Review

Clinical Application of Picosecond Laser: An Update and Critical Review

Kar Wai Alvin Lee [1,*], Kwin Wah Lisa Chan [1], Cheuk Hung Lee [1] and Tin Hau Sky Wong [2]

[1] Everkeen Medical Centre, Hong Kong
[2] Madaes Medical Centre, Hong Kong
* Correspondence: alvin429@yahoo.com

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Abstract: **Background:** Picosecond laser technology has moved beyond its original role in tattoo clearance and now occupies a widening place in medical and aesthetic dermatology. During year 2024–2026, the literature expanded across pigmentary disorders, melasma, nevus of Ota, acne scarring, photorejuvenation, tattoo complications, and several exploratory indications. At the same time, enthusiasm has been tempered by inconsistent study quality, frequent reliance on retrospective series, and persistent concerns regarding dyspigmentation in darker phototypes. **Methods:** A comprehensive literature review was conducted covering publications from 2024 to 2026 on clinical application of Picosecond laser. The source framework was based on MEDLINE, PubMed, and Ovid database retrieval. Studies included systematic reviews, meta-analyses, randomized trials, retrospective comparative studies, case series, case reports, mechanistic investigations, and technology-focused reviews. All studies were classified according to the Oxford Centre for Evidence-Based Medicine 2009 Levels of Evidence. **Results:** Recent evidence suggests that picosecond lasers are most strongly supported for selected pigmentary disorders and as an adjunctive modality in skin rejuvenation and acne scarring. Melasma remains the most controversial indication: several studies showed clinical improvement, yet high-level syntheses did not establish clear superiority over established topical regimens and underscored relapse and hypopigmentation concerns. For nevus of Ota and related dermal melanocytoses, results were generally favorable, especially in Asian populations and pediatric cohorts, although most data remained observational. Emerging reports also described use in lichen planus pigmentosus, xanthelasma, androgenetic alopecia, photodamage, argyria, and tattoo-related complications. Mechanistic work supported a dual action of pigment fragmentation and dermal remodeling, but translational gaps remain. **Conclusions:** Picosecond lasers have become a versatile platform with meaningful clinical utility, particularly for benign pigmented lesions, selected dermal melanocytoses, acne scarring, and rejuvenation. However, the evidence base remains uneven, with relatively few robust randomized studies and limited long-term outcome data. Current practice should therefore emphasize phenotype-specific treatment selection, conservative parameter choice in skin of color, and careful counseling regarding recurrence and dyspigmentation. Better-designed comparative trials and standardized reporting are needed to define the true comparative value of picosecond technology.

Keywords: laser therapy; skin diseases; pigmentary; melanosis; cicatrix; acne; nevus; pigmented; tattooing

1. Introduction

Picosecond laser systems have become a prominent part of contemporary dermatologic practice because their ultrashort pulse durations favor photoacoustic disruption of pigment with less thermal diffusion than conventional nanosecond devices [1]. This property has broadened their clinical reach from tattoo treatment to benign pigmented lesions, inflammatory dyschromias, dermal melanocytoses, rejuvenation, and scar remodeling [2,3]. In parallel, growing use in patients with darker phototypes has intensified interest in whether picosecond platforms can preserve efficacy while reducing the risk of post-inflammatory pigment alteration, a central consideration in real-world laser practice [4].

For melasma, enthusiasm has been driven by the theoretical advantage of melanosome fragmentation with limited collateral injury, yet the best available syntheses indicate that superiority over conventional topical regimens has not been

established and that adverse pigmentary shifts remain clinically relevant [5]. Practical treatment articles have therefore moved toward combination strategies, integrating picosecond irradiation with barrier support, dermal biostimulation, or adjunctive topical therapy in an effort to improve durability rather than simply accelerate early clearance [1]. At the same time, engineering-oriented analyses indicate that wavelength selection, spot size, and target depth are not interchangeable variables but determinants of both efficacy and complication risk [6].

