

The Use of Laser Therapy in the Treatment of Vulvar Lichen Sclerosus: Clinical Approaches, Perspectives and Literature Review

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Abstract

Vulvar Lichen Sclerosus (VLS) is a chronic inflammatory dermatosis characterised by atrophic lesions and intense pruritus that can significantly impair quality of life. Topical corticosteroids remain the standard treatment, yet their long-term use is limited by adverse effects and incomplete symptom control. The integration of laser technologies has therefore emerged as a promising alternative, targeting both fibrosis and underlying inflammation.

This study is based on a corpus of recent scientific literature, including randomised clinical trials, prospective studies, and systematic reviews assessing the efficacy and safety of fractional CO₂, Er:YAG lasers, and low-level laser therapy (LLLT). Clinical outcomes evaluated include pruritus intensity, dyspareunia, tissue fibrosis, and quality of life improvement. A synthesis of laser treatment protocols was conducted, comparing laser monotherapy with its combination with corticosteroids. Evaluation criteria included clinical outcomes (symptom reduction, tissue elasticity), histological findings (fibrosis regression), and socioeconomic parameters (costs, recurrence of medical visits).

Optimisation of laser parameters (fluence, number of sessions) and combination with topical agents may significantly enhance the management of VLS. Faster reduction of inflammation and fibrosis is expected, potentially lowering long-term corticosteroid dependence. These benefits could translate into improved patient comfort, fewer recurrences, and greater overall satisfaction.

Key words: Vulvar lichen sclerosus; laser therapy; fractional CO₂ laser; Er:YAG laser; low-level laser therapy; regenerative medicine; platelet-rich plasma; corticosteroids; photobiomodulation; tissue regeneration; fibrosis; personalised medicine.

INTRODUCTION

Vulvar lichen sclerosus (VLS) is a chronic, progressive, inflammatory dermatosis primarily affecting the vulvar and perianal regions. It is characterised by epithelial thinning, sclerosis, hypopigmentation, and progressive loss of elasticity, often resulting in pruritus, burning, fissures, and, in advanced cases, introital stenosis leading to dyspareunia and urinary discomfort. Although it predominantly affects postmenopausal women, it can appear at any age and has a significant impact on quality of life and sexual function.

Histologically, VLS is defined by epidermal atrophy, homogenisation of collagen fibres in the upper dermis, and a dense subepithelial lymphocytic infiltrate. The pathogenesis remains multifactorial and incompletely

understood, involving genetic predisposition, autoimmunity, hormonal influences, and environmental triggers.

At the immunological level, VLS is marked by overactivation of CD8⁺ T lymphocytes, increased expression of cytokines such as interleukin-6, interleukin-17, and tumour necrosis factor- α , and reduced expression of the extracellular matrix protein ECM1, essential for dermo-epidermal cohesion.

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This cascade leads to chronic inflammation, tissue hypoxia, and fibrotic remodelling through excessive collagen I and III synthesis combined with decreased matrix metalloproteinase (MMP) activity. Dysbiosis of the vaginal microbiota may further exacerbate immune dysregulation and disease persistence.

Recent advances in imaging and molecular diagnostics—such as optical coherence tomography, elastography, and evaluation of biomarkers including calprotectin and MMP-2/-9—have improved early disease detection and monitoring of therapeutic response.

Conventional management relies mainly on potent topical corticosteroids, which, although effective in controlling inflammation, often fail to achieve durable remission and are associated with potential side effects such as skin atrophy and tachyphylaxis. The growing understanding of the pathophysiological mechanisms of VLS has thus stimulated interest in alternative, tissue-targeted strategies. Among these, laser-based therapy has emerged as a promising option that directly addresses both the inflammatory and structural components of the disease, promoting regeneration, vascularisation, and long-term symptom control.

PATHOPHYSIOLOGY AND PATHOGENIC MECHANISMS

The pathogenesis of VLS involves a subepithelial lymphocytic infiltrate dominated by CD8+ T-cells, with overexpression of pro-inflammatory cytokines such as interleukin-6, interleukin-17, and tumour necrosis factor- α . Down-regulation of the ECM1 gene, crucial for dermo-epidermal junction integrity, contributes to tissue fragility.

Advanced stages display excessive fibrosis due to increased synthesis of collagen types I and III and reduced activity of matrix metalloproteinases (MMPs), leading to aberrant tissue remodelling. Recent findings also suggest a possible contribution of vaginal microbiota dysbiosis, supporting

the hypothesis of a microbe-immune interaction that may perpetuate local inflammation.

Emerging diagnostic tools such as optical coherence tomography and ultrasound elastography allow early detection of connective tissue changes, while biomarkers including calprotectin and MMP-2/-9 are being evaluated as indicators of disease progression.

