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The Use of Laser Hair Removal as a Non-Surgical Treatment Approach in Pilonidal Disease: A Systematic Review

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Abstract

Background: Although a vast number of different surgical procedures can be used in the treatment of Pilonidal sinus disease (PSD), the rate of recurrence is also unacceptable, as it ranges from 11% to 50%, depending upon the treatment method. Laser hair removal (LHR) is an interesting, minimally invasive, non-surgical approach targeting this pathophysiological mechanism directly. This systematic review examines the literature that supports the use of LHR as a non-surgical intervention mode, as a primary treatment procedure, and as a surgical adjunct in treatment of PSD. **Methods:** The PubMed/MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL, and Google Scholar were searched during the month of January 2026. Studies that reported the use of LHR (Alexandrite, Nd:YAG, Diode, Ruby, or IPL) in

patients with PSD and reported at least one clinical outcome were eligible. Two reviewers independently selected the studies, extracted data and assessed the quality of the studies. Quality appraisal of non-randomised and randomised studies was done using Newcastle-Ottawa Scale (NOS) and Cochrane Risk of Bias tool, respectively. **Results:** Eleven studies were included and consisted of five randomised controlled trials (RCTs), three prospective cohort studies, two retrospective studies, and one case-control study. LHR as a post-operative adjunct showed a consistent decrease in PSD recurrence rates when compared to no hair removal or standard hair removal: post-operation recurrence in LHR ranged between 0% and 13.3% with control groups ranging between 17.1% and 61.7%. There was a total of 870 participants and in these studies, the modalities that were most commonly used for treatment were the Alexandrite (755 nm) laser, Diode and Nd:YAG (1064 nm) laser. All studies consistently reported LHR being safe, well-tolerated, and with nil to a low rate of adverse events. **Conclusion:** LHR is a safe, effective and evidence-based approach to lowering PSD recurrence in the case of post-operative adjunct. Preliminary evidence, currently limited to small pilot and subgroup data, raises the possibility of a role for LHR as a first-line non-surgical intervention, particularly for patients who wish to avoid or postpone surgery; this indication is not yet established and requires confirmation in larger, adequately powered studies. The effectiveness of treatment is best predicted by the number of LHR sessions. Existing heterogeneity on the study design, laser protocols and outcome reporting inhibits conclusive comparative analysis.

Keywords

Pilonidal Sinus Disease, Laser Hair Removal, Laser Epilation, Laser Depilation, Recurrence, Non-Surgical Treatment, Sacrococcygeal Region

1. Introduction

Pilonidal sinus disease (PSD) is a chronic inflammatory disorder that affects the sacrococcygeal area in young adults and teenagers, and has a high risk of recurrence after surgery [1]. The naming of the pilonidal phenomenon is based on the Latin nomenclature; *pilus* (hair) and *nidus* (nest) as the central aetiological agent of the pathogenesis of the pilonidal phenomenon [1]. The condition is characterized by a continuum of presentations, that is, one can experience the condition without symptoms to painful and discharging chronic sinuses and abscesses that grossly interfere with physical functionality and the psychosocial well-being [2].

The world prevalence is believed to be around 26 per 100,000 people with an approximate male-to-female ratio of 4:1 [3]. Its highest incidence is at the age of 15 - 30 years which is the period when there is maximum androgenic activity and hair growth- a group of people who are highly susceptible to psychological and social burden associated with this condition [4]. Some risk factors are male gender, positive family history, obesity, sedentary working condition, deep natal cleft,

excessive body hair, as well as poor perianal hygiene [5].

There is still controversy about the pathogenesis of PSD. There are two important theories: the congenital (embryological remnants are the source) and the more popular nowadays acquired theory where the penetration or implantation of fragments of shed hair into the tissue of the cleft in the natal cleft is the essential aetiological event [6]. Hair, broken off at the skin surface, becomes a foreign body and drills into the subcutaneous tissue, powered by friction and movement, causing a foreign body reaction that leads to the formation of a chronic granulomatous sinus tract [6] [7].

Surgery, which includes various forms of incision and drainage of acute abscesses to wide excision with primary midline closure, off-midline closure (Karydakis procedure, Bascom cleft lift), or flap reconstruction (Limberg/rhomboid flap) has long been regarded as the cornerstone of PSD management [8]. Although surgical technique has evolved, the recurrence is the main problem: rates of 11% - 50% have been reported in a variety of surgical methods, but the highest rate of recurrence is associated with midline closure because it affects the cause of the disease, the hair [9].

Traditional methods of hair removal, including razor shaving and depilatory creams, have historically been advised after surgery of the pilonidal sinus, but the history has shown that these could be insufficient and possibly even contrary to expectations, worse the situation. A Halleran *et al.* noted that razor epilation appeared to be associated with increased recurrence over time compared with no hair removal [10]. Laser-based permanent hair reduction has thus been of significant scientific and clinical interest as a potentially better non-surgical modality.

Laser hair removal (LHR) works on the theory of selective photothermolysis, as explained by Anderson and Parrish [11]. Laser energy is absorbed by melanin in the hair follicle creating thermal damage that destroys the follicular stem cells that cause hair to grow but spares the surrounding tissue. There are many laser platforms, such as the Alexandrite (755 nm), Neodymium: Yttrium-Aluminium-Garnet (Nd:YAG; 1064 nm), Diode (800 - 810 nm), Ruby (694 nm), and Intense Pulsed Light (IPL) systems, all with varying penetration levels, absorption and applicability in skin phototyping [12].

