Journal of Lasers in Medical Sciences

J Lasers Med Sci. 2025;16:e9

Original Article

http://journals.sbmu.ac.ir/jlms

doi 10.34172/jlms.2025.09

Pulsed Dye, Fractional CO2, and Nd:YAG Lasers: A Comprehensive Evaluation in the Management of Nail Psoriasis

Amirhossein Rahimnia[1,2], Amirhoushang Ehsani[1,2], Nafiseh Esmaeili[1,2], Zeinab Aryanian[1], Zahra Razavi[1,2], Mina Koohian Mohammadabadi[3], Ala Ehsani[4,5*]

[1]Autoimmune Bullous Diseases Research Center, Razi Hospital, Tehran University of Medical Sciences, Tehran, Iran
[2]Department of Dermatology, Razi Hospital, Tehran University of Medical Sciences, Tehran, Iran
[3]Department of Medicine, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
[4]Skin Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[5]Student Research Committee, Faculty of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran

***Correspondence to**
Ala Ehsani,
Email: ehsani.ala83@gmail.com

Received: January 11, 2025
Accepted: March 11, 2025
ePublished: April 21, 2025

Abstract

Introduction: Nail psoriasis poses a notable challenge due to its significant impact on patient's quality of life and its resistance to traditional treatments. Recent interest has focused on laser therapies, which offer targeted treatment by addressing the underlying inflammatory processes of the disease. This study evaluated the effectiveness and safety of pulsed dye laser (PDL), fractional CO2 laser, and Nd:YAG (neodymium-doped yttrium aluminum garnet) laser for nail psoriasis.

Methods: In this randomized clinical trial, 40 patients with mild to moderate bilateral nail psoriasis were enrolled at Razi hospital. The participants were divided into four groups: Nd:YAG laser, PDL, fractional CO2 laser, and a control group treated with calcipotriol/betamethasone ointment. Each received four treatment sessions over four months. The Nail Psoriasis Severity Index (NAPSI) was used to evaluate effectiveness, while pain and satisfaction were assessed using the visual analog scale (VAS). Statistical significance was determined, with $P<0.05$ as the threshold.

Results: The study found that PDL achieved the highest reduction in NAPSI scores, with a significant 62.4% decrease, followed by a 54.6% decrease with the fractional CO2 laser. In contrast, the Nd:YAG laser achieved a less notable 32.4% improvement, while the ointment control group showed a 15.9% decrease. Pain was least reported in the PDL group, and satisfaction scores were highest among these patients. The PDL and fractional CO2 lasers outperformed both the Nd:YAG laser and the topical therapy in effectiveness and patient comfort.

Conclusion: PDL and fractional CO2 laser treatments are superior interventions for managing nail psoriasis, providing a significant improvement in NAPSI scores and better patient experiences compared to the Nd:YAG laser and topical ointment. These findings endorse the inclusion of laser therapy in management plans for nail psoriasis, suggesting further research into optimizing their use and potential combination with other therapies.

Trial Registration: https://irct.behdasht.gov.ir/; identifier: IRCT20220723055530N4.

Keywords: Psoriasis; Laser therapy; Topical administration; Treatment outcome; Adverse effects.

Introduction

Nail psoriasis affects 25%–50% of psoriasis patients, with severity often increasing in those with an early start or a positive family history.[1] It serves as a risk factor for psoriatic arthritis, as up to 70% of PsA patients present with nail changes.[2] The psychosocial burden is significant; over 90% of plaque-type psoriasis patients with nail involvement report distress due to the visible and unsightly appearance of their nails, impacting their quality of life.[3] A strong correlation between the Dermatology Life Quality Index (DLQI) and the Nail Psoriasis Severity Index (NAPSI) underscores the importance of monitoring both metrics in affected patients.[4]

Nail psoriasis manifests as matrix changes (e.g., pitting, leukonychia, red spots in the lunula, nail plate crumbling) or bed changes (e.g., oil drop discoloration, onycholysis, subungual hyperkeratosis, splinter hemorrhages).[1] Severe cases often require a personalized therapeutic approach.[5,6] Topical treatments include corticosteroids, vitamin D3 analogs, tazarotene, calcineurin inhibitors, anthralin, and intralesional steroids, but their efficacy is often limited, necessitating systemic treatments like methotrexate, cyclosporine, or retinoids, and in severe cases, biologics such as anti-TNF-α and anti-IL-17 agents.[6]

Please cite this article as follows: Rahimnia A, Ehsani A, Esmaeili N, Aryanian Z, Razavi Z, Koohian Mohammadabadi M, et al. Pulsed dye, fractional CO2, and Nd:YAG lasers: a comprehensive evaluation in the management of nail psoriasis. *J Lasers Med Sci.* 2025;16:e9. doi:10.34172/jlms.2025.09.

Laser therapies, increasingly used for nail psoriasis, offer a relatively safe and effective option, either alone or in combination with other treatments.[7] Vascular lasers like pulsed dye laser (PDL) target abnormal microcirculation, reducing psoriatic lesions.[8] Studies indicate that PDL is particularly effective in treating onycholysis and subungual hyperkeratosis.[9] Nd:YAG (neodymium-doped yttrium aluminum garnet) lasers, with deeper penetration compared to PDL, and fractional CO2 lasers, which enhance drug delivery through the nail plate, have also shown promise in reducing NAPSI scores.[10-12]

The unique wavelength and chromophore target of each laser system determine its penetration depth and therapeutic potential. PDL (595 nm) targets oxyhemoglobin and penetrates 1.25 mm, while Nd:YAG (1064 nm) reaches up to 4 mm, affecting deeper dermal structures.[12] Comparative studies have shown no significant differences in therapeutic outcomes between PDL and Nd:YAG lasers when combined with topical therapies.[7]

Excimer lasers, though FDA-approved for psoriasis since 2000, are less effective for nail psoriasis due to limited UVB penetration through the nail plate.[13] Fractional CO2 lasers, particularly when combined with topical therapies, improve drug delivery and demonstrate efficacy in both matrix and bed changes, making them a valuable alternative.[10,11]

Despite limited studies, laser systems remain an attractive, non-invasive treatment option due to their efficacy and safety. This study aimed to compare the efficacy and safety of PDL, Nd:YAG, and fractional CO2 lasers against conventional topical therapy with betamethasone/calcipotriol ointment.