Beyond alexandrite-specific meta-analysis, broader systematic reviews of laser-based therapies describe heterogeneous efficacy signals and remind clinicians that short-term lightening does not necessarily translate into stable long-term disease control [7]. Similar caution applies to disorders such as lichen planus pigmentosus, where randomized evidence has not uniformly confirmed the benefit suggested by case-based experience [8].

Given the rapid growth of this field, an updated synthesis is needed. The present review critically evaluates the studies published between 2024 and 2026 on the clinical application of picosecond lasers, with emphasis on therapeutic indications, comparative effectiveness, safety in skin of color, and quality of evidence. All included studies were additionally classified according to the Oxford Centre for Evidence-Based Medicine 2009 framework to place current enthusiasm within an explicit hierarchy of evidence.

2. Methods

A comprehensive literature review was conducted covering publications from 2024 to 2026 on clinical application of Picosecond laser. The source framework was based on MEDLINE, PubMed, and Ovid database retrieval. Eligible publications included systematic reviews, meta-analyses, randomized and split-face comparative trials, retrospective comparative studies, case series, case reports, mechanistic laboratory studies, conference proceedings, narrative or comprehensive reviews. Data were extracted narratively from the supplied citations and available article-level information, with emphasis on study design, indication, treatment modality, comparator when present, efficacy outcomes, safety observations, and clinical relevance. All studies were classified using the Oxford Centre for Evidence-Based Medicine 2009 Levels of Evidence [9].

3. Results

Sethi et al. [10] reported a prospective case series examining the use of a 755-nm picosecond alexandrite platform for lichen planus pigmentosus and pigmentary demarcation lines in patients with skin of color. The study is notable because it addressed two difficult-to-treat pigmentary disorders in a population that is especially vulnerable to treatment-induced dyspigmentation. Clinical improvement was substantial across the small cohort, with particularly strong responses in lichen planus pigmentosus and minimal adverse effects. Although the sample was limited and non-comparative, the paper supports the practical impression that picosecond alexandrite treatment may be a useful option for recalcitrant hyperpigmentation when conservative parameters and careful follow-up are used (Level 4).

Alrubaiaan et al. [11] performed a systematic review and meta-analysis on the 755-nm picosecond alexandrite laser for nevus of Ota. Ten studies involving 558 patients were synthesized, providing one of the largest focused evidence summaries for this indication. The pooled excellent response rate was moderate at 36.8%, while post-inflammatory hyperpigmentation and hypopigmentation were reported at relatively low frequencies. The review supports clinical utility but also shows that outcomes are not uniformly dramatic and that pigmentary complications remain relevant. Because the underlying evidence base consisted mainly of non-randomized studies, the article is best interpreted as moderate-level supportive evidence rather than definitive proof of superiority over established Q-switched approaches (Level 2a).

Abdul-Rahman et al. [12] systematically reviewed the safety and efficacy of picosecond laser therapy in skin of color, a topic of considerable clinical importance given the expanding use of energy-based devices in higher Fitzpatrick phototypes. The review assembled heterogeneous studies across multiple indications and concluded that picosecond lasers can be effective in darker skin when parameters are chosen carefully. Its major contribution lies less in quantifying superiority than in highlighting the current safety envelope, common complications, and areas where evidence remains thin. The paper reinforces that skin of color should not be treated as a niche subgroup but as a central population in picosecond laser research (Level 2a).

Chua et al. [13] conducted a systematic review and meta-analysis of randomized controlled trials evaluating 755-nm picosecond alexandrite lasers in melasma. Five RCTs comprising 139 patients were included. The synthesis found that triple combination cream outperformed picosecond alexandrite therapy in reducing MASI scores, and post-inflammatory hyperpigmentation appeared more frequent with picosecond treatment when compared with topical creams. No clear signal of irreversible severe harm emerged, but the overall certainty was low because of small trials and limited follow-up. This article is especially important because it counters technology-driven optimism and suggests that picosecond alexandrite treatment in melasma should currently be reserved for selected or refractory cases (Level 1a).

