

Comparative Clinical Outcomes of Fractional CO₂ Laser-Assisted Topical Therapy for Nail Psoriasis: A Systematic Review

Review began 10/12/2026

Review ended 10/19/2026

Published 10/24/2026

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DOI: 10.7759/cureus.118505

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Abstract

Fractional carbon dioxide (FCO₂) laser-assisted topical therapy has been investigated to enhance drug delivery in nail psoriasis, but improvement from baseline does not establish whether laser pretreatment provides additional clinical benefit. This systematic review evaluated the comparative efficacy, safety, tolerability, and durability of FCO₂-assisted topical therapy. PubMed/MEDLINE, Scopus, and Web of Science were searched from inception through September 18, 2026. Comparative controlled studies were eligible, and risk of bias was assessed using the Cochrane RoB 2 tool. Five studies involving 134 participants were included. Three compared FCO₂-assisted topical therapy with the same topical agent alone, one compared two FCO₂-assisted topical regimens, and one compared laser-assisted topical corticosteroid therapy with intralesional corticosteroid treatment. Although nail severity improved over time across studies, direct comparative effects were inconsistent and varied by topical agent, comparator, and assessment time. Between-treatment advantages were observed in selected tazarotene and methotrexate comparisons, whereas other comparisons showed no clear incremental benefit. Laser-assisted corticosteroid treatment achieved broadly comparable short-term outcomes to intralesional therapy with less procedural pain and greater patient satisfaction. Four of five principal efficacy results were at high risk of bias, and one raised some concerns. Meta-analysis was not appropriate because of substantial heterogeneity. Current evidence does not establish a consistent incremental efficacy advantage of laser assistance. More rigorous, adequately powered trials with appropriate paired analyses and standardized follow-up are needed before routine adjunctive use can be recommended.

Categories: Dermatology

Keywords: fractional co2 laser, laser-assisted drug delivery, nail psoriasis, systematic review, topical therapy

Introduction And Background

Nail involvement affects approximately 50% to 79% of patients with cutaneous psoriasis and up to 80% of those with psoriatic arthritis [1]. Its clinical impact extends beyond visible dystrophy, with pain, impaired dexterity, difficulty with routine activities, and cosmetic and social concerns contributing to a measurable reduction in health-related quality of life; patients with nail involvement report greater impairment than those with psoriasis without nail disease [2]. Nail disease is also closely associated with psoriatic arthritis; in a large cross-sectional analysis, nail involvement was the strongest clinical predictor of concomitant psoriatic arthritis [3].

Management is challenging because the therapeutic target lies beneath a dense keratinized nail plate, nail growth is slow, and treatment choice must account for the number of affected nails, matrix or bed involvement, concomitant skin or joint disease, and treatment burden [4]. Topical and injectable therapies are generally used for limited nail disease, whereas systemic treatment is considered for more extensive, resistant, or clinically burdensome involvement, particularly when accompanied by cutaneous psoriasis or psoriatic arthritis [4]. Even when local therapy is appropriate, poor transungual penetration can restrict drug delivery to the nail bed and matrix [4,5].

Ablative fractional laser-assisted drug delivery has been developed to address this barrier: fractional carbon dioxide (FCO₂) laser creates microscopic ablation channels that increase tissue permeability and can enhance uptake of subsequently applied topical agents [5]. Experimental work in ex vivo nail tissue has shown that FCO₂ laser microporation increases penetration of a topically applied fluorescent compound through multiple layers of both healthy and mycotic nail plates, providing a mechanistic basis for transungual drug delivery [6].

Clinical studies have consequently evaluated FCO₂ laser before several topical therapies [7]. A previous

How to cite this article

Mubarah T M, Salham Alnuaimi N, Alameer G A, et al. (October 24, 2026) Comparative Clinical Outcomes of Fractional CO₂ Laser-Assisted Topical Therapy for Nail Psoriasis: A Systematic Review. Cureus 18(10): e118505. DOI 10.7759/cureus.118505

systematic review concluded that ablative CO₂-assisted topical treatment appeared effective and generally well tolerated, but also emphasized substantial variation in treatment protocols and outcome assessment [7]. The central interpretive problem is that improvement from baseline after a laser-assisted regimen does not establish the incremental benefit of laser pretreatment [8]. In randomized studies, separate within-group comparisons against baseline can be misleading when the clinically relevant inference depends on the direct difference between treatment conditions [8]. This distinction is particularly important when topical agents, comparators, severity indices, treatment schedules, and follow-up times differ across studies [7,8].

This systematic review therefore aimed to critically synthesize the comparative clinical evidence for FCO₂ laser-assisted topical therapy in nail psoriasis, prioritizing between-treatment over within-group effects while also examining safety, tolerability, durability of response, and methodological limitations.

Review

Methods

Study Design and Reporting Standards

This systematic review evaluated comparative controlled studies of FCO₂ laser-assisted topical therapy for nail psoriasis in which treatment allocation was reported as random. Parallel-group and within-participant designs, including nail-level, hand-level, and side-level allocation, were eligible. The review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [9]. This review was not registered, and no formal protocol was prepared. The comparator restrictions were not documented in a prospective protocol or registration record.

Literature Search Strategy

PubMed/MEDLINE, Scopus, and Web of Science were searched from database inception through September 18, 2026. The search combined terms describing nail psoriasis with terms identifying fractional carbon dioxide laser therapy, ablative fractional laser treatment, laser microoperation, and laser-assisted or trans ungual drug delivery. Terminological variants were incorporated to account for differences in indexing and terminology across databases. The search was not restricted by the topical pharmacologic agent delivered.

Reference lists of included studies and relevant reviews were additionally screened for potentially eligible reports. Duplicate records were removed before screening. Search syntax was adapted to the indexing structure of each database, as detailed in Table 1.

Database	Search strategy	Coverage and search date
PubMed/MEDLINE	("nail psoriasis"[Title/Abstract] OR "psoriatic nail"[Title/Abstract] OR "psoriatic nails"[Title/Abstract] OR "psoriatic nail disease"[Title/Abstract] OR (nail*[Title/Abstract] AND psoria*[Title/Abstract])) AND ("fractional CO2"[Title/Abstract] OR "fractional carbon dioxide"[Title/Abstract] OR "CO2 laser" [Title/Abstract] OR "carbon dioxide laser"[Title/Abstract] OR "fractional laser"[Title/Abstract] OR "ablative fractional laser"[Title/Abstract] OR microporation[Title/Abstract] OR "laser-assisted drug delivery" [Title/Abstract] OR "laser assisted drug delivery"[Title/Abstract] OR "transungual delivery" [Title/Abstract])	Database inception to September 18, 2026
Scopus	TITLE-ABS-KEY(("nail psoriasis" OR "psoriatic nail" OR "psoriatic nails" OR "psoriatic nail disease" OR (nail* AND psoria*)) AND ("fractional CO2" OR "fractional carbon dioxide" OR "CO2 laser" OR "carbon dioxide laser" OR "fractional laser" OR "ablative fractional laser" OR microporation OR "laser-assisted drug delivery" OR "laser assisted drug delivery" OR "transungual delivery"))	Database inception to September 18, 2026
Web of Science	TS=(("nail psoriasis" OR "psoriatic nail" OR "psoriatic nails" OR "psoriatic nail disease" OR (nail* AND psoria*)) AND ("fractional CO2" OR "fractional carbon dioxide" OR "CO2 laser" OR "carbon dioxide laser" OR "fractional laser" OR "ablative fractional laser" OR microporation OR "laser-assisted drug delivery" OR "laser assisted drug delivery" OR "transungual delivery"))	Database inception to September 18, 2026
Additional searching	Reference lists of included studies and relevant reviews were screened manually for additional potentially eligible comparative studies.	Completed September 18, 2026

TABLE 1: Database search strategies

Eligibility Criteria

Eligibility was defined according to the Population, Intervention, Comparator, Outcomes, and Study design framework. Studies were eligible when they enrolled individuals with fingernail and/or toenail psoriasis and evaluated FCO₂ laser-assisted delivery of a topical pharmacologic agent using a concurrent comparative treatment condition.

