IN-DEPTH REVIEW

Light and Laser-based Treatments for Hidradenitis Suppurativa: A Systematic Review

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ABSTRACT

Background*:* Hidradenitis suppurativa (HS) is characterized by painful, recurrent lesions occurring mainly in intertriginous areas. The pain, odor, and disfigurement caused by HS significantly impacts quality of life and is challenging to treat. A comprehensive systematic review evaluating the use of light and laser-based treatments for HS is lacking.
Methods*:* We performed a systematic review by searching Cochrane, MEDLINE and Embase. Title, abstract and full text screening, and data abstraction were done in duplicate.
Results: Forty studies met the inclusion criteria, representing a total of 821 patients. Included studies were comprised of 5 randomized within-patient controlled trials, 1 randomized controlled trial, and 34 case series. Overall, treatments with the most reported cases were laser surgery, photodynamic therapy (PDT), and laser field treatments which showed a response in 80% (n=344/431), 73% (n=122/167) and 71% (n=84/101) of treated patients respectively. The pooled response rate for psoralen plus ultraviolet A was 69% (n=9/13).
Conclusion: Our results suggest that laser surgery using carbon dioxide (CO_2) laser or a combination of CO_2 and Nd:YAG lasers has a moderate response rate for HS with the most reported cases. Laser for field treatment and PDT also had moderate response rates with a large number of reported cases. However, extrapolation of these results may be limited due to the majority of the studies being case series, lack of standardized outcomes being assessed, and insufficient long term follow up results.

INTRODUCTION

Hidradenitis suppurativa (HS) is characterized by painful, recurrent papules and nodules occurring mainly in intertriginous areas. The pain, odor, and disfigurement caused by HS significantly impacts patients' quality of life and is associated with increased rates of anxiety and depression.[1-3] Moreover, the symptoms of HS can be physically limiting and interfere with employment and personal functioning.[4, 5] Early diagnosis and management of HS reduces the risk of disease progression.[6] Treatment for HS are often multimodal and include medical, surgical, and laser and light-based therapies. Although treatment with tumor necrosis factor inhibitors, interleukin-1 inhibitors, antibiotics and others have been reported, these

treatments may be associated with significant cost, adverse effects, declining efficacy, and possible drug-drug interactions. In practice, patients may express the preference to avoid systemic treatments if possible. Light and laser-based management is known to be a safe and effective treatment option for many dermatological conditions. Furthermore, light and laser-based treatment provides the advantage of avoiding the adverse effects and drug interactions associated with systemic therapies. Light and laser-based treatments commonly employed for HS include psoralen plus ultraviolet A (PUVA), photodynamic therapy (PDT), neodymium-doped yttrium aluminum garnet (Nd:YAG) laser, carbon dioxide (CO_2) laser, and others[7-10]. These treatments are thought to reduce HS lesions by debulking tissue and by reducing the amount of hair follicles, sebaceous glands, and bacterial load.[11] Although laser and light-based treatments for HS have been reported, little is known about their comparative effectiveness. The aim of this systematic review is to summarize outcomes for light and laser-based treatments used for HS, enabling physicians to better predict clinical response.

METHODS

A systematic review of the literature was conducted adhering to PRISMA reporting guidelines.[12] The study protocol was registered in the PROSPERO database (CRD42020223612).

Study eligibility criteria

Eligibility criteria for this review were:

- Population: individuals of any age and sex with HS
- Intervention (exposure): Nd:YAG laser, PDT, CO_2 laser, intense pulse light (IPL), PUVA
- Comparator: patients with HS not exposed to intervention
- Outcomes: pain, lesion count, hidradenitis severity score (HSS), visual analogue scale (VAS), dermatology life quality index (DLQI), recurrence, healing time, physician global assessment (PGA), sartorius score, lesion area and severity index (LASI), patient satisfaction, clinical response
- Study design: cohort, cross-sectional, and case-series

Literature search and screening

MEDLINE, Embase, the Cochrane Database of Systematic Reviews, and PubMed were searched on June 12, 2020 using variations of the keywords “hidradenitis suppurativa” and “light” (Tables S1-S4). No date or language restrictions were applied. Title, abstract, and full-text screening were conducted by two independent reviewers (I.M., S.M.) using Covidence online systematic review software (www.covidence.org). Any conflicts between reviewers were resolved by discussion until a consensus was reached.

Data extraction

Data extraction was completed by three independent reviewers (I.M., S.M., S.K.) on a standardized extraction form.

Level of evidence assessment

Level of evidence was assessed using a modified hierarchy proposed by Guyatt and Sackett, where: (1) prospective controlled trial; (2) retrospective study or large case series; (3) small case series.[13]

Data synthesis

After data collection, we determined that quantitative evidence synthesis was not feasible due to differences between the studies included in our review. Specifically, differences in study design, HS severity, heterogeneity in treatment modalities, patient populations, and outcome measurement. Instead, our results are presented in narrative form for each outcome

RESULTS

Study selection

Our literature search yielded 460 articles, 405 of which were excluded based on title and abstract review (**Figure 1**). Of the 55 studies retrieved for full text screening, 15 were excluded. A total of 40 studies were ultimately included in the review, 6 of which were conference abstracts.

The included studies were published between 1987 and 2020 and included 5 randomized within-patient controlled trials, 1 randomized controlled trial, and 34 case series (**Table 1**). The majority of studies were conducted in Spain (n=7), North America (n=6), United Kingdom (n=5), and Italy (n=4) (**Table 1**).

Patient characteristics (age/sex)

In total, our pooled analysis includes 821 patients, 87% (n=623/716) females, with mean age of 33 years, ranging from 15 to 73 years of age.

Targeted phototherapy

A total of 22 studies[14-35] included in our review reported on targeted phototherapy using lasers and energy-based devices in patients with HS, representing a sample size of 724 patients with a mean age of 37.2 years (range: 14-73), and 76.3% (n=497/651[†]) were female. Overall, targeted phototherapy improved lesions in 77.6% (n=413/532) of HS patients. Adverse effects were reported in 22.9% (n=122/532) of treated patients (**Table 2**).