Methods and Materials

Study Design

This randomized clinical trial was conducted on 40 patients attending the dermatology clinic at Razi hospital, Tehran University of Medical Sciences, between 2023 and 2024. Patients with Fitzpatrick skin types II–IV, aged 18–65 years, diagnosed with psoriasis, including nail involvement, were recruited. Psoriasis diagnosis was based on recognized clinical features (erythematous papules and plaques with silvery scales involving nails) confirmed by two dermatologists.

Sample Size Calculation Method

Due to the absence of similar studies, the correlation between repeated measurements was assumed to be 0.2, and the expected effect size was set at 1.4 ($\Delta = 1.4$). Additionally, considering a type I error (α) of 0.05 and a power ($1-\beta$) of 0.80, the minimum required sample size for each group was estimated to be 10 participants.

The sample size was calculated using the following formula:

$$n = R\left[\left(1+\frac{1}{\gamma}\right)^2 \frac{\left(Z_{1-\alpha/2}+Z_{1-\beta}\right)^2}{\Delta^2} + \frac{Z_{1-\alpha/2}^2}{4}\right]$$

This estimation ensures adequate statistical power for detecting meaningful differences across treatment groups.

Inclusion and Exclusion Criteria

Eligible participants were adults aged 18 to 65 years who voluntarily signed informed consent forms, adhered to study protocols, and demonstrated willingness and compliance for follow-up visits. Patients included in the study had bilateral nail involvement in mild to moderate psoriasis and negative smear and culture results for onychomycosis. Patients were excluded if they were pregnant, breastfeeding, or had used topical or systemic psoriasis treatments within the previous three months. Additional exclusion criteria included severe psoriasis requiring systemic therapy, psoriatic arthritis needing systemic treatment, erythrodermic, pustular, or drug-induced psoriasis, active bacterial or viral infections in the treatment area, a history of skin cancers, photosensitivity, uncontrolled systemic diseases, seizure history, hypertrophic scars or keloids, subungual hematomas, nevi, or nail trauma within the past three months.

Patient Evaluation

Demographic data, including age, gender, and Fitzpatrick skin type, were recorded. A comprehensive medical history was taken, and all the patients underwent a detailed dermatological examination. The severity of nail involvement was assessed using the Overall NAPSI Scale, Nail Matrix NAPSI, and Nail Bed NAPSI for all affected nails. The patients were divided into four groups (n = 10 each) via block randomization to receive one of the following treatments:

1. Nd:YAG 1064-nm laser (Elite Plus, Cynosure® Inc., Westford, USA).
2. PDL (V-beam, Perfecta- Candela® Laser Corporation, Wayland, MA, USA).
3. Fractional CO2 Laser (EdgeONE®, Jeysis Medical Inc., Seoul, South Korea).
4. Control group - calcipotriol/betamethasone dipropionate ointment (Tehran Chemie Pharmaceutical, Tehran, Iran).

Treatment Protocol

Laser treatment was performed in 4 sessions, each 4 weeks apart.

For the Nd:YAG 1064-nm Laser, using the Elite Plus device from Cynosure® Inc., Westford, USA, the parameters included an energy of 20 J/cm², a pulse duration of 10 ms, and a spot size of 5 mm, with continuous cold air cooling. The technique involved two passes of the laser across the nail matrix, lateral folds, and nail bed with 10%–20% overlap.

PDL treatment was carried out with the V-beam Perfecta from Candela® Laser Corporation, Wayland, MA, USA. The parameters for PDL were a pulse duration of 6 ms, a spot size of 10 mm, and an energy of 6 J/cm², using the Dynamic Cooling Device (DCD) to enhance patient comfort and minimize epidermal damage. The DCD system delivered a precise cryogen spray (30 ms spray duration with a 20 ms delay) prior to each laser pulse, providing effective cooling of the treated area. The technique was the same as Nd:YAG, involving two passes of the laser across the nail matrix, lateral folds, and nail bed with 10–20% overlap.

Fractional CO2 Laser treatments, performed using the EdgeONE® from Jeysis Medical Inc., Seoul, South Korea, involved the following parameters: 40 mJ pulse energy, 20 W power, 2 ms pulse duration, density of 2.9% (256 dots/cm²), spot size of 1 cm², and a stack of 3-5. The laser beam was targeted specifically to the nail plate.

Post-treatment care included ice packs, application of broad-spectrum sunscreen (SPF ≥ 50), and adherence to protective measures for three months. Clinical evaluations were performed at baseline, before each laser session, and 3 months after the final session (to account for full nail growth following laser therapy). Nail severity was reassessed using the NAPSI scales, and photographic documentation with a DSLR camera was obtained. The patients were asked to complete the visual analog scale (VAS) (0–10) to evaluate their perceived improvement and pain immediately after each laser session. Adverse events, including pain, periungual atrophy, and nail deformities, were documented.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics, Version 28 (IBM Corp., Armonk, NY, USA). Descriptive statistics summarized categorical data as frequencies and percentages and continuous data as means with standard deviations or medians with interquartile ranges, as appropriate. The Kolmogorov-Smirnov test assessed the normality of data distribution. Group comparisons used the chi-square test for categorical variables and the independent samples *t* test or Mann-Whitney U test for continuous variables, depending on data distribution. For within-group comparisons, the paired *t* test or Wilcoxon test was applied. Multiple group comparisons over time were conducted using repeated measures ANOVA or the Friedman test, with Bonferroni post hoc tests for significant differences. Non-parametric data were analyzed using the Kruskal-Wallis test. Adverse events were evaluated descriptively to assess the safety profiles of the treatment modalities. A threshold of 0.05 was used to determine statistical significance for *P* values.