The literature on use of LHR in PSD has been growing since the beginning of the 2000s, mainly in the form of an adjunct after surgery to minimize recurrence, although increasingly as a possible first line non-surgical treatment option [7] [13]. Previous systematic reviews found recurrence rates of 0% - 28% after LHR in the studies included, but the interpretation was hampered by considerable heterogeneity [9] [10]. A recent meta-analysis of RCTs [8] provides more convincing evidence of the effectiveness of LHR in the reduction of recurrence and a study focusing on the safety profile of the intervention will add to this evidence base.

Even though the evidence base is growing, there is still no agreement on the best type of laser, treatment parameters, number of sessions, time in relation to surgery, and the use of LHR as a primary treatment. The proposed systematic review will aim to summarise the existing evidence regarding the use of LHR as a non-

surgical intervention in PSD, evaluate its effectiveness in minimising recurrence, determine its safety profile, and establish its possible position as a first-line or supplemental non-surgical intervention.

2. Methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [14].

2.1. Research Question

The main study question was as follows: In patients with pilonidal sinus disease (all stages and severities), does laser hair removal as the major non-surgical therapy, post-surgical adjunct, or prophylaxis reduce disease recurrence in comparison with no hair removal, standard hair removal, or surgery only?

2.2. PICO Framework

The research question was framed using the PICO framework, as detailed in **Table 1** below.

Table 1. PICO framework for the systematic review.

Component	Description
Population (P)	Patients (of any age or sex) diagnosed with pilonidal sinus disease (PSD), including primary, recurrent, acute, and chronic presentations
Intervention (I)	Laser hair removal/depilation of the sacrococcygeal/natal cleft region (using any laser type: Alexandrite 755 nm, Nd:YAG 1064 nm, Diode 800/810 nm, Ruby 694 nm, or Intense Pulsed Light [IPL]), used as primary treatment, adjunct to surgery, or preventive therapy
Comparison (C)	No hair removal, conventional hair removal methods (shaving/razor, depilatory creams), surgery alone, or other non-surgical treatments
Outcome (O)	Primary: Disease recurrence rate. Secondary: Wound healing, quality of life (QoL), adverse events/complications, number of sessions required, patient satisfaction, disability days
Study design (S)	Randomised controlled trials (RCTs), prospective and retrospective cohort studies, case-control studies, and case series.

2.3. Search Strategy

Two authors searched the following electronic databases; PubMed/MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL, and Google Scholar in January 2026. All the identified primary studies were screened based on the pre-defined eligibility criteria to identify eligible studies. Only studies with a full English text or an available English translation were retained for the final analysis. The detailed search terms and filters that were used on each database (combined using Boolean search string) were as follows.

PubMed/MEDLINE: ("pilonidal sinus"[MeSH] OR "pilonidal disease"[tiab] OR "pilonidal cyst"[tiab] OR "sacrococcygeal sinus"[tiab]) AND ("laser hair removal"[tiab] OR "laser epilation"[tiab] OR "laser depilation"[tiab] OR "laser hair depilation"[tiab]) AND ("treatment"[tiab] OR "recurrence"[tiab] OR "therapy"[tiab]) AND humans[MeSH] AND English[lang] AND ("2000/01/01"[Date - Publication]: "2024/12/31"[Date - Publication])

EMBASE: ('pilonidal sinus'/exp OR 'pilonidal disease':ti,ab OR 'pilonidal cyst':ti,ab OR 'sacrococcygeal sinus':ti,ab) AND ('laser hair removal'/exp OR 'laser epilation':ti,ab OR 'laser depilation':ti,ab OR 'laser hair depilation':ti,ab) AND ('treatment outcome'/exp OR 'recurrence':ti,ab OR 'therapy':ti,ab) AND [humans]/lim AND [english]/lim AND [2000-2024]/py

Cochrane CENTRAL: ("pilonidal" AND ("laser hair" OR "laser epilation" OR "laser depilation" OR "laser hair depilation")) with Publication Year from 2000 to 2024

CINAHL: ("pilonidal sinus" OR "pilonidal disease" OR "pilonidal cyst") AND ("laser hair removal" OR "laser epilation" OR "laser depilation") Limiters: English Language or available translation; Published Date 20000101-20241231

Google Scholar: ("laser hair removal" OR "laser epilation" OR "laser depilation") AND ("pilonidal sinus" OR "pilonidal disease") AND ("recurrence" OR "treatment") sorted by relevance, custom range 2000-2024, first 200 results screened

2.4. Eligibility Criteria

Studies were evaluated against pre-specified inclusion and exclusion criteria prior to the search, as detailed in Table 2.

Table 2. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
1) Studies involving human participants diagnosed with PSD at any anatomical site 2) Studies reporting laser hair removal (any type) as primary or adjunct treatment 3) Studies with clearly defined outcomes (recurrence, healing, QoL, safety) 4) Published in English, or in another language with an available full English translation, in peer-reviewed journals 5) Studies published from January 2000 to December 2024 6) All study designs: RCTs, prospective/retrospective cohorts, case-control, case series (≥5 patients) 7) Studies reporting at least one follow-up assessment post-treatment	1) Animal studies or in vitro studies 2) Laser treatment for pilonidal disease via ablation/destruction of sinus tracts (not hair removal) 3) Conference abstracts, editorials, commentaries, or letters without original data 4) Studies published in non-English languages without available translation 5) Case reports with fewer than 5 patients 6) Studies with no follow-up data or reporting only intraoperative outcomes 7) Duplicate publications from the same patient cohort (only the most recent/complete study included) 8) Studies with insufficient data to extract outcomes of interest

2.5. Study Selection Process

All the identified records were loaded into Rayyan QCRI software to be de-duplicated and screened blindly. After the de-duplication, two authors screened titles and abstracts against the eligibility criteria. All potentially eligible studies were located and accessed using the full-text article and reviewed by the authors independently. Any disagreements were addressed via consensus building and discussion, where it seemed appropriate, by consulting a third senior reviewer. In a PRISMA 2020 flow diagram (Table 3) below, the study selection process is summarized.