CO_2

CO_2 laser was employed in 10 studies (n=396), with 78.5% (n=311/396) of patients showing improvement (**Table 2**).[15-17, 19-21, 24-26, 28] Adverse events were reported in 26.2% of cases (n=103/393). All 10 studies found that CO_2 laser was an effective treatment modality. In a study of 24 patients, Lapins et al. showed that CO_2 laser treatment with healing by secondary intention was safe, beneficial, and rapidly effective with a mean resolution period of 4 weeks. The majority of patients (91.7%, n=22/24) experienced no recurrence in treated areas. Overall, all patients reported satisfaction with this treatment modality.[24] The treatments were well tolerated in all patients, and average healing time post procedure was 8.8 weeks.[21] Among patients with recurrent HS, Mikkelsen et al. found that CO_2 laser surgery with healing by secondary intention was effective with high patient satisfaction rates (94.8%, n=55/58). Improvement was reported as great in 75.8% (n=44/58) of patients and mild in 19.0% (n=11/58). Overall, 91.4% (n=53/58) of patients stated they would recommend the procedure.[28]

Nd:YAG

Four studies consisting of 92 patients reported on the use of Nd:YAG in HS[27, 29, 32, 33]. Among studies with reported outcomes, 85% (n=30/35) of treated patients showed improvement (**Table 2**) and adverse events were reported in 15% of cases (n=8/53). Overall, 3 of the 4 studies found that Nd:YAG laser

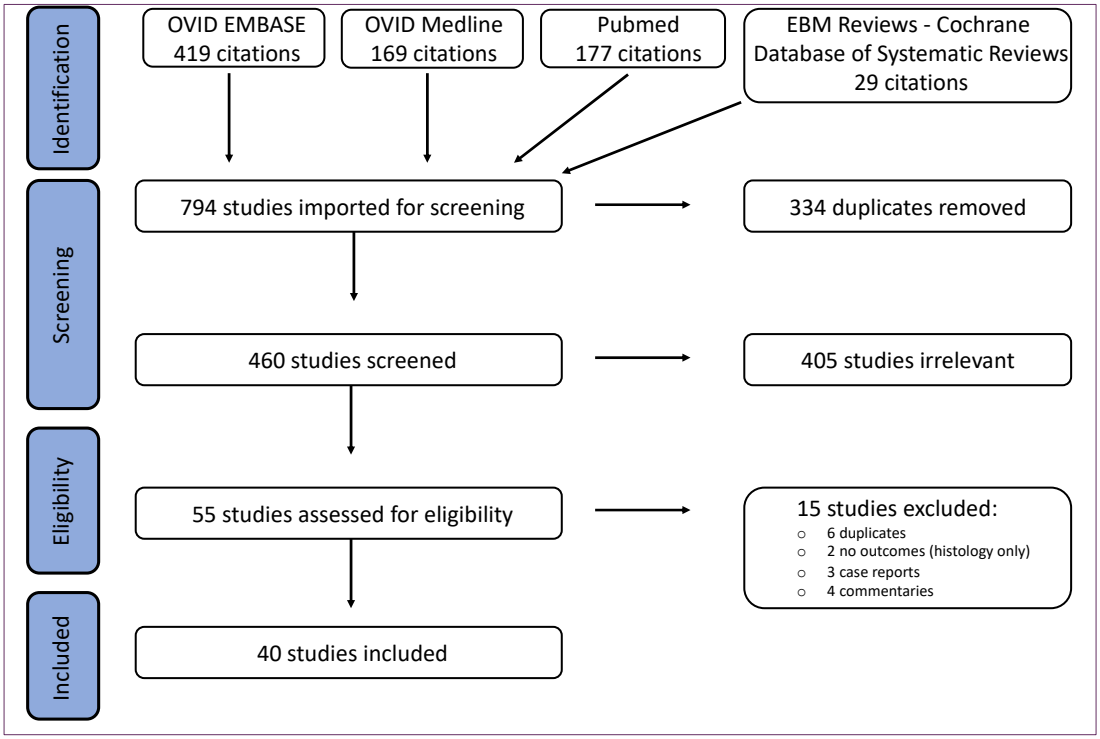

Figure 1: PRISMA diagram of study selection process

treatment improved HS.[27, 32, 33] In a study of 15 HS patients, Vossen et al. found that Nd:YAG for hair removal prevented disease progression. Patients reported a decrease in the number of monthly flares and average HS disease severity, as measured by a numerical response scale (NRS), was significantly lower post treatment (NRS 6.4 ± 2.8 vs NRS 3.6 ± 3.5). Overall, 67% (n=10/15) of patients recommended the treatment.[32]

Nd:YAG/CO_2 combined

Two studies combined Nd:YAG and CO_2 laser treatment (n=58), with both reporting a benefit in HS (**Table 3**).[14, 23] In a study comparing Nd:YAG laser with combined CO_2 and Nd:YAG lasers in 20 patients, combination treatment resulted in better outcomes compared to Nd:YAG alone (mean improvement in CO_2 and Nd:YAG: 90% ± 20.52 vs mean improvement in Nd:YAG: 70.68% ± 23.55).