Eligible comparators were restricted to the same topical treatment without laser assistance, an alternative topical pharmacologic regimen delivered after the same FCO₂ laser procedure, or intralesional corticosteroid therapy. These comparisons addressed distinct questions and were synthesized separately; only comparisons against the same topical treatment alone directly evaluated the incremental contribution of laser pretreatment. Studies comparing an FCO₂-assisted topical regimen with FCO₂ laser monotherapy were excluded because they primarily evaluated the added contribution of the topical agent. Intralesional corticosteroids were retained to compare local corticosteroid-based treatment strategies using laser-assisted topical delivery or intralesional administration. Intralesional non-corticosteroid comparators were excluded because they introduced differences in both active drug class and administration route beyond this defined comparison. These restrictions limit the scope of the review and do not imply that excluded treatments are ineffective or clinically unimportant.

The principal outcome for comparative synthesis was the between-treatment difference in overall nail-psoriasis severity measured using the Nail Psoriasis Severity Index (NAPSI), modified NAPSI (mNAPSI), Nijmegen-Nail Psoriasis Activity Index Tool (N-NAIL), or another defined clinical nail-severity measure. Where a registered or author-designated primary assessment time point was identifiable, that result was prioritized; otherwise, the final eligible assessment was used.

Secondary outcomes included nail-matrix and nail-bed scores, individual nail signs, dermoscopic findings, optical coherence tomography findings, histopathological outcomes, patient-reported improvement, satisfaction, quality of life, procedural pain, adverse events, treatment withdrawal, and post-treatment durability or recurrence.

Non-comparative studies, uncontrolled studies, observational reports without an eligible concurrent comparator, case reports, case series, reviews, protocols without results, conference abstracts without sufficient full-text outcome data, duplicate or overlapping reports, and studies without separately

extractable nail-psoriasis outcomes were excluded. The eligibility criteria are summarized in Table 2.

PICOS element	Inclusion criteria	Exclusion criteria
Population	Individuals with fingernail and/or toenail psoriasis	Non-psoriatic nail disorders or psoriatic nail findings that could not be extracted separately
Intervention	FCO ₂ laser-assisted delivery of a topical pharmacologic treatment for nail psoriasis	Interventions not directed at nail psoriasis or multimodal laser regimens in which the independent contribution of FCO ₂ -assisted topical therapy could not be isolated
Comparator	Same topical treatment without FCO ₂ assistance; another topical pharmacologic regimen delivered after the same FCO ₂ procedure; or intralesional corticosteroid therapy.	FCO ₂ laser monotherapy as the comparator; intralesional non-corticosteroid therapy; or no concurrent comparator.
Outcomes	At least one extractable comparative NAPSI, mNAPSI, N-NAIL, or other defined clinical nail-severity outcome	No extractable comparative nail-severity outcome
Study design	Comparative controlled study using participant-, hand-, side-, or nail-level allocation reported as random	Non-comparative or uncontrolled studies, observational studies without an eligible comparator, case reports, case series, reviews, protocols without results, or conference abstracts without sufficient full-text data

TABLE 2: Study eligibility criteria according to the PICOS framework

FCO₂, fractional carbon dioxide laser; mNAPSI, modified Nail Psoriasis Severity Index; NAPSI, Nail Psoriasis Severity Index; N-NAIL, Nijmegen-Nail Psoriasis Activity Index Tool; PICOS, Population, Intervention, Comparator, Outcomes, and Study.

Study Selection

Two reviewers independently performed title/abstract screening, full-text eligibility assessment, data extraction, and risk-of-bias assessment. Disagreements were resolved through discussion until consensus was reached. Following duplicate removal, titles and abstracts were screened against the predefined eligibility criteria. Potentially eligible reports underwent full-text assessment. Reasons for exclusion at the full-text stage were documented according to prespecified eligibility categories. Reports describing the same or overlapping study population were evaluated together to prevent duplicate inclusion. Study selection was documented using a PRISMA 2020 flow diagram [9].

Data Extraction

Data were extracted using a standardized form. Extracted variables included study design, country, allocation unit, randomization and masking procedures, sample size, participant characteristics, number of treated nails, intervention and comparator regimens, topical agent and formulation, FCO₂ device and treatment parameters, number and interval of treatment sessions, treatment duration, outcome instruments, assessment time points, duration of follow-up, participant attrition, adverse events, and patient-reported outcomes.

Post-treatment values, changes from baseline, and percentage reductions were extracted as reported together with available measures of dispersion, confidence intervals, and comparative P-values. These measures were recorded separately and were not treated as interchangeable. Total, nail-matrix, and nail-bed severity scores were extracted separately when reported. Missing numerical values were not imputed.

Comparative between-treatment findings were prioritized over within-treatment changes from baseline. Within-group improvement alone was not interpreted as evidence of comparative effectiveness. In within-participant studies, results were attributed to an intervention only when treatment-specific hand-, side-, or nail-level data were available. Participant-level outcomes that could not be attributed to either treatment condition were summarized descriptively.

Internal inconsistencies in source reports, including discrepancies in denominators, outcome values, or P values, were documented rather than resolved by assumption. Where narrative findings conflicted with corresponding numerical tables, the treatment-specific tabulated result was prioritized when it provided the clearer comparative estimate, and the inconsistency was disclosed.

Risk-of-Bias Assessment

Risk of bias was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool [10], targeting the effect of assignment to intervention. The assessment focused on the principal comparative efficacy result contributed by each trial to the synthesis. When more than one eligible nail-severity result was reported, the registered or author-designated primary outcome at the principal assessment time point was identified as the principal result. Additional eligible results were assessed separately when relevant to the synthesis.

The five RoB 2 domains were evaluated: bias arising from the randomization process; bias due to deviations from intended interventions; bias due to missing outcome data; bias in measurement of the outcome; and bias in selection of the reported result. Domain-level and overall judgments were classified as low risk, some concerns, or high risk according to the RoB 2 decision framework.