TYPES OF LASER AND MECHANISMS OF ACTION

Fractional CO₂ Laser

Fractional CO₂ laser therapy operates through fractional photothermolysis, alternating between micro-ablative columns and intact tissue zones. This mechanism induces selective removal of abnormal keratinocytes while stimulating fibroblast proliferation, collagen and elastin synthesis, and neovascularisation. The resulting controlled thermal coagulation reduces chronic inflammation and restores vulvar trophicity, making it particularly suitable for severe or fibrotic forms of VLS.

Er:YAG Laser

The Er:YAG laser emits light at 2940 nm, which is highly absorbed by water—the main constituent of cutaneous tissue. This allows precise ablation of superficial lesions with minimal lateral thermal damage. The Er:YAG laser promotes epidermal renewal and fibroblast activation, improving dermo-epidermal structure and skin barrier function. It is best suited for mild to moderate disease and for patients with a higher risk of post-inflammatory reactions.

Low-Level Laser Therapy (LLLT)

LLLT, or photobiomodulation, uses wavelengths between 600 and 1100 nm to achieve deeper penetration without thermal injury. By stimulating mitochondrial cytochrome-c oxidase activity, it enhances ATP production, reduces oxidative stress, and modulates inflammatory cascades. LLLT may alleviate neuropathic pain and complement ablative laser therapies during recovery phases.

Table 1. Comparison of the different types of laser

Type of Laser	Primary Effect	Specific Indications	Risks and Side Effects
Fractional CO₂	Deep remodelling; stimulation of collagen and elastin	Severe lesions, advanced fibrosis, deep tissue regeneration	Erythema, oedema, transient discomfort, hyperpigmentation risk
Er:YAG	Targeted photovaporisation; precise ablation	Superficial lesions, moderate epidermal atrophy	Local hypersensitivity, possible rapid recurrence if incomplete
LLLT	Inflammatory modulation, mitochondrial activation	Neuropathic pain, post-laser recovery, adjunct therapy	No major adverse effects reported

DISCUSSION

Randomised and prospective studies have consistently shown that laser therapy leads to marked improvement in pruritus, pain, and vulvar morphology. Clinical benefits persist for up to twelve months post-treatment. Histological analyses demonstrate decreased dermal fibrosis, increased vascularisation, and restoration of epithelial thickness. Comparative trials indicate that fractional CO₂ laser achieves more profound remodelling, whereas Er:YAG provides faster recovery and better tolerance. LLLT serves as an adjuvant, particularly in patients with

chronic pain. Combined protocols are being explored to optimise efficacy and minimise recurrence. Clinical data reveal : pruritus reduction: 60–80%, sustained up to 12 months; pain and dyspareunia: 50–70% improvement, particularly with CO₂ + PRP; elasticity and trophicity: histological evidence of increased suppleness, vascular density, and reduced fibrosis; recurrence: lower rates than with corticosteroid therapy and reduced need for maintenance. These outcomes translate into substantial gains in comfort, sexual function, and quality of life.

Table 2. *Improvement of symptoms pre- and post-treatment*

Symptom	Before Treatment (%)	After Treatment (%)	Improvement (%)	Main References
Severe pruritus	85–90	20–25	~60–70	Polak et al. (2023), Freedman et al. (2022), Ferrari et al. (2021), Bianchi & Lorusso (2022), Ivanova & Petrov (2021)
Pain / Dyspareunia	70–80	25–35	~50–60	Freedman et al. (2022), Polak et al. (2023), Ivanova & Petrov (2021), Vorobyov et al. (2019)
Reduced tissue elasticity	80–85	40–45	~40–50	Bianchi & Lorusso (2022), Ferrari et al. (2021), Ivanova & Petrov (2021), Freedman et al. (2022)
Visible inflammation	70–75	25–30	~60	Vorobyov et al. (2019), Polak et al. (2023), Freedman et al. (2022), Truchot et al. (2020)

Conventional management relies on topical corticosteroids, immunomodulators, and supportive emollients, requiring long-term adherence and periodic follow-up. Annual costs range from 150 to 600 \$, with cumulative expenses over time and risk of side effects.

500 to 1500 \$ per session, typically three to five sessions, but long-term benefits may offset these expenses by reducing recurrence, medication use, and medical visits. Economic analyses indicate superior cost-effectiveness and improved quality of life over a multi-year horizon.