Other lasers

Two studies (n=31) reported on the use of 'other' lasers, including PEHT (Pediatric Endoscopic Hidradenitis Treatment) and diode laser in HS patients.[18, 34] Collectively, treatment showed improvement in 93.5% (n=29/31) of patients studied. In a study by Esposito et al., PEHT was found to be an effective treatment for HS and patients reported satisfaction with results. Recurrence in untreated locations was reported in only 18% (n=2/11) of patients, which were successfully resolved using the same treatment.[34] In a study by Fabbrocini et al., diode laser reduced Sartorius score, improved HiSCR, and reduced DLQI. Overall, 90% of patients experienced improvement, with 5% (n=1/20) having complete response, 35% (n=7/20) good response, 50% (n=10/20) partial response,

and 10% (n=2/20) no response. The Sartorius score improved from 28.6 ± 13.0 at baseline to 19.8 ± 12.3 post-treatment.[18]

IPL

Four studies (n=83) in our review assessed the use of IPL for the treatment of HS. Overall, IPL led to improvement in 65% (n=54/83) of patients and adverse events were reported in 25% (n=16/64) (**Table 2**).[22, 30, 31, 35] Highton et al., reported that IPL treatment resulted in long-term clinical improvement of lesions in 17 HS patients in an intra-individual controlled trial. Clinical improvement was also corroborated by independent analysis of clinical photographs and patient reported satisfaction.[22] Another study of 25 HS patients found that IPL was useful as an adjuvant treatment for HS patients with mild to moderate disease, and 52% (n=13/25) of patients reported reduced disease activity.[31]

Photodynamic therapy (PDT)

17 studies[8, 36-51] reported on the use of PDT in patients with HS (n=167). The mean age was 33.3 years (range: 17-62) and 68.9% (n=115/167) were female. Overall, PDT was effective in 70.7% (n=118/167) of patients. Adverse events were screened for in 38.3% (n=64/167) of the PDT cohort, and were reported in 35.9% (n=23/64).

A number of photosensitizers were used in PDT. Ten studies (n=121)[8, 37, 43-46, 48-51] reported on PDT for HS with the photosensitizer aminolevulinic acid (ALA). In this cohort, 78.5% (n=95/121) of treated patients responded. Suarez-Valladares et al. found that in a series of HS patients treated with intralesional ALA-PDT, 76.3% (n=29/38) achieved complete remission.[8] In a smaller study of five Hurley stage II or III HS patients with recalcitrant disease, no significant improvement was seen, despite mild improvements in Sartorius score, VAS, and DLQI in all patients (mean change from baseline to post-treatment: Sartorius = -1.6, VAS = -0.3, DLQI = -6.4%). Swelling and blistering was present in 40% (n=2/5) of patients after the first treatment for 8-10 days.[52]

Other photosensitizers utilized for PDT in HS include methylene blue, methyl amino levulinate, and tetracycline. Overall, four studies consisting of 28 patients were included in this cohort.[36, 38, 41, 42] Of those that reported individual patient outcomes, 94.4% (n=17/18) of patients reported improvement. Adverse effects were screened in 72.2% (n=13/18) of patients and of these, adverse effects were reported in 92.3% (n=12/13). Agut-Busquet et al. followed 7 HS Hurley stage II and III patients treated with PDT and methylene blue. PDT and methylene blue treatment improved DLQI and reduced lesion size in 85.7% (n=6/7) of patients after 1 month.[36] Relapse was reported in 28.6% (n=2/7) at 7 and 12 weeks post-treatment.

Psoralen plus ultraviolet A (PUVA)

PUVA to treat HS was examined in a single retrospective chart review.[7] A total of 13 patients were treated with a regimen involving a 15 min bath containing 30 mL of 1-2% 8-methoxypsoralen lotion followed by broadband ultraviolet A. Treatments were performed twice weekly, with a median of 25 (range: 3–57) treatments. Overall, five patients were reported to have ‘clear or near clear’ HS, four patients reached ‘moderate clearance’, and four showed ‘no to minimal’ improvement. Overall, bath PUVA was effective in 69% (n=9/13) of patients in this series and was well tolerated. Adverse events were recorded for two patients and included erythema and claustrophobia.

DISCUSSION

The studies included in our review reported on patients with both moderate and advanced disease. Many of the studies included in our review utilize laser-based treatments for surgery of affected sites in patients with advanced disease resistant to other therapies. Our results suggest that laser-based surgery is associated with a moderate response rate based on a large sample of pooled patients. Furthermore, many of the studies employing laser devices for surgery of HS lesions included patients with long standing and recalcitrant disease, suggesting that these treatment modalities can be employed an adjuncts with success even in patients with advanced disease.

Likewise, treatment modalities that utilize laser-based field therapy of affected areas using Nd:YAG, IPL, or diode laser were associated with a mild response rate based on a large sample of pooled patients. Laser field treatments for HS were employed in patients with both early and advanced disease, suggesting that this treatment modality is appropriate both to treat advanced disease and as a prophylactic therapy to target follicular inflammation and prevent disease progression.

A number of adverse events were reported in the studies included in our review. Overall, PDT was associated with the highest rates of reported adverse events (36%). Laser field treatments had less reported adverse events compared to lasers employed for surgical treatment of HS lesions (18% vs 25%). A number of factors may contribute to this observed difference, including differences in study quality and reporting of adverse events, given that only 105 out of 424 patients treated with laser surgery for HS had adverse events recorded. Some of the adverse events reported for laser surgery included pain, infection, hypertrophic scaring, contracture and wound dehiscence. Side effects associated with PDT included pain, erythema, blistering, burning. Bath PUVA was generally well tolerated, although two patients reported erythema and claustrophobia. Collectively, these findings suggest that while light therapy is a moderately effective treatment modality, adverse events are not uncommon, and patients should be counselled on the risks and benefits of light therapy.

While the mechanism underlying the effectiveness of light-based treatments for HS are not well understood, several possibilities have been suggested. CO_2 laser vaporization and excision removes epithelial sinus tracts which may contain debris and bacteria that can lead to relapse.[53] Non-ablative lasers cause thermal damage to the dermis, which may initiate a wound-healing response with upregulation of procollagen mRNA, matrix metalloproteinases, and cytokines that contribute to wound healing.[54]

Our study has several limitations. Many studies did not report on the side effects of light-based therapies, which restricts our analysis on treatment tolerability. Secondly, some studies reported aggregate data and outcomes for individual patients could not be extracted. Moreover, different outcome measures were used in the studies included in our review, further challenging comparisons between studies. Finally, the majority of the included studies were case series, which limits the generalizability of our analysis.

CONCLUSION

Despite these limitations, our review provides important information that must be

interpreted in a clinical context. First, light-based treatments show moderate benefit in both early and advanced disease. Second, laser devices and PDT have moderate clearance rates for patients with HS, however access to the technology and impractical treatment delivery (especially with extensive disease) may be a barrier. Third, adverse events are not uncommon with light therapy and patients should be counselled on these risks. Though randomized control trials would be the ideal way to validate our findings, studies with treatment comparators are needed to further delineate the therapeutic ladder for HS.