Chebotareva et al. [14] presented a comprehensive approach to melasma treatment using an alexandrite picosecond laser combined with dermal polyrevitalization concepts. The article appears to focus on protocol design and multimodal

therapeutic reasoning, positioning picosecond energy delivery within a broader treatment strategy rather than as a stand-alone intervention. Its clinical value lies in addressing a common problem in melasma management: early improvement without durable disease control. By emphasizing supportive dermal and barrier-directed measures, the study adds to the emerging view that melasma outcomes may depend as much on treatment context as on wavelength selection. However, interpretive strength is limited by the likely non-comparative nature of the report (Level 4).

Shimojo et al. [15] offered a theoretical analysis of large-spot picosecond laser treatment for pigmented lesions in Asian skin using a melanosome disruption threshold fluence model. Although not a conventional clinical trial, the work is highly relevant because it connects device physics to bedside decision-making. The authors showed that optimal spot size varies with lesion depth and wavelength; large spots appear more advantageous for dermal targets at near-infrared wavelengths, whereas smaller spots may be preferable for epidermal targets. A limited clinical validation component supported feasibility. The study does not establish comparative clinical superiority, but it provides a rational framework for parameter selection and may help explain inconsistent outcomes across picosecond laser series (Level 4).

Lin et al. [16] compared a 730-nm picosecond laser with a 532-nm Q-switched Nd:YAG laser for facial pigmented disorders in a retrospective comparative study. The investigators concluded that the 730-nm picosecond approach was more effective and safer for the studied facial lesions, suggesting that wavelength tailoring may enhance selectivity while limiting collateral injury. The study is clinically relevant because it moves beyond generic "picosecond versus nanosecond" arguments and instead evaluates a specific modern platform against a traditional alternative. However, the retrospective design and likely heterogeneity of lesions reduce certainty. Even so, the article strengthens the argument that picosecond systems may offer genuine advantages in carefully chosen pigmentary indications (Level 2b).

Lê et al. [17] reported the largest known series of bilateral nevus of Ota treated with a 1064-nm picosecond Nd:YAG laser. Twenty-nine Vietnamese patients received serial treatments, and all improved, with 88.9% achieving good improvement to complete clearance after nine sessions. No severe adverse events were described. This paper is especially valuable because bilateral nevus of Ota is uncommon, and treatment evidence is usually fragmented. The findings support picosecond Nd:YAG treatment as a practical modality for dermal melanocytosis in Asian patients, with apparent tolerability and progressive efficacy over multiple sessions. Nevertheless, the absence of a comparator prevents conclusions regarding superiority over nanosecond platforms (Level 4).

Aljoaib et al. [18] conducted a systematic review and meta-analysis of laser-based therapies for melasma. While not limited exclusively to picosecond systems, the study is highly pertinent because it situates picosecond lasers within the broader therapeutic landscape. The authors synthesized randomized evidence and found that laser and light approaches can improve melasma, but outcomes varied by modality, adjunctive therapy, and comparator. For picosecond platforms, the review did not establish clear dominance over established non-laser therapy. This broader perspective is important because it discourages interpretation of picosecond data in isolation and reminds clinicians that melasma remains a chronic relapsing disorder rather than a purely device-responsive condition (Level 1a).

Rutnin et al. [19] performed a split-face randomized controlled trial assessing a 1064-nm picosecond laser for lichen planus pigmentosus. Twelve patients with biopsy-confirmed disease were enrolled, and the treated side received four sessions while the contralateral side served as control. At six months, no significant differences were observed in melanin index, modified pigmentation scores, or physician global assessment. The treatment was well tolerated and not associated with major adverse events, but efficacy was limited. This trial is one of the more sobering pieces in the recent literature because it challenges extrapolation from anecdotal success and highlights that not all pigmentary disorders respond equally well to picosecond intervention (Level 2b).

Tzermias et al. [20] discussed laser application and artificial intelligence in a dermatology book chapter. Although non-clinical and not restricted to picosecond devices, the chapter is relevant because it frames future laser practice as increasingly integrated with image analysis, treatment planning, and predictive analytics. In the context of picosecond technology, AI could eventually refine patient selection, endpoint recognition, and safety monitoring in complex pigmentary disorders. The chapter does not provide direct treatment outcomes and therefore should not be read as therapeutic evidence. Its value is conceptual: it broadens the discussion from what current devices do to how decision support may optimize their use in increasingly individualized laser dermatology (Level 4).