Results

Forty patients (198 fingernails), comprising 22 males and 18 females, entered the study. The participants' ages ranged from 19 to 63 years, with a mean age of 40.1 years (SD = 11.8). The duration of psoriasis varied from 1 to 25 years, with a mean of 8.6 years (SD = 6.7). Nail psoriasis duration ranged from 3 months to 12 years, with a mean duration of 3.2 years (SD = 2.8). Nine participants (22.5%) were cigarette smokers, and 11 (27.5%) had a family history of psoriasis. Skin type classification showed the majority had Fitzpatrick skin types III (60%), followed by types IV (25%) and II (15%). The average number of affected nails per patient was 4.95 (SD = 1.96). The distribution of patients among the different treatment groups was as follows: the Nd:YAG 1064-nm laser group consisted of 10 patients, with a total of 51 nails treated; the PDL group also included 10 patients and treated 47 nails; the fractional CO2 Laser group comprised 10 patients and treated 50 nails, while the control group, which used calcipotriol/betamethasone dipropionate ointment, included another 10 patients with 50 nails treated. No significant differences were found in baseline scores for Overall NAPSI, Nail Matrix NAPSI, or Nail Bed NAPSI between the treatment groups (Table 1).

Out of 40 patients, three withdrew: one from the fractional CO2 laser group due to pain, one from the betamethasone/calcipotriol group due to lack of improvement, and one from the Nd:YAG laser group due to worsened skin condition, requiring systemic medication. None experienced side effects from the laser treatments.

NAPSI Score and Components for Each Laser Treatment

Pulsed Dye Laser

At baseline, the mean Overall NAPSI score for the PDL group was 22.1 (SD = 6.0). Nail Matrix NAPSI scores at baseline averaged 10.8 (SD = 3.2), while Nail Bed NAPSI scores averaged 11.3 (SD = 3.1). Assessments demonstrated progressive reductions, with mean Overall NAPSI scores of 18.0 (SD = 5.2) after the first month, 14.0 (SD = 4.8) after the second month, 10.5 (SD = 4.2) after the third month, and 8.3 (SD = 3.8) after the fourth month, reflecting a 62.4% decrease ($P < 0.001$). At 3 months post-treatment, the mean Overall NAPSI score was 9.2 (SD = 3.9), showing a slight worsening compared to the fourth month, but this change was not statistically significant ($P = 0.085$).

Nail Bed NAPSI scores decreased significantly starting from the second month, with a score of 4.2 (SD = 2.3) at month four, reflecting a 62.8% reduction ($P < 0.001$). Nail Matrix NAPSI scores began to decrease from the first month, with a score of 4.1 (SD = 2.2) after the fourth month, reflecting a 62.0% reduction ($P < 0.001$; Figure 1)

Fractional CO2 Laser

The baseline mean Overall NAPSI score for the fractional CO2 Laser group was 21.6 (SD = 6.2). Nail Matrix NAPSI scores at baseline averaged 10.7 (SD = 3.1), while Nail

Table 1. Baseline Nail Psoriasis Severity Index Score

NAPSI Score	PDL	Nd:YAG Laser	Fractional CO2 Laser	Control Group	*P* Value
Nail Matrix	10.8 ± 3.2	10.9 ± 3	10.7 ± 3.1	10.9 ± 3.3	0.81
Nail Bed	11.3 ± 3.1	11 ± 3.2	10.9 ± 3	11.1 ± 3.4	0.77
Overall	22.1 ± 6	21.9 ± 5.8	21.6 ± 6.2	22 ± 5.7	0.74

NAPSI, Nail Psoriasis Severity Index; PDL, pulsed dye laser; Nd:YAG, neodymium-doped yttrium aluminum garnet.

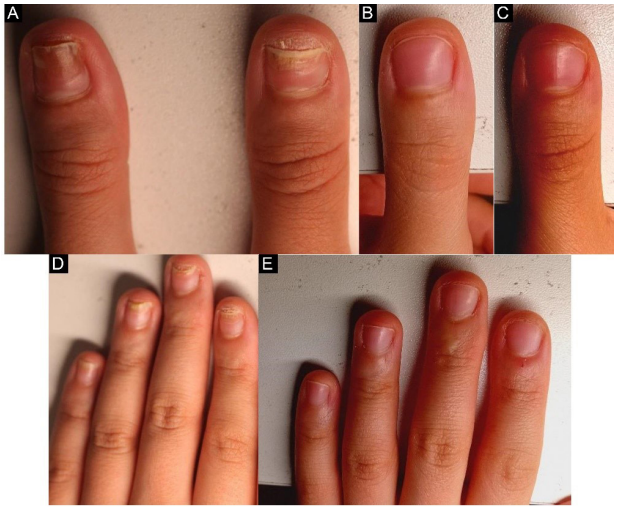

Figure 1. Pulsed Dye Laser Treatment Outcomes. (A) Bilateral thumbs prior to PDL treatment, (B) Left thumb after laser intervention, (C) Right thumb after laser intervention, (D) Left hand before undergoing laser therapy, and E. Left hand following PDL treatment

Bed NAPSI scores averaged 10.9 (SD = 3.0). Reductions were noted throughout the study, with mean Overall NAPSI scores of 19.0 (SD = 5.7) after the first month, 16.8 (SD = 5.4) after the second month, 14.2 (SD = 5.2) after the third month, and 11.8 (SD = 4.9) after the fourth month, reflecting a 54.6% decrease from baseline ($P < 0.001$). At 3 months post-treatment, the mean Overall NAPSI score was 11.5 (SD = 4.8), showing a slight improvement compared to the fourth month, but this change was not statistically significant ($P = 0.09$).