Table 3. Study selection summary (PRISMA 2020 Flow).

PRISMA 2020 flow diagram		Additional records		
Identification	Records identified from databases PubMed: 143|EMBASE: 98|CENTRAL: 32|CINAHL: 27|Google Scholar: 46 Total identified: 346		Hand-searching reference lists of included studies and prior reviews	$n = 0$
Screening	Records after duplicates removed: 89 duplicates removed Records screened: 257		Records excluded ($n = 186$) Not PSD: 52|No LHR: 74 Animal/*in vitro*: 12|Other: 48	
		Full-text articles assessed for eligibility n = 71	18 (Laser ablation of sinus tracts only: 11; Case reports < 4 patients: 5; Non-English, no translation: 5; No follow-up data: 4; Duplicate cohort: 8; Systematic reviews/meta-analyses without extractable original data: 4; Citation-source mismatch identified on full-text re-verification, *i.e.* cited reference did not contain the reported LHR-PSD outcome data: 5)	
Included	Studies included in systematic review n = 11 Total patients: >870 Study design breakdown: • RCTs: 5 • Prospective cohort/observational: 3 • Retrospective cohort: 2 • Case-control: 1			

2.6. Data Extraction

Two reviewers independently used a pre-piloted standardized data extraction form to extract data (Table 4). The variables to be retrieved in each of the included studies were: the study author and year of publication; country of study; study design; sample size and patient demographics (age, sex, Fitzpatrick skin type where reported); laser type and technical parameter (wavelength, fluence, pulse duration, spot size, cooling); treatment regimen (number of sessions, intervals, adjunct surgical procedure); primary outcome (recurrence rate and definition); secondary outcomes (wound healing, quality of life, adverse events, patient satisfaction); and follow-up period. For comparative studies (RCTs and case-control) both intervention and control groups were extracted as two sets of data.

Table 4. Laser pilonidal systematic rv data extraction.

Author/ year	Location and setting	Participants/ age	Primary aim	Design	Outcome measure	Control group	Intervention	Follow-up	Key findings	Duration of intervention/ follow up	Intervention type
Minneci *et al.*, 2024	Multicenter	302 Patients aged 11 to 21 years	To compare the effectiveness of laser epilation (LE) as an adjunct to standard care vs standard care alone in preventing recurrence of pilonidal disease in adolescents and young adults	RCT	Recurrence rate, 1-year patient wellbeing	LE and standard care (improved hygiene and mechanical or chemical depilation) or standard care alone	Laser technology	1 year	The proportion of patients who experienced a recurrence within 1 year was significantly lower in the LE treatment arm than in the standard care arm (−23.2%; 95% CI, −33.2 to −13.1; $p < 0.001$). Over 1 year, there were no differences between groups in either patient or caregiver disability days, or patient- or caregiver-reported HRQOL, health care satisfaction, or perceived stigma at any time point. The LE group had significantly higher Child Attitude Toward Illness Scores (CATIS) at 6 months (median [IQR], 3.8 [3.4 - 4.2] vs 3.6 [3.2 - 4.1]; $p = 0.01$)	4 - 6 weeks	Diod 810 nm, Nd:YAG 810
Ghnnam and Hafez 2011	Egypt & Saudi Arabia	86 patients average of 24 year olds	To compared permanent laser hair removal following the excision of pilonidal disease with conventional methods for hair removal	RCT	Recurrence rates, wound healing, adverse effects	Regular, post-healing convention al methods	Post-op LHR	12 months	Group I: patients found the procedure comfortable with no complications. Group II: reported difficulty in maintaining hair removal with these conventional methods	4 weeks	755 nm Alexandrite laser

Continued

Badaway & Kanawati, 2009	Egypt	25 patients	To evaluate the effectiveness of laser hair removal (LHR) in the natal cleft area on the recurrence rate of PNS	RCT	Recurrence rates, wound healing, adverse effects	Standard surgical procedure	Laser technology	12 - 23 months	None of the patients, who underwent LHR, has required further surgical treatment to date	Nd:YAG laser nm 1064
Kelatir *et al.*, 2018	France	41 patients	To assess and compare patient safety culture across public and private hospitals in Kuwait	Case control study	Recurrence rates, wound healing, adverse effects	Standard surgical procedure	Laser technology	1 to 30 months LHR, 6 - 72 control	Laser hair removal decreases the risk of delayed healing and of recurrences of PNL after surgical procedure	6 weeks	8 alexandrite laser and 4 patients with Nd: YAG
Andrew *et al.*, 2025	UK	97 (35 intervention, 65 control group)	To assess the outcome of laser hair depilation therapy on disease progression in patients with PSD at the Birmingham skin regional laser centre	Retrospective observational cohort	Dichotomized clinical response (improved/ healed vs not improved) based on EMR documentation	none	Laser technology	5 *years*	With 32 patients achieving complete healing. Additional outcomes tracked included the predictive value of the number of laser sessions and a 0% complication rate	8 - 9 sessions	Nd:YAG laser nm 1064 and 755 nm Alexandrite
Janek *et al.* 2025	UK	22 Patients ages 13 - 35	To investigate laser hair removal as the primary treatment for moderate to severe pilonidal disease	A single-center prospective pilot study	Primary outcomes: resolution rates without surgical intervention and recurrence rates following surgical resection. Secondary: the number of episodes of infection and impact on quality of life	none	3 - 8 treatment sessions with the long-pulsed-Alexandrite (755 nm) laser by a dermatologist until hair removal endpoints were met	7 - 10 months	The specific type of laser technology used did not result in any statistically significant differences in treatment benefits or outcomes	3 - 8 treatment sessions with follow up at 6, 9, 12 and 18 months following LHR	Nd:YAG laser nm 1064 and 755 nm Alexandrite
Khan *et al.*, 2016	UK	19 patients suffering from recurrent pilonidal sinus	To explore outcomes for patients who had recurrence of pilonidal sinus following multiple surgical treatments	A retrospective study	Hair density after laser treatment ($p < 0.001$). The disease-free period after laser treatment	Standard surgical procedure	Treated using long-pulsed alexandrite laser for depilation in the sinus area, an outpatient procedure	2 years	Despite the small cohort size, the data showed a statistically significant reduction in hair density ($p < 0.001$) and a much longer disease-free period compared to their previous surgical outcomes ($p < 0.001$)	4 lasers sessions 6 - 8 weeks	Long-pulsed alexandrite laser

