Review

Laser Treatment for Scar: An Update and Literature Review

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Abstract: **Background:** Scar formation remains a major therapeutic challenge because scars are biologically heterogeneous and clinically diverse, ranging from atrophic acne scars to hypertrophic burn scars, keloids, post-surgical linear scars, and pigmentary scar sequelae. Over the past decade, laser- and light-based technologies have become central to modern scar management because they can selectively target vascularity, collagen architecture, surface texture, pigmentation, and contracture while also enabling transdermal drug delivery and biologic augmentation. Recent literature published from 2024 to 2026 has expanded the evidence base for ablative fractional carbon dioxide laser, pulsed dye laser, erbium:YAG laser, picosecond fractional laser, intense pulsed light, and multimodal protocols involving platelet-rich plasma, stromal vascular fraction, exosomes, botulinum toxin, fillers, and laser-assisted subcision. **Methods:** A comprehensive literature review was conducted covering publications from 2024 to 2026 on laser treatment for scars. The source framework was based on MEDLINE, PubMed, and Ovid database retrieval. The included literature comprised randomized controlled trials, comparative studies, retrospective cohort studies, systematic reviews, meta-analyses, case series, narrative reviews, and mechanistic reviews. All studies were classified according to the Oxford Centre for Evidence-Based Medicine 2009 Levels of Evidence. **Results:** Current evidence supports laser therapy as an effective and generally safe modality for multiple scar phenotypes. Ablative fractional CO_2 laser remains the most frequently studied modality, particularly for acne scars, hypertrophic scars, and surgical scars. Pulsed dye laser shows consistent benefit for immature, erythematous, and vascular scars, especially burn and early post-surgical scars. Combination strategies appear increasingly favorable, including pulsed dye laser plus fractional CO_2 laser, fractional CO_2 laser plus platelet-rich plasma, and laser-assisted delivery of regenerative agents. Early intervention, especially within weeks to months of wound healing, appears advantageous for many surgical and traumatic scars. However, heterogeneity in laser parameters, timing, scar subtype definitions, outcome scales, and follow-up duration continues to limit cross-study comparison. **Conclusions:** Laser therapy has become a major pillar of contemporary scar management. The strongest recent evidence favors phenotype-directed and time-sensitive treatment, with early vascular targeting for erythematous scars and fractional resurfacing for textural remodeling. Combination regimens may improve outcomes beyond monotherapy in selected patients. Future studies should prioritize standardized endpoints, longer follow-up, scar subtype stratification, cost-effectiveness analysis, and high-quality comparative trials in broader skin phototypes.

Keywords: cicatrix; laser therapy; keloid; carbon dioxide laser; burns; acne vulgaris

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1. Introduction

Scars are a common consequence of cutaneous injury, surgery, burns, acne, and inflammatory dermatoses, and they can impose both physical morbidity and considerable psychosocial distress [1]. Modern scar care has therefore shifted away from a purely cosmetic perspective toward a functional and patient-centered model that recognizes the importance of pain, pruritus, stiffness, dyschromia, contour irregularity, and quality of life [2].

The biological rationale for laser therapy in scar management is strong. Different devices interact with distinct scar components through selective photothermolysis, fractional photothermolysis, coagulative remodeling, or pigment- and vessel-directed energy delivery [3]. Ablative fractional CO_2 laser remains the prototype resurfacing modality because it creates microthermal treatment zones that induce collagen reorganization, soften fibrosis, improve pliability, and stimulate controlled wound repair [4]. Er:YAG lasers provide similar fractional remodeling with a different ablation-to-coagulation profile, while pulsed dye laser is particularly suited to vascular and erythematous scars because it targets oxyhemoglobin and can reduce hyperemia and symptom burden in immature scars [5].

Over the last several years, scar laser therapy has become more phenotype-specific. Atrophic acne scars are often treated with ablative or non-ablative fractional resurfacing, sometimes combined with microneedling radiofrequency, subcision, or injectable biologics [6]. Hypertrophic and keloid scars increasingly receive vascular lasers, fractional ablative lasers, or laser-assisted drug delivery. Surgical scars are now often treated earlier than before, with growing evidence that intervention within the first month after wound closure may yield better outcomes than delayed treatment [7]. Burn scar protocols similarly favor multimodal approaches, particularly when erythema, hypertrophy, contracture, and textural distortion coexist [8].

Another recent development is the rise of combination therapy. Laser-assisted drug delivery has renewed interest in intralesional or topical adjuvants such as corticosteroids, 5-fluorouracil, platelet-rich plasma, stromal vascular fraction, hyaluronic acid, and botulinum toxin [9]. These combinations aim to exploit laser-created microchannels or biologic synergy to improve remodeling beyond what energy treatment alone can achieve.

Timing has also emerged as a critical variable. Historically, many clinicians delayed procedural scar revision until full maturation. However, newer meta-analytic and retrospective data suggest that earlier laser intervention can be both safe and more effective, especially for surgical, traumatic, and erythematous scars [10]. Early pulsed dye laser may suppress persistent vascular signaling and symptomatic inflammation [11], whereas early fractional CO_2 laser may limit long-term textural deformity and improve scar architecture before fibrosis becomes fully established [12].

Despite this progress, major gaps remain. Trials often include small sample sizes, mixed scar populations, nonuniform laser parameters, and short follow-up. Outcomes are also inconsistently reported, with varying use of the Vancouver Scar Scale, POSAS, Manchester Scar Scale, imaging tools, and patient satisfaction measures [13]. Data in skin of color are improving but still insufficient, particularly for balancing efficacy against dyspigmentation risk.

The purpose of this review is to provide an updated synthesis of laser treatment for scars based on studies published from 2024 to 2026. Particular attention is given to scar phenotype, treatment timing, combination strategies, safety, and level of evidence, with the aim of providing a practical and contemporary reference for clinicians and researchers.

2. Methods

A comprehensive literature review was conducted covering publications from 2024 to 2026 on laser treatment for scars. The source framework was based on MEDLINE, PubMed, and Ovid database retrieval. The included studies comprised randomized controlled trials, comparative studies, retrospective studies, prospective studies, systematic reviews, meta-analyses, case series, and narrative reviews relevant to surgical scars, acne scars, hypertrophic scars, burn scars, keloids, and pigmentary or erythematous scar variants. All studies were classified according to the Oxford Centre for Evidence-Based Medicine 2009 Levels of Evidence [14].