Zhang et al. [21] carried out a prospective randomized trial comparing a 1064-nm fractional picosecond laser with intense pulsed light for facial rejuvenation in 38 Asian women. Both modalities improved global photoaging measures, pigmented spots, and skin lightness. However, the picosecond arm showed better improvement in periorbital fine lines and T-zone pores. Adverse effects were limited mainly to transient erythema. This trial suggests that fractional picosecond treatment is not merely a pigment device but a legitimate rejuvenation tool, particularly for textural concerns. Even so, the study was modest in size and focused on short-term outcomes, so long-term comparative durability remains unknown (Level 2b).

Hang et al. [22] published a commentary emphasizing hypopigmentation after picosecond laser treatment and translating histologic observations into clinical caution. The piece is not a primary outcome study, but it serves as a counterweight to technology-centered enthusiasm. By focusing on melanocyte modulation and pigmentary disruption, the authors argue

that picosecond-induced hypopigmentation is biologically plausible and not an isolated clinical curiosity. The commentary is especially relevant to melasma and skin of color, where overtreatment may convert a cosmetic problem into a more difficult dyspigmentation disorder. Its contribution is therefore advisory rather than evidentiary, reminding clinicians that less thermal damage does not equate to absence of pigmentary risk (Level 5).

Chebotareva et al. [23] reported a randomized controlled trial comparing alexandrite picosecond laser therapy alone with the same laser combined with dermal polyrevitalization in melasma. The study addressed an increasingly important clinical question: whether adjunctive biorevitalization can enhance response or reduce recurrence in a notoriously relapsing disease. The combined protocol reportedly achieved superior outcomes, supporting the concept that melasma therapy may benefit from simultaneous targeting of pigment, inflammation, and dermal milieu. While promising, the trial appears to be relatively small and disease chronicity complicates interpretation of short-term gains. Nonetheless, it represents a thoughtful move away from single-modality intervention and toward combination-based management (Level 2b).

Rebelo-Marques et al. [24] presented a hybrid review of lasers and ultrasound in aesthetic medicine. The picosecond-relevant portion of the article places these systems within a broader ecosystem of noninvasive technologies used for pigmentation, rejuvenation, and contour-related skin quality concerns. Rather than offering a narrowly focused evidence synthesis, the review combines structured literature retrieval with expert interpretation. This makes the article useful for contextual understanding, especially around comparative downtime, patient selection, and future technological convergence. However, because it spans multiple device classes and incorporates expert synthesis, it is not a definitive comparative source for picosecond practice alone. Its relevance is chiefly integrative and forward-looking (Level 4).

Arenas et al. [25] described a case report of multimodal treatment for facial atrophic acne scarring using energy-based devices and injectables, including a picosecond laser component. The case underscores an important real-world principle: acne scars are heterogeneous, and successful treatment often requires a layered strategy rather than a single device. In the reported patient, picosecond fractional treatment was combined with erbium:YAG resurfacing, microneedling radiofrequency, and fillers, producing progressive scar and texture improvement without significant complications. Although this single-patient experience cannot define efficacy, it illustrates how picosecond technology may be incorporated into broader scar algorithms, especially when textural irregularity, dyspigmentation, and volume loss coexist (Level 4).

Zou et al. [26] retrospectively evaluated picosecond laser treatment combined with sodium hyaluronate composite injection for mixed-type melasma in 30 women. Three treatment sessions produced a marked reduction in mean MASI score, from 18.30 at baseline to 8.20 post-treatment, with high patient satisfaction and only mild transient adverse effects. This study is clinically attractive because it mirrors routine practice, where practitioners often pair energy-based procedures with injectable or barrier-supportive measures. However, absence of a control group, short follow-up, and the chronic relapsing nature of melasma limit the strength of inference. The data support short-term benefit but not yet durable disease modification (Level 2b).