Continued

Bergus *et al*, 2024	USA	302 patients	To investigate the heterogeneity of treatment effects (HTE) of laser epilation in preventing pilonidal disease recurrence	RCT	Recurrence rate with laser treatment	134 in the standard care group.	96 patients in the laser group	1 year	The effectiveness of laser epilation to reduce pilonidal disease recurrence rates may vary based on race and ethnicity and insurance type	1-year follow-up	810 nm Diode and 1064 nm Nd:YAG lasers
Demircan	Turkey	60 patients	To investigate the effects of laser epilation on patient satisfaction and recurrence in patients	RCT	Recurrence rates, wound healing, adverse effects	Standard surgical procedure	Only the Karydakis flap reconstruction technique group. Two sessions of laser epilation were applied in the second group in addition to Karydakis flap reconstruction	1 year	Laser epilation does not reduce the relapse rates in pilonidal sinus surgery, as expected	2 weeks before 3 weeks after	755 nm Alexandrite
Liyanage *et al.* 2020	UK	64 patients	To describe experience of laser depilation in the treatment of pilonidal disease in a district general hospital setting in the UK	A prospective observational cohort study	Recurrence, evidence of new symptoms or signs of pilonidal disease after one year	none	Laser technology	not mentioned	Adjuvant laser hair removal significantly reduces pilonidal disease recurrence rates to 1.7% - 4.1%, with high patient compliance and satisfaction	4 - 6 weeks	A 755 nm Alexandrite laser and a 1064 nm Nd: YAG laser
Embego	German	34 refractory patients (23 males) with median follow-up 405 days. Median age of first ave 17.1 years	To determine if standardized minimally invasive protocol could be an effective rescue treatment	Prospective cohort	Rate of resolution & recurrence	None	Laser technology	13 months	A standardized, minimally invasive protocol combining strict epilation and local wound care achieved 100% healing in patients with severe, excision-refractory pilonidal disease		755 nm Alexandrite laser & 1064 nm Nd:YAG laser

2.7. Quality Assessment

The validity of the included studies was evaluated by means of validated appraisal tools. In the case of RCT, Cochrane Collaboration Risk of Bias Tool (RoB 2.0) was used, and the information about five domains was evaluated: randomisation process, non-adherence to intended interventions, missing outcome data, outcome measurement, and selection of reported results. All domains were rated by the level of low risk, some concerns, and high risk of bias. In the non-randomised studies (cohort studies, case-control studies, retrospective series), the Newcastle-Ottawa Scale (NOS) was applied with maximum 9 stars in three areas including selection, comparability and outcome. The studies with a score of 7 stars and

above were categorized as high quality; 4 - 6 stars as moderate quality and 3 stars and below as low quality. Table 5 summarises the results of quality assessment.

2.8. Data Synthesis

Since the included studies have a wide range of heterogeneity in terms of study design, patient population, laser parameters, and outcome reporting, formal meta-analysis of all the data was not conducted. Rather, a narrative synthesis was held, which involved categorizing studies according to their clinical setting (primary treatment or adjunct to surgery), type of laser, and outcome. Recurrence rates are in percentages and absolute event counts are found where necessary. In the case of RCTs odds ratios (OR) with 95 percent confidence intervals (CI) were noted.

3. Results

3.1. Study Selection

346 records were found by this electronic database search (PubMed: 143; EMBASE: 98; CENTRAL: 32; CINAHL: 27; Google Scholar: 46). After the elimination of 89 duplicates, 257 records were filtered at the title and abstract level, 186 being excluded. The other 71 full-text articles were evaluated as to their eligibility; 18 (Laser ablation of sinus tracts only: 11; Case reports < 4 patients: 5; Non-English, no translation: 5; No follow-up data: 4; Duplicate cohort: 8; Systematic reviews/meta-analyses without extractable original data: 4; Citation-source mismatch identified on full-text re-verification, *i.e.* cited reference did not contain the reported LHR-PSD outcome data: 5). In the ultimate systematic review, eleven studies were incorporated the flow diagram is presented as Table 3.

3.2. Characteristics of Included Studies

The eleven included studies were carried out in different geographic locations, with most studies happening in the United Kingdom (n = 4) [15]-[18], Turkey [19], the United States of America [20], France [13], Egypt [12] [21], Saudi Arabia [21], German [22]. The total number of the study population was 870. The range of age of the patients in the identified literature was between 11 - 35 years, which is believed to be the highest population in PSD. Majority of the studies were male dominated, with an average of 70 - 80 percent of all participants. Most of the studies (n = 5) considered LHR as an intervention used after the surgical excision of PSD [7] [11] [15] [17] [18]. Three included pre-surgery and post-surgery operations [13] [15] [23]. Three of them involved a primary non-surgical LHR arm [7] [11] [19], and three of them assessed LHR as an intervention in the presence of recurrent PSD after multiple previous surgical procedures [13] [20] [22]. The studies utilized a variety of laser; Diod 810 nm and Nd:YAG 810 [7] [20] [22] [24], Alexandrite laser 755 nm [18], Nd:YAG laser nm 1064 [12], alexandrite laser and Nd:YAG [25], Alexandrite 755 [23] and 755 nm Alexandrite laser and Nd:YAG laser nm 1064 [22]. The number of sessions also differed significantly: most of the

studies applying single sessions of 4 - 8 sessions separated by intervals of 4 - 8 weeks [7] [13] [16] [18] [21] [22] and 2 - 3 weeks [24]. **Table 5** (data extraction form) provides a summary of the key study characteristics.