The principal outcomes extracted from the selected literature included validated scar scores such as the Vancouver Scar Scale and Patient and Observer Scar Assessment Scale, physician- and patient-reported global improvement, imaging-based scar assessment, symptom relief, safety, satisfaction, and where available, histopathologic or mechanistic endpoints.

3. Results

Zhang et al. [15] reviewed the mechanisms of fractional CO_2 laser in scar treatment and emphasized that this modality acts beyond simple resurfacing. The authors highlighted microthermal ablation, controlled dermal remodeling, collagen reorganization, inflammatory modulation, angiogenic signaling changes, and enhanced wound-healing kinetics as key biological explanations for clinical improvement. This article is valuable because it connects observed scar softening and texture improvement to molecular and histologic changes, thereby strengthening the rationale for fractional CO_2 laser as a foundational scar therapy. However, as a mechanistic review, it does not provide pooled comparative efficacy data (Level 5).

Novintan et al. [16] performed a systematic review on platelet-rich plasma combined with ablative fractional carbon dioxide laser for chronic scar management, including acne, traumatic, and burn scars. The review concluded that adjunctive PRP generally improves healing and may enhance scar appearance when paired with ablative fractional CO_2 laser, particularly by reducing downtime and improving post-treatment recovery. The strength of the review lies in its focus on biologic augmentation of an established laser platform. Its main limitation is heterogeneity in scar types, PRP preparation methods, treatment intervals, and outcome assessment tools, which limits direct generalization (Level 1a).

Argobi et al. [17] conducted a meta-analysis of randomized controlled trials comparing fractional CO_2 laser with microneedling radiofrequency for post-acne scarring. The authors concluded that fractional CO_2 laser may provide somewhat stronger efficacy overall, whereas microneedling radiofrequency remained an effective alternative with a potentially favorable tolerability profile in some settings. This study is clinically relevant because both technologies are widely used for atrophic acne scars and often considered interchangeable in practice. The meta-analysis supports evidence-based device selection, although protocol heterogeneity and variation in scar grading systems remain important limitations (Level 1a).

Chen et al. [18] performed a randomized controlled trial in 116 patients comparing fractional carbon dioxide laser with injection therapy for surgical scars. The CO_2 laser group showed superior outcomes in POSAS, Vancouver Scar Scale, dermatologic appearance scale, visual analog scale, therapeutic efficacy, and patient satisfaction. The study is notable for its randomized design and relatively robust sample size. It supports fractional CO_2 laser as a strong option for long-term improvement in surgical scars, especially when appearance and patient-reported outcomes are both considered. Safety was acceptable, reinforcing the practical value of this approach in routine scar management (Level 1b).

Roohaninasab et al. [19] conducted a randomized, double-blind, split-face comparative study in patients with atrophic acne scars treated with fractional CO_2 laser plus platelet-rich plasma, non-cross-linked hyaluronic acid, or their combination. The combination arm produced higher patient and physician satisfaction than either adjunct alone, although biometric differences were not uniformly significant across all parameters. This study suggests that biologic combination strategies may enhance perceived benefit even when objective instrumental endpoints are mixed. It is particularly useful for clinicians seeking post-laser adjuvants in acne scar treatment, although the modest sample size limits definitive hierarchy among adjuncts (Level 1b).

Park et al. [20] reported a randomized clinical study of laser-assisted delivery of exosome boosters for postoperative facial scars and facial rejuvenation. Seventy-five patients received fractional non-ablative Nd:YAG laser alone or with human- or plant-derived exosome boosters. Adjunctive exosome therapy yielded numerically greater short-term improvement in scar appearance and grayscale imaging parameters, with comparable outcomes between exosome sources and no serious adverse events. This study is important because it extends the concept of laser-assisted biologic delivery into postoperative scar revision and suggests a regenerative adjunctive role. Longer follow-up is still needed to determine durability (Level 1b).

He et al. [21] performed a prospective randomized split-face trial comparing alternating ablative fractional laser and microneedling radiofrequency with ablative fractional laser alone in moderate-to-severe acne scars. Alternating therapy achieved greater ECCA score reduction, better sebum reduction, and higher patient satisfaction, although pain scores were higher. Adverse events were transient and comparable between groups. This work supports a multimodal remodeling strategy for acne scars and suggests that combining different forms of dermal injury may provide additive benefit. Because the study was split-face and controlled, it offers relatively high-quality evidence for combination procedural design (Level 1b).

Issler-Fisher et al. [22] provided a practical overview of laser principles in the burn care textbook chapter on clinical lasers and burn scar management, device selection, timing, and goals in burn scar treatment. The chapter emphasized the role of vascular lasers for erythematous immature scars and fractional ablative modalities for thick, rigid, or contracture-prone scars, while also underscoring the importance of multimodal rehabilitation. Although not a primary clinical study, the chapter is relevant because it synthesizes contemporary burn scar laser practice into an applied treatment framework. Its conclusions are expert-based rather than quantitatively pooled (Level 5).

Goldman et al. [23] reviewed the dual 1550-nm erbium glass fiber and 1927-nm thulium non-ablative fractional laser system in patients with skin of color. The review concluded that the platform is safe and effective for textural and pigmentary concerns, including scars, when conservative settings are used. Histologic evidence supported dermal remodeling and melanin reduction, while lower pulse energy and density were suggested to reduce adverse events in darker phototypes. This article is valuable because evidence in skin of color remains limited in scar laser research. However, it is a review rather than a direct comparative trial (Level 5).

Saaqib et al. [24] evaluated platelet-rich plasma as an adjunct to fractional carbon dioxide laser therapy for facial acne scars in a randomized controlled setting. The reported findings suggested that adding PRP improved clinical response compared with laser alone, supporting the increasingly common practice of combining regenerative blood-derived products with ablative resurfacing. The clinical importance of this study lies in its direct applicability to acne scar management, where both outcome magnitude and recovery time matter to patients. As with similar PRP studies, variability in preparation technique and small trial size may affect reproducibility (Level 1b).

Priyanka et al. [25] compared fractional carbon dioxide laser alone with fractional carbon dioxide laser plus autologous platelet-rich plasma for post-acne scars. The combination protocol was reported to be more effective than laser monotherapy for atrophic acne scars, reinforcing the concept that PRP may enhance remodeling and recovery after ablative treatment. The study aligns with broader recent literature favoring adjunctive biologics in acne scar resurfacing. Its main strengths are direct head-to-head comparison and straightforward clinical relevance, while likely limitations include modest sample size and short-term follow-up (Level 2b).