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Table 1. Characteristics of included studies (n=40)

Author, year	Location	Study design, LOE	Intervention	N[#]	Mean age (±SD/range)	F: M	Key findings
Abdel Azim, 2018	Egypt	RCT^ (1)	Nd:YAG CO_2+Nd:YAG	20	29.7 (5)	11:9	Higher satisfaction and lower recurrence rates using combined CO_2 and Nd:YAG
Agut-Busquet, 2016	Spain	Case series (3)	PDT	7	28.9	3:4	Good results using PDT with intralesional MB
Andino Navarrete, 2014	Chile	Case series (3)	PDT	5	26 (5)	4:1	5-ALA and 635nm light improved quality of life and reduced disease severity
Belotto, 2013*	Brazil	Case series (3)	PDT	5	NS	5:0	PDT improved inflammation and drainage
Braunberger, 2018*	USA	Case series (3)	CO_2	38	37.5	NS	CO2 laser excision is a safe and effective treatment
Bu, 2017	China	Case series (3)	PDT	7	24.4	0:7	Surgery combined with PDT improved DLQI and VSS scores
Calzavara-Pinton, 2013	Italy	Case series (3)	PDT	6	34 (10.9)	5:1	MAL-PDT was effective and well tolerated
Crocco, 2015	Brazil	Case series (3)	CO_2	3	29.3	2:1	CO_2 laser effective in Hurley III HS
Darlymple, 1987	UK	Case series (3)	CO_2	6	NS	5:1	CO_2 laser was effective with minimal scarring
Esposito, 2020	Italy	Case series (3)	PEHT	11	15.7	9:2	PEHT was effective with low recurrence rates
Fabbrocini, 2018	Italy	Case series (3)	Diode laser	20	26.6 (7.84)	14:6	1064nm intralesional diode laser reduced Sartorius score and DLQI, increased HiSCR
Fadel, 2015	Egypt	RCT^ (1)	PDT	10	27.1 (5.09)	7:4	Significant reduction in HS-LASI with PDT
Finley, 1996	USA	Case series (3)	CO_2	7	(20-46)	NS	CO_2 laser is effective with low recurrence rates
Giacaman, 2019*	Spain	Case series (3)	PDT	8	NS	43:34	Adalimumab and PDT decreased lesions and pain
Gold, 2004	USA	Case series (3)	PDT	4	27.8 (19-46)	4:0	ALA-PDT is effective in HS patients who did not respond to medical therapy
Grimstad, 2019	Norway	Case series (2)	CO_2	156	39.3 (9.91)	191:67	Better response with surgical versus medical treatments. CO_2 laser was most effective.
Hazen, 2010*	USA	Case series (3)	CO_2	61	38.5 (21-73)	42:19	CO_2 laser excision and marsupialization is effective for persistent or late-stage HS
Highton, 2011	UK	Case series (3)	IPL	17	34 (17-50)	14:3	IPL reduced Sartorius scores compared to control with good patient satisfaction
Jain, 2012	India	Case series (3)	CO_2 Nd:YAG	4	(30-40)	4:0	Deroofing with CO_2 laser combined with Nd:YAG was effective with no recurrence
Lapins, 1994	Sweden	Case series (3)	CO_2	24	36 (22-57)	21:3	CO_2 laser was effective for patients with chronic HS with low recurrence rates
Lapins, 2002	Sweden	Case series (3)	CO_2	34	33.9 (11.0/15-55)	31:3	Scanner-assisted CO_2 laser ablation improved scarring and had high patient satisfaction
Madan, 2008	UK	Case series (3)	CO_2	9	39 (27-52)	8:1	CO_2 laser was an effective treatment for patients with recalcitrant HS

Mahmoud, 2010	USA	RCT^ (1)	Nd:YAG	22	41 (19-72)	19:3	Nd:YAG + topical BPO & clindamycin better than topical BPO & clindamycin alone
Mikkelsen, 2015	Denmark	Case series (3)	CO_2	58	37.8 (21-54)	48:10	CO_2 laser treatment effective for recurrent HS
Naouri, 2020	France	RCT^ (1)	Nd:YAG	31	NS	NS	Nd:YAG laser for hair removal has no effect on disease flares
Passeron, 2009	France	Case series (3)	PDT	4	NS	NS	PDL-PDT was not effective in treating HS
Piccolo, 2014	Italy	Case series (3)	IPL	2	32 (26-38)	1:1	IPL completely resolved HS lesions
Rodriguez-Prieto, 2013	Spain	Case series (3)	PDT	3	47 (36-62)	0:3	No recurrence after ALA-PDT
Rucker Wright, 2009	USA	Case series (3)	Nd:YAG	20	NS	NS	Nd:YAG laser reduced HS-LASI scores
Shareef, 2011	UK	Case series (3)	PUVA	13	35 (25-66)	11:2	PUVA is an effective treatment in some patients
Sotiriou, 2009	Greece	Case series (3)	PDT	5	33.6 (25-43)	2:3	No significant improvement after ALA-PDT
Strauss, 2005	UK	Case series (3)	PDT	4[$]	NS	NS	No significant improvement after ALA-PDT
Suarez-Valladares, 2018[*]	Spain	Case series (3)	PDT	5	NS	NS	Resolution with no recurrence after ALA-PDT
Suarez-Valladares, 2017	Spain	Case series (3)	PDT	38	36 (30-44)	18:20	Complete response in most patients after ALA-PDT
Theut Riis, 2018	Denmark	Case series (3)	IPL	25	39.2 (10.9/17-63)	25:0	IPL effective as an adjuvant treatment in a subset of patients
Valladares-Narganes, 2015	Spain	Case series (3)	PDT	27	30.3 (19-62)	11:16	ALA-PDT effective in most patients and improved Sartorius score
Vilarrasa, 2019[*]	Spain	Case series (3)	PDT	28	46	13:15	ALA-PDT improved DLQI and pain
Vossen, 2018	The Netherlands	Case series (3)	Nd:YAG	15	34.1 (10.1)	5:10	Nd:YAG reduced number of flares and reduced disease severity
Wilden, 2019	Germany	RCT (1)	IPL + radiofrequency	41	38 (23-57)	31:12	IPL and radiofrequency reduced lesion count and DLQI compared to either treatment alone
Xu, 2011	USA	RCT^ (1)	Nd:YAG	19	37 (23-54)	16:3	Nd:YAG improved HS-LASI score
Zhang, 2016	China	Case series (3)	PDT	3	(17-38)	0:3	ALA-PDT ineffective for late-stage HS