For within-participant studies, allocation of nails, hands, or treatment sides, potential differential deviations, missing participants, possible treatment contamination, assessor masking, and the paired nature of observations were considered within the relevant domains. Statistical analyses that did not account for paired or clustered observations were regarded primarily as unit-of-analysis limitations affecting precision and statistical inference rather than, by themselves, evidence of bias due to deviations from intended interventions. Domain-level and overall judgments for the principal efficacy results were summarized in a traffic-light plot.

Data Synthesis and Statistical Analysis

Meta-analysis was not performed because the included studies differed substantially in topical agents, comparator regimens, allocation units, laser parameters, treatment schedules, clinical outcome instruments, effect measures, and assessment times. Most comparisons were represented by a single small study, and between-treatment findings were frequently reported without corresponding effect estimates and confidence intervals.

Four studies used within-participant allocation at the nail, hand, or side level, but none reported the variance of the within-participant treatment difference or the correlation between paired measurements. Consequently, the available data did not support a reliable pooled paired-effect estimate. Findings were therefore synthesized narratively according to comparator type. Comparisons of FCO₂-assisted topical therapy with the same topical treatment alone were considered separately from comparisons of different FCO₂-assisted topical regimens and comparisons with intralesional therapy. Comparative between-arm, between-hand, between-side, or between-nail findings were prioritized over within-group changes.

The direction and magnitude of comparative effects were described using reported endpoint values, changes from baseline, percentage reductions, measures of dispersion, confidence intervals, and P values where available. Statistical significance was not used alone to classify an intervention as effective or ineffective, and vote counting based solely on P values was avoided.

Dermoscopic, histopathological, imaging-based, safety, tolerability, and patient-reported outcomes were summarized descriptively because of differences in assessment instruments, definitions, denominators, and follow-up schedules. Statistical heterogeneity, meta-regression, funnel plots, and formal publication-bias testing were not undertaken because no meta-analysis was performed and the number of included studies was small.

Results

Study Selection

The database and citation searches identified 112 records. After removal of 22 duplicate records, 90 records underwent title and abstract screening, of which 68 were excluded. Twenty-two reports were sought for full-text retrieval; one potentially eligible report could not be retrieved. Twenty-one reports were assessed for eligibility, and 16 were excluded for prespecified reasons. Five comparative clinical studies were included in the systematic review and narrative synthesis (Figure 1).

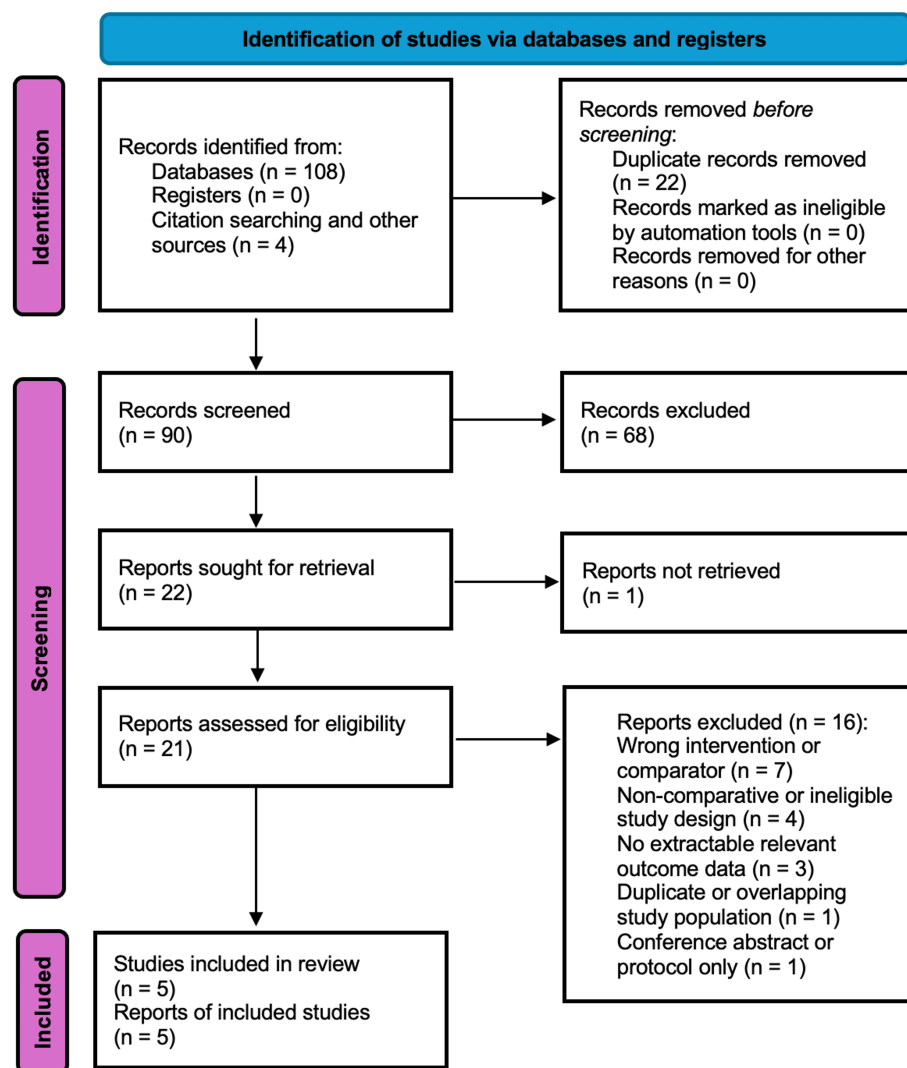


FIGURE 1: PRISMA 2020 flow diagram of the study selection process

The diagram summarizes study identification, screening, eligibility assessment, and inclusion in the systematic review, adapted from the PRISMA 2020 statement [9]. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Study Characteristics

Five comparative clinical studies published between 2022 and 2025 were included [11-15]. Across the five studies, 134 participants were enrolled or randomized, with individual study sample sizes ranging from 11 to 36. Four studies were conducted in Egypt [12-15], and one was conducted in Denmark [11]. Four studies used inpatient allocation at the nail, hand, or side level [11-14], whereas Nassar et al. [15] used patient-level parallel-group allocation.

Random allocation was reported in all five studies, although the methods used to generate the allocation sequence and ensure allocation concealment were incompletely reported in most studies. Ortner et al. [11] used an opaque envelope containing an even- or odd-number allocation code after ranking nails according to baseline N-NAIL score. Moftah et al. [13] used sealed-envelope allocation. Essa Abd Elazim et al. [12] and Nassar et al. [15] reported random allocation without further methodological details, whereas Afify et al. [14] stated that the treatment side was selected randomly. Blinded outcome assessment was reported for photograph-based NAPS scoring in Ortner et al. [11] and by two blinded dermatologists in Essa Abd Elazim et al. [12]. In the study by Ortner et al. [11], in-clinic N-NAIL assessment was unblinded. The blinded party was not specified in Nassar et al. [15], and assessor blinding was not reported in the study by Moftah et al. [13] or Afify et al. [14].

Ten of 11 participants completed the 24-week study period in the study by Ortner et al. [11]; one participant attended the end-of-trial visit at week 12 because biological treatment was required. Essa Abd Elazim et al.