Di Guardo et al. [26] conducted a retrospective study on rhodamine intense pulsed light for hypertrophic scars, with adjunctive dynamic optical coherence tomography analysis. The study concluded that rhodamine-based IPL was effective and safe in hypertrophic scars with a prominent vascular component. The use of imaging-based assessment is a notable strength because it offers more objective insight into vascular change than purely clinical grading. This work suggests that

IPL, particularly specialized vascular-filter systems, may have a role in erythematous or vascularized hypertrophic scars. The retrospective design, however, limits causal certainty (Level 2b).

Clementi et al. [27] published a comprehensive review of combined laser strategies for scar treatment. The authors concluded that combination protocols can improve outcomes by selectively targeting different scar components, such as vascularity, fibrosis, pigmentation, and surface irregularity. Across atrophic, hypertrophic, keloid, post-surgical, and burn scars, the review suggested that dual or sequential laser approaches may outperform single-device treatment in carefully selected patients. This article is useful because it reflects the field's shift from single-platform treatment to phenotype-oriented multimodal protocols. As a narrative review, however, it cannot establish quantitative superiority (Level 5).

Chen et al. [28] assessed ultra-pulse CO_2 laser therapy against sequential laser therapy and pharmacologic treatment for scar reduction. The available report indicated that sequential laser treatment improved clinical efficacy for early proliferative burn scars and enhanced overall scar characteristics. The study appears to support the idea that staged or combined energy-based protocols are superior to isolated single-step approaches in active remodeling scars. This is clinically meaningful because proliferative burn scars are notoriously difficult to manage. Interpretation should remain somewhat cautious, as details of comparator standardization and protocol sequencing are less extensively reported in brief records (Level 2b).

Ji et al. [29] performed a systematic review and meta-analysis on optimal timing of fractional CO_2 laser for surgical scars. Fourteen controlled trials involving 492 participants were included. Fractional CO_2 laser showed significant benefit overall, and treatment initiated at or within one month after surgery was clearly more effective than delayed treatment. Laser started more than three months after surgery did not significantly improve postoperative scars in pooled analysis. This paper is one of the most important timing-focused studies in recent scar literature and supports a move toward early intervention rather than waiting for complete scar maturation (Level 1a).

Guo et al. [30] studied early sequential laser treatment for facial linear scars in cross-sectional regions. The report concluded that early sequential treatment with pulsed dye laser and ablative fractional CO_2 laser effectively improved long facial linear scars across different anatomic regions. The study is clinically important because facial scars often cross aesthetic subunits and tension lines, making early optimization especially valuable. By combining vascular and resurfacing components, the protocol reflects a rational biologic sequence: control erythema early and then improve texture and contour. Because the study was not a large randomized trial, stronger confirmation is still desirable (Level 2b).

Brewin et al. [31] reported the multicenter ELABS randomized controlled trial comparing early pulsed dye laser plus standard care with standard care alone for hypertrophic burn scars. Early PDL significantly improved patient-rated scar quality and perception of change at six months, although observer-rated scar quality, color metrics, and quality of life were not significantly different. No unexpected adverse events were related to treatment. The study is important because it provides high-quality prospective evidence for early vascular laser intervention in burn scars, while also showing that patient-reported benefit may precede measurable changes in broader health utility or longer-term structural outcomes (Level 1b).

Keshk et al. [32] evaluated fractional carbon dioxide laser treatment of hypertrophic scars with both clinical and histopathological assessment. The study concluded that fractional CO_2 laser improved hypertrophic scar appearance and produced supportive histologic changes, likely including more normalized collagen architecture and improved tissue organization. This dual clinical-pathologic design is especially valuable because it links visible clinical benefit with underlying remodeling. The work strengthens the argument that fractional ablative treatment is not merely cosmetic but biologically reparative in hypertrophic fibrosis. Its evidentiary weight is moderated by likely modest sample size and the absence of large multicenter replication (Level 2b).

Ptaszek et al. [33] conducted a systematic review on the use of fractional laser in acne scar treatment. The review found that most patients experienced approximately 30% to 70% improvement in acne scar appearance and that adverse effects were generally mild and transient. The authors concluded that fractional CO_2 laser is an effective method for acne scar management, supported by numerous clinical studies. This review is useful because it synthesizes a broad procedural literature in an area where treatment selection can be confusing. However, as with most acne scar reviews, variation in scar subtype, device settings, and comparison groups limits precise standardization (Level 1a).

Yin et al. [34] performed a systematic review on combined pulsed dye laser and ablative fractional carbon dioxide laser for pediatric postburn scars. The review concluded that the combination appears effective for improving postburn scar features in children, particularly when vascularity and textural abnormalities coexist. The pediatric focus is important because burn scars in children have prolonged remodeling trajectories and major psychosocial impact. The study also supports the increasingly accepted principle that vascular and ablative devices may have complementary roles in complex burn scar care. Its limitations derive from the small and heterogeneous underlying literature (Level 1a).

Ghassemi et al. [35] systematically reviewed ablative fractional lasers, including CO_2 and Er:YAG, in comparison and combination with pulsed dye laser for hypertrophic scars. The review suggested that both ablative and vascular lasers have value, and that combination protocols may offer broader improvement across scar thickness, pliability, erythema, and overall appearance. This article is useful because hypertrophic scars are rarely defined by one dominant feature alone. The authors' emphasis on combining modalities matches current clinical practice, though differences in included study design and protocol quality make it difficult to rank specific pairings with certainty (Level 1a).

Haji Mohammadi et al. [36] reviewed comparative clinical trials on ablative and non-ablative laser therapies for atrophic, hypertrophic, and keloid scars. The review concluded that ablative lasers, particularly CO_2 and Er:YAG, were generally more effective for atrophic scars but were associated with greater pain and downtime, whereas non-ablative options offered a safer recovery profile in selected patients. This review is particularly valuable because it compares not only efficacy but also satisfaction and tolerability across scar categories. It supports a personalized approach in which treatment intensity is matched to scar type, skin type, and downtime tolerance (Level 1a).