Nail Bed NAPSI scores decreased significantly starting from the first month, with a 50.5% reduction in the fourth month ($P < 0.001$). Nail Matrix NAPSI scores also showed progressive reductions, reflecting a 53.3% decrease ($P < 0.001$; Figure 2).

Nd:YAG Laser

In the Nd:YAG laser group, the baseline mean Overall NAPSI score was 21.9 (SD = 5.8). A gradual reduction in this score was observed, reaching 18.5 (SD = 5.8) at two months, 16.2 (SD = 5) at three months, and 14.8 (SD = 4.7) by month four. Despite this reduction, the trend was not statistically significant ($P > 0.05$). Three months post-treatment, the mean score was 14.2 (SD = 4.6), indicating a minimal, non-significant improvement, with a total reduction of 32.4% by month four.

The baseline Nail Bed NAPSI score was 11.0 (SD = 3.2), and the Nail Matrix NAPSI score was 10.9 (SD = 3.0).

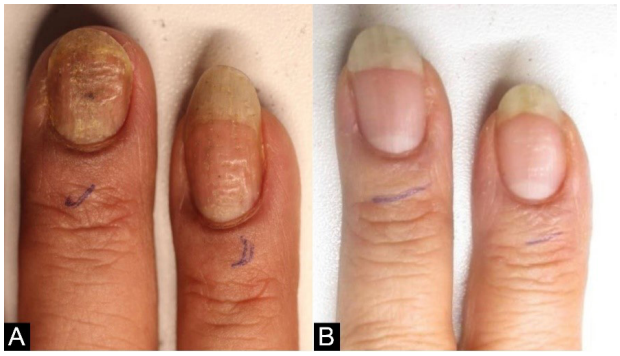

Figure 2. CO2 Fractional Laser Treatment Outcomes. (A) Left index and middle fingers prior to laser treatment, and (B) Left index and middle fingers after laser intervention

Changes in Nail Bed NAPSI began at month two, but the reduction by month four and the slight increase observed at three months (7.4, SD = 2.9) were not statistically significant ($P > 0.05$). The total reduction in Nail Bed NAPSI was 34.5%. Similarly, Nail Matrix NAPSI scores started decreasing by month two, but the reduction to 6.8 (SD = 2.6) by month four was also not significant ($P > 0.05$), resulting in a 37.6% total reduction by month four.

Control Group - Calcipotriol/Betamethasone Dipropionate Ointment

In the control group, the mean baseline Overall NAPSI score was 22.0 (SD = 5.7). Minor reductions in the Overall NAPSI score were observed starting from the third month, with scores of 22.0 (SD = 5.7) at month one, 21.9 (SD = 5.6) at month two, 19.6 (SD = 5.3) at month three, and 18.5 (SD = 5.1) at month four. The total reduction from baseline to month four was 15.9%, but this change was not statistically significant ($P > 0.05$). At three months post-treatment, the mean Overall NAPSI score was 18.0 (SD = 5.0), showing a minimal, non-significant improvement ($P = 0.250$).

For the Nail Bed NAPSI, the mean baseline score was 11.1 (SD = 3.4), with a slight reduction observed by month four, approximately 17.18%. This change was also not statistically significant ($P = 0.220$). Similarly, Nail Matrix NAPSI scores, which started decreasing at month three (baseline mean: 10.9, SD = 3.3), showed a reduction of about 17.4% by month four, but this was not statistically significant ($P = 0.220$; Figures 3 and 4).

Statistical Comparisons Between Groups

In this study, statistical comparisons between groups

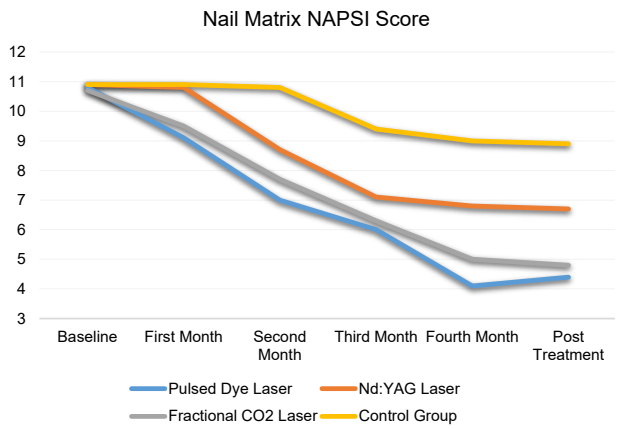

Figure 3. Nail Matrix NAPSI Score

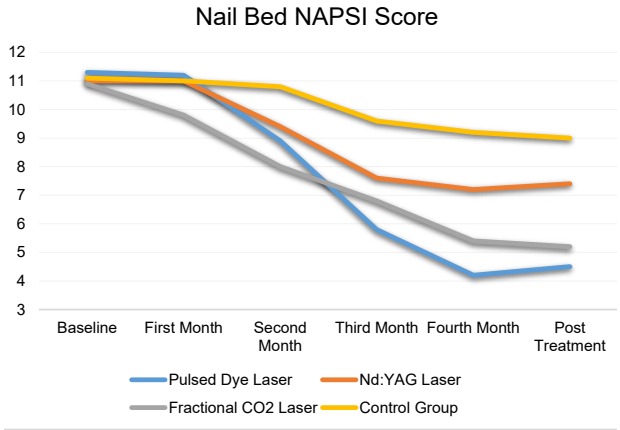

Figure 4. Nail Bed NAPSI Score

indicated that both the PDL and fractional CO2 Laser treatments were significantly more effective in reducing NAPSI scores compared to the Nd:YAG laser and the control group using calcipotriol/betamethasone dipropionate ointment, with *P* values of $P < 0.05$ for both lasers.

