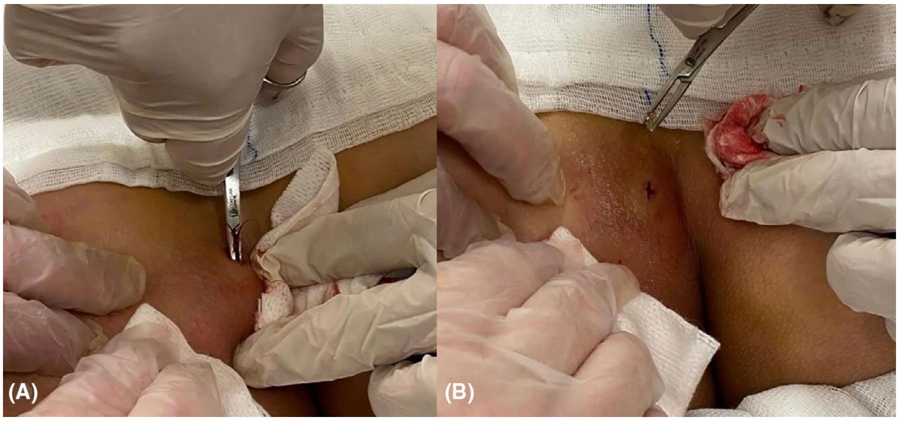

FIGURE 2 (A) Expansion of sinuses/pits with a mosquito clamp and (B) crystallized phenol application using a clamp and absorption with sterile gauze.

group, additional applications were performed as needed until full epithelialization, with healing time measured from the first procedure. Telephone interviews were used when in-person visits were not feasible; patients with suspected recurrence were invited for examination.

Statistical analysis

Categorical variables were presented as frequencies and compared using chi-square or Fisher's exact tests. Normally distributed variables were reported as mean ± SD, whereas non-normally distributed and ordinal variables (including pain scores, satisfaction scores, number of pits and recovery times) were reported as median with interquartile range (IQR). Propensity score matching (nearest neighbour, 3:1) included age, sex, prior surgery and year of operation, selected a priori because of their known association with both treatment allocation and outcomes. Balance was assessed using standardized mean differences (SMD), with values <0.10 considered acceptable. All post-matching covariates were well balanced; however, some differences (such as abscess history and ASA grades) persisted. No sensitivity analysis for unmeasured confounding was performed, which we acknowledge as a limitation. A *p*-value <0.05 was considered statistically significant. Analyses were performed using R version 4.2.3. The STROBE checklist was used to structure the manuscript.

RESULTS

A total of 897 patients were analysed: 161 underwent diode laser and 736 phenol treatment. After 1:3 propensity score matching, 161 laser and 483 phenol cases were included (Table 1). Median age was 26 (22–32) years, with a strong male predominance (80.4%). Accordingly, in the laser and phenol groups, the median BMI was comparable (25.8 [23–28] kg/m^2 vs. 26.3 [24–29] kg/m^2, $p = 0.1$). Most patients were classified as ASA I. The median number of pits/sinuses (2 [2, 3] vs. 2 [2–4]; $p = 0.08$), smoking status (42% vs. 51%; $p = 0.08$) and prior PSD surgery (21% vs. 19%; $p = 0.64$) were comparable. However, the history of abscess was significantly higher in the laser group (54 patients [34%] vs. 76 patients [16%]; $p = 0.01$).

Median operating time was significantly longer in the laser group compared to the phenol group (16 [11–20] vs. 5 [5–10] minutes; $p < 0.01$) (Table 2). An endoscopic camera was used in 57.8% of laser cases (93 patients), increasing the operating time (17 [15–20] vs. 10 [10–14.5] min, $p < 0.01$).

Same-day discharge was less frequent in the laser group (37 patients [23%] vs. 483 patients [100%]; $p < 0.01$). The remaining 124 patients (77%) in the laser group were discharged on the first postoperative day. Return to daily activities was 2 (1–5) days after laser, while it was same-day after phenol ($p < 0.01$). The complication rate was 6.8% (11 patients) in the laser group, including purulent discharge ($n = 7$), seroma ($n = 3$), and bleeding ($n = 1$), whereas no complications were reported in the phenol group ($p < 0.01$). Median 24-hour pain scores were also higher after laser (2 [1–3] vs. 1 [0–2], $p = 0.01$).