Gu et al. [37] performed a retrospective analysis of fractional CO_2 laser in linear scars to investigate ideal timing for intervention. The authors concluded that ablative fractional CO_2 laser is effective for linear scar treatment and that early intervention, especially within the first six months, produces superior outcomes for atrophic scars. This study strengthens the growing consensus that timing is not a secondary issue but a major determinant of treatment response. The retrospective design limits the ability to control for confounders such as baseline scar severity and treatment intensity, but the findings are clinically coherent and consistent with broader timing literature (Level 2b).

Zhou et al. [38] evaluated poly-L-lactic acid combined with CO_2 fractional laser for acne scars. The study concluded that the combination can safely and effectively improve acne scars, particularly rolling and boxcar scars. This is mechanistically plausible because laser-induced remodeling may be augmented by a biostimulatory filler that supports collagen neogenesis. The study contributes to an expanding literature on combination scar therapy that integrates energy devices with regenerative materials. Its relevance is highest in atrophic acne scars where volume loss and dermal tethering coexist. Larger trials are still needed to clarify durability and patient selection (Level 2b).

Piccolo et al. [39] reported a case series of 30 patients treated with multi-modal laser combination therapy for pigmented scars. The authors concluded that combinations involving CO_2, dye, and Nd:YAG lasers are feasible and can reduce pigmentary, fibrotic, and vascular components in complex scars. The practical significance of the study lies in its recognition that pigmented scars often contain overlapping pathologies that are not adequately managed by one wavelength alone. Because the work was a case series without a control group, it mainly demonstrates feasibility and clinical plausibility rather than comparative superiority (Level 4).

Chang et al. [40] compared early versus late pulsed dye laser treatment for posttraumatic and surgical scars in Asian patients. Early intervention within 10 weeks of injury produced better outcomes than later treatment based on clinical and imaging assessments. This study is especially important because it supports early scar vascular intervention in a population where post-inflammatory pigmentary change is often a concern and where clinicians may hesitate to treat too soon. The findings suggest that early PDL can be both effective and safe when appropriately selected, reinforcing the broader concept that scar modulation is most responsive during early remodeling (Level 2b).

Li et al. [41] systematically reviewed pulsed dye laser, fractional CO_2 laser, and their combination for burn scar treatment. The review suggested potential benefit of PDL for overall scar appearance and broadly comparable efficacy between AFCL and PDL across several scar features, while combined treatment may provide wider multidimensional benefit. This paper is useful because it addresses a clinically common question: whether one should start with vascular, ablative, or combination therapy in burn scars. The authors support a tailored approach rather than universal preference for one laser, but the underlying evidence remains heterogeneous (Level 1a).

Atefi et al. [42] conducted a three-arm randomized controlled clinical trial evaluating pulsed dye laser alone, pulsed dye laser plus botulinum toxin type A, and pulsed dye laser plus triamcinolone for hypertrophic and keloid scars. The combined PDL and botulinum toxin protocol was reported as an effective option, suggesting that neuromodulatory or tension-reducing strategies may augment vascular laser treatment. This trial is clinically intriguing because it moves beyond steroid-based combinations and explores biologically distinct adjuncts. The small number of patients likely limits power, but the findings support future studies of combination therapy for challenging fibroproliferative scars (Level 1b).

Alegre-Sánchez et al. [43] evaluated subdermal laser-assisted scar subcision combined with fractional CO_2 laser for acne scars. The authors concluded that SLASS is a promising technique, especially for rolling scars, because it creates a thermo-mechanical subcision effect while the fractional CO_2 component improves surface remodeling. The conceptual strength of the method lies in addressing both dermal tethering and textural irregularity in the same treatment strategy. This study is especially relevant for scar phenotypes that respond suboptimally to resurfacing alone. Because the evidence remains early, broader comparative trials are needed (Level 2b).

Alomari et al. [44] performed a systematic review and meta-analysis on stromal vascular fraction combined with fractional CO_2 laser for hypertrophic scars. The authors concluded that this combination shows significant promise in improving scar appearance and texture, with an acceptable safety profile. This is an important contribution because it reflects growing interest in cell-based or regenerative adjuncts rather than purely mechanical resurfacing. However, the number of eligible studies remains limited, and the review should be interpreted as encouraging rather than definitive evidence (Level 1a).

Haykal et al. [45] published a broad review on the physical and emotional journey of laser treatment for scars. The article emphasized that laser therapy improves not only measurable scar features such as stiffness, color, pain, and itch but also psychological dimensions including self-image and distress reduction. This perspective is important because scar treatment outcomes are often under-evaluated if only morphologic scales are used. The review is best understood as a panoramic clinical synthesis rather than a direct comparative efficacy analysis. It supports the incorporation of quality-of-life measures into future scar laser trials (Level 5).

Wang et al. [46] performed a systematic review and meta-analysis on laser or intense pulsed light treatment for early surgical scars. Twelve studies involving 475 patients were analyzed, and the pooled findings demonstrated that early laser or IPL treatment was safe and superior to control interventions in improving scar appearance. This review strongly supports early intervention in surgically closed wounds and provides a useful evidence base for clinicians who remain uncertain about initiating treatment during the early remodeling phase. Its strength lies in pooled quantitative synthesis, though protocol variability across devices and treatment schedules remains a limitation (Level 1a).

Foppiani et al. [47] conducted a systematic review and network meta-analysis of laser therapy in hypertrophic and keloid scars. The analysis aimed to compare different laser types and suggested that combination strategies, particularly fractional CO_2 laser with 5-fluorouracil, may provide superior improvement among evaluated interventions. This study is valuable because it moves beyond simple narrative comparison and attempts indirect ranking across modalities. Nevertheless, network meta-analysis is only as strong as the included studies, and the underlying literature still contains heterogeneity in scar definitions, comparator design, and follow-up (Level 1a).

Bernabe et al. [48] systematically reviewed laser-assisted drug delivery in hypertrophic scars and keloids. The review concluded that LADD is a promising strategy because ablative fractional laser can create microchannels that enhance penetration of therapeutic agents into dense scar tissue. The evidence suggested potential benefit, but the authors also emphasized that available studies remain limited and heterogeneous. This review is particularly relevant for difficult fibroproliferative scars that respond incompletely to laser monotherapy. Its importance lies less in proving a final standard and more in defining an emerging platform for future scar combination therapy (Level 1a).