ALA: aminolevulinic acid, **BPO:** benzoyl peroxide, **CO_2:** carbon dioxide, **DLQI:** Dermatology Life Quality Index, **F:** female, **HiSCR:** Hidradenitis Suppurativa Clinical Response, **HS:** hidradenitis suppurativa, **HS-LASI:** Hidradenitis Suppurativa Lesion, Area, and Severity Index, **IPL:** intense pulsed light, **LOE:** Level of evidence, **MAL:** methyl aminolevulinate, **M:** male, **Nd:YAG:** neodymium-doped yttrium aluminum garnet, **NS:** not specified, **PDL:** pulsed dye laser, **PDT:** photodynamic therapy, **PEHT:** pediatric endoscopic HS treatment, **PUVA:** psoralen and ultraviolet A, **RCT:** randomized controlled trial

[*] Abstract only

[#] Number of participants included in analysis

[$] 2 participants completed the study

^ Randomized within-patient controlled trial

Key to evidence-based support: (1) prospective controlled trial; (2) retrospective study or large case series; (3) small case series or individual case reports

Table 2. Summary of treatment outcomes by phototherapy intervention for HS

Light and Laser-based Treatment Modality (pooled n)	% Patients with Any Response (n)	% Adverse Events (n)
Laser surgery: **CO_2 laser, CO_2 + Nd:YAG, PEHT, intralesional diode laser (431)**	80 (344)	25 (105/424)
CO2 (396)	79 (311)	26 (103/393)
CO2 + Nd:YAG (4)	100 (4)	NR
PEHT (11)	100 (11)	0 (0/11)
Intralesional diode laser (20)	90 (18)	10 (2/20)
Field treatment: **Nd:YAG laser, IPL, diode (101)**	71 (84)	18 (24/134)
PDT (169)	73 (124)	36 (23/64)
PUVA (13)	69 (9)	15 (2/13)

n - number of patients with outcomes reported
CO2: carbon dioxide, **IPL:** intense pulsed light, **Nd:YAG:** neodymium-doped yttrium aluminum garnet, **PDL:** pulsed dye laser, **PDT:** photodynamic therapy, **PEHT:** pediatric endoscopic HS treatment, **PUVA:** psoralen and ultraviolet A

Table 3. Results of included studies examining multiple outcome measures on hidradenitis suppurativa

Author, Year	N	Mean age (±SD/ range)	Intervention	Outcome measure	Mean before (±SD)	Mean after (±SD)	Delta	Conclusion
Abdel Azim, 2018	20	29.7 (±5)	Nd:YAG and combined CO_2/Nd:YAG	PGA	CO_2/Nd:YAG: 20.6 Nd:YAG: 20.4	CO_2/Nd:YAG: 16.9 Nd:YAG: 24.1	CO_2/Nd:YAG: -3.7 Nd:YAG: 3.7	CO_2+Nd:YAG superior to Nd:YAG alone. Combined treatment had a lower rate of recurrence and higher patient satisfaction.
				VAS patient satisfaction	N/A	CO_2/Nd:YAG: 24; Nd:YAG: 17	N/A	
Agut-Busquet, 2018	7	28.9	I-PDT	VAS	4.6 (±1.4)	N/A	N/A	I-PDT is more effective for HS Hurley stage II than stage III. At 6 months, 5/7 patients had no recurrence.
				DLQI	9.4 (±3.9)	2.2 (±2.1)	-7.2	
				PGA	3 (±2.2)	N/A	N/A	
				US assessments	Large transverse diameter	Reduced diameter in treated lesions	N/A	
Andino Navarrete, 2014	5	26 (±5)	PDT (5-ALA; 635nm light)	Sartorius	35.4 (±4.98)	18.2 (±8.11)	-17.2	PDT improved QOL and reduced severity of disease.
				DLQI	28.8 (±2.68)	7.49 (±2.79)	-21.31	
				VAS	3 (±0)	0.8 (±0.45)	-2.2	
Belotto, 2013	5	N/A	PDT[#]	Inflammation, drainage, erythema, edema	N/A	Reduced drainage and inflammation in 60%; partial reduction in 40%.	N/A	PDT improves inflammation and drainage
Braunberger, 2018	38	37.5	CO_2 laser	Healing time in smokers	N/A	Smokers: 6 months Non-smokers: 6 months	N/A	After CO_2 excision – smoking did not affect healing time but diabetics had a prolonged healing time.
				Healing time in diabetics	N/A	Diabetics: 7.3 months Non-diabetics: 5.4 months	N/A	3 patients experienced recurrence at a mean of 6 months post procedure.
				Recurrence	N/A	3 patients	N/A	
Bu, 2017	7	24.4	Surgery combined with PDT	Healing time	N/A	29.4 days	N/A	Surgery in combination with PDT improved DLQI. No recurrence. Advantage of faster healing and less scaring.
				Recurrence	N/A	No recurrence	N/A	
				DLQI	24.1 (±4.3)	5 months post treatment: 4.9 (± 2.8)	-19.2	
				VSS	N/A	4.6 (±2.4)	N/A	
Calzavara-Pinton, 2013	6	34 (± 10.9)	MAL-PDT	Clinical response	N/A	No/poor response: 17%; Moderate: 50%; Marked: 33%	N/A	2/6 patients had marked improvement, 3 had moderate improvement, and 1 had no/poor response with MAL-PDT treatment.
				Local reaction	N/A	Absent: 17%; Moderate: 83%; Marked: 0%	N/A	
				Cosmesis	N/A	33%	N/A	
Crocco, 2015	3	29.3	CO_2 laser	Clinical response	Patient 1: abscesses in axilla Patient 2: abscesses in axillary, inframammary and inguinal regions Patient 3: abscesses in axilla & groin	Patient 1: successful treatment Patient 2: successful treatment Patient 3: successful treatment	N/A	CO2 laser effective in Hurley III HS.
Darlymple, 1987	6	(20-43)	CO_2 laser	Wound healing	N/A	3-7 weeks	N/A	Patients reported limited scarring. All patients were disease free at 9 months to 3 years follow up. All
				Recurrence	N/A	None	N/A	