Wang et al. [27] investigated the mechanisms of pigment reduction and skin rejuvenation induced by picosecond laser treatment in a porcine model. The study showed melanosome disruption, progressive pigment clearance, macrophage-associated phagocytosis of pigment debris, suppression of tyrosinase expression, and subsequent collagen remodeling with barrier-related protein changes. Although preclinical, the work is valuable because it provides biologic plausibility for two frequently claimed clinical outcomes: pigment lightening and rejuvenation. It also supports the concept that picosecond treatment affects both melanogenesis and dermal regeneration. Translation to human practice requires caution, but the study helps explain why picosecond platforms can influence more than superficial pigment alone (Level 4).

Arenas et al. [28] reported a case of occupational photodamage treated with a personalized multimodal laser protocol that included a 1064-nm picosecond component for global photorejuvenation and pigment modulation. The staged approach also employed lesion-specific treatment for solar lentigines, reflecting an individualized strategy rather than reliance on a single platform. The patient achieved sustained improvement in texture, pigmentation, and overall skin quality without significant adverse events. As with other case reports, the main value is demonstrative rather than confirmatory. Still, the report highlights a realistic niche for picosecond devices: integration into customized photodamage management, especially when diffuse textural change and focal pigmentary lesions coexist (Level 4).

Zhang et al. [29] retrospectively compared fractional 1064-nm picosecond Nd:YAG laser therapy with low-fluence Q-switched Nd:YAG for melasma in 99 women. The picosecond group showed faster and greater early mMASI reduction after both two and five treatment sessions, while both modalities appeared safe. Post-inflammatory hyperpigmentation occurred in both arms but was numerically lower with picosecond treatment. This study is one of the more clinically practical comparative melasma papers because it evaluates a commonly used traditional laser against a newer alternative. However, its retrospective design and limited follow-up mean that the key unanswered question remains long-term recurrence, not merely short-term pigment lightening (Level 2b).

Kroma-Szal et al. [30] published a comprehensive review on non-tattoo applications of picosecond lasers. The article surveyed indications including acne scars, striae, pigmentary disorders, and photoaging, emphasizing the broad versatility of picosecond technology. Its main contribution is synthesis rather than new clinical data. The review argues that picosecond systems can outperform nanosecond devices through stronger photoacoustic action and reduced collateral thermal

injury, particularly in darker phototypes. At the same time, because it is a broad review rather than a strict systematic meta-analysis, the conclusions are best viewed as supportive but not definitive. The paper is useful as a map of expanding indications and recurring clinical themes (Level 4).

Haji Mohammadi et al. [31] systematically reviewed comparative clinical trials of ablative and non-ablative laser therapies for atrophic, hypertrophic, and keloid scars. Picosecond lasers were part of the broader non-ablative scar literature examined. The review concluded that outcomes depend heavily on scar phenotype and combination strategy, with no single modality uniformly superior across all scar types. For picosecond technology, the implication is that its role in scar care is promising but currently adjunctive and incompletely defined. This article adds important perspective because it prevents overgeneralization from acne scar data to all scars. It also underscores the need for scar-type-specific trial design rather than pooled "scar improvement" claims (Level 2a).

Jing et al. [32] conducted a prospective randomized split-face trial comparing a 1064-nm picosecond Nd:YAG laser with fractional micro-lens array against electro-optical synergy for post-acne erythema. Both sides improved, but the picosecond micro-lens approach demonstrated greater reductions in erythema and also favorable changes in certain texture-related measures. This study is noteworthy because post-acne erythema is often discussed separately from atrophic scarring, yet in practice the two frequently coexist. The trial suggests that fractional picosecond treatment may influence vascular-red inflammatory aftermath as well as pigmentation and texture. Sample size was limited, but the study meaningfully broadens the clinical scope of picosecond platforms in acne sequelae (Level 2b).

Shimojo et al. [33] performed an in-silico-supported meta-analysis examining irradiation parameters and outcomes for picosecond laser treatment of nevus of Ota. By combining pooled clinical data with mechanistic modeling, the authors sought to explain why efficacy and complication rates vary across studies. The review suggests that response is closely linked to technical parameters rather than merely to device category, and that inappropriate assumptions about fluence or endpoint may partly account for inconsistent results. This work is valuable because it connects evidence synthesis with dosimetric reasoning. While not a substitute for prospective trials, it supports more rational protocol design for dermal melanocytosis, particularly in Asian skin (Level 2a).