The PDL group showed a 62.4% reduction in Overall NAPSI scores by the fourth month, while the fractional CO2 group exhibited a 54.6% decrease, both achieving statistical significance ($P < 0.001$).

The PDL group showed a significant reduction in NAPSI scores when compared to the Nd:YAG laser ($P = 0.04$) and the control group using the ointment ($P = 0.03$). These p-values suggest that PDL was significantly more effective than both the Nd:YAG laser and the topical ointment.

Similarly, the fractional CO2 laser was significantly more effective than both the Nd:YAG laser ($P = 0.02$) and the control group using the ointment ($P = 0.01$), with these comparisons showing statistically significant differences.

However, when comparing PDL with fractional CO2 lasers, the difference in effectiveness was minimal, with a *P* value of 0.09, indicating no statistically significant difference between the two treatments. This suggests that while both laser treatments showed substantial reductions in NAPSI scores, their effectiveness was comparable, and the observed difference was not large enough to reach statistical significance.

On the other hand, the Nd:YAG laser and the topical ointment showed only slight improvements in NAPSI scores, which were not statistically significant, with *P* values greater than 0.05 ($P > 0.05$).

Visual Analog Scale Assessments

Patients' perceptions of pain and treatment outcomes were evaluated using the VAS, where patients rated their pain and perceived improvement on a scale from 0 to 10. Pain levels during the treatment sessions were highest for the Nd:YAG laser group, with a median VAS score of approximately 6.34/10. This was followed by the fractional CO2 laser group, which reported a median VAS score of 5.75/10, indicating moderate discomfort. The lowest pain levels were recorded in the PDL group, where patients had a median VAS score of 4.13/10, suggesting relatively less discomfort during the treatment process.

Regarding treatment satisfaction and perceived improvement, the PDL group showed the highest level of improvement, with a median satisfaction score of 6.89/10. The fractional CO2 laser group followed closely, with a median improvement score of 6.47/10. Patients in the Nd:YAG laser group reported less perceived improvement, with a median score of 4.25/10, indicating that this treatment was less effective in their view. The control group, which was treated with Calcipotriol/Betamethasone, had the lowest reported satisfaction, with a median score of 3.54/10.

Adverse Events

All treatments were well-tolerated. The most commonly reported adverse events included mild pain during laser application (35%), transient periungual erythema (22.5%), and temporary nail discoloration (10%). Adverse events, such as purpura and localized pain, were typically resolved 10 days post-treatment. Management strategies included the use of cold compresses to alleviate pain and erythema, and the patients were advised to avoid trauma to the affected area during recovery. No long-term adverse effects, including nail deformities or scarring, were reported during the study duration.

Discussion

Nail psoriasis is a chronic, often difficult-to-manage condition that can significantly impact a patient's quality of life due to its unsightly nature and associated discomfort.[14] The primary clinical manifestations of nail psoriasis include pitting, onycholysis, subungual hyperkeratosis, and sometimes discoloration. These changes not only affect the aesthetics of the nails but also lead to functional impairment and psychological distress, contributing to the considerable burden faced by patients.[15] Moreover, these symptoms often coexist with

other forms of psoriasis, particularly plaque psoriasis, which can complicate treatment.[16]

In recent years, significant advancements have been made in the treatment options for nail psoriasis. Traditionally, topical therapies such as corticosteroids, vitamin D analogs, and tars have been the mainstay of treatment. However, many patients do not achieve satisfactory results with these therapies, especially when the condition is severe or resistant to standard treatments.[17] Consequently, laser treatments have gained popularity due to their targeted action and the growing body of evidence supporting their efficacy in managing nail psoriasis.[1,2]

Laser therapy for nail psoriasis primarily aims at reducing inflammation, promoting healing, and restoring nail integrity.[18] The three laser modalities most commonly used for nail psoriasis include PDL, fractional CO2 laser, and Nd:YAG laser. Each of these lasers operates through different mechanisms and offers varying degrees of efficacy and safety.[11]

The PDL emerged as the most effective treatment option, with a 62.4% reduction in the NAPSI in the study. PDL works by selectively targeting the vascular components of the skin, particularly the abnormal blood vessels associated with psoriasis. This modality uses a yellow light (585–595 nm) to penetrate the skin and coagulate blood vessels, leading to a reduction in the inflammatory response.[19] As inflammation is a key pathological aspect of nail psoriasis, this laser effectively diminishes the inflammatory cycle, thereby improving the overall health of the nail.[20]

PDL has been shown to modulate cutaneous vascular abnormalities, which are central to the pathogenesis of psoriasis.[9] Psoriatic nails often exhibit changes in microcirculation, and PDL's ability to selectively target these altered vessels allows for the reduction of inflammation and the regression of psoriatic lesions.[21] Moreover, the high efficacy of PDL in clinical practice is consistent with earlier studies that demonstrated its ability to achieve significant NAPSI reductions in both nail and skin psoriasis. A substantial advantage of PDL is its ability to treat localized psoriatic changes while minimizing systemic side effects.[8,22]