Two patients (1%) in the laser group were readmitted due to pain and managed successfully with nonsteroidal anti-inflammatory drugs, whereas no readmissions occurred in the phenol group, though this difference was not statistically significant ($p = 0.06$). Repeated phenol applications were required in 277 patients (56.3%) during the first month of follow-up, with 51 patients (10.7%) needing more than 5 applications. The median number of applications in the phenol group was 2 (1–3). All patients in the laser group underwent only a single laser application ($p < 0.01$).

Median healing time was shorter with laser (25 [16–30] vs. 42 [21–63] days; $p < 0.01$) (Figure 3). Median follow-up was 45 (26–59) months in the laser and 40 (21–58) months in the phenol group. Recurrence rates were similar (12% [19 patients] vs. 14% [70 patients]; $p = 0.47$). The overall success rate was 85.1% ($n = 137$) in the laser group and 85.5% ($n = 413$) in the phenol group ($p = 0.99$). Patient satisfaction scores were higher with laser (10 [9, 10] vs. 10 [8–10]; $p = 0.01$) (Figure 4).

In a subgroup analysis of recurrent cases (Table 3), abscess history was higher in the laser group ($p = 0.01$), whereas the prior

TABLE 1 Patient demographics and clinical characteristics before and after propensity score matching.

Characteristics	Unmatched comparisons: Laser ablation N = 161	Unmatched comparisons: Phenol injection N = 736	p value	Std. diff.	Matched comparisons: Laser ablation N = 161	Matched comparisons: Phenol injection N = 483	p value	Std. diff.
Age, years[a]	26 (20–31)	26 (23–32)	0.07	−0.16	26 (20–31)	25 (21–31)	0.76	−0.03
Sex, male[a]	127 (79)	628 (85)	0.06	0.16	127 (79)	391 (81)	0.65	−0.05
BMI, kg/m^2	25.8 (23–28)	26.3 (24–29)	0.1		25.8 (23–28)	26.3 (24–29)	0.1	
ASA score								
1	144 (89)	451 (61)	<0.01		144 (89)	304 (63)	<0.01	
2	17 (11)	266 (36)			17 (11)	171 (35)		
3	0 (0)	19 (3)			0 (0)	8 (2)		
Smoking	66 (42)	376 (51)	0.06		66 (42)	245 (51)	0.08	
Pits or sinuses	2 (2–3)	2 (2–4)	0.03		2 (2–3)	2 (2–4)	0.08	
History of abscess	54 (34)	111 (15)	<0.01		54 (34)	76 (16)	<0.01	
Previous PSD procedure[a]	34 (21)	96 (13)	0.01	0.2	34 (21)	92 (19)	0.64	0.05
Follow-up time, months	45 (26–59)	42 (23–58)	0.8	−0.02	45 (26–59)	40 (21–58)	0.61	0.04

Pilonidal sinus disease treatment.

Note: Data are expressed as number (percentage) or median (IQR, interquartile range).

Abbreviations: ASA, American Society of Anaesthesiologists; BMI, body mass index; PSD, pilonidal sinus disease; Std. diff., standardized mean difference.

[a]Covariates included in the model were age, sex, previous PSD procedure, and year of diagnosis.

history of surgery was comparable between groups ($p = 0.8$). Laser showed a longer operating time, a higher complication rate, a longer time to resume daily activities, but a shorter healing time ($p < 0.05$). Postoperative pain scores did not differ ($p = 0.14$).

DISCUSSION AND CONCLUSIONS

This study presents a comparative analysis of two treatment approaches for PSD, diode laser and crystallized phenol, using propensity score-matched analysis. To the best of our knowledge, this is among the largest matched cohorts reported in the literature [15–17]. Our findings demonstrated that the laser technique is associated with a faster complete recovery time and requires only a single application. Conversely, the phenol technique has a lower complication rate but often necessitates multiple applications. Both methods demonstrated low complication rates and were successfully applied in a large cohort with long-term follow-up, supporting their safety and feasibility in routine practice.