Laser therapy entails higher initial costs, approximately

Table 3. *Comparison of the costs of the different types of treatment*

Type of Treatment	Estimated Annual Cost (USD)	Number of Visits / Sessions	Remarks
Topical corticosteroids (e.g., clobetasol 0.05%)	\$150 – \$600/year	Follow-up every 3–6 months	Generally covered; long-term use risks skin atrophy and tachyphylaxis
Immunomodulators (tacrolimus, pimecrolimus)	\$400 – \$1,200/year	Continuous application	Cost varies depending on insurance tier; variable efficacy
Laser Therapy – Fractional CO ₂	\$800 – \$2,500 per session → \$2,400 – \$7,500 per treatment cycle (3 sessions)	3–5 sessions spaced 4–6 weeks apart	Usually not covered; high upfront cost but long-lasting benefit
Laser Therapy – Er:YAG	\$700 – \$2,000 per session → \$2,100 – \$6,000 per treatment cycle	3–5 sessions	Slightly lower session cost than CO ₂ ; faster healing

Laser monotherapy achieves 60–80% symptom reduction with minimal side effects such as transient erythema or oedema. However, standardisation of parameters (fluence, pulse duration, session interval) remains lacking, and recurrence occurs in 10–30% of cases within a year.

Combination therapy leverages the rapid anti-inflammatory action of corticosteroids with the regenerative potential

of laser treatment. Clinical studies (Polak 2023; Ivanova & Petrov 2021; Freedman 2022) report faster symptom relief, enhanced elasticity, and modestly reduced recurrence rates.

This strategy appears promising for optimising both inflammation control and tissue restoration, while limiting cumulative steroid exposure.

Table 4. *Improvement of symptoms with laser-treatment alone or combined with topical steroids*

Criteria	Laser Only	Laser + Steroids
Pruritus control	Gradual (3–4 sessions)	Faster (steroid effect)
Fibrosis reduction	Excellent, esp. CO ₂	Comparable or slightly superior
Recurrence (12 mo)	10–30%	Slightly lower
Side effects	Erythema, oedema	Same + possible irritation
Strengths	Suitable for steroid-intolerant patients	Early inflammation control
Limitations	More sessions	Non-standardised timing/dose

LITERATURE REVIEW

The growing interest in the use of lasers for the treatment of vulvar lichen sclerosus (VLS) has led to an increasing number of clinical studies assessing their efficacy and safety. This literature review aims to analyse the main scientific publications on the subject, highlighting the clinical outcomes, the mechanisms of action described, and the limitations of the existing studies. The objective is to establish a solid scientific basis to justify the integration of laser therapies into the management of VLS and to identify future research perspectives.

Several clinical trials have been conducted to compare the efficacy of fractional CO₂, Er:YAG, and low-level laser therapy (LLLT) in the management of VLS. Overall, the results show an improvement in subjective symptoms (pruritus, pain, discomfort) as well as visible tissue regeneration demonstrated by imaging and histological analyses. Patients treated with fractional CO₂ laser showed a significant increase in epithelial thickness, improved vascularisation, and a histologically confirmed reduction in fibrosis. The Er:YAG laser, on the other hand, demonstrated better immediate tolerance, with a reduction in burning sensations and faster recovery, although its effectiveness on connective tissue reorganisation remains slightly lower than that of the CO₂ laser.

Clinical studies have also compared the effectiveness of laser treatment with that of standard corticosteroid therapy. The results demonstrated a more durable improvement with laser therapy, particularly in terms of recurrence reduction and decreased need for continuous treatment. However, the studies vary regarding the duration of the observed effects, with some suggesting the

need for long-term follow-up to confirm the sustainability of the achieved benefits.

Ferrari et al. (2021) conducted a retrospective study on 28 patients treated with the Er:YAG laser, demonstrating a marked reduction in pruritus and dyspareunia, with minimal side effects (transient erythema). Bianchi and Lorusso (2022) reported a prospective study involving 35 patients treated with fractional CO₂ laser combined with platelet-rich plasma (PRP) injection. The authors highlighted a clear reduction in fibrosis and an improvement in sexual function, while stressing the importance of rigorous follow-up to maintain the long-term benefits. Vorobyov et al. (2019) described a fractional CO₂ laser treatment protocol in 24 patients, showing a significant decrease in inflammation (assessed by biopsy) and a low recurrence rate after twelve months. Ivanova and Petrov (2021) reported that combining Er:YAG laser therapy with immunomodulatory ointments made it possible to reduce the required drug dosage and improve functional recovery (reduction of pruritus, better elasticity). Zimmer et al. (2022) explored photobiomodulation in the treatment of chronic pain related to VLS, observing a statistically significant improvement in pain and quality-of-life scores. Truchot et al. (2020) reported a significant improvement in pruritus (average reduction of 75%), a decrease in local erythema, and better tissue elasticity at three months. Biopsies performed in ten patients at six months revealed a reduction in subepithelial fibrosis and a more homogeneous remodelling of the dermal matrix. Marchand et al. (2021), in their retrospective study on the contribution of the Er:YAG laser in 20 patients with moderate VLS, demonstrated relief of pruritus and dyspareunia in 80% of cases. The authors also emphasised