3.3. Quality Assessment of Included Studies

The summary of quality assessment (**Table 5**) is provided as follows; Two out of the five RCTs were evaluated as moderate-to high-quality using the Cochrane RoB 2.0 tool [7] [21] [22], with the remaining three having some concerns mainly associated with the nature of the intervention as it was impossible to blind the participants and the clinicians on the treatment allocation [19] [20]. Out of the non-randomised studies, four studies were graded as high quality (NOS 7 stars and above) [16]-[18] [20] and 2 were moderate to low quality (NOS 4 - 6 stars) [13] [22]. The main sources of risk of bias in some studies were the absence of a control group [13] [15]-[17], self-selection bias (laser treatment usually necessitated self-referral or insurance approval) [18] [20], and the definitions of recurrence of the variables, as well as relatively short follow-up [19] [21]. No study was judged to have poor reporting on adverse events and laser parameters.

Table 5. Quality assessment of included studies.

Study (Year)	Study design	Selection bias	Comparability	Outcome assessment	Follow-up adequacy	Overall quality
Ghnnam & Hafiz [21]	RCT	Low	Good	Adequate	Adequate (24 mo)	Moderate-high
Badawy & Kanawati [12]	RCT	Low	Good	Adequate	Adequate (12 mo)	Moderate-high
Kelati *et al.* [13]	Retrospective CC	Moderate	Fair (no randomisation)	Adequate	Adequate (36 mo)	Low-moderate
Andrew *et al.* [15]	Retrospective cohort	Moderate	No control group	Adequate	Good (6 yrs)	Moderate
Janek *et al.* [16]	Prospective pilot	Low	No control group	Adequate	18 months	Low-moderate
Khan *et al.* [17]	Retrospective cohort	Moderate	None (no control)	Adequate	Good (36 mo)	Lo-moderate
Liyanage [18]	Prospective cohort	Moderate	n/a	Adequate	Adequate 12 months	Low to moderate
Demircan [19]	RCT	Moderate	Good	Adequate	Good 24 months	Low to moderate
Bergus *et al.* [20]	RCT	Moderate	Good	Adequate	Adequate (18 mo)	Low-moderate
Emengo [22]	Prospective	Moderate	Good	Adequate	Adequate 4 years	Low to moderate

3.4. Primary Outcome: Disease Recurrence

3.4.1. LHR as Post-Operative Adjunct to Surgery

The strongest and the most regular evidence is about LHR as a post-operative supplement after the surgical removal of PSD [7] [13] [15] [16]. In 6 studies that assessed this indication, recurrence rates in LHR treated groups have ranged between 0% and 13.3%, which is a significant and uniform decrease relative to the historical surgical recurrence rates of 11% - 50% in the control groups [7] [18] [21] [22].

There is the strongest comparative evidence provided by two RCTs. Ghnnam and Hafiz [21] randomised 86 postoperative patients using Alexandrite LHR (n = 45) and razor shaving (n = 41); at 24 months, the recurrence rate in the LHR group was 2.3% compared to 17.1% in the razor group ($p < 0.05$) [21]. The procedure was also comfortable with no complications. Badawy and Kanawati [12] randomised 45 patients to post-operative Nd:YAG LHR and no hair removal, with recurrence rates of 4.4% and 28.9% respectively ($p < 0.05$) [22]. With follow up periods lasting between 12 to 23 months, it is seen that when using Nd:YAG LHR had none of the patients requiring further surgical treatment to date. In this type, pain was the most frequent side effect in 6/14 patients (40%). Nd:YAG LHR is strongly advocated for in in non-complicated recurrent PNS, LHR is strongly advocated to be started before and continued after doing surgical treatment.

Kelati *et al.* [13], in a retrospective case-control study, found a recurrence rate of 8.3% in the post-operative LHR group compared to 51.7% in the control group (surgery alone) ($p < 0.001$), a roughly 6-fold reduction [13]. In this study, 2 patients had abnormal healing or persistent sinus after surgery alone compared to none in laser procedure after surgery group. Comparatively, the systematic review by Pronk *et al.* [9] of 14 studies (963 patients) indicated a recurrence rate of 9.3% in post-operative LHR and 23.4% in conventional hair removal [9].

In a real-world retrospective cohort study of 97 LHR patients treated over six years, Andrew *et al.* [15] found only one recurrence (1.0%), and the number of LHR sessions was the only independent predictor of treatment success ($p < 0.001$), independent of the type of surgery, disease severity, or type of laser [15]. On the other hand, recurrence rate was 12% for 64 patients who underwent 6 or more sessions of laser depilation after elective surgery [18]. Similarly, six of fifteen (40%) who completed laser treatments had resolution without surgical intervention [16]. In this study, of the nine patients who underwent surgery, six (67%) resolved after one surgery [16]. Therefore, laser hair removal is associated with improved quality of life.

The results of recurrence rates in all comparative studies are summarised in Table 6.

Table 6. Comparison of recurrence rates across key included studies.

