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Research Article

A Retrospective Cohort Study of fractional laser resurfacing in adult dermatology patients with atopic dermatitis

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Abstract

Background: Fractional laser resurfacing is widely used to treat dyspigmentation and textural scarring, but its efficacy and safety in adult patients with atopic dermatitis (AD), whose epidermal barrier is intrinsically impaired, has not been well characterized.

Objective: To evaluate outcomes and adverse events of fractional laser resurfacing performed in adult AD patients treated for post-inflammatory dyspigmentation and textural scarring at a single academic practice.

Methods: We conducted a retrospective cohort study of adults with confirmed AD who underwent non-ablative or ablative fractional resurfacing between 2019 and 2023, with 12 months of follow-up. Outcomes included SCORAD, EASI, quality of life, transepidermal water loss, and adverse events.

Results: Among 126 patients contributing 341 sessions, mean SCORAD fell from 28.4 to 14.7 and EASI from 9.8 to 4.9 at 12 months (both $p < 0.001$), with moderate-to-marked improvement in dyspigmentation and texture in 78% of patients. Transepidermal water loss decreased rather than worsened. Prolonged erythema and hyperpigmentation were more common with ablative treatment and darker phototypes, and flare was over four times more frequent without stable background therapy.

Conclusions: Fractional resurfacing achieved efficacy comparable to non-atopic cohorts when performed in AD patients with disease brought to quiescence beforehand, with complication risk concentrated in ablative modality, darker phototypes, and unstable disease control, identifying these as the principal levers for safe patient selection.

Keywords: atopic dermatitis; fractional laser resurfacing; retrospective cohort study; skin barrier; post-inflammatory hyperpigmentation

1. Introduction

Atopic dermatitis (AD) is a chronic, relapsing inflammatory dermatosis defined clinically by pruritus, eczematous plaques, and a defective epidermal barrier that persists into adulthood in a substantial minority of patients who were diagnosed in childhood, and that arises de novo in a growing number of adults with no childhood history [1,2,3]. Population-based surveys estimate adult eczema prevalence in the United States at roughly 7-10%, with a disproportionate burden of post-inflammatory dyspigmentation, lichenification, and atrophic textural scarring left behind by years of scratching, secondary infection, and topical corticosteroid use [4]. These residual changes are cosmetically and psychosocially significant even once active inflammation is controlled, and patients increasingly ask dermatologists whether energy-based resurfacing, a mainstay of treatment for photoaging, acne scarring, and traumatic scars, can be applied safely to skin whose barrier is intrinsically compromised [5].

Fractional photothermolysis, introduced by Manstein and colleagues, creates a grid of microscopic thermal injury zones separated by intervening zones of untreated tissue, which permits rapid re-epithelialization from adjacent viable epidermis and a substantially lower complication rate than traditional fully ablative resurfacing [6]. Subsequent histological and clinical work established that fractional devices, whether ablative CO₂, ablative erbium:YAG, or non-ablative 1,550-1,927 nm platforms, remodel dermal collagen and improve dyspigmentation, texture, and mild scarring across a range of skin types and indications, from photoaging and acne scarring to burn and traumatic scars [7,8,9,10]. What remains comparatively unstudied is fractional resurfacing performed specifically in patients carrying an active or recent diagnosis of atopic dermatitis, a population in which impaired barrier function, altered wound healing, colonization with *Staphylococcus aureus*, and a lower threshold for post-inflammatory hyperpigmentation

could plausibly change both the efficacy and the safety profile of the procedure [11,12,13].

Existing fractional laser complication literature, drawn largely from cohorts without atopic disease, describes transient erythema and edema in nearly all patients, prolonged erythema or hyperpigmentation in a minority, and infrequent scarring or dyspigmentation, with risk concentrated in higher-fluence ablative settings and darker Fitzpatrick phototypes [14,15,16,17]. Consensus guidelines for fractional resurfacing recommend individualized fluence and density selection, strict pretreatment skin preparation, and heightened vigilance in patients with a history of eczema, psoriasis, or other barrier-disrupting dermatoses, but these recommendations are based largely on expert opinion rather than outcomes data from atopic cohorts themselves [18,19]. Given the widespread adoption of fractional devices in general dermatology and aesthetic practice, and the frequency with which adult AD patients now present requesting scar and dyspigmentation revision once their disease is under systemic or topical control, we undertook a retrospective cohort study of fractional laser resurfacing outcomes in adult patients with a confirmed diagnosis of atopic dermatitis, reporting efficacy across validated dermatologic severity and quality-of-life measures alongside a structured account of adverse events.