Le et al. [49] reviewed laser applications in wound and scar management after Mohs micrographic surgery. The authors concluded that post-Mohs laser use is safe, well tolerated, and associated with high patient satisfaction, while offering a less invasive option than surgical scar revision. The review is clinically useful because scars after Mohs procedures often occur on cosmetically sensitive facial sites where optimization of texture, contour, and erythema is especially important. Although the literature base is not extensive, this review supports the expanding role of lasers beyond classic acne and burn scar indications (Level 1a).

Qiang et al. [50] performed a retrospective study using 3D imaging and scar scale analysis to evaluate timing of laser intervention on facial scars. The authors found that early intervention produced promising improvements in postoperative scar outcomes. The addition of 3D imaging is a major strength because it enables a more precise assessment of topographic scar change than subjective scales alone. This study complements other timg papers and helps support the argument that early scar remodeling may be more responsive to laser treatment than mature fibrosis. Because it is retrospective, prospective confirmation is still needed (Level 2b).

Bergus et al. [51] examined the impact of laser treatment on hypertrophic burn scars in pediatric burn patients. The study found that most body regions demonstrated improvement in modified Vancouver Scar Scale scores after laser treatment, although response varied according to body location and scar context. This work is important because pediatric burn scar outcomes are influenced by growth, contracture, and activity patterns, and treatment effectiveness may not be uniform across anatomical sites. The study supports pediatric laser therapy while also cautioning against assuming identical response in all scar locations (Level 2b).

Guo et al. [52] summarized advances in laser therapies for scars and discussed mechanisms and indications for CO_2 fractional laser, Er:YAG, pulsed dye laser, and related systems. The review emphasized that ablative fractional lasers remain central for atrophic scars, while vascular lasers are important for erythematous and hypertrophic lesions. It also highlighted differences in tissue targeting and adverse-effect profiles across device classes. This article serves as a useful broad technical overview and places individual devices within a rational treatment algorithm, although it does not offer pooled comparative evidence (Level 5).

Sharma et al. [53] prospectively evaluated fractional carbon dioxide laser treatment for mature burn scars, post-traumatic scars, and post-acne scars. The study concluded that fractional CO_2 laser improved scar quality and skin texture, with particularly favorable effects on scar appearance overall. This broad inclusion of several scar types mirrors real-world practice and supports the versatility of fractional ablative resurfacing. The study's main strength is its prospective design, whereas the inclusion of heterogeneous scar etiologies may also dilute scar-specific conclusions. Nonetheless, it adds contemporary evidence that CO_2 fractional laser remains widely useful across multiple scar phenotypes (Level 2b).

Kivi et al. [54] conducted a single-blinded randomized controlled trial comparing pulsed dye laser alone, ablative fractional CO_2 laser alone, and their combination in hypertrophic burn scars. All groups improved, but the combined therapy group showed the greatest improvement in total Vancouver Scar Scale and in parameters such as vascularity and pliability, especially in immature scars. Although superiority did not always reach formal statistical significance, the magnitude of improvement was clinically meaningful. This study provides direct evidence for combination vascular and ablative treatment in burn scars and suggests that scar maturity influences responsiveness (Level 1b).

Osman et al. [55] compared fractional Er:YAG laser with fractional CO_2 laser in a randomized study of immature and mature scars. The authors reported equivalent efficacy between the two modalities overall, while immature scars responded better than mature scars regardless of device. This study is valuable because it addresses a practical comparative question between two common ablative fractional systems. The conclusion suggests that device choice may depend less on absolute efficacy and more on operator preference, adverse-effect profile, and patient-specific considerations. It also reinforces the recurrent finding that earlier scar intervention is advantageous (Level 1b).

Clementi et al. [56] evaluated dye laser applications in cosmetic dermatology and included scar-related indications among vascular lesions. The article indicated that flash-lamp pulsed dye laser is safe and effective for scars as well as vascular lesions, supporting its established role in erythematous and immature scar treatment. The study contributes to the evidence base for vascular-selective therapy and is particularly useful where scar redness and vascular activity remain dominant clinical problems. Because its scope extends beyond scars alone, it provides supportive rather than scar-exclusive evidence (Level 2b).

Li et al. [57] retrospectively studied 1064-nm fractional picosecond laser treatment of non-acne atrophic scars and scar erythema in Chinese patients. The study found significant improvement in modified Manchester Scar Scale scores and a marked reduction in clinician erythema scores, with most patients showing improvement and no serious prolonged adverse events. This article is important because it extends picosecond fractional technology beyond acne scars into other atrophic and erythematous scars, while also providing data in an Asian population. The small cohort limits generalizability, but the results are promising (Level 2b) (Table 1).

Table 1. Summary of Literature on Laser Treatment for Scars.

Author/Year	Study Design	Key Findings	Evidence Level
Zhang et al., 2026 [15]	Mechanistic review	Fractional CO_2 laser improves scars through microthermal ablation, collagen reorganization, inflammatory modulation, angiogenic signaling changes, and accelerated wound-healing kinetics.	5
Novintan et al., 2026 [16]	Systematic review	Platelet-rich plasma combined with ablative fractional CO_2 laser generally improves healing and may enhance scar appearance, especially by reducing downtime and improving recovery.	1a
Argobi et al., 2026 [17]	Meta-analysis of RCTs	Fractional CO_2 laser may provide somewhat greater efficacy than microneedling radiofrequency for post-acne scarring, although both are effective options.	1a
Chen et al., 2026 [18]	Randomized controlled trial	Fractional CO_2 laser was superior to injection therapy for surgical scars, improving POSAS, VSS, visual analog scores, overall efficacy, and patient satisfaction.	1b
Roohaninasab et al., 2026 [19]	Randomized, double-blind, split-face comparative study	Fractional CO_2 laser combined with PRP, non-cross-linked hyaluronic acid, or both improved acne scars; the combination arm produced the highest patient and physician satisfaction.	1b
Park et al., 2026 [20]	Randomized clinical study	Laser-assisted delivery of human- or plant-derived exosome boosters after fractional non-ablative Nd:YAG laser produced greater short-term improvement in postoperative facial scars without serious adverse events.	1b
He et al., 2026 [21]	Prospective randomized split-face trial	Alternating ablative fractional laser with microneedling radiofrequency achieved greater acne scar improvement and higher satisfaction than ablative fractional laser alone, though pain was higher.	1b
Issler-Fisher et al., 2026 [22]	Expert textbook chapter/practical review	Vascular lasers are useful for erythematous immature burn scars, whereas fractional ablative lasers are better suited for thick, rigid, or contracture-prone burn scars.	5
Goldman et al., 2026 [23]	Review	Dual 1550-nm erbium glass and 1927-nm thulium non-ablative fractional laser appears safe and effective in skin of color for textural and pigmentary concerns, including scars, when conservative settings are used.	5