[12] reported 27 completers among 32 enrolled participants, without reporting reasons for the five non-completions. Nassar et al. [15] reported 34 completers among 36 randomized participants; two participants withdrew from the intralesional injection group because of treatment-associated pain. Moftah et al. [13] reported 35 participants in the Methods and Results sections but 36 in the Abstract. Afify et al. [14] reported outcomes for 20 participants without a separate participant-flow statement.

All five studies evaluated FCO₂ laser-assisted topical drug delivery. The topical agents investigated were calcipotriol/betamethasone dipropionate (Cal/BD), tazarotene, methotrexate (MTX), and triamcinolone acetonide (TA) [11-15]. Clinical outcomes included NAPSI, mNAPSI, and N-NAIL. Dermoscopic outcomes were assessed in three studies [12,13,15], optical coherence tomography (OCT) was used by Ortner et al. [11], and histopathological assessment was performed in a subset of 16 participants in the study by Moftah et al. [13]. All five studies also reported patient-reported or patient-centered outcomes. Final assessments ranged from two months after treatment initiation in the study by Afify et al. [14] to three months after completion of a four-month treatment course in the study by Moftah et al. [13] (Table 3).

Study	Country and design	Participants and population	Intervention and comparator	Laser parameters and treatment schedule	Outcomes and follow-up
Ortner et al., 2022 [11]	Denmark; open-label randomized inpatient trial; nail-level allocation	n = 11; 10 completed 24 weeks; 144 nails, including 71 fingernails and 73 toenails; median age 52 years (IQR, 22); 27% female	FCO ₂ laser plus daily Cal/BD foam vs daily Cal/BD foam alone	DeepFX UltraPulse CO ₂ , 10,600 nm; 10% density; OCT-guided pulse energy; nail plate treated at baseline and nail folds at baseline, weeks 6 and 12; Cal/BD for 24 weeks	N-NAIL, photograph-based NAPSI, OCT, PROMs, and safety; assessments at weeks 6, 12, and 24
Essa Abd Elazim et al., 2022 [12]	Egypt; randomized single-blind inpatient left-to-right study; hand-level allocation	n = 32 enrolled; 27 completed; 22 male patients and five female patients among completers; mean age 45.19 ± 15.99 years; bilateral fingernail psoriasis	FCO ₂ laser plus tazarotene 0.1% gel vs tazarotene alone	Multixel FCO ₂ , 10,600 nm; 140 mJ; 150 spots/cm ² ; 2-3 passes; three sessions at 4-week intervals; tazarotene daily for 3 months	mNAPSI, dermoscopy, patient global assessment, and adverse events; assessments at months 1, 2, 3, and 6
Moftah et al., 2025 [13]	Egypt; randomized inpatient comparative study; hand-level sealed-envelope allocation	n = 35 in the Methods and Results; n = 36 in the Abstract; mean age 38.37 ± 12.94 years; 25 male patients and 10 female patients; bilateral fingernail psoriasis	FCO ₂ laser plus MTX 1% gel vs MTX 1% gel alone	SmartXide DOT; 15 W; dwell time 500 µs; spacing 700 µm; Smart Stack 3; monthly sessions for four months; MTX daily for four months	Total, matrix, and bed NAPSI; dermoscopy; histopathology in 16 participants; pain, erythema, and satisfaction; assessment at the end of treatment and three months after treatment
Afify et al., 2023 [14]	Egypt; comparative inpatient pilot study; treatment side selected randomly	n = 20; 78 nails, including 74 fingernails and four toenails; 40 MTX-treated and 38 Cal/BD-treated nails; mean age 40.30 ± 14.43 years; 13 females and 7 males	FCO ₂ laser plus topical MTX solution vs FCO ₂ laser plus Cal/BD	BISON Fire-Xel; one pass; MTX 0.1 mL of 25 mg/mL per affected nail or a fingertip amount of Cal/BD; four sessions at two-week intervals; topical agents applied after each session	NAPSI, adverse events, and satisfaction; assessments at months 1 and 2; no longer-term post-treatment assessment reported
Nassar et al., 2022 [15]	Egypt; randomized single-blind parallel-group study; patient-level allocation	n = 36 randomized; 34 completed; 16 injection-treated and 18 laser-treated participants; 78 injection-treated and 84 laser-treated fingernails; age range 13-61 years	FCO ₂ laser plus topical TA vs intralesional TA	SmartXide DOT C60; 10 W; stack 4; dwell time 500 µs; spacing 550 µm; single pass; topical TA 10 mg/mL, 0.1 mL/digit, or intralesional TA 0.02-0.05 mL at each of four injection points; six sessions at two-week intervals	Total, matrix, and bed NAPSI; dermoscopic scores; pain, satisfaction, and adverse events; assessments at weeks 6, 12, and 24

TABLE 3: Characteristics and treatment protocols of the included comparative clinical studies

Cal/BD, calcipotriol/betamethasone dipropionate; FCO₂, fractional carbon dioxide; IQR, interquartile range; MTX, methotrexate; N-NAIL, Nijmegen-Nail Psoriasis Activity Index Tool; NAPSI, Nail Psoriasis Severity Index; mNAPSI, modified Nail Psoriasis Severity Index; OCT, optical coherence tomography; PROMs, patient-reported outcome measures; TA, triamcinolone acetonide.

Clinical Outcomes and Durability of Response

Ortner et al. [11] randomized nails within participants to calcipotriol/betamethasone dipropionate (Cal/BD) foam with or without FCO₂ laser pretreatment. Of 11 enrolled participants, 10 completed 24 weeks, while one attended the end-of-trial visit at week 12 because biological treatment was required. At week 24, the reported reduction in median unblinded, in-clinic N-NAIL score was 85% with laser-assisted treatment and 66% with Cal/BD alone (P=0.62). The corresponding reductions in blinded, photograph-based NAPSI scores were 78% and 58%, respectively (P=0.45). OCT findings also showed no significant between-treatment difference at the end of the trial (P=0.888). Because Cal/BD treatment continued throughout the 24-week study period, durability after treatment withdrawal could not be assessed.

Essa Abd Elazim et al. [12] randomized hands to FCO₂ laser plus tazarotene 0.1% gel or tazarotene alone; 27 of 32 enrolled participants completed the study. Total, matrix, and bed mNAPSI scores decreased in both treatment hands at three and six months. Statistically significant between-hand differences in total and

matrix mNAPSI were reported from month one ($P=0.043$ and $P=0.008$, respectively), whereas the difference in bed mNAPSI was reported as significant at month six ($P=0.001$). At month six, mean total mNAPSI was 13.15 ± 7.77 in the combination hand and 16.52 ± 7.60 in the tazarotene-only hand ($P=0.001$). Mean percentage reductions were greater with combination therapy for total mNAPSI (48.15% vs 31.48% ; $P<0.001$), matrix mNAPSI (61.57% vs 47.75% ; $P=0.024$), and bed mNAPSI (33.73% vs 9.61% ; $P=0.001$). The source table contained misaligned between-hand P -values, which were interpreted sequentially and corroborated against the corresponding comparisons in the source abstract where available. Assignments dependent on column order alone remain uncertain; the affected P -values should therefore be interpreted cautiously and should not determine the comparative conclusion. Dermoscopic improvement in onycholysis was reported in 22 of 25 cases in the combination hand and 16 of 25 in the tazarotene-only hand; no between-hand statistical comparison was reported for these dermoscopic findings. As topical treatment lasted three months, the month-six assessment represented a three-month post-treatment follow-up.