Minimally invasive techniques are recommended for the treatment of simple and symptomatic PSD [18]. Laser and phenol have garnered increasing research interest in recent years to determine the optimal treatment modality. However, existing studies have often been limited by small sample sizes, which weaken recommendations in current guidelines [5, 18]. Consensus is lacking for complicated or recurrent presentations, especially in patients with a higher number of pits, abscess history or prior surgeries [2, 5, 19–21]. In this study, it is noteworthy that minimally invasive treatments were applied irrespective of the number of pits, abscess history or previous PSD surgery.

Previous studies have reported that both laser and phenol can be administered consecutively during the healing process if necessary [9, 14, 20, 22, 23]. Girgin et al. [24] demonstrated that a single phenol application achieved a 64% success rate, whereas more than two applications increased the success rate to 95%. Similarly, another study reported that the success rate improved from 44.4% after the first application to 97.4% after the tenth application, with a median of 2 applications (range 1–14) [21]. In our study, all patients in the laser group underwent a single application, whereas the median number of phenol applications was 2 (IQR: 1–3, $p < 0.01$). Notably, in the phenol group, 56.3% of patients required repeated applications, with the number of applications reaching up to 20 in one case. These repeat applications were considered part of the intended phenol treatment protocol rather than treatment failure. However, this can be considered a major drawback of phenol treatment, also highlighted by a recent review by Gil et al. [20]. Despite its feasibility as an outpatient procedure, the increased number of applications led to a higher frequency of hospital visits. Furthermore, as phenol injection was performed under local anaesthesia, debridement of sinus tracts was challenging, potentially contributing to the need for multiple applications.

One advantage of minimally invasive techniques is their flexibility in being performed under general, regional or local anaesthesia, depending on surgeon and patient preferences, influencing hospital

TABLE 2 Early and late clinical outcomes of PSD laser ablation and phenol injection treatment.

Outcomes	Laser ablation N = 161	Phenol injection N = 483	p value
Operating time, min	15 (10–19)	5 (5–10)	<0.01
Postoperative pain in 24 h	2 (1–3)	1 (0–2)	0.01
Length of hospital stay			
Same-day discharge	37 (23)	363 (100)	<0.01
Discharge after 24 h	124 (77)	0 (0)	
Return to daily life, days	2 (1–5)	Same day	<0.01
Complications	11 (6.8)	0 (0)	<0.01
Readmission	2 (1)	0 (0)	0.06
Number of applications	1 (1)	2 (1–3)	<0.01
Complete healing time, days	25 (16–30)	42 (21–63)	<0.01
Recurrence			
Yes	19 (12)	70 (14)	0.47
No	137 (85)	413 (86)	
Unknown	5 (3)	0 (0)	
Overall success rate	137 (85.1)	413 (85.5)	0.99
Satisfaction score—Likert scale	10 (9–10)	10 (8–10)	0.01

Note: Data are expressed as number (percentage) or median (IQR interquartile range).

Abbreviation: PSD, pilonidal sinus disease.

length of stay [3, 16]. ESCP guidelines support local anaesthesia for minimally invasive procedures in PSD by a low level of evidence due to the lack of adequately powered randomized trials [5]. Local anaesthesia facilitates immediate discharge, offering logistical and economic benefits. In our study, patients in the phenol group were not hospitalized, resuming daily activities immediately following the procedure, whereas some laser patients stayed overnight for comfort, not due to procedural or anaesthetic necessity. Therefore, the observed difference in hospital stay should not be interpreted as an advantage of phenol over laser but rather as a reflection of patient preference.

Operating time was significantly longer in the laser group, largely due to the frequent use of endoscopic camera assistance, although both procedures remained shorter than conventional excisional techniques [16, 17]. Pain assessment and complication risk analysis are critical in PSD evaluation. In two studies comparing laser and phenol, it was shown that laser was associated with lower postoperative pain [15, 17]. In our study, postoperative pain was significantly higher in the laser group compared to the phenol group, although pain remained mild in both cohorts. Contrary to the study by Taşkın et al. [17] showing lower complication rates in laser, Emral et al. [15] reported comparable complication rates. In our study, postoperative complication rates were significantly different: 6.8% in the laser group versus none in the phenol group. Notably, complications in the laser group were minor, including seroma formation and purulent discharge, none of which required intervention. A systematic review on non-excisional methods reported a wide range of complication rates (1.6%–9.5%—laser and 0%–16%—phenol) highlighting the challenge of defining complications [2]. Nonetheless, the complication rates observed in our study were consistent with the existing literature. However, the absence of complications in the phenol group does not imply that the technique is entirely risk-free. A low rate of wound complications in the phenol technique has been noted as a key advantage [4] although rare but serious adverse effects, such as chemical burns and tissue necrosis, have also been reported [16]. Therefore, surgical experience and careful management of potential complications remain crucial in optimizing outcomes. Two patients in the laser group required readmission for pain but were managed with NSAIDs. We believe this reflected patient-related factors such as suboptimal adherence to analgesics rather than a side effect of the laser itself.