The fractional CO2 laser, which demonstrated a 54.6% reduction in NAPSI scores in the study, represents an effective tool for dermal remodeling. This laser works by creating microthermal zones within the skin, which induce healing through controlled thermal injury to the dermis.[23] These microthermal zones promote collagen production and tissue remodeling, leading to the resolution of psoriatic plaques.[24] In the context of nail psoriasis, the fractional CO2 laser's ability to target both the superficial epidermis and deeper dermal layers is advantageous, as it stimulates healing and encourages the resolution of psoriatic manifestations both at the cutaneous surface and subungually.[25]

The mechanism of fractional CO2 laser treatment, which involves fractional ablation, is particularly useful for patients with extensive nail involvement. By stimulating the dermis and the underlying nail matrix, it facilitates the regeneration of healthy tissue while simultaneously reducing the severity of inflammation and hyperkeratosis.[10] This treatment also helps in reducing subungual hyperkeratosis, a common symptom of nail psoriasis.[10] While slightly less effective than PDL, the fractional CO2 laser remains an essential modality in the management of nail psoriasis, especially for those with more widespread disease.

The Nd:YAG laser, with a 32.4% reduction in NAPSI, demonstrated the lowest efficacy of the three modalities in this study. This laser operates at a wavelength of 1064 nm, which allows it to penetrate deeper layers of the skin compared to PDL and CO2 lasers. As a result, it can target deeper dermal layers and may be more effective in treating psoriasis that affects the deeper regions of the skin.[26] However, the lower NAPSI reduction observed with the Nd:YAG laser suggests that it may be less effective in treating the superficial manifestations of nail psoriasis, such as pitting and onycholysis.

Despite its lower efficacy in this context, the Nd:YAG laser holds potential when used in combination with other modalities. Its deeper penetration could provide complementary benefits when treating more complex or resistant cases of nail psoriasis. The ability of Nd:YAG to treat deeper layers may also be beneficial in cases where other therapies fail to address the underlying vascular or dermal issues.[27,28] However, the efficacy of Nd:YAG laser treatments could likely be optimized with adjustments to treatment parameters, including energy settings and treatment intervals, to increase its effectiveness in managing nail psoriasis.

A critical component of the success of any dermatological treatment is patient satisfaction, which is often influenced by both the effectiveness and the tolerability of the therapy. Among the three laser modalities examined, the PDL received the highest patient satisfaction ratings, primarily due to its relatively low pain levels during treatment. Pain management is a significant concern when treating chronic conditions like nail psoriasis, where long-term adherence to therapy is required. The study highlighted that PDL's ability to provide substantial therapeutic benefits with minimal pain makes it more acceptable to patients.[7] This aligns with other findings in the literature, which emphasize the importance of pain reduction in improving patient compliance.[29]

The fractional CO2 and Nd:YAG lasers, while still effective, tend to cause more discomfort during treatment, which may discourage some patients from pursuing these therapies, particularly over extended treatment periods. Managing pain effectively not only improves

the patient experience but also plays a crucial role in ensuring consistent treatment adherence, which is vital for the long-term management of chronic dermatologic conditions like psoriasis.[26-28,30]

The safety profiles of all three laser treatments were favorable, with mild and transient side effects reported. Erythema, hyperpigmentation, and mild edema were the most common adverse effects, and these were typically resolved within a few hours to days following the treatment. Such side effects are consistent with the existing literature, which indicates that laser therapies for psoriasis generally carry a low risk of serious long-term complications.[11,29,31]

Compared to traditional systemic therapies, which often involve significant side effects such as immunosuppression or gastrointestinal disturbances,[32] laser treatments present a safer alternative, especially for patients who are hesitant to pursue more aggressive treatments due to concerns about adverse effects. Laser therapies, by targeting the affected tissues with precision, minimize systemic exposure and significantly reduce the risk of side effects, making them a particularly attractive option for patients with localized or resistant forms of psoriasis.[33]

The main limitation of this study is the small sample size (n = 40), which may affect the generalizability of the results. Larger studies are needed to confirm our findings and allow for more detailed subgroup analyses. Additionally, the relatively short follow-up period (three months post-treatment) limits our ability to assess the long-term efficacy of laser therapy, highlighting the need for extended follow-up studies. While NAPSI scoring was used as an objective measure, incorporating histological, dermoscopic or sonographic evaluations could provide deeper insights into the treatment effects.

Looking ahead, future research should explore the combination of laser treatments with systemic therapies or biologic agents to enhance treatment outcomes, particularly in patients with severe or persistent forms of psoriasis. As personalized treatment becomes more prevalent, it will be important to consider both the severity of the disease and the unique characteristics of each patient. Further studies should also focus on refining laser parameters—such as pulse duration, energy levels, and treatment intervals—to improve efficacy and patient comfort. These advancements could help develop more targeted and less painful treatment protocols, thereby optimizing the clinical management of nail psoriasis.

This study highlights the critical role of personalized treatment strategies in managing nail psoriasis, emphasizing that while PDL proved to be the most effective treatment for the majority of patients, an individualized approach is necessary. For patients with more severe or deeper nail involvement, a combination of Nd:YAG and PDL or fractional CO2 lasers may offer better outcomes. The study also calls for further research to optimize laser treatment parameters, taking into account factors such as disease severity, skin type, and pain tolerance. The integration of laser therapies, especially vascular-targeted treatments like PDL, is crucial in addressing the inflammation and abnormal blood vessels central to nail psoriasis, making these lasers suitable as frontline options for resistant cases.

Conclusion

The results from this study provide compelling evidence for the efficacy and safety of laser treatments, particularly PDL and fractional CO2 lasers, in managing nail psoriasis. These therapies, through their unique mechanisms of action, offer significant benefits over traditional treatments, including high efficacy, minimal side effects, and improved patient satisfaction. Moving forward, personalized care, optimized treatment regimens, and the exploration of combination therapies will likely enhance the role of lasers in the comprehensive management of nail psoriasis.