								recurrences were in untreated areas.
Esposito, 2020	11	15.7	Pediatric endoscopic hidradenitis treatment (PEHT)	Postoperative VAS	0.7	N/A	N/A	PEHT was effective with good patient satisfaction and results.
				Time to restart work/school	N/A	1.8 days	N/A	
				Wound healing time	N/A	32.5 days	N/A	
				Recurrence	N/A	2 (18%) patients developed lesions in untreated locations	N/A	
Fabbrocini, 2018	20	26.6 (± 7.84)	Diode laser 1064nm	Sartorius	28.6 (±13.0)	19.8 (±12.3)	-8.8	Laser treatment reduced Sartorius score, improved HiSCR, and reduced DLQI.
				PGA	10 (50%) mild; 10 (50%) moderate	N/A	N/A	
				HiSCR	N/A	6 (30%) not achieved; 14 (70%) achieved	N/A	
				Clinical response	N/A	1 (5%) complete response; 7 (35%) good response; 10 (50%) partial response; 2 (10%) no response	N/A	
Fadel, 2015	10	27.1 (±5.09)	PDT (Niosomal methylene blue (NMB) vs. free methylene blue (FMB) as a photosensitizer to IPL)	Photos	Patient 1: lesions in right axilla Patient 2: groin lesions in a female Patient 3: extensive fibrosis in axilla Patient 4: Hurley stage 3	Patient 1: complete clearance of lesions Patient 2: improvement in lower part of lesion Patient 3: mild improvement Patient 4: moderate improvement	N/A	Photosensitization with NMB was more effective compared to photosensitization with FMB.
				HS-LASI	NMB: 14.9 (±6.6); FMB: 14.0 (±7.2)	NMB: 3.6 (±3.4); FMB: 7.9 (±5.6)	NMB: -11.3; FMB: -6.1	
				Reduction in percentage of lesions	N/A	NMB: 77.3 (±18.9); FMB: 44.1 (±28.2)	N/A	
Finley, 1996	7	(20-46)	CO_2 laser	Healing time	N/A	6.6 weeks (±1.9)	N/A	CO_2 laser treatment with healing by second intention was effective for HS. All patients were satisfied with results and reported good cosmesis.
				Recurrence	N/A	1 patient 8 months post procedure	N/A	
Giacaman, 2019	8	38 (median)	I-PDT	Lesions	N/A	Decrease in lesions	N/A	There was a decrease in inflammatory lesions and pain.
				Pain	N/A	Decrease in pain	N/A	
Gold, 2004	4	27.8 (19-46)	ALA-PDT and blue light	Lesions	Patient 1: lesions in axillae and inguinal area Patient 2: lesions in axillae Patient 3: lesions in inguinal areas Patient 4: lesions in inguinal area	Patient 1: 75% clearance of lesions Patient 2: 75% clearance of lesions Patient 3: complete clearance of lesions Patient 4: 75% clearance of lesions	N/A	ALA-PDT and blue light phototherapy is an effective treatment for patients who did not respond to medical therapy.

Grimstad, 2019	156	39.3 (±9.91)	CO_2 laser, CO_2 laser and topical clindamycin, CO_2 laser and systemic antibiotic	Sartorius score	CO_2 laser (n=156): 57; CO_2 laser and topical clindamycin (n=5): 85; CO_2 laser and systemic antibiotic (n=1): 123	N/A	CO_2 laser (n =156): -33; CO_2 laser and topical clindamycin (n=5): -36; CO_2 laser and systemic antibiotic (n =1): -87	CO_2 laser was the most effective intervention studied. Almost half of patients treated with a combination of surgical and medical treatments had a significant improvement in Sartorius score.
				DLQI	CO_2 laser (n=156): 14; CO_2 laser and topical clindamycin (n=5): 14; CO_2 laser and systemic antibiotic (n=1): 13	N/A	CO_2 laser (n =156): -5; CO_2 laser and topical clindamycin (n=5): -6; CO_2 laser and systemic antibiotic (n =1): 0	
Hazen, 2010	61	38.5 (21-73)	CO_2 laser excision and marsupialization	Recurrence of disease	N/A	Recurrence in 2 patients. Average of 4.1 years without recurrence in treated areas (range of 1-17 years).	N/A	CO_2 laser excision & marsupialization effective therapy for persistent or late-stage HS (when scarring and sinus tract formation present).
				Comfort/ patient satisfaction	N/A	Treatments well tolerated in all patients.	N/A	
				Healing time	N/A	8.8 weeks	N/A	
Highton, 2011	17	34 (17-50)	IPL (Harmony laser; 2x/week for 4 weeks on one area vs contralateral side not treated - served as control)	Sartorius score	N/A	3 months post treatment: -56%. 6 months: -44%. 12 months: -33%. Control side - 3 months: -10%. 6 months: -10%. 12 months: 3%.	Significant reduction in HS exam score on treated side ($p<0.001$). Significant difference between treated and control sides ($p<0.001$).	Reduction in severity of HS with IPL. Mean examination score was improved and maintained at 12 months. Improvement was also reported by independent analysis of clinical photographs. Patients reported high levels of satisfaction with treatment. Treated side had significant reduction in Sartorius score maintained at 12 months ($p=0.001$).
				Patient satisfaction	N/A	Treatment side Disease clearance: 1 patient Excellent results: 2 patients Good results: 10 patients 4 patients: fair results Control side: No change: 15 patients Slight improvement: 1 patient Slight decline: 1 patient	N/A	
Jain, 2012	4	(30-40)	Nd:YAG and CO2 laser	Recurrence of disease	N/A	No recurrence	N/A	Deroofing with CO_2 laser combined with Nd:YAG laser is effective in treating HS, with no recurrence observed up to 3 years.