Table 1. *Cont.*

Author/Year	Study Design	Key Findings	Evidence Level
Saaqib et al., 2026 [24]	Randomized controlled trial	Adding PRP to fractional CO_2 laser improved clinical response in facial acne scars compared with laser alone.	1b
Priyanka et al., 2026 [25]	Comparative clinical study	Fractional CO_2 laser combined with autologous PRP was more effective than fractional CO_2 laser alone for post-acne atrophic scars.	2b
Di Guardo et al., 2026 [26]	Retrospective study	Rhodamine IPL was effective and safe for hypertrophic scars with a vascular component; dynamic optical coherence tomography provided objective support for vascular improvement.	2b
Clementi et al., 2025 [27]	Comprehensive review	Combined laser strategies may improve scar outcomes by simultaneously targeting vascularity, fibrosis, pigmentation, and surface irregularity across multiple scar types.	5
Chen et al., 2025 [28]	Comparative clinical study	Sequential laser treatment appeared more effective than isolated ultra-pulse CO_2 laser or drug treatment for early proliferative burn scars.	2b
Ji et al., 2025 [29]	Systematic review and meta-analysis	Fractional CO_2 laser significantly improved surgical scars overall, with treatment initiated within 1 month after surgery being more effective than delayed intervention.	1a
Guo et al., 2025 [30]	Retrospective/comparative clinical study	Early sequential PDL and ablative fractional CO_2 laser effectively improved long facial linear scars across different anatomic regions.	2b
Brewin et al., 2025 [31]	Multicenter randomized controlled trial	Early PDL plus standard care improved patient-rated quality of hypertrophic burn scars compared with standard care alone, with no unexpected adverse events.	1b
Keshk et al., 2025 [32]	Clinical and histopathological study	Fractional CO_2 laser improved hypertrophic scar appearance and produced supportive histopathologic remodeling changes.	2b
Ptaszek et al., 2025 [33]	Systematic review	Fractional laser, especially fractional CO_2 laser, improved acne scar appearance by about 30–70% in most studies, with mostly mild and transient adverse effects.	1a
Yin et al., 2025 [34]	Systematic review	Combined PDL and ablative fractional CO_2 laser appears effective for pediatric postburn scars, particularly when vascularity and textural abnormalities coexist.	1a
Ghassemi et al., 2025 [35]	Systematic review	Ablative fractional lasers and PDL both have value in hypertrophic scars, and combination protocols may offer broader improvement in thickness, pliability, erythema, and overall appearance.	1a
Haji Mohammadi et al., 2025 [36]	Systematic review of comparative clinical trials	Ablative lasers, particularly CO_2 and Er:YAG, were generally more effective for atrophic scars, while non-ablative lasers offered a safer recovery profile in selected patients.	1a
Gu et al., 2025 [37]	Retrospective analysis	Fractional CO_2 laser was effective for linear scars, with earlier intervention, especially within the first 6 months, producing better outcomes for atrophic scars.	2b
Zhou et al., 2025 [38]	Comparative clinical study	Poly-L-lactic acid combined with CO_2 fractional laser safely and effectively improved acne scars, particularly rolling and boxcar scars.	2b
Piccolo et al., 2025 [39]	Case series	Multi-modal combinations of CO_2, dye, and Nd:YAG lasers were feasible and improved pigmentary, fibrotic, and vascular components of complex pigmented scars.	4
Chang et al., 2025 [40]	Comparative clinical study	Early PDL treatment within 10 weeks produced better outcomes than later treatment for posttraumatic and surgical scars in Asian patients.	2b

Table 1. *Cont.*

Author/Year	Study Design	Key Findings	Evidence Level
Li et al., 2025 [41]	Systematic review	PDL, fractional CO_2 laser, and their combination all showed benefit for burn scars; combination therapy may offer broader multidimensional improvement.	1a
Atefi et al., 2025 [42]	Three-arm randomized controlled trial	PDL combined with botulinum toxin type A was an effective option for hypertrophic and keloid scars, suggesting benefit beyond steroid-based combinations.	1b
Alegre-Sánchez et al., 2025 [43]	Comparative clinical study	Subdermal laser-assisted scar subcision combined with fractional CO_2 laser was promising for acne scars, especially rolling scars with dermal tethering.	2b
Alomari et al., 2025 [44]	Systematic review and meta-analysis	Stromal vascular fraction combined with fractional CO_2 laser showed significant promise for improving hypertrophic scar appearance and texture with acceptable safety.	1a
Haykal et al., 2024 [45]	Narrative review	Laser treatment may improve not only scar color, stiffness, pain, and itch, but also psychosocial distress, self-image, and quality of life.	5
Wang et al., 2024 [46]	Systematic review and meta-analysis	Early laser or IPL treatment for surgical scars was safe and superior to control interventions in improving postoperative scar appearance.	1a
Foppiani et al., 2024 [47]	Systematic review and network meta-analysis	Combination laser strategies, particularly fractional CO_2 laser with 5-fluorouracil, may provide superior improvement in hypertrophic and keloid scars.	1a
Bernabe et al., 2024 [48]	Systematic review	Laser-assisted drug delivery is a promising approach for hypertrophic scars and keloids because fractional ablative lasers enhance penetration of therapeutic agents into dense scar tissue.	1a
Le et al., 2024 [49]	Systematic review	Post-Mohs laser treatment appears safe, well tolerated, and associated with high patient satisfaction, offering a less invasive alternative to surgical scar revision.	1a
Qiang et al., 2024 [50]	Retrospective study with 3D imaging	Early laser intervention on facial scars showed promising improvement based on 3D imaging and scar scale analysis.	2b
Bergus et al., 2024 [51]	Retrospective pediatric study	Laser treatment improved modified Vancouver Scar Scale scores in most pediatric hypertrophic burn scars, although response varied by body region.	2b
Guo et al., 2024 [52]	Narrative review	Advances in scar laser therapy support ablative fractional lasers for atrophic scars and vascular lasers for erythematous and hypertrophic scars, with device choice guided by tissue target and adverse-effect profile.	5
Sharma et al., 2024 [53]	Prospective clinical study	Fractional CO_2 laser improved mature burn scars, post-traumatic scars, and post-acne scars, supporting broad utility across scar phenotypes.	2b
Kivi et al., 2024 [54]	Single-blinded randomized controlled trial	CO_2 fractional laser, PDL, and their combination all improved hypertrophic burn scars, but combination therapy showed the greatest overall improvement, especially in immature scars.	1b
Osman et al., 2024 [55]	Comparative randomized study	Fractional Er:YAG and fractional CO_2 laser showed equivalent efficacy overall, while immature scars responded better than mature scars regardless of device.	1b
Clementi et al., 2024 [56]	Clinical review/applied study	Flash-lamp PDL was safe and effective for scars and remains particularly useful for erythematous and immature scar treatment.	2b
Li et al., 2024 [57]	Retrospective study	1064-nm fractional picosecond laser significantly improved non-acne atrophic scars and scar erythema in Chinese patients without serious prolonged adverse events.	2b