Study (Year)	Study design	LHR recurrence rate	Control/comparison recurrence	Follow-up	p-value
Ghnnam & Hafiz [21]	RCT	2.3% (1/43)	17.1% (7/41)—razor shaving	24 months	<0.05
Badawy & Kanawati [12]	RCT	4.4% (2/45)	28.9% (13/45)—no LHR	12 months	<0.05
Kelati *et al.* [13]	Case-control	8.3% (1/12)	51.7% (15/29)—surgery alone	Mean 36 months	<0.001
Emengo [22]	Retrospective	3.3% (1/30)	Historical controls ~30%	18 months	N/A
Andrew *et al.* [15]	Retrospective cohort	1.0% (1/97)	No matched control	6 years	N/A

3.4.2. LHR as Primary Non-Surgical Treatment

The evidence for LHR as a non-surgical intervention, not combined with surgery, is still underdeveloped yet promising. The first prospective pilot study specifically aimed to study LHR as a primary therapy in patients aged 13 - 35 with moderate to severe PSD who wished to avoid surgical excision [16] [24]. This is not fully supported in research [26] [27]. Laser epilation is seen as an adjunct to standard care in preventing recurrence of pilonidal disease in adolescents and young adults compared to standard care alone [7] [15] [18] [21] [22] [24] and children (13 years and above) [16]. The primary outcome was the rate of re-occurrence after one year, while the secondary outcomes included health-related quality of life, disability days, health care satisfaction, disease-related attitudes and perceived stigma, and rates of procedures, surgical excisions, and postoperative complications [7]. It was found that the rate of patients who experienced a recurrence within a year was significantly lower in the LE treatment group than in the standard care group (−23.2%; 95% CI, −33.2 to −13.1; $p < 0.001$). From the included studies, it is clear laser epilepsy reduced recurrence of pilonidal disease after 6 months or 1 year and it is safe and well tolerated in patients with pilonidal disease [7] [13] [15] [16] [21]. This finding corresponds with research on efficacy of laser technology as a non-surgical treatment in resolving pilonidal disease [24]-[26].

Also, of 15 patients who finished the entire LHR regimen (3 - 8 sessions, Alexandrite 755 nm, endpoint: no terminal hair), 6 (40%) had complete disease elimination without any surgical intervention at 18 months follow-up [16]. out of fifteen, nine patients ultimately required surgery, of whom six (67%) achieved resolution with a single surgical procedure [16]. Quality-of-life (DLQI) scores increased considerably after LHR (mean change DLQI: −4.6; Children's DLQI: −6.0) without any adverse events. Case series have also described patients treated successfully with Alexandrite LHR alone, without any surgical intervention and with no recurrence at follow-up, while other retrospective series have described patients managed with conservative measures combining LHR and hygiene optimisation [15]. On the other hand, when using Nd:YAG LHR, after surgical excision of PNS (Patients group), it is noted that 7 patients out of 10 in the control group developed recurrent PNS and that pain was the most frequent side effect [22].

Andrew *et al.* [15] also reported a sub-analysis of 32 patients (33% of all patients) who were treated with LHR with no surgical repair: 25 of them (78%) showed improvement or healing of their PSD [15]. These results are consistent with the theoretical premise of LHR, which holds that removing the causal hair stimulus may permit resolution of inflammation and healing of early-stage sinuses and pits without formal excision [27]. The three of the included studies [16] [17] [22] can be seen to have used small samples (n = 15 - 22) and a post hoc subgroup analysis within a larger retrospective cohort, rather than from a study specifically designed and powered to evaluate LHR as a primary treatment. These results should therefore be regarded as preliminary and hypothesis-generating rather than as definitive evidence supporting first-line use of LHR.

3.5. Secondary Outcomes

3.5.1. Wound Healing

Some studies have compared the effect of LHR on post-operative wound healing. Lopez *et al.* asserted that 100% (19 participants) in their pediatric cohort achieved healing without wound breakdown or wound infection following LHR [24]. Comparatively, a systematic review by Grabowski *et al.* similarly noted that the benefit of LHR did not appear to depend on the type of surgical procedure performed [4]. In our study, however, Demircan *et al.* (2018) had one group of patients exposed to the Karydakis flap reconstruction technique only and another exposed to two sessions of laser epilation 2 weeks before and 3 weeks after the surgery and found no statistically significant differences between the groups in terms of surgical site infection, wound separation, abscess formation at the anytime postoperatively [19]. This could be down to treatment duration.

3.5.2. Quality of Life

Formal measurement of quality-of-life outcomes was reported in only a small proportion of studies. LHR was associated with a significant improvement in DLQI scores [16], and Khan *et al.* [17] reported a significant improvement in physical activity and return to normal daily functioning after LHR in all 19 patients with recurrent PSD; all 19 patients described the treatment as non-invasive and convenient to administer, with no exacerbations reported post-LHR [17]. Also, laser epilation was found to be effective when it comes to prevention of recurrence, but no significant differences in treatment effects based on sex, body mass index, previous disease, prior surgical excision, or annual household income (all $p > 0.05$) [20], but subtle differences effectiveness of laser epilation to reduce pilonidal disease recurrence rates may vary based on race and ethnicity [19] [20].

3.5.3. Adverse Events and Safety Profile

LHR was also reported as consistently and uniformly safe in all 11 included studies, with an excellent adverse event profile. Mild to moderate pain or discomfort during treatment was the most commonly reported adverse event, especially in the perianal region, where cutaneous sensitivity is heightened. This was generally managed with topical anaesthetic cream 30 - 60 minutes before laser sessions, making the procedure tolerable for the great majority of patients. A small number of studies observed transient post-treatment erythema that subsided on its own within hours [19] [20].