Lapins, 1994	24	36 (22-57)	CO_2 laser with healing by secondary intention	Recurrence of disease	N/A	Recurrence: 2 No recurrence: 22	N/A	CO_2 laser treatment with secondary intention for patients with chronic HS is beneficial, safe, and quick, leaving patients with good cosmetic and functional results.
				Healing time	N/A	4 weeks (3-5 weeks)	N/A	
				Scarring/cosmetic appearance	N/A	All patients satisfied with scar appearance.	N/A	
				Patient satisfaction	N/A	Patients found this method favourable, willing to repeat procedure if required.	N/A	
Lapins, 2002	34	(±11.0/15-55)	Scanner-assisted CO_2 laser ablation	Recurrence	N/A	Recurrence: 4 No recurrence: 30	N/A	CO_2 laser with scanner is a fast and efficient treatment of HS, with satisfactory cosmetic and functional results.
				Healing time	N/A	4 weeks (3-5 weeks)	N/A	
				Pain in post-op period (Scale from 0-3)	N/A	Classified as 3: 4 Classified as 2: 15 Classified as 1: 9 Classified as 0: 6	N/A	
				Patient satisfaction	N/A	Condition better than pre surgery: 31 patients Hardly changed: 2 patients Worse: 1 patient	N/A	
Madan, 2008	9	39 (27-52)	CO_2 laser excision (prophylactic oral antibiotics for 2 weeks post-op)	Recurrence of disease	N/A	No recurrence: 6 Active HS at untreated sites adjacent to treated sites: 2	N/A	CO_2 laser is an effective treatment for patients with recalcitrant HS, with patients reporting high satisfaction scores.
				Patient satisfaction	N/A	8.5/10 (range of 7-10)	N/A	
				Wound healing time	N/A	2 weeks (range of 1-4)	N/A	
Mahmoud, 2010	22	41 (19-72)	Nd:YAG laser (combined with topical benzoyl peroxide wash and clindamycin lotion; benzoyl peroxide and clindamycin alone used as control)	Modified Sartorius score (HS Lesion Area and Severity Index)	At baseline for all sites combined: 31 (SD: 14.9) All control sites combined: 29 (SD:13.2)	At 6 months Treated sites: 7.6 (SD: 4.1) Mean for all control sites: 19.9 (SD: 10.9)	Average improvement over all anatomic sites was 72.7% on laser treated side and 22.9% on control side ($p< 0.05$).	Nd:YAG laser & topical benzoyl peroxide + clindamycin are associated with progressive improvement of HS lesions, and are more effective than topical benzoyl peroxide + clindamycin alone. Overall high level of patient satisfaction with treatment.
				Patient satisfaction - Pain associated with HS	N/A	Pain significantly less: 77% Moderately less: 15% Pain unchanged: 8%	N/A	
				Patient satisfaction	N/A	Generally satisfied: 55/58 patients	N/A	
Mikkelsen, 2015	58	37.8 (21-54)	CO_2	Patient satisfaction	N/A	94.8% (n=55/58) of patients reported a small (n=11) or great improvement (n=44)	N/A	CO_2 laser surgery is an effective treatment for symptomatic HS lesions. Patient satisfaction is high despite a moderate number of recurrences.

				Recurrence of disease	N/A	29.3% (n=17/58) of patients reported recurrence of disease in treated areas	N/A	
Naouri, 2020	31	Not specified	Nd:YAG laser (4 treatments at 6 week intervals)	Inflammatory lesion count	Week 0 Untreated: 5.86 (±6.29). Treated: 5.89 (±4.68).	Week 22 Untreated: 1.69 (±15.01) Treated: -1.25 (±10.77) Week 30 Untreated: -0.81 (±6.08). Treated: -2.56 (±4.22).	Weeks 0-30 Untreated: -6.67. Treated: -8.45.	The laser had no impact on disease recurrence. The effectiveness of laser hair removal in reducing the amount of inflammation lesions decreases with time.
				Proportion of responders to Hidradenitis Suppurativa Clinical Response (HiSCR)	N/A	1-month post tx Treated side: 73.7% Control side: 52.6% (P= 0.29). 3-month post tx Both treated and control sides: 52.6%	No significant difference in number of flares between treated and untreated sites at 1 and 3-month follow-up	
Passeron, 2009	4	Not specified	PDL-PDT (ALA, only one side of axilla or groin was treated – the other used as control)	Sartorius score	PDL-PDT side: 11.25 Control side: 11	At 1 month PDL-PDT side: 8.25. Control side: 13 At 3 months PDL-PDT side: 9 Control side: 8.67	Baseline to month 3 PDL-PDT side: -2.25 Control side: -2.33	PDL-PDT not effective in treating HS.
				VAS	N/A	Pain was high during treatment. Mean: 8 (6-9)	N/A	
Piccolo, 2014	2	32 (26-38)	IPL (6 sessions)	Sartorius score	30 (24-36)	N/A	N/A	HS lesions were completely resolved, along with achieving hair removal.
				Recurrence	N/A	HS pustular papules resolved post treatment	N/A	
Rodriguez-Prieto, 2013	3	47 (36-62)	PDT (intralesional 5-ALA and irradiated with diode laser)	Recurrence of disease	N/A	Patient 1: No recurrence at 9 months Patient 2: No recurrence after 14 months Patient 3: resolution of symptoms after 7 months	N/A	No recurrence post intralesional PDT in all 3 patients.
Sharef, 2011	13	35 (25-66)	PUVA (bath)	DLQI	16 (11-26)	N/A	N/A	Bath PUVA is possibly an effective treatment modality for some people with HS.
				Disease clearance	N/A	Clear/near clear: 5 patients; moderate clearance: 4; no-minimal: 4	N/A	
Sotiriou, 2009	5	33.6 (25-43)	PDT (topical 5-ALA)	Sartorius score	18.8	17.2	-1.6	No significant improvement post treatment.
				VAS – disease severity and pain	2.4	2.1	-0.3	
				DLQI	N/A	N/A	Reduction in mean of 6.4%	
	4		PDT (topical ALA)	Sartorius score	17.8	23.3	5.5	