Moftah et al. [13] allocated hands by sealed envelope to FCO₂ laser plus MTX 1% gel or MTX 1% gel alone. The Abstract reported 36 participants, whereas the Methods and Results reported 35; therefore, the analyzed denominator of 35 was retained. Mean NAPSI decreased from 24.71 ± 11.01 to 9.60 ± 5.56 in the combination hand and from 23.26 ± 11.18 to 11.74 ± 6.55 in the monotherapy hand after four months of treatment, with no significant between-hand difference in absolute NAPSI at that assessment ($P=0.234$). The mean percentage reduction was greater with combination therapy (59.96% vs 49.53% ; $P=0.003$ in the source table). Three months after treatment completion, mean NAPSI was 2.57 ± 4.92 versus 4.80 ± 4.78 ($P=0.001$), and mean percentage reductions from baseline were 90.99% versus 79.36% ($P=0.001$). Matrix and bed NAPSI scores also differed significantly between hands at this assessment ($P<0.001$ and $P=0.005$, respectively), whereas no significant between-hand differences were reported at the end of treatment ($P=0.206$ and $P=0.217$). Three months after treatment, nail-level dermoscopic analysis involving 124 nails per group showed greater improvement with laser assistance in pitting (85.8% vs 67.9% ; $P=0.001$), fuzzy lunula (98.4% vs 88.5% ; $P=0.032$), and subungual hyperkeratosis (96.4% vs 77.6% ; $P=0.001$). In the histopathological subset of 16 participants, percentage reductions in nail-plate thickness and subungual thickness were greater in the combination hand ($P=0.011$ and $P=0.012$, respectively), whereas absolute follow-up thicknesses did not differ significantly between treatments ($P=0.497$ and $P=0.084$). The source narrative reported $P=0.000$ for some comparisons that were reported differently in the corresponding tables; table values were retained in this review.

Across these three studies, statistically significant between-treatment differences were reported at month six by Essa Abd Elazim et al. [12] and three months after treatment completion by Moftah et al. [13], whereas Ortnier et al. [11] reported no significant between-treatment differences at week 24. The studies differed in topical agent, outcome measure, assessment timing, and statistical analysis.

Afify et al. [14] compared topical MTX with Cal/BD, with both regimens applied after the same FCO₂ laser procedure, in 20 participants involving 78 treated nails (40 MTX-treated and 38 Cal/BD-treated nails). Median total NAPSI decreased from 8 (IQR 3.5-13) to 1 (IQR 0-4) with MTX and from 6.5 (IQR 3.5-9) to 2 (IQR 0.5-3.5) with Cal/BD at two months. Both treatment sides showed significant within-side reductions at one and two months. No significant between-regimen differences were reported for total NAPSI at baseline, one month, or two months ($P=0.271$, $P=0.513$, and $P=0.647$, respectively), or for matrix or bed NAPSI at any assessment. Between-regimen values were taken from the source between-group table because the Cal/BD medians differed from those reported in the within-group table. Because both treatment sides received FCO₂ laser, this study did not evaluate the incremental effect of laser treatment. Follow-up ended two months after the first treatment session.

Nassar et al. [15] randomized 36 participants to FCO₂-assisted topical TA or intralesional TA, with 18 participants initially allocated to each group. Two participants withdrew from the intralesional injection group because of treatment-associated pain, leaving 18 laser-treated and 16 injection-treated participants. By week 12, median total NAPSI decreased from 13.5 to 5 with laser-assisted treatment and from 17.5 to 4 with intralesional injection. Median dermoscopic scores decreased from 18 to 6 and from 22.5 to 5, respectively, with significant within-group reductions in both groups ($P<0.001$). Baseline matrix NAPSI differed significantly between groups (median 10 in the injection group vs 2 in the laser group; $P=0.01$). At week 12, no significant between-group differences were reported for total NAPSI ($P=0.17$), matrix NAPSI ($P=0.12$), bed NAPSI ($P=0.59$), or dermoscopic score ($P=0.48$). The between-group dermoscopic score was significantly different at week six ($P=0.04$). Within each group, total NAPSI and dermoscopic scores did not differ significantly between weeks 12 and 24. However, week-24 numerical values, exact P -values, and between-group comparisons were not reported. The source Discussion stated that no relapse was observed at week 24, although supporting numerical data were not provided.

Overall, the included comparative studies demonstrated consistent within-group improvements following treatment, whereas statistically significant between-treatment differences were observed only in selected comparisons and varied according to the topical agent, outcome measure, and assessment time. The principal clinical outcomes across all treatment comparisons are summarized in Table 4.

Study	Comparison	Design/analysis unit	Outcome	Assessment	FCO ₂ -assisted regimen	Comparator	Statistical test	Test statistic	Between-group P-value
Ortner et al., 2022 [11]	FCO ₂ + Cal/BD vs Cal/BD alone	Randomized inpatient; nail-level allocation; 10/11 completed	Median N-NAIL reduction (%)	Week 24	85	66	Paired t-test; Bonferroni correction	Not reported	0.62
Ortner et al., 2022 [11]	FCO ₂ + Cal/BD vs Cal/BD alone	Randomized inpatient; nail-level allocation	Median NAPSI reduction (%)	Week 24	78	58	Paired t-test; Bonferroni correction	Not reported	0.45
Essa Abd Elazim et al., 2022 [12]	FCO ₂ + tazarotene 0.1% vs tazarotene alone	Randomized inpatient; hand-level allocation; 27/32 completed	Total mNAPSI (mean ± SD)	Month 6 (3 months post-treatment)	13.15 ± 7.77	16.52 ± 7.60	Not specified for this comparison	Not reported	0.001
Essa Abd Elazim et al., 2022 [12]	FCO ₂ + tazarotene 0.1% vs tazarotene alone	Randomized inpatient; hand-level allocation	Total mNAPSI reduction (%)	Month 6	48.15	31.48	Not specified for this comparison	Not reported	<0.001
Moftah et al., 2025 [13]	FCO ₂ + MTX 1% gel vs MTX 1% gel alone	Randomized inpatient; hand-level allocation	Total NAPSI (mean ± SD)	End of treatment	9.60 ± 5.56	11.74 ± 6.55	Mann–Whitney U test	Not reported	0.234
Moftah et al., 2025 [13]	FCO ₂ + MTX 1% gel vs MTX 1% gel alone	Randomized inpatient; hand-level allocation	Total NAPSI (mean ± SD)	3 months post-treatment	2.57 ± 4.92	4.80 ± 4.78	Mann–Whitney U test	Not reported	0.001
Afify et al., 2023 [14]	FCO ₂ + MTX vs FCO ₂ + Cal/BD	Comparative inpatient pilot study; 20 participants; 78 nails	Total NAPSI, median (IQR)	Month 2	1 (0–4)	2 (0.5–3.5)	Mann–Whitney U test	Z = −0.457	0.647
Nassar et al., 2022 [15]	FCO ₂ + topical TA vs intralesional TA	Randomized parallel-group; patient-level allocation; 34/36 completed	Total NAPSI, median (IQR)	Week 12	5 (5)	4 (4.75)	Mann–Whitney U test	Not reported	0.17
Nassar et al., 2022 [15]	FCO ₂ + topical TA vs intralesional TA	Randomized parallel-group; patient-level allocation	Total NAPSI / Dermoscopic score	Week 24	Not reported	Not reported	Not reported	Not reported	Not reported