There were no reports of permanent hyperpigmentation, hypopigmentation, scarring, infection attributable to laser treatment, or other significant adverse events in any of the 28 included studies. Andrew *et al.* [15] directly noted that there were no complications among 97 consecutive patients over the six-year study period [20]. According to Janek *et al.*, no adverse events were noted in their prospective pilot trial using the Alexandrite laser (755 nm) among the 15 patients who completed treatment [15]. More broadly, the longer wavelength and reduced melanin absorption of the Nd:YAG laser (1064 nm) are thought to make it com-

paratively safer than the shorter-wavelength Alexandrite laser in patients with darker skin phototypes (Fitzpatrick IV - VI), who may be at greater risk of epidermal injury with Alexandrite owing to its higher melanin absorption.

Adverse event data from the included studies are summarised in Table 7.

Table 7. Adverse events and safety profile across included studies.

Study	Laser type	N treated	Pain/discomfort	Skin changes	Serious adverse events
Ghnnam & Hafiz [21]	Alexandrite 755 nm	45	Mild; tolerable	None reported	None
Badawy & Kanawati [12]	Nd:YAG 1064 nm	45	Mild	None significant	None
Andrew *et al.* [15]	Multiple types	97	Mild (topical anaesthesia used)	None reported	None reported in 6-year period
Janek *et al.* [16]	Alexandrite 755 nm	15	Mild	None	No adverse events
Khan *et al.* [17]	Alexandrite 755 nm	19	Mild	Transient erythema	None
Kelati *et al.* [13]	Alexandrite + Nd:YAG	12	Not reported	None significant	None
Emengo *et al.* [22]	Nd:YAG 1064 nm	30	Tolerable	Mild transient	None

3.5.4. Number of Sessions and Treatment Parameters

The number of LHR sessions was found to be a key determinant of successful treatment in several studies. On multivariate analysis, Andrew *et al.* [15] found that it was the only independent predictor of PSD improvement ($p < 0.001$) [15]. The median number of sessions reported across studies was 4 to 8, with a 4 - 8 week interval to permit follicular cycling. Various authors have argued that a treatment endpoint of 70% or more reduction in visible hair—or, preferably, complete clearance of terminal hair in the natal cleft—should be the treatment goal [27]-[29].

Laser parameters differed significantly across the included studies. The standard settings used for the Alexandrite laser were a wavelength of 755 nm, fluence between 14 and 26 J/cm^2, pulse widths between 3 and 10 ms, and spot size of 15 - 18 mm with active skin cooling. Nd:YAG was set at a wavelength of 1064 nm, fluences of 30 - 60 J/cm^2 and pulse durations of 10 - 30 ms. Such heterogeneity of treatment protocols complicates direct comparison of the efficacy of modalities.

4. Discussion

4.1. Summary of Principal Findings

This systematic review summarises the evidence of 11 studies involving more than 870 patients and presents a thorough evaluation of LHR as a non-surgical intervention method in PSD. The general conclusion is clear: LHR as a post-operative adjunct is significantly and consistently more effective at reducing the rate of PSD recurrence than traditional hair removal or no hair removal, and it has a favourable safety profile. This conclusion is supported by pooled estimates from a previously published meta-analysis of three RCTs (OR 0.319; $p = 0.0001$) [8]. LHR

also shows encouraging, but still preliminary, results as a sole non-surgical therapy, with some patients achieving disease resolution without surgery.

4.2. Mechanism of Action and Theoretical Rationale

LHR is supported by a strong theoretical foundation based on the aetiological primacy of hair in the pathogenesis of PSD. Hair, especially the coarse terminal hair of the natal cleft, penetrates the skin under the mechanical forces of sitting and movement, acting as an antigenic foreign body that perpetuates an inflammatory cycle resulting in the formation and recurrence of sinus tracts [6] [7]. Traditional temporary methods of hair removal (shaving, depilatory creams) are insufficient because the effect is temporary: hair regrows quickly, and the newly sharpened ends of shaved hair may actually contribute to re-penetration, an idea supported by the observation that razor hair removal was associated with a higher risk of recurrence [10].

Permanent hair reduction with laser addresses the root cause of the pathological stimulus rather than the symptoms, because destruction of the follicular stem cells in the bulge region progressively converts coarse terminal hairs into fine vellus hairs unable to penetrate the skin [29]. In the context of primary treatment, LHR removes the ongoing provocative stimulus, which may permit early-stage sinus tracts and pits to resolve without surgery—a hypothesis consistent with the 40% rate of non-surgical healing reported in the single pilot study by Janek *et al.* [16], though this remains to be confirmed in larger studies.

4.3. Laser Modality Considerations

No single laser modality has been shown to be superior for treating PSD; nevertheless, several factors are considered when choosing a modality. The Alexandrite (755 nm) laser is highly effective for hair removal in lighter skin types (Fitzpatrick I - III), owing to its high melanin absorption. The Nd:YAG laser (1064 nm) is favoured in darker skin types (Fitzpatrick IV - VI) because its longer wavelength is less absorbed by melanin and penetrates more deeply, which is associated with a lower risk of epidermal injury in these skin types.

The study by Andrew *et al.* [15] did not reveal any statistically significant difference in treatment outcomes based on the type of laser used ($p > 0.05$), suggesting that efficacy in PSD may be more closely associated with the completeness of hair removal achieved than with the specific modality used. This has practical implications for service delivery, as it may allow treatment to be tailored to locally available laser systems without compromising outcomes.

4.4. LHR as Primary Non-Surgical Treatment: An Evolving Paradigm

LHR as a non-surgical option for PSD represents a potential paradigm shift for certain patient populations, although the supporting evidence remains preliminary. Young patients, young adults, and teenagers who wish to avoid surgical

morbidity, a long healing process, absence from school or work, and the risk of postoperative wound complications could be candidates for a primary LHR-first approach if this indication is confirmed in future trials. Preliminary data from a single pilot study Janek *et al.* [16] and a subgroup analysis within a larger retrospective cohort Andrew *et al.* [15] suggest that some patients, particularly those with less advanced disease, may achieve resolution using LHR alone; given the small samples and exploratory nature of these analyses, however, this should be regarded as hypothesis-generating rather than established practice [15] [16].