Another key outcome was complete healing time. Previous studies and guidelines have recommended phenol over excisional methods for its shorter healing time, albeit with a low level of evidence [5, 18]. Similarly, laser is advocated for faster healing [23], with reported median healing times of 18–47 days [3]. A review by Gil et al. [20] found phenol healing times of 7–56 days. Another study reported remarkably short complete healing times, with a mean of 15–20 days in both groups [16]. Compared with the existing literature, our findings were consistent for both groups. The prolonged healing time associated with phenol may be attributed to the lower rate of achieving definitive cure with a single application, as noted in previous studies [21, 22, 24, 25]. Additionally, faster wound healing with laser was attributed to its contraction effect, accelerating tract closure [15]. Success rates for phenol range from 62% to 95%, depending on the number of applications [25]. A large study involving 1026 patients undergoing phenol reported an 84.3% success rate, with a mean of 2.1 applications [26]. While additional applications increase the overall success, they also prolong healing. In contrast, laser studies have demonstrated success rates of 80–95% with a single application [2, 3, 13, 27, 28]. Similarly, in our study, success rates were 85% for the laser and 86% for the phenol group.

Recurrence rates increase with longer follow-up [29]. A meta-analysis [29] showed phenol recurrence increasing from 14.1% at 24 months to 40.4% at 60 months, and laser from 5.1% to 36.6% over the same period. Our recurrence rates were 12% (laser) and 14% (phenol) at a median follow-up of 45 and 40 months, respectively. These findings are consistent with previously reported data while follow-up durations exceeded those of the previous studies. A prospective study on phenolization reported 4 of 7 patients relapsed after 50 months, underscoring the need for extended follow-up [30]. These results further support the long-term efficacy of both techniques in maintaining acceptable recurrence rates with high patient satisfaction.

FIGURE 3 Complete healing time comparison for laser vs. phenol groups.

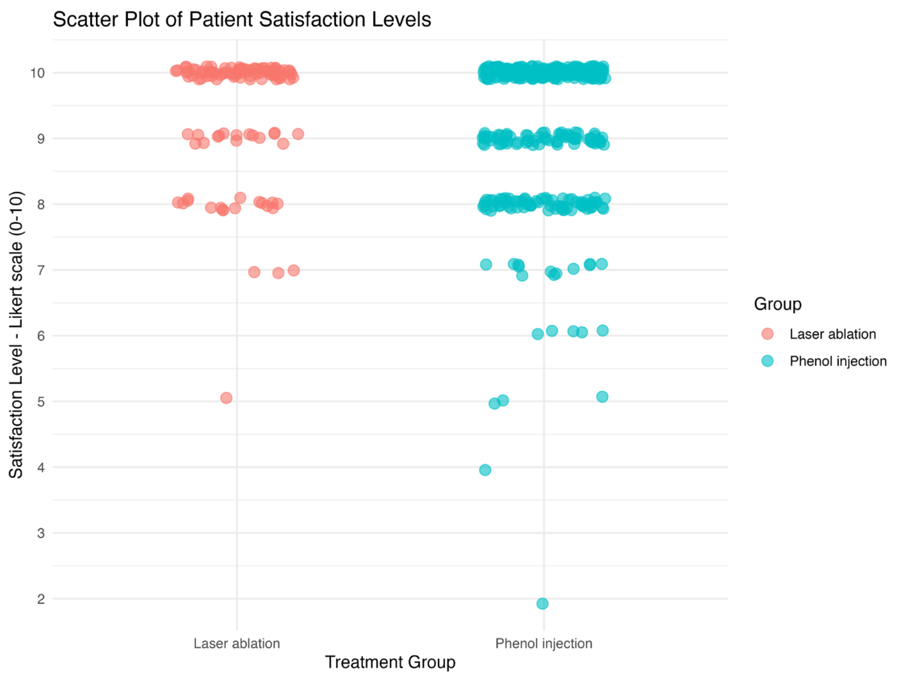

FIGURE 4 Patient satisfaction level comparison for laser vs. phenol groups.