Strauss, 2005		Not specified		VAS – disease severity	8.1	7.1	-1	No significant improvement post treatment. Worsening symptoms for 2 patients.
				VAS - pain	7	5.3	-1.7	
Suarez-Valladares, 2018	5	Not specified	PDT (intralesional ALA)	Qualitative descriptions by investigators	N/A	All patients achieved a complete response in the treated lesion	N/A	Resolution of disease in 3/3 patients. No recurrence noted at follow up.
Suarez-Valladares, 2017	38	36 (30-44)	I-PDT (5-ALA)	Response to treatment	N/A	Complete response: 29 patients Persistence: 8 patients Recurrence: 1 patient	N/A	A complete response (no lesions or symptoms) rate of 76.3%. I-PDT is a potential effective alternative treatment to HS.
				DLQI	Median = 10 (7-17)	Median = 1 (0-2.25)	-9	
				HSS	Median = 28.5 (11.75-38.5)	Median = 0 (0-45)	-28.5	
Theut Riis, 2018	25	39.2 (SD 10.9/17-63)	IPL	Patient reported disease activity	N/A	Reduced disease activity: 13/25 patients	N/A	IPL can be used as an adjuvant treatment for HS - in those with mild to moderate disease with minimal scar tissue.
				Hair reduction	N/A	Effect on hair in 17/25 patients	N/A	
Valladares-Narganes, 2015	27	30.3 (19-62)	I-PDT (5-ALA)	Modified Sartorius score	20.67	8.81	-11.86	21/27 patients had either a good or complete response to treatment. Intralesional application of PDT allows the light to reach various depths with the lowest amount of energy needed. It may be an effective treatment for HS.
				Response to treatment	N/A	Complete response: 10 (37%) Good response: 11 (41%) Partial response: 5 (19%)	N/A	
				VAS - pain	N/A	Severe pain (9): 1 Moderate (6-9): 4 Low (<6): 22	N/A	
Vilarrasa, 2019	28	46	PDT (topical 5-ALA)	DLQI & EVA (pain visual scale)	N/A	N/A	All patients showed improvement in DLQI & EVA	All patients improved in DLQI and EVA scores 8 weeks post last treatment session. Ultrasound showed a resolution in the lesions of 13 patients, partial resolution in 12 patients, and poor in 3.
				Ultrasound	N/A	Resolution of lesions: 13 patients Partial resolution: 12 patients Poor: 3 patients	N/A	
Vossen, 2018	15	34.1 (10.1)	Nd:YAG laser (hair removal on patients with mild HS)	Number of HS flares/month (Questionnaire)	<1 flare: 4 patients 1 flare: 2 patients 2 flares: 1 patient 3 flares: 3 patients >3 flares/continuous inflammation: 5 patients	<1 flare: 8 patients 1 flare: 0 2 flares: 3 patients 3 flares: 3 patients >3 flares/ continuous inflammation: 1 patient	Decrease in number of monthly flares (p=0.019).	Laser hair removal can be used to prevent the progression of disease. Results include decrease in the number of monthly flares, average HS disease severity was significantly lower post treatment (NRS 6.4 ± 2.8 versus NRS 3.6 ± 3.5). Overall treatment satisfaction was rated with a NRS score of 6.7 ± 2.4. 2/3 patients would recommend the treatment.
				NRS disease severity (0-10)	NRS 6.4 (±2.8)	NRS 3.6 (±3.5) p= 0.01	-2.8	
				NRS overall treatment satisfaction (0-10)	N/A	NRS 6.7 (±2.4)	N/A	

Wilden, 2019	13	38 923-57)	IPL and radiofrequency (RF)	Active lesions count	N/A	N/A	IPL: 0.8 RF group: -0.4 IPL+RF group: -1.3 Whole cohort on crossover to IPL+RF for 24 weeks: -3.6 (p=0.001).	IPL + RF is a promising treatment for HS, increasing in effect over time and without severe side effects.
				DLQI	N/A	N/A	IPL group: -1.3 RF group: -5.1 IPL+ RF group: -6.6 (p=0.025). Whole cohort on crossover to IPL+RF for 24 weeks: -5.2 (p=0.003).	
Wollina, 2004	17	(29-41)	Transdermal CO_2	Clinical response	N/A	N/A	Improvement of granulation and reduction of discharge and malodor 1-week post treatment	
Xu, 2011	19	37 (23-54)	1064nm Nd:YAG laser	Lesion Area and Severity Index (LASI)	N/A	N/A	All sites: -31.6% (p<0.05) Axillary sites: -24.4% (p=0.08) Inguinal site: -36.8% (p=0.001).	The percentage change in modified HS-LASI score after 2 months was –31.6% (p<.001) averaged over all anatomic sites. HS-LASI scores trended down from baseline to 1 month and 2 months after treatment for both axilla and inguinal sites.
Zhang, 2016	3	(17-38)	PDT (ALA)	DLQI	26.67 (1.15)	Session 1: 24.67 Session 2: 24.33 Session 3: 24.33	N/A	No improvement for late-stage HS.

DLQI: Dermatology Life Quality Index; **HSS:** Hidradenitis severity score; MAL: methyl amino; **N:** number of participants; **PDT:** photodynamic therapy **I-PDT:** intralesional photodynamic therapy **PUVA:** psoralen plus ultraviolet A**; US:** ultrasonographic; **VAS:** visual analogue scale; **VSS:** Vancouver Scar Scale; **QOL:** quality of life
MCID: minimum clinically important difference NRS 30 – 30% reduction to baseline numerical rating score\
tetracycline used as a photosensitizer combined with 600nm red light