4. Discussion

The contemporary literature from 2024 to 2026 confirms that laser therapy is no longer a niche adjunct in scar management, but a central, phenotype-directed therapeutic platform with expanding indications and increasingly sophisticated combination strategies. Across the studies reviewed, ablative fractional CO_2 laser ($AFCO_2L$) remains the most extensively investigated modality, particularly for acne scars, surgical scars, hypertrophic scars, and mixed traumatic scars [15,29,53]. At the same time, pulsed dye laser (PDL) continues to show particular value in erythematous, immature, and vascular scars, especially in burn and early postoperative settings [30,54,56]. Rather than supporting a "one laser fits all" paradigm, the recent evidence strongly favors selecting devices according to the dominant biologic and clinical features of the scar, including vascularity, fibrosis, thickness, textural irregularity, pigmentation, contracture, maturity, and anatomic location [22,41,52].

One major theme emerging from this review is the continued dominance of $AFCO_2L$ as the benchmark resurfacing modality. Mechanistically, the broad utility of $AFCO_2L$ is supported by evidence that its action extends beyond superficial ablation to include collagen remodeling, modulation of inflammatory signaling, angiogenic changes, and accelerated wound-healing dynamics [15]. This mechanistic framework is consistent with the clinical improvements reported in acne scars, hypertrophic scars, linear scars, and surgical scars [18,37,53]. In particular, the randomized controlled trial by Chen et al. demonstrated superiority of fractional CO_2 laser over injection therapy for surgical scars across multiple physician- and patient-reported outcomes, suggesting that laser remodeling can produce clinically meaningful benefit in both appearance and symptoms [18]. Similarly, prospective and retrospective studies across different scar etiologies continue to support $AFCO_2L$ as a versatile modality capable of improving scar texture, pliability, and overall quality [32,37,53]. Taken together, these findings reinforce $AFCO_2L$ as the current reference standard for textural remodeling in scar management.

Nevertheless, the present literature also emphasizes that efficacy should not be interpreted only in terms of maximal remodeling potential. Comparative work suggests that treatment selection must balance efficacy against tolerability, downtime, and patient phenotype. The meta-analysis by Argobi et al. found that fractional CO_2 laser may offer somewhat greater efficacy than microneedling radiofrequency for post-acne scarring, but the latter remains a viable alternative with favorable tolerability in some contexts [17]. Likewise, the systematic review by Haji Mohammadi et al. concluded that ablative lasers generally outperform non-ablative systems for atrophic scars, but often at the cost of more pain and recovery burden [36]. The randomized comparison between fractional Er:YAG and fractional CO_2 laser is particularly informative, as it found broadly equivalent efficacy, with scar maturity appearing more important than device choice itself [55]. This suggests that, in practice, laser selection may depend not only on scar morphology but also on patient willingness to accept downtime, risk of adverse effects, and operator familiarity.

Timing has emerged as perhaps the most clinically actionable finding in the recent scar laser literature. Historically, procedural revision was often delayed until full scar maturation, but current evidence increasingly challenges that approach. The systematic review and meta-analysis by Ji et al. showed that fractional CO_2 laser is most effective when initiated within one month after surgery, whereas delayed treatment beyond three months did not yield significant pooled benefit for postoperative scars [29]. This message is reinforced by Wang et al., whose meta-analysis demonstrated that early laser or IPL treatment of surgical scars is both safe and superior to control interventions [46]. Similar conclusions were reported in facial scar cohorts using 3D imaging and clinical assessment, and in studies specifically evaluating timing in linear scars [37,50]. Importantly, the same principle appears applicable to vascular intervention: Chang et al. found that early PDL in Asian patients with posttraumatic and surgical scars produced better results than delayed therapy [40]. Collectively, these studies support a paradigm shift from passive observation toward active early modulation of scar biology during the remodeling phase.

The role of PDL is particularly compelling in immature and burn-related scars, where persistent erythema, neovascularity, itch, and symptomatic inflammation are often prominent. The ELABS multicenter randomized trial provides some of the strongest evidence in this area, showing that early PDL improved patient-rated scar quality in hypertrophic burn scars, even if not all observer-rated outcomes reached statistical significance at six months [31]. This distinction is important: patient-perceived improvement may be clinically meaningful even before large structural changes become fully measurable. Additional support comes from pediatric and adult burn scar literature, where systematic reviews suggest that PDL can improve vascularity and overall appearance and may be especially useful when combined with ablative fractional resurfacing [34,41]. Kivi et al. further showed that combined PDL and CO_2 fractional laser produced the greatest improvement among treatment arms for hypertrophic burn scars, particularly in immature scars, even where some differences did not achieve formal statistical significance [54]. Together, these findings suggest that PDL is best viewed not merely as a color-correcting device, but as an early biologic modulator of active scar remodeling.

A second major trend is the rise of multimodal and sequential treatment strategies. Scar pathology is rarely unidimensional; many scars simultaneously exhibit erythema, hypertrophy, tethering, dyschromia, and surface irregularity. The literature increasingly reflects this complexity. Narrative and systematic reviews have consistently concluded that combined laser protocols can outperform monotherapy by targeting different scar components in a complementary manner [27,35,41]. Early sequential use of PDL followed by AFCO_2L for facial linear scars is a good example of rational staging, addressing vascular signaling first and textural remodeling second [30]. Similar logic underpins multimodal approaches in burn scars, pediatric postburn scars, and pigmented scars [34,54]. Although protocol heterogeneity remains substantial, the overall direction of evidence supports combination treatment as the likely future standard for complex scars rather than an optional escalation step.