TABLE 4: Principal clinical outcomes according to treatment comparison and assessment time

Cal/BD, calcipotriol/betamethasone dipropionate; FCO₂, fractional carbon dioxide laser; IQR, interquartile range; mNAPSI, modified Nail Psoriasis Severity Index; MTX, methotrexate; NAPSI, Nail Psoriasis Severity Index; N-NAIL, Nijmegen-Nail Psoriasis Activity Index Tool; NR, not reported; SD, standard deviation; TA, triamcinolone acetonide.

Safety, Tolerability, and Patient-Reported Outcomes

Adverse events were reported descriptively in all five studies. Ascertainment methods and reporting denominators varied across studies, and no trial reported serious adverse events separately.

In the study by Essa Abd Elazim et al. [12], all participants experienced transient mild-to-moderate pain during laser sessions (mean visual analog scale [VAS] score, 4.74 ± 2.07). Moftah et al. [13] reported minimal pain during treatment sessions in 20% of participants. In the study by Ortner et al. [11], painful sensations after laser treatment lasted less than 10 seconds, with median treatment-related discomfort scores of 3 at week 6 and 1 at week 24. In the study by Afify et al. [14], pain during treatment did not differ between treatment sides ($P=1.000$). In the study by Nassar et al. [15], two participants withdrew from the intralesional injection group because of treatment-associated pain. Among completers, pain severity differed significantly between treatment groups ($P=0.003$), with severe pain reported in 5 of 16 injection-treated participants and in none of the 18 laser-treated participants, whereas 7 of 18 laser-treated participants reported no pain.

Bleeding and periungual erythema occurred in two participants after laser treatment in the study by Essa Abd Elazim et al. [12], whereas no adverse effects were reported with topical tazarotene. Moftah et al. [13] reported transient erythema lasting 24–48 hours in 37.1% of participants after laser sessions. In the study by Ortner et al. [11], 2,073 of 2,176 smartphone images were suitable for safety assessment. Monitoring identified erythema (minimal, 44%; definite, 31%), swelling (28%), and crusting (27%). In-clinic adverse

events, each occurring in one participant, included acute paronychia, onychocryptosis, persistent post-laser erythema, transient application-site pain, proximal interphalangeal joint pain, and transient reduction in grip strength. In the study by Afify et al. [14], bleeding did not differ between treatment sides ($P=1.000$), whereas yellow nail discoloration lasting two days after each treatment session occurred in all MTX-treated nails and in none of the Cal/BD-treated nails ($P<0.001$). Nassar et al. [15] reported subungual hematoma in 3 of 16 injection-treated participants, Koebner phenomenon in 1 of 18 laser-treated participants, and paronychia in 2 of 18 laser-treated participants, with no significant between-group difference ($P=0.1$).

Patient-reported outcomes favored laser-assisted treatment in several studies. Essa Abd Elazim et al. [12] reported higher patient global assessment scores for the combination hand than for the tazarotene-only hand (7.33 ± 2.53 vs 5.59 ± 2.41 ; $P<0.001$). Moftah et al. [13] reported higher satisfaction scores for the laser-assisted hand than for the MTX-only hand (9.23 ± 1.17 vs 8.54 ± 1.24 ; $P=0.02$). In the study by Nassar et al. [15], 12 of 18 laser-treated participants and 3 of 16 injection-treated participants reported high satisfaction ($P=0.007$). Afify et al. [14] found no significant difference in satisfaction between MTX-treated and Cal/BD-treated sides ($P=0.980$). In the study by Ortnier et al. [11], the median modified Dermatology Life Quality Index decreased from 5 to 2, and patient-rated disease severity decreased from 7 to 2. Because both treatment regimens were administered within the same participant, these patient-level outcomes could not be attributed to either treatment arm individually. Safety, tolerability, and patient-reported outcomes across the included studies are summarized in Table 5.

Study	Safety denominator	Procedural pain or discomfort	Adverse events	Withdrawals due to adverse events	Patient-reported outcomes	Reported test statistic	P-value
Ortner et al., 2022 [11]	11 participants; 2,073/2,176 smartphone images suitable for safety assessment	Pain lasting <10 seconds after laser; median discomfort (0–10): 3 at week 6 and 1 at week 24	Erythema (minimal, 44%; definite, 31%), swelling (28%), and crusting (27%); acute paronychia, onychocryptosis, persistent post-laser erythema, transient application-site pain, proximal interphalangeal joint pain, and transient reduction in grip strength (one participant each)	Not reported	Median mDLQI decreased from 5 to 2; patient-rated disease severity decreased from 7 to 2; no treatment preference at week 24	Not reported	Not reported
Essa Abd Elazim et al., 2022 [12]	27 participants	Transient mild-to-moderate pain during laser sessions in all participants; VAS 4.74 ± 2.07	Bleeding and periungual erythema after laser in two participants; no adverse effects reported with topical tazarotene	Not reported	Patient global assessment: 7.33 ± 2.53 vs 5.59 ± 2.41	Not reported	Not reported
Moftah et al., 2025 [13]	35 participants	Minimal pain during treatment sessions in 20%	Transient erythema in 37.1% following laser treatment	Not reported	Satisfaction (VAS 0–10): 9.23 ± 1.17 vs 8.54 ± 1.24	Not reported	Not reported
Afify et al., 2023 [14]	20 participants	No significant between-side difference in procedural pain	No significant between-side difference in bleeding; transient yellow nail discoloration reported with MTX treatment but not Cal/BD treatment	Not reported	Completely satisfied: 8/20 vs 8/20; comparison based on overall satisfaction distribution	$\chi^2 = 0.182$ (overall satisfaction)	0.980 (overall satisfaction)
Nassar et al., 2022 [15]	16 injection-treated and 18 laser-treated participants	Severe pain: 5/16 vs 0/18; no pain: 0/16 vs 7/18	Subungual hematoma in 3/16 injection-treated participants; Koebner phenomenon in 1/18 and paronychia in 2/18 laser-treated participants	2 participants withdrew from the injection group because of pain	Highly satisfied: 3/16 vs 12/18	Pain: 13.8; adverse events: 6.0; satisfaction: 9.8	Pain: 0.003; adverse events: 0.100; satisfaction: 0.007

TABLE 5: Safety, tolerability, and patient-reported outcomes

Cal/BD, calcipotriol/betamethasone dipropionate; mDLQI, modified Dermatology Life Quality Index; MTX, methotrexate; VAS, visual analog scale.