Ma et al. [34] analyzed the efficacy of picosecond laser treatment for nevus of Ota and concluded that 1064-nm picosecond Nd:YAG treatment is both safe and effective, with outcomes influenced by selected treatment parameters. The study strengthens the accumulating clinical impression that dermal melanocytosis is one of the more dependable indications for picosecond lasers. Its importance lies in reinforcing parameter-dependent variability, echoing conclusions from mechanistic and meta-analytic work. However, because the design appears observational and non-randomized, it provides supportive rather than high-level comparative evidence. Even so, it helps consolidate nevus of Ota as a leading indication in the current picosecond literature (Level 2b).

Zhang et al. [35] produced a scoping review on laser treatment of benign pigmented lesions, including café-au-lait macules, nevus of Ota, Becker nevus, and related conditions. Picosecond devices were examined alongside other laser classes. The review is useful because it emphasizes lesion-specific heterogeneity rather than treating "pigmented lesions" as a single category. For picosecond lasers, the review suggests growing utility, especially for selected dermal and mixed lesions, but also makes clear that response profiles and adverse events differ substantially by diagnosis and skin type. As a scoping review, it prioritizes breadth and mapping over pooled effect estimation (Level 4).

Chen et al. [36] reported the effectiveness and safety of 1064-nm picosecond Nd:YAG treatment for nevus of Ota in children. Pediatric laser data are often limited, so even relatively small studies are clinically relevant. The authors found the treatment to be safe and effective, supporting use in younger patients when appropriately selected. The study contributes to a growing body of evidence suggesting that picosecond platforms can be applied across age groups for dermal melanocytosis. Nevertheless, pediatric treatment decisions also depend on tolerance, psychosocial burden, and long-term pigment stability, issues that retrospective or brief observational reports cannot fully resolve (Level 2b).

Hang et al. [37] presented a case series describing hypopigmentation following picosecond laser treatment for melasma. This report is clinically important because it shifts attention from efficacy to a potentially distressing complication. The series suggests that hypopigmentation may occur across different wavelengths and settings, and that improvement of melasma cannot be considered in isolation from pigmentary safety. The paper complements later commentary from the same authors by grounding caution in observed cases rather than theory alone. Its limitations are those of any case series: absence of denominator data and inability to identify risk factors with certainty. Even so, the signal is strong enough to influence practice (Level 4).

Zhao et al. [38] retrospectively studied picosecond alexandrite treatment for acquired bilateral nevus of Ota-like macules in children. Pediatric ABNOM data are comparatively sparse, and this report therefore fills an important niche. The study supported both safety and efficacy, indicating that the alexandrite picosecond platform may be a useful option for this dermal pigmentary disorder even in younger patients. The findings are relevant to clinical practice because ABNOM can be cosmetically burdensome and often overlaps with concerns about dyspigmentation risk in darker skin. However, the retrospective design and lack of long-term controlled comparison limit claims of superiority over alternative pigment-targeting systems (Level 2b).

Castro et al. [39] reported a case of traumatic facial atrophic scars treated with a combined laser protocol incorporating variable-pulse picosecond technology. The protocol also included other laser modalities, reflecting the complexity of traumatic scar remodeling. The case showed meaningful improvement in scar depth, texture, and appearance, supporting the practical concept that picosecond treatment may complement ablative or resurfacing methods rather than replace them. For clinicians, the message is that picosecond lasers may be especially useful in multimodal scar programs where both pigment alteration and collagen remodeling are desired. However, as a single case report, the article cannot define reproducibility or optimal sequencing (Level 4).

Luo et al. [40] assessed melasma treatment using picosecond laser combined with Shumin Star, reporting favorable clinical efficacy and suggesting that skin barrier function may serve as an additional outcome marker. This is a noteworthy conceptual shift, because melasma studies often focus almost exclusively on pigmentation scores while neglecting barrier health and tolerability. The article supports the broader trend toward combination therapy and toward multidimensional assessment beyond MASI reduction alone. Yet the exact independent contribution of the picosecond component remains difficult to isolate, particularly if the study lacked a robust comparator. The work is therefore hypothesis-generating and practice-informing, rather than definitive (Level 2b).