the good tolerance of the laser, with only transient erythema and limited discomfort during the procedure. Bonnet-Duquennoy et al. (2022) published an overview in the *Revue Française de Gynécologie Obstétrique* on laser treatments for VLS, stressing the importance of precise clinical evaluation prior to initiating therapy and long-term follow-up to detect early recurrences. They also emphasised the need to clarify optimal parameters (fluence, pulse duration, fractional or ablative-fractional mode) to standardise protocols. Finally, Lecron et al. (2022), in a survey conducted among several French-speaking university hospitals, highlighted significant variability in practice concerning laser settings (CO₂ or Er:YAG) and the number of prescribed sessions.

Nevertheless, the short-term patient satisfaction rate (three to six months) was generally high (>80%), suggesting a clear clinical relevance of these treatments.

FUTURE PERSPECTIVES AND INNOVATIONS

Combining laser treatment with regenerative modalities such as platelet-rich plasma (PRP) or mesenchymal stem-cell-derived exosomes may enhance fibroblast activation, collagen synthesis, and immune regulation. Such integrative approaches could accelerate healing, reduce recurrence, and improve the overall quality of

tissue repair.

Ex vivo tissue models enable detailed study of laser-tissue interactions, improving understanding of energy delivery and biological effects. Artificial intelligence and machine learning are increasingly applied to medical imaging to predict treatment outcomes based on histological and morphological patterns, paving the way for personalised, data-driven therapeutic strategies.

Future progress requires standardised, multicentre protocols defining optimal laser settings, number of sessions, and combination regimens. Incorporating biomarkers into pre-treatment evaluation could allow adaptation of parameters to individual tissue phenotypes, ensuring both safety and maximal efficacy.

STUDY LIMITATIONS

Current research is limited by the small size and heterogeneity of study populations, variable laser settings, and inconsistent evaluation criteria. Objective measurements of histological change are seldom used, and long-term data beyond twelve months are lacking. Larger multicentre randomised controlled trials with harmonised protocols are required to establish robust clinical guidelines.

Table 5. Summary of Main Clinical Studies Evaluating Laser Therapy for Vulvar Lichen Sclerosus

Reference	Language	Type of Laser	Number of Patients	Clinical Outcomes	Adverse Effects
Stewart et al. (2021)	English	Fractional CO ₂	50	↓ Pruritus, trophic improvement	Temporary redness and oedema
Kofler et al. (2023)	English	Er:YAG	35	↓ Atrophic lesions, ↑ tissue elasticity	Local sensitivity
Marzec et al. (2023)	English	Fractional CO ₂	20	↓ Fibrosis, ↑ vascularisation	Transient hyperpigmentation
Gómez-Friero et al. (2019)	English	Er:YAG / LLLT	28	Good epithelial regeneration, ↓ pain	Mild irritation
Ferrari et al. (2021)	Italian	Er:YAG	28	↓ Pruritus, ↓ dyspareunia, few adverse effects	Transient redness
Bianchi & Lorusso (2022)	Italian	Fractional CO ₂ + PRP	35	↓ Fibrosis, improved sexual function	Temporary local redness
Vorobyov et al. (2019)	Russian	Fractional CO ₂	24	↓ Inflammation (biopsies), low recurrence rate < 12 months	Temporary erythema and oedema
Ivanova & Petrov (2021)	Russian	Er:YAG + topical agents	30	↓ Need for immunomodulators, faster functional recovery	Mild burning sensation
Hirsch et al. (2021)	English	LLLT	25	↓ Neuropathic pain, modulation of inflammation	No major adverse reactions

CONCLUSIONS

The integration of laser technologies into the therapeutic arsenal for vulvar lichen sclerosis represents a major advance, offering a durable and effective alternative to conventional regimens.

Fractional CO₂ and Er:YAG lasers demonstrate strong potential for reversing histopathological damage and improving function and comfort. Combining laser therapy with regenerative or anti-inflammatory modalities could further enhance outcomes while reducing corticosteroid dependency.

Standardisation of parameters and implementation of personalised, biomarker-guided protocols will be essential to optimise results. The future of VLS management lies in combined, adaptive, and evidence-based approaches that not only restore tissue integrity but also elevate the overall standard of vulvar health care.

Conflicts of interest

The author declares that there are no conflicts of interest.

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Availability of data and materials

Not applicable.

Ethics approval

This type of study is exempt from ethical approval.

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