Feasibility of Quantitative Synthesis

Meta-analysis was not performed because the reported data did not support a reliable pooled estimate. Three studies evaluated the addition of FCO₂ laser to a topical agent versus the same topical agent alone [11–13], one compared two FCO₂-assisted topical regimens [14], and one compared FCO₂-assisted topical TA with intralesional TA [15]. The studies differed in topical agents, outcome measures, summary statistics, and assessment schedules. Between-treatment comparisons were reported primarily as p-values without corresponding effect estimates or confidence intervals. Four studies used inpatient allocation at the nail, hand, or side level [11–14], but none reported the variance of within-participant differences or the correlation between paired measurements. Accordingly, the findings were synthesized narratively according to treatment comparison, and no quantitative synthesis or between-study heterogeneity analysis was performed.

Risk of Bias Assessment

The risk-of-bias assessment indicates that the comparative evidence should be interpreted with caution.

Four of the five principal efficacy results were judged to be at high overall risk of bias, while the remaining result raised some concerns; none of the principal results was judged to be at low risk. The main limitations arose from incomplete reporting of the randomization process and from outcome measurement, particularly where assessor masking was absent or could not be established. These concerns are especially relevant when interpreting apparent between-treatment differences, because knowledge of treatment allocation may have influenced subjective nail-severity assessments in some trials. Missing outcome data were less prominent overall but introduced additional uncertainty in studies with unexplained attrition or treatment-related withdrawal. Importantly, a high risk-of-bias judgment does not imply that the observed treatment effects are necessarily spurious; rather, it reduces confidence that the reported estimates are free from systematic error. Accordingly, the comparative findings should be considered suggestive rather than definitive, particularly when supported predominantly by results at high risk of bias. The domain-level and overall judgments for the principal efficacy results are summarized in Figure 2.

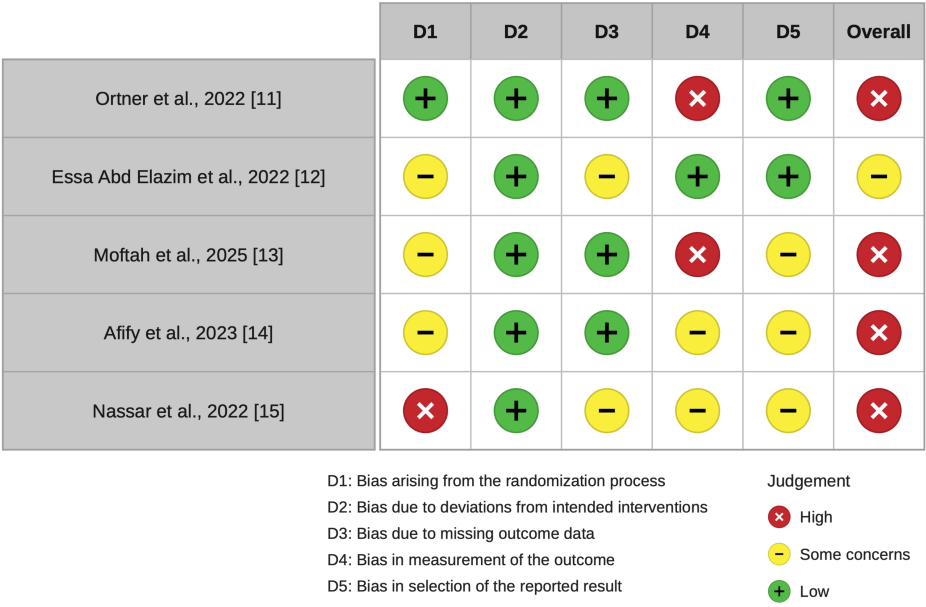


FIGURE 2: Risk-of-bias assessment of the principal comparative efficacy results of the included trials using the Cochrane Risk of Bias 2 (RoB 2) tool

D1, bias arising from the randomization process; D2, bias due to deviations from intended interventions; D3, bias due to missing outcome data; D4, bias in measurement of the outcome; D5, bias in selection of the reported result. Green indicates low risk of bias, yellow indicates some concerns, and red indicates high risk of bias. Risk of bias was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool [10].

Discussion

Every included study recorded improvement in nail severity after FCO2 laser-assisted topical therapy [11-15], yet the evidence that the laser itself provides additional benefit was considerably less uniform. Among the three add-on comparisons, one showed numerically greater improvement without a clear between-treatment difference, whereas two reported differences favoring the laser-assisted side at later assessments [11-13]. The direction of effect was therefore generally compatible with an incremental benefit, but its magnitude and reliability remain uncertain. Timing may also be relevant. In the study by Moftah et al. [13], the clearer difference appeared three months after treatment completion, while in the study by Essa Abd Elazim et al. [12], the nail-bed difference became apparent only at the later post-treatment assessment. Slow nail growth and delayed expression of changes within the nail unit are plausible explanations, but chance and measurement bias in small samples cannot be excluded. Afify et al. [14] and Nassar et al. [15] addressed different questions, namely the choice of topical agent after laser exposure and laser-assisted delivery versus intralesional treatment.

A recent systematic review reported favorable NPSI responses across several laser modalities, including pulsed dye, Nd:YAG, and FCO2 lasers, while also documenting substantial clinical and methodological heterogeneity [16]. Such evidence remains difficult to interpret when treatment response is defined primarily by change from baseline rather than direct comparison with an appropriate control [8]. Evidence for local pharmacologic therapy is itself variable; a review informing the GRAPPA recommendations found insufficient evidence to recommend several topical agents specifically for nail disease in patients with psoriatic arthritis [17]. The present synthesis therefore places greater emphasis on whether laser assistance

changes the outcome relative to the accompanying treatment rather than whether the combined regimen improves over time.

The mechanistic rationale remains convincing but should not be equated with clinical efficacy. In an in vitro bovine hoof model, fractional ablative laser treatment substantially increased transungual delivery of methotrexate [18]. Drug transport through laser-created channels is also influenced by solubility, molecular weight, tissue binding, and channel characteristics [19]. The clinical contribution of laser assistance may therefore differ according to the delivered agent and treatment protocol. Cross-trial differences, however, cannot establish that one drug is intrinsically better suited to laser-assisted delivery.

Treatment utility also extends beyond severity scores. In the comparison with intralesional triamcinolone, broadly similar clinical outcomes accompanied by less procedural pain and greater satisfaction with laser-assisted treatment may be relevant when repeated local therapy is required [15]. Patient-reported outcomes deserve greater attention, although existing nail-specific instruments vary considerably in the health domains they capture [20]. The current safety evidence remains too small and inconsistently ascertained to establish that FCO₂ treatment is definitively safer [11-15].