Acknowledgments

We would like to express our deepest gratitude to the Autoimmune Bullous Diseases Research Center and the Laser Center of Razi Hospital, Tehran University of Medical Sciences, for their invaluable support, resources, and expertise throughout this research. We also extend our thanks to the dedicated staff and patients at Razi Hospital, whose contributions were instrumental to the success of this study.

Authors' Contribution

Conceptualization: Amirhoushang Ehsani, Nafiseh Esmaeili, Amirhossein Rahimnia.
Data curation: Amirhossein Rahimnia, Zeinab Aryanian, Zahra Razavi, Mina Koohian Mohammadabadi.
Formal analysis: Mina Koohian Mohammadabadi, Ala Ehsani, Zeinab Aryanian, Zahra Razavi.
Investigation: Amirhossein Rahimnia, Zahra Razavi, Ala Ehsani, Zeinab Aryanian.
Methodology: Amirhoushang Ehsani and Amirhossein Rahimnia.
Project administration: Amirhoushang Ehsani, Nafiseh Esmaeili, Amirhossein Rahimnia
Resources: Amirhoushang Ehsani, Nafiseh Esmaeili.
Supervision: Amirhoushang Ehsani, Nafiseh Esmaeili.
Validation: Zahra Razavi, Zeinab Aryanian.
Visualization: Ala Ehsani, Mina Koohian Mohammadabadi.
Writing–original draft: Amirhossein Rahimnia, Mina Koohian Mohammadabadi, Ala Ehsani.
Writing–review & editing: Amirhossein Rahimnia, Amirhoushang Ehsani, Nafiseh Esmaeili.

Competing Interests

There are no competing interests.

Ethical Approval

This study adhered to the principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of Tehran University of Medical Sciences under the approval ID: IR.TUMS.MEDICINE.REC.1402.710. All participants provided written informed consent after receiving a comprehensive explanation of the study's objectives, procedures, potential risks,

and benefits. Participation was voluntary, and the patients were allowed to withdraw at any stage without affecting their future medical care. Additionally, the trial was registered in the Iranian Registry of Clinical Trials (IRCT) with the registration number IRCT20220723055530N4.

Funding
The authors received no financial support for the research, authorship, and/or publication of this article.