Suh et al. [41] described nine tattoo removal cases treated with four different picosecond laser protocols. The authors concluded that the R20-style approach achieved the most impressive clinical improvement in this small series. Although tattoo removal is a more established picosecond indication than many other topics in this review, the study is still useful because it examines protocol variation rather than device efficacy in general. It reminds clinicians that outcome can depend not only on wavelength and pulse duration, but also on treatment density and sequencing. The very small sample and case-series design preclude generalization, but the report contributes practical insight into procedural optimization (Level 4).

Su et al. [42] evaluated the safety and efficacy of a 1064-nm picosecond Nd:YAG laser for xanthelasma palpebrarum. This represents an example of picosecond technology extending into less traditional lesion-directed use. The study concluded that the treatment showed promising efficacy with a potentially favorable safety profile, an important consideration given the delicate periocular location and the need to avoid scarring or textural injury. The article is clinically interesting because xanthelasma is often approached surgically, chemically, or with other laser systems. While the evidence level is modest, it suggests that picosecond platforms may offer a tissue-sparing alternative for carefully selected patients (Level 2b).

Hameed et al. [43] authored a mini review on laser technology in ophthalmology and dermatology. Picosecond lasers were discussed as part of a wider narrative on precision applications in modern medicine. The article does not offer indication-specific comparative outcomes, but it is relevant because it situates dermatologic picosecond treatment within a broader medical trend toward minimally invasive, high-precision energy delivery. As a mini review, its conclusions are necessarily broad and interpretive. The main value for this review lies in conceptual framing rather than evidentiary weight: picosecond systems are presented not as isolated cosmetic tools, but as part of a larger precision-medicine movement in laser therapeutics (Level 4).

Chandrashekar et al. [44] reviewed laser treatment in nail disorders. Picosecond lasers are not central to routine nail practice, but the inclusion of this article is important because it shows how laser dermatology is broadening across subspecialty domains. The review surveyed onychomycosis, nail psoriasis, warts, and related conditions, illustrating the diversity of laser applications while also exposing the limited role of high-level evidence in niche indications. For picosecond technology specifically, the article is more peripheral than foundational. Nonetheless, it contributes to the larger theme that enthusiasm for newer laser platforms often outpaces rigorous condition-specific validation (Level 4).

Wu et al. [45] studied a 755-nm picosecond laser combined with bioactive polymer dots in a nude mouse model of photodamage. The work showed enhanced skin repair and reversal of photoaging-related features, suggesting a possible synergistic approach between energy-based treatment and biologically active materials. Although preclinical, the study is intriguing because it points toward future combinatorial strategies that may expand beyond conventional laser-alone protocols. Its direct clinical relevance is limited, but it parallels human studies showing that picosecond treatment may induce both pigmentary and rejuvenative benefits. The article is best interpreted as translational groundwork rather than a guide for current standard practice (Level 4).

Jia et al. [46] examined the safety and efficacy of dual-wavelength picosecond Nd:YAG treatment in the comprehensive management of facial atrophic acne scars. The study concluded that the approach was effective and well tolerated, supporting the role of picosecond platforms in scar remodeling. Of particular interest is the use of both 1064-nm and 532-nm settings, which suggests attempts to address not only scar topography but also associated dyschromia. This paper adds to the growing literature separating acne-scar picosecond use from its earlier pigment-centered identity. Still, as with much of the acne-scar literature, questions remain regarding comparative efficacy against established fractional resurfacing modalities and the durability of observed improvements (Level 2b).

Kim et al. [47] reported a case of generalized argyria treated with low-fluence Q-switched Nd:YAG plus picosecond laser therapy. Argyria is rare, and treatment evidence is correspondingly sparse. The significance of this case lies in show-

ing that picosecond technology may serve as part of a combination approach for exogenous dermal deposition disorders beyond melanin-related pathology. Clinical improvement was observed, suggesting that the photoacoustic advantages of