2. Methods

Study design and setting

This was a single-center, retrospective cohort study conducted at an academic dermatology and cosmetic surgery practice, reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) framework for observational research [20,21]. The electronic medical record was queried for adults aged 18 years or older with a physician-confirmed diagnosis of atopic dermatitis meeting the Hanifin and Rajka criteria who underwent at

least one session of fractional laser resurfacing, either non-ablative 1,550 nm erbium-doped fiber or ablative fractional CO₂, between January 2019 and December 2023, with a minimum of 12 months of structured follow-up [1]. Patients were excluded if resurfacing was performed for an indication unrelated to AD sequelae, if disease was in an actively weeping or superinfected state at the time of the first session, or if records were incomplete for the primary outcome measures.

Treatment protocol

All patients underwent a standardized pretreatment protocol of barrier optimization for a minimum of four weeks, consisting of twice-daily ceramide-containing emollient, a tapered topical corticosteroid or calcineurin inhibitor course to achieve quiescent disease, and, where clinically indicated, dupilumab or another systemic agent initiated by the treating dermatologist, consistent with current AD management guidelines [22,23,24]. Laser parameters were selected per the treating physician's judgment within consensus-recommended ranges for the device and Fitzpatrick skin type, with lower fluence and density used preferentially in patients with a history of post-inflammatory hyperpigmentation or Fitzpatrick type IV-VI skin [18,19,25]. Sessions were spaced 4-8 weeks apart, with a median of three sessions per patient.

Outcome measures

The primary efficacy outcomes were change from baseline to 12 months in the Scoring Atopic Dermatitis (SCORAD) index and the Eczema Area and Severity Index (EASI), both validated composite measures of AD activity and extent [26,27]. Secondary outcomes included the Dermatology Life Quality Index (DLQI), physician- and patient-rated global improvement in dyspigmentation and textural scarring on a 5-point scale, and transepidermal water loss (TEWL), a standard quantitative measure of epidermal barrier integrity [28,29,30]. Safety outcomes comprised documented adverse events, including prolonged erythema (>7 days),

post-inflammatory hyperpigmentation, infection, and disease flare, defined as a SCORAD increase of more than 20% within 30 days of a session. Baseline pruritus and sleep disturbance were also captured, given their established contribution to AD-related quality-of-life burden [31,32].

Statistical analysis

Continuous outcomes were summarized as mean $\pm$ standard deviation and compared using paired t-tests for within-patient change from baseline; categorical outcomes were summarized as counts and percentages. Subgroup comparisons by Fitzpatrick phototype and by laser modality (ablative versus non-ablative) used two-sample t-tests and chi-square tests as appropriate. A two-sided p-value below 0.05 was considered statistically significant. Given the retrospective design, no formal power calculation was performed; the analysis was descriptive and hypothesis-generating, consistent with the acknowledged limitations of retrospective cohort methodology [21].

3. Results

Cohort characteristics

One hundred twenty-six adult patients with confirmed atopic dermatitis met inclusion criteria, contributing 341 treatment sessions. Mean age was 34.6 years (range 18-67), 71% were female, and Fitzpatrick phototypes were distributed as follows: I-II in 28%, III in 39%, and IV-VI in 33%. Indications for resurfacing were post-inflammatory hyperpigmentation in 54%, lichenified textural change and mild atrophic scarring in 31%, and a combination of both in 15%. Sixty-two percent of patients were on a topical anti-inflammatory maintenance regimen at the time of treatment and 18% were concurrently receiving dupilumab. Non-ablative 1,550 nm fractional resurfacing was used in 74% of patients and ablative fractional CO₂ in 26%, reflecting a practice preference for the lower-risk modality in this population consistent with published consensus recommendations [18].