References

1. Griffiths CE, Barker J, Bleiker TO, Chalmers R, Creamer D. Rook's Textbook of Dermatology. 9th ed. Wiley-Blackwell; 2016.
2. Oram Y, Akkaya AD. Treatment of nail psoriasis: common concepts and new trends. Dermatol Res Pract. 2013;2013:180496. doi: 10.1155/2013/180496.
3. Choi JW, Kim BR, Seo E, Youn SW. Identification of nail features associated with psoriasis severity. J Dermatol. 2017;44(2):147-53. doi: 10.1111/1346-8138.13565.
4. Prevezas C, Katoulis AC, Papadavid E, Panagakis P, Rigopoulos D. Short-term correlation of the Psoriasis Area Severity Index, the Nail Psoriasis Area Severity Index, and the Dermatology Life Quality Index, before and after treatment, in patients with skin and nail psoriasis. Skin Appendage Disord. 2019;5(6):344-9. doi: 10.1159/000499348.
5. Bardazzi F, Starace M, Bruni F, Magnano M, Piraccini BM, Alessandrini A. Nail psoriasis: an updated review and expert opinion on available treatments, including biologics. Acta Derm Venereol. 2019;99(6):516-23. doi: 10.2340/00015555-3098.
6. Rendon A, Schäkel K. Psoriasis pathogenesis and treatment. Int J Mol Sci. 2019;20(6):1475. doi: 10.3390/ijms20061475.
7. Arango-Duque LC, Roncero-Riesco M, Usero Bárcena T, Palacios Álvarez I, Fernández López E. Treatment of nail psoriasis with pulsed dye laser plus calcipotriol betametasona gel vs. Nd:YAG plus calcipotriol betamethasone gel: an intrapatient left-to-right controlled study. Actas Dermosifiliogr. 2017;108(2):140-4. doi: 10.1016/j.ad.2016.09.009.
8. Hern S, Stanton AW, Mellor RH, Harland CC, Levick JR, Mortimer PS. In vivo quantification of the structural abnormalities in psoriatic microvessels before and after pulsed dye laser treatment. Br J Dermatol. 2005;152(3):505-11. doi: 10.1111/j.1365-2133.2005.06435.x.
9. Yin N, Choudhary S, Nouri K. Pulsed dye laser for the treatment of nail psoriasis. Cutis. 2013;92(3):129-35.
10. El Sharkawy DA, El-Komy MH, Sobhi RM, Abdel Raouf NM, Fahim A. Fractional CO2 laser versus fractional CO2 laser plus betamethasone/calcipotriol ointment in the treatment of nail psoriasis. Dermatol Surg. 2023;49(6):570-4. doi: 10.1097/dss.0000000000003791.
11. Jaalouk D, Algarin YA, Pulumati A, Humeda J, Nouri K. Lasers for the treatment of nail psoriasis: a systematic review. Int J Dermatol. 2024;63(11):1484-94. doi: 10.1111/ijd.17304.
12. Meesters AA, Pitassi LH, Campos V, Wolkerstorfer A, Dierickx CC. Transcutaneous laser treatment of leg veins. Lasers Med Sci. 2014;29(2):481-92. doi: 10.1007/s10103-013-1483-2.
13. Al-Mutairi N, Noor T, Al-Haddad A. Single blinded left-to-right comparison study of excimer laser versus pulsed dye laser for the treatment of nail psoriasis. Dermatol Ther (Heidelb). 2014;4(2):197-205. doi: 10.1007/s13555-014-0057-y.
14. Gupta AK, Cooper EA. Psoriatic nail disease: quality of life and treatment. J Cutan Med Surg. 2009;13 Suppl 2:S102-6. doi: 10.2310/7750.2009.00027.
15. Canal-García E, Bosch-Amate X, Belinchón I, Puig L. Nail psoriasis. Actas Dermosifiliogr. 2022;113(5):481-90. doi: 10.1016/j.ad.2022.01.006.
16. Crowley JJ. Challenges in psoriasis treatment: nail, scalp, and palmoplantar involvement. In: Weinberg JM, Lebwohl M, eds. Advances in Psoriasis: A Multisystemic Guide. Cham: Springer; 2021. p. 343-62. doi: 10.1007/978-3-030-54859-9_26.
17. Grinnell M, Bonomo L, Rabach M. Nail psoriasis: a review of treatment options. J Psoriasis Psoriatic Arthritis. 2017;2(4):85-91. doi: 10.1177/2475530317002004O4.
18. Wiznia LE, Quatrano NA, Mu EW, Rieder EA. A clinical review of laser and light therapy for nail psoriasis and onychomycosis. Dermatol Surg. 2017;43(2):161-72. doi: 10.1097/dss.0000000000000841.
19. Elwan NM, Gheida SF, Hawwam SA, Ahmed AH. Evaluation of the effect of pulsed dye laser on chronic psoriatic plaque. J Dermatolog Treat. 2018;29(8):786-91. doi: 10.1080/09546634.2018.1466025.
20. Peruzzo J, Garbin GC, Maldonado G, Cestari TF. Nail psoriasis treated with pulsed dye laser. An Bras Dermatol. 2017;92(6):885-7. doi: 10.1590/abd1806-4841.20175918.
21. Treewittayapoom C, Singvahanont P, Chanprapaph K, Haneke E. The effect of different pulse durations in the treatment of nail psoriasis with 595-nm pulsed dye laser: a randomized, double-blind, intrapatient left-to-right study. J Am Acad Dermatol. 2012;66(5):807-12. doi: 10.1016/j.jaad.2011.12.015.
22. Oram Y, Karincaoğlu Y, Koyuncu E, Kaharaman F. Pulsed dye laser in the treatment of nail psoriasis. Dermatol Surg. 2010;36(3):377-81. doi: 10.1111/j.1524-4725.2009.01448.x.
23. Sanad EM, El-Esawy FM, Hassan ME. The efficacy of fractional CO2 laser in treatment of post acne scars. Benha J Appl Sci. 2022;7(5):101-5. doi: 10.21608/bjas.2022.244600.
24. Alora MB, Anderson RR, Quinn TR, Taylor CR. CO2 laser resurfacing of psoriatic plaques: a pilot study. Lasers Surg Med. 1998;22(3):165-70. doi: 10.1002/(sici)1096-9101(1998)22:3<165::aid-lsm4>3.0.co;2-n.
25. Afify AA, Shaheen MA, El-Banna MG. Fractional CO2 laser in the treatment of nail psoriasis: how can it help? Arch Dermatol Res. 2023;315(6):1705-15. doi: 10.1007/s00403-023-02574-w.
26. Hesham Ali Elwan Y, Abdel Azim A, Starace M, Shawky Abd Elhafiz H. Nd:YAG laser in the treatment of nail psoriasis: clinical and dermoscopic assessment. Dermatol Pract Concept. 2021;11(2):e2021140. doi: 10.5826/dpc.1102a140.
27. Khashaba SA, Gamil H, Salah R, Salah E. Efficacy of long-pulsed Nd-YAG laser in the treatment of nail psoriasis: a clinical and dermoscopic evaluation. J Dermatolog Treat. 2021;32(4):446-52. doi: 10.1080/09546634.2019.1668908.
28. Kartal SP, Canpolat F, Gonul M, Ergin C, Gencturk Z. Long-pulsed Nd:YAG laser treatment for nail psoriasis. Dermatol Surg. 2018;44(2):227-33. doi: 10.1097/dss.0000000000001294.
29. Shehadeh W, Matz H, Ellenbogen E, Sprecher E, Artzi O. Pulse-dye laser followed by betamethasone-calcipotriol and fractional ablative CO2-laser-assisted delivery for nail psoriasis. Dermatol Surg. 2021;47(4):e111-6. doi: 10.1097/dss.0000000000002835.
30. Alakad R, Nassar A, Atef H, Eldeeb F. Fractional CO2 laser-assisted delivery versus intralesional injection of methotrexate in psoriatic nails. Dermatol Surg. 2022;48(5):539-44. doi: 10.1097/dss.0000000000003418.

31. Chandrashekar BS, Madura C, Shenoy C, Chandar A, Roopa MS, Narayana NL. Laser treatment in nail disorders: a comprehensive review. Indian Dermatol Online J. 2025;16(1):59-71. doi: 10.4103/idoj.idoj_776_24.
32. Bacigalupi RM, Boh E. Traditional systemic therapy I: methotrexate and cyclosporine. In: Weinberg JM, Lebwohl M, eds. Advances in Psoriasis: A Multisystemic Guide. London: Springer; 2014. p. 117-30. doi: 10.1007/978-1-4471-4432-8_10.
33. Thibodeaux Q, Koo J. Laser therapy in psoriasis. In: Weinberg JM, Lebwohl M, eds. Advances in Psoriasis: A Multisystemic Guide. Cham: Springer; 2021. p. 93-101. doi: 10.1007/978-3-030-54859-9_8.