This study has several limitations. The retrospective design carries a risk of bias, and despite propensity score matching, residual confounding from unmeasured variables cannot be excluded. Excluding variables such as abscess history or ASA score from the matching criteria may have introduced selection bias, but parameters were chosen as extensively as possible while maintaining sample size. Procedures were performed in different institutions with varying anaesthesia and discharge policies, so the observed difference in hospital stay likely reflects institutional differences regarding patient preferences rather than a procedural requirement. Although our cohort is among the largest with long-term follow-up, prospective randomized trials with standardized protocols are needed to validate these results. Cost analysis was not feasible because of differing healthcare settings, though the laser group's treatment in a public hospital could likely reduce costs compared with private settings.

Both laser and phenol appear effective for PSD, demonstrating recurrence and complication rates that are consistent with previously published studies, along with high patient satisfaction. Phenol offers the advantage of an ambulatory procedure with faster return to daily activities, whereas laser requires fewer applications and achieves healing faster. Considering patient preferences and

TABLE 3 Comparison in recurrence-matched cases.

	Laser ablation N = 19	Phenol injection N = 70	*p* value
Previous PSD procedure	6 (32)	20 (29)	0.8
Previous abscess	10 (53)	14 (20)	0.01
Number of pits/sinuses	2 (2–3)	2 (2–4)	<0.01
Operating time, min	16 (11–20)	5 (5–10)	<0.01
Postoperative complication	2 (11)	0 (0)	0.04
Postoperative pain in 24 h	1 (0.25–2.75)	1 (1–2)	0.14
Return to daily life, days	1.5 (1–3.5)	Same day	<0.01
Complete healing time, days	22 (19–30)	42 (21–99)	<0.01

Note: Data are expressed as number (percentage) or median (IQR interquartile range).
Abbreviations: IQR, interquartile range; PSD, pilonidal sinus disease.

institutional resources, both minimally invasive techniques are viable options. However, randomized controlled trials with larger cohorts are needed to provide a higher level of evidence. The present data may serve as a rationale for such a trial, establishing equipoise between the techniques.

AUTHOR CONTRIBUTIONS

Abdullah Sami Maden: Data curation; methodology; visualization. **Afag Aghayeva:** Data curation; investigation; methodology. **Bilgi Baca:** Validation; conceptualization; supervision. **Cigdem Benlice:** Conceptualization; investigation; writing – review and editing. **Fahrettin Acar:** Data curation; methodology. **İnci Kurtul:** Investigation; data curation; methodology; visualization. **Metincan Erkaya:** Formal analysis; methodology; data curation; software. **İsmail Ahmet Bilgin:** Conceptualization; methodology; investigation; validation; visualization; writing – review and editing; writing – original draft; supervision; project administration; data curation; resources. **İsmail Hamzaoglu:** Conceptualization; methodology; supervision. **Osman Dogru:** Supervision; conceptualization; validation; resources. **Nur Ramoglu:** Methodology; writing – review and editing; writing – original draft; data curation; validation; investigation; resources; project administration. **Ersin Turan:** Methodology; data curation; investigation; writing – original draft; visualization. **Onur Saylık:** Data curation; writing – original draft; methodology; resources. **Tayfun Karahasanoglu:** Conceptualization; methodology; supervision.

ETHICS STATEMENT

Ethical approval for this study was obtained from Acıbadem Mehmet Ali Aydınlar University (ID: 2025-01/43). All procedures were performed in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

FUNDING INFORMATION

There is no grant support or financial relationship.

CONFLICT OF INTEREST STATEMENT

All the authors declare that they have no financial or personal relationships with any organizations that could inappropriately influence (bias) their work. There are no conflicts of interest related to the research, authorship or publication of this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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