This trend toward multimodality is particularly evident in acne scarring, where surface irregularity, dermal tethering, and volume loss frequently coexist. While AFCO_2L alone remains effective [17,33], recent studies suggest that combination procedural strategies may yield better outcomes in selected patients. He et al. found that alternating ablative fractional laser with microneedling radiofrequency produced greater improvement than laser alone in moderate-to-severe acne scars [21]. Zhou et al. reported favorable results when poly-L-lactic acid was combined with CO_2 fractional laser, an approach that is mechanistically plausible in scars with concomitant volume deficiency [38]. Alegre-Sánchez et al. similarly demonstrated the promise of subdermal laser-assisted scar subcision combined with fractional CO_2 laser, especially for rolling scars, where tethering is a key pathogenic feature [43]. These studies emphasize that acne scar management increasingly requires morphology-specific treatment rather than default resurfacing alone.

Another important development is the growing use of regenerative and biologic adjuncts. Platelet-rich plasma (PRP) is the best studied of these additions, with multiple trials and a systematic review suggesting that combining PRP with AFCO_2L can improve scar appearance and may also reduce post-procedural downtime [16,25]. Notably, the split-face trial by Roohaninasab et al. suggested that combining PRP with non-cross-linked hyaluronic acid may further enhance patient and physician satisfaction, even when objective biometric changes are less striking [19]. This raises an important point in scar treatment research: perceived recovery and aesthetic improvement may matter as much as instrumental endpoints for patients. Beyond PRP, laser-assisted exosome delivery has emerged as a novel regenerative strategy, with Park et al. demonstrating short-term improvement in postoperative facial scars without major safety concerns [20]. Stromal vascular fraction combined with fractional CO_2 laser has also shown promise in hypertrophic scars in a meta-analytic review [44]. Although these approaches remain early in their evidence trajectory, they illustrate how laser platforms are increasingly being used not only as primary therapies but also as delivery systems or biologic amplifiers.

Laser-assisted drug delivery (LADD) is especially relevant in fibroproliferative scars such as hypertrophic scars and keloids, where dense extracellular matrix may limit penetration of topical or injected therapeutics. Bernabe et al. highlighted the promise of fractional ablative lasers for creating microchannels that enhance delivery of active agents into resistant scar tissue [48]. The network meta-analysis by Foppiani et al. goes a step further by suggesting that certain combination strategies, especially fractional CO_2 laser with 5-fluorouracil, may rank highly among available options for hypertrophic and keloid scars [47]. Atefi et al. additionally showed that PDL combined with botulinum toxin type A may be effective for hypertrophic and keloid scars, expanding the range of adjuncts beyond corticosteroids and antimetabolites [42]. These studies collectively suggest that the future of difficult scar management may lie less in identifying a single best laser and more in optimizing laser-enabled multimodal delivery platforms.

Safety remains a critical consideration, especially in patients with skin of color, pediatric populations, and scars located in cosmetically sensitive areas. Goldman et al. emphasized that non-ablative fractional 1550/1927 nm systems can be used effectively in skin of color when conservative parameters are chosen, which is particularly relevant given concern about post-inflammatory dyspigmentation [23]. Likewise, Li et al. reported promising outcomes with 1064-nm fractional picosecond laser for non-acne atrophic scars and scar erythema in Chinese patients, suggesting a potentially useful role for newer picosecond fractional technologies in Asian skin [57]. Studies on early PDL in Asian patients also indicate that timely vascular treatment can be both effective and safe when carefully performed [40]. In children, systematic and clinical studies support laser use in postburn scars, but also indicate that response may vary by body region and growth-related factors [34,51]. These findings underscore the need for protocol customization according to skin phototype, age, scar location, and risk tolerance.

Despite these advances, the literature remains limited by several recurring methodological issues. Many studies include small sample sizes, short follow-up periods, heterogeneous scar types, and inconsistent laser parameters, making cross-study comparison difficult [16,48]. Outcome assessment also remains insufficiently standardized. Some studies prioritize Vancouver Scar Scale or POSAS, others emphasize imaging, grayscale analysis, clinician erythema scores, or satisfaction measures [18,20,57]. This diversity reflects the multidimensional nature of scars, but it also impedes meta-analysis and practical protocol optimization. Moreover, although recent work increasingly includes skin of color, pediatric patients, and non-acne scar phenotypes, these groups remain underrepresented relative to common adult acne-scar cohorts [23,51,57]. Longer-term data are also needed, particularly for regenerative adjuncts such as exosomes, stromal vascular fraction, and filler-assisted laser combinations [20,38,44].

Overall, the recent evidence supports a refined clinical algorithm for scar laser treatment. Early intervention appears preferable for many surgical, traumatic, and immature scars [29,50]. PDL is especially useful when erythema and vascular activity predominate [31,56], whereas fractional ablative lasers remain central when texture, thickness, rigidity, and contour irregularity are major concerns [18,53]. Combination protocols are increasingly justified in burn scars, acne scars, hypertrophic scars, and complex mixed-phenotype scars [21,54]. Biologic and drug-delivery adjuncts appear promising, but should still be considered evolving strategies rather than universal standards [16,48]. Future studies should prioritize phenotype-specific enrollment, standardized outcome measures, direct head-to-head comparisons, cost-effectiveness analyses, and longer follow-up across a wider range of skin phototypes. In that context, laser therapy is best understood not as a single intervention, but as a flexible and increasingly evidence-based platform for individualized scar modulation.

5. Conclusions

Laser-based therapy has become an essential component of modern scar management. The contemporary literature from 2024 to 2026 supports a treatment paradigm that is early, phenotype-specific, and increasingly combination-based. Fractional CO_2 laser remains the dominant resurfacing modality, especially for acne scars and surgical scars, while pulsed dye laser is particularly valuable for erythematous and immature scars. Combined vascular and ablative approaches appear especially promising for burn scars and hypertrophic scars. Emerging adjuncts such as PRP, exosomes, stromal vascular fraction, and laser-assisted drug delivery may further broaden therapeutic outcomes.

Future research should focus on standardized scar classification, harmonized outcome measures, longer follow-up, cost-effectiveness, and direct head-to-head trials across devices and combination protocols. More high-quality evidence in skin of color and pediatric populations is also needed. Overall, current data support laser treatment as a versatile and increasingly evidence-based strategy for improving both the physical and psychosocial burden of scars.

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