Confidence in comparative efficacy is nevertheless limited. Sample sizes were small, four studies used inpatient designs, laser parameters and outcome instruments varied, and assessment schedules were inconsistent [11-15]. Four principal efficacy results were at high risk of bias, while none were at low risk (Figure 2). Effect estimates with confidence intervals were often unavailable, and within-participant correlations or paired variances were not reported, preventing reliable quantitative pooling [11-14]. Geographic concentration, with four studies conducted in Egypt, also constrains generalizability [11-15]. At the review level, quantitative synthesis was appropriately avoided because the available data could not support a defensible pooled estimate. Future within-person trials should follow design-specific reporting standards [21], with concealed allocation, masked outcome assessment, prespecified primary outcomes and time points, paired analyses with confidence intervals and within-participant correlations, standardized laser protocols, separate matrix and bed reporting, adequate post-treatment follow-up, and validated patient-reported measures.

FCO₂ laser-assisted topical therapy remains a biologically plausible and clinically relevant local strategy, but current comparative evidence does not establish a consistent incremental efficacy advantage across topical agents and treatment settings.

Conclusions

FCO₂ laser-assisted topical therapy was associated with improvement in nail psoriasis across the included studies; however, direct comparisons did not demonstrate a consistent incremental benefit of laser assistance over topical therapy alone. Comparative effects varied according to the topical agent, comparator, and assessment time, and confidence in these findings was limited by small samples, methodological heterogeneity, and predominantly high risk of bias. In one comparative trial, laser-assisted topical corticosteroid therapy achieved broadly similar short-term clinical outcomes to intralesional corticosteroid treatment with less procedural pain and greater patient satisfaction, suggesting a potential tolerability advantage. Well-powered, prospectively registered trials with concealed allocation, blinded outcome assessment, appropriate paired analyses, and standardized follow-up are needed before FCO₂ laser pretreatment can be recommended as a routine adjunct to topical therapy.

Additional Information

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All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

- 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, 99:516-23. [10.2340/00015555-3098](#)
- Stewart CR, Algu L, Kamran R, Leveille CF, Abid K, Rae C, Lipner SR: The impact of nail psoriasis and treatment on quality of life: a systematic review. *Skin Appendage Disord*. 2021, 7:83-9. [10.1159/000512688](#)
- Langenbruch A, Radtke MA, Krensell M, Jacobi A, Reich K, Augustin M: Nail involvement as a predictor of concomitant psoriatic arthritis in patients with psoriasis. *Br J Dermatol*. 2014, 171:1123-8. [10.1111/bjd.13272](#)
- Hadeler E, Mosca M, Hong J, Brownstone N, Bhutani T, Liao W: Nail psoriasis: a review of effective therapies and recommendations for management. *Dermatol Ther (Heidelb)*. 2021, 11:799-831. [10.1007/s13555-021-00523-x](#)
- Haedersdal M, Erlendsson AM, Paasch U, Anderson RR: Translational medicine in the field of ablative fractional laser (AFXL)-assisted drug delivery: a critical review from basics to current clinical status. *J Am Acad Dermatol*. 2016, 74:981-1004. [10.1016/j.jaad.2015.12.008](#)
- Ortner VK, Nguyen N, Brewer JR, Solovyeva V, Haedersdal M, Philipsen PA: Fractional CO(2) laser ablation leads to enhanced permeation of a fluorescent dye in healthy and mycotic nails-an imaging investigation of laser-tissue effects and their impact on ungual drug delivery. *Lasers Surg Med*. 2022, 54:861-74. [10.1002/lsm.23541](#)
- Tartaglia J, Piaserico S, Naldi L, Sechi A: Ablative CO2-assisted laser for topical drug delivery in nail psoriasis: a systematic review. *Skin Appendage Disord*. 2024, 10:156-66. [10.1159/000535022](#)
- Bland JM, Altman DG: Comparisons against baseline within randomised groups are often used and can be highly misleading. *Trials*. 2011, 12:264. [10.1186/1745-6215-12-264](#)
- Page MJ, McKenzie JE, Bossuyt PM, et al.: The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021, 372:n71. [10.1136/bmj.n71](#)
- Sterne JA, Savović J, Page MJ, et al.: RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ*. 2019, 366:l4898. [10.1136/bmj.l4898](#)
- Ortner VK, Mandel VD, Skak K, et al.: Investigating the efficacy and safety of calcipotriol/betamethasone dipropionate foam and laser microporation for psoriatic nail disease-a hybrid trial using a smartphone application, optical coherence tomography, and patient-reported outcome measures. *Dermatol Ther*. 2022, 35:e15965. [10.1111/dth.15965](#)
- Essa Abd Elazim N, Mahmoud Abdelsalam A, Mohamed Awad S: Efficacy of combined fractional carbon dioxide laser and topical tazarotene in nail psoriasis treatment: a randomized intrapatient left-to-right study. *J Cosmet Dermatol*. 2022, 21:2808-16. [10.1111/jocd.14536](#)
- Hassan Moftah N, H Abbas Helmy W, Mohamed Elbakry A, Mohammed Gamal-Edeen A, Al-Sayed Al-Kady N: Combined fractional CO2 laser 10,600 nm with methotrexate 1% gel versus methotrexate 1% gel alone in the treatment of nail psoriasis: a randomized comparative study. *Arch Dermatol Res*. 2024, 317:153. [10.1007/s00403-024-03636-3](#)
- Afify AA, Shaheen MA, El-Banna MG: Fractional CO(2) laser in the treatment of nail psoriasis: how can it help?. *Arch Dermatol Res*. 2023, 315:1705-15. [10.1007/s00403-023-02574-w](#)
- Nassar A, Atef H, Eldeeb F, Alakad R: Comparison of fractional laser-assisted drug delivery and intralesional injection of triamcinolone acetonide in nail psoriasis. *J Dtsch Dermatol Ges*. 2022, 20:788-96. [10.1111/ddg.14731](#)
- Jaalouk D, Algarin YA, Pulumati A, Humeda J, Nouri K: Lasers for the treatment of nail psoriasis: a systematic review. *Int J Dermatol*. 2024, 63:1484-94. [10.1111/ijd.17304](#)
- Laheru D, Antony A, Carneiro S, et al.: Management of nail disease in patients with psoriatic arthritis: an updated literature review informing the 2021 GRAPPA treatment recommendations. *J Rheumatol*. 2023, 50:433-7. [10.3899/jrheum.220313](#)
- Nguyen HX, Banga AK: Effect of ablative laser on in vitro transungual delivery. *Int J Pharm*. 2018, 544:402-14. [10.1016/j.ijpharm.2017.09.048](#)
- Wenande E, Anderson RR, Haedersdal M: Fundamentals of fractional laser-assisted drug delivery: an in-depth guide to experimental methodology and data interpretation. *Adv Drug Deliv Rev*. 2020, 153:169-84. [10.1016/j.addr.2019.10.003](#)
- Abid K, Algu L, Kamran R, Leveille CF, Rae C, Lipner SR, Klassen AF: Content analysis of patient-reported outcome measures used in patients with nail conditions: a systematic review. *JAMA Dermatol*. 2021, 157:1509-11. [10.1001/jamadermatol.2021.4539](#)
- Pandis N, Chung B, Scherer RW, Elbourne D, Altman DG: CONSORT 2010 statement: extension checklist for reporting within person randomised trials. *BMJ*. 2017, 357:j2835. [10.1136/bmj.j2835](#)