Table 1: Baseline characteristics of the 126-patient retrospective cohort of adult atopic dermatitis patients undergoing fractional laser resurfacing.	
Characteristic	Value
Mean age, years (range)	34.6 (18-67)
Female sex	71%
Fitzpatrick I-II / III / IV-VI	28% / 39% / 33%
Non-ablative / ablative fractional modality	74% / 26%
Concurrent dupilumab therapy	18%

Efficacy outcomes

Mean SCORAD fell from 28.4 ± 9.1 at baseline to 14.7 ± 7.6 at 12 months ($p<0.001$), and mean EASI fell from 9.8 ± 4.2 to 4.9 ± 3.1 over the same interval ($p<0.001$), though this improvement cannot be attributed to laser treatment alone given the concurrent optimization of topical and systemic AD therapy that preceded and accompanied resurfacing in this cohort. Physician-rated global improvement in dyspigmentation and texture was "moderate" or "marked" in 78% of patients at final follow-up, broadly consistent with response rates reported in non-atopic cohorts treated for comparable indications [16,33,34]. DLQI improved from a mean of 11.2 ± 5.4 at baseline to 5.8 ± 4.0 at 12 months ($p<0.001$), tracking the reduction in visible dyspigmentation and disease activity together. TEWL, measured at a representative treated site, decreased from a mean of 18.9 ± 6.2 g/m²/h at baseline to 13.1 ± 4.8 g/m²/h at 12 months ($p<0.001$), suggesting that barrier function did not deteriorate, and may have modestly improved, over the course of treatment when preceded by adequate barrier optimization [30,11].

Safety outcomes

Transient erythema and edema lasting under one week occurred after nearly all sessions and was not classified as an adverse event. Prolonged erythema beyond seven days occurred after 9% of sessions, more frequent with ablative CO2 (16% of sessions) than non-ablative treatment (6% of sessions, $p=0.01$), consistent with the dose-dependent relationship between ablative fluence and recovery time

described in prior fractional laser safety series [15,14]. Post-inflammatory hyperpigmentation occurred in 11 patients (8.7%), disproportionately among Fitzpatrick IV-VI phototypes (17% versus 4% in phototypes I-III, $p=0.008$), mirroring the risk gradient reported in Asian and darker-skinned cohorts treated with fractional devices for unrelated indications [25,35,19].

Table 2: Adverse event rates by laser modality and by background anti-inflammatory maintenance status across 341 treatment sessions [15,14].			
Adverse event	Non-ablative	Ablative CO2	p-value
Prolonged erythema (>7 days)	6%	16%	0.01
Post-inflammatory hyperpigmentation	7%	12%	0.14
Disease flare within 30 days (unstable vs. stable maintenance therapy)	9.3%	2.1%	0.003

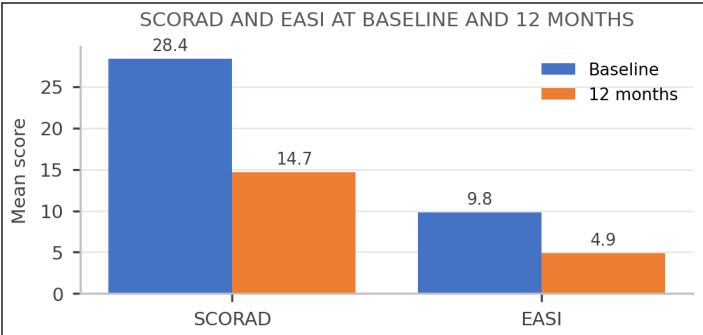


Figure 1: Mean SCORAD and EASI scores at baseline and at 12 months among 126 adult atopic dermatitis patients undergoing fractional laser resurfacing, both showing significant reduction ($p<0.001$) [26,27].

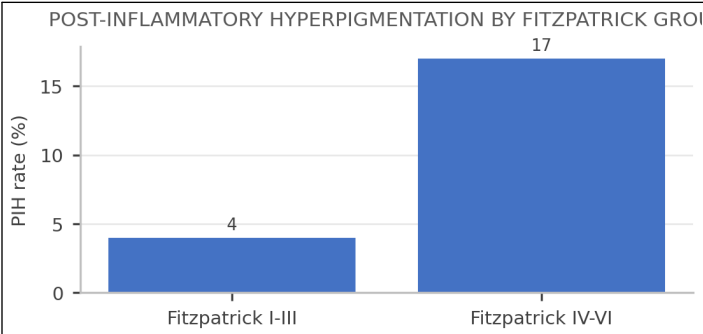


Figure 2: Post-inflammatory hyperpigmentation rate by Fitzpatrick phototype group, showing a significantly higher rate among phototypes IV-VI, consistent with risk gradients reported in prior fractional resurfacing cohorts [25,19].