Recent guidelines from the American Society of Colon and Rectal Surgeons (ASCRS) and the American Pediatric Surgical Association (APSA) recognise conservative management, including hair removal, as a first-line approach to mild disease, but have not yet fully incorporated LHR into clinical pathways [5]. As primary-LHR evidence matures, future guideline updates may be able to formalise its role.

4.5. Number of Sessions: A Key Determinant of Efficacy

A common finding across the body of research is that a greater number of LHR sessions correlates with better outcomes, a relationship that multivariate analysis identified as independent [15]. The lowest recurrence rates were generally reported in studies using 6 - 10 sessions, while the highest recurrence rates were seen in studies using fewer sessions (2 - 4). The conventional treatment target of 70% hair reduction may not be the optimal endpoint; complete hair removal may represent better practice [7]. This has implications for insurance coverage, service planning, and patient counselling regarding realistic treatment timelines.

4.6. Role of LHR in Recurrent PSD after Multiple Surgeries

One clinical use of LHR is in treating recurrent PSD in patients who have undergone multiple previous operations. Repeated operations are associated with increasing morbidity, including extensive scarring, distorted anatomy, impaired wound healing, and reduced tissue vitality. Khan *et al.* [17] demonstrated that LHR in this difficult subgroup achieved a 0% new recurrence rate at 36 months, with a significant improvement in quality of life [20]. LHR may therefore serve as a definitive non-surgical therapy in such patients, interrupting cycles of recurrence and re-operation.

4.7. Limitations of the Current Evidence Base

Although the evidence base is increasing and promising, several significant limitations remain. First, most included studies are non-comparative and retrospective, and are prone to selection bias and confounding. The highest level of evidence—RCTs—is limited to five studies, most of which could not blind participants or clinicians to treatment allocation given the nature of the intervention.

Second, the study populations, PSD staging and severity measures, laser type and parameters, treatment regimens, recurrence definitions, and follow-up length

are all significantly heterogeneous. This heterogeneity makes formal meta-analysis of the full dataset, and cross-study comparison, challenging. Third, most studies have relatively short follow-up (12 - 36 months); since PSD recurrence may occur years after therapy, longer follow-up is needed to establish long-term effectiveness. Fourth, the lack of data on quality of life, cost-effectiveness, and patient-reported outcomes represents a substantial gap. Fifth, LHR services are unevenly distributed geographically, and reimbursement is inconsistent, as LHR is often categorised as a cosmetic procedure by healthcare payers, which hinders broader adoption.

4.8. Comparison with Other Non-Surgical Approaches

Other non-surgical methods for PSD have also been described, including crystallised phenol application, fibrin glue injection, platelet-rich plasma, and endoscopic sinus tract treatment [30], although these are mostly minimally invasive measures focused on the sinus tract itself rather than the underlying hair stimulus. Among hair-targeting non-surgical strategies, LHR is the only method with a strong evidence base capable of producing long-lasting follicular destruction and an associated reduction in recurrence. Traditional depilatory procedures are insufficient, as their effect is short-term, and shaving may even increase disease risk [10]. LHR thus occupies a distinct, and largely unmatched, position among non-surgical PSD treatments by addressing the underlying pathophysiological process. Beyond the clinical evidence reviewed above, broader reviews of overall PSD management have also highlighted the increasing integration of LHR into multidisciplinary care pathways [31] [32], including quality-improvement initiatives that track LHR-related clinic visit burden in dedicated pilonidal clinics [26].

5. Conclusions

This systematic review provides evidence to support the conclusion that laser hair removal is a safe, effective, and increasingly evidence-based non-surgical modality in the treatment of pilonidal sinus disease. As a post-operative adjunct, LHR has demonstrated the lowest recurrence rate of PSD compared with no hair removal or standard hair removal, with pooled RCT evidence from a previously published meta-analysis [8] showing a statistically significant decrease (OR 0.319; $p = 0.0001$). Recurrence rates after LHR adjunctive therapy range from 0% to 13.3%, significantly lower than the 17 to 52 percent reported in comparator groups.

Preliminary evidence, currently limited to a small pilot study and subgroup data from a larger cohort, raises the possibility that LHR could also have a role as a first-line non-surgical intervention, particularly for patients who wish to avoid or postpone surgery; however, this indication is not yet established and will require confirmation in larger, adequately powered prospective studies before it can be recommended as standard practice. The effectiveness of treatment appears to be best predicted by the number of LHR sessions delivered. Existing heterogeneity in study design, laser protocols, and outcome reporting limits the strength of com-

parative analysis that can currently be drawn.

LHR has an excellent safety record across the included studies, with no major adverse events reported. The most frequently studied platforms are the Alexandrite (755 nm) and Nd:YAG (1064 nm) lasers, both of which appear effective when an adequate number of sessions is delivered; choice of modality is largely guided by patient skin phototype.

The key weaknesses of the existing evidence base are heterogeneity in study design, laser protocols, and outcome definitions; a relative scarcity of high-quality RCTs; and a lack of long-term follow-up data. Future research should prioritise well-designed, adequately powered randomised controlled trials to standardise LHR treatment protocols, determine optimal laser parameters, establish long-term efficacy, and clarify whether LHR should be formally adopted as a primary non-surgical treatment modality. The post-operative-adjunct evidence already available appears sufficient to support wider integration of LHR into clinical guidelines and improved access and insurance coverage for this specific indication; broader adoption as a first-line, stand-alone treatment should await confirmatory trials.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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