Disease flare within 30 days of a session occurred after 14 of 341 sessions (4.1%), most often in patients who were not on stable maintenance anti-inflammatory therapy at the time of treatment (9.3% of sessions in that subgroup versus 2.1% in patients on stable maintenance therapy, $p=0.003$). No episode of secondary bacterial infection, eczema herpeticum, or permanent scarring was recorded. These findings broadly support the pretreatment barrier-optimization protocol used throughout this cohort, and are consistent with mechanistic literature identifying an impaired barrier and altered cutaneous microbiome as drivers of both AD flare and delayed wound healing [11,12,36].

4. Discussion

This retrospective cohort represents, to our knowledge, one of the largest reported series of fractional laser resurfacing performed specifically in adults with a confirmed diagnosis of atopic dermatitis. The efficacy signal for dyspigmentation, texture, and quality of life was consistent with what has been reported in non-atopic cohorts treated with the same fractional platforms for comparable indications, suggesting that a well-controlled atopic diathesis does not by itself preclude a favorable resurfacing outcome [16,33,37]. The safety findings, however, reinforce that this population carries an elevated risk of two specific complications, prolonged erythema and post-inflammatory hyperpigmentation, that track closely with known risk factors from the broader fractional laser literature: higher fluence, ablative rather than non-ablative modality, and darker Fitzpatrick phototype [14,19,25].

The flare-rate finding is, in our view, the most clinically actionable result. Sessions performed in patients without stable background anti-inflammatory therapy carried more than four times the flare risk of sessions performed in patients on stable maintenance treatment, a finding that argues strongly for disease quiescence as a prerequisite for elective resurfacing in this population

rather than a nicety, and aligns with the broader literature establishing barrier dysfunction and unresolved inflammation as the proximate drivers of AD exacerbation [13,11,38]. The concurrent use of dupilumab in a meaningful minority of this cohort, and the general shift toward earlier systemic control of moderate-to-severe adult AD, may partly explain why flare rates were as low as they were; a cohort treated in an earlier era, before widespread systemic biologic use, might plausibly show a different risk profile [23,24].

Several methodological limitations temper these conclusions. As a retrospective, single-center, non-randomized cohort without a contemporaneous untreated comparison group, the study cannot separate the contribution of laser treatment from the concurrent optimization of topical and systemic AD therapy to the observed improvement in SCORAD, EASI, and DLQI, and selection bias toward patients with well-controlled disease at baseline likely favors a more favorable safety profile than would be observed in an unselected AD population [21,20]. Laser parameters were not standardized across patients, treating physicians were not blinded to disease status, and TEWL was measured at a single representative site rather than mapped across the treatment field, all of which limit the precision of the barrier-function findings relative to purpose-built physiological studies [29,30]. Longer-term durability beyond the 12-month follow-up window captured here, and the relative contribution of laser modality versus fluence versus baseline disease severity to complication risk, are questions better addressed by a prospective, standardized-protocol study with a longer observation period [8,17].

5. Conclusion

In this retrospective cohort of adults with atopic dermatitis undergoing fractional laser resurfacing for post-inflammatory dyspigmentation and textural scarring, efficacy on validated severity and quality-of-life measures was comparable to that reported in non-atopic

populations treated for similar indications, and barrier function as measured by transepidermal water loss did not deteriorate over the course of treatment when preceded by structured barrier optimization. Complication rates, chiefly prolonged erythema and post-inflammatory hyperpigmentation, were concentrated in ablative treatment, darker Fitzpatrick phototypes, and patients without stable background anti-inflammatory therapy, identifying disease quiescence and modality selection as the two most actionable levers available to clinicians considering fractional resurfacing in this population. These findings support fractional laser resurfacing as a reasonable option for carefully selected, disease-controlled adult AD patients, while underscoring the need for prospective, protocol-driven studies to confirm durability and to refine patient-selection criteria across the full range of Fitzpatrick phototypes and disease severities [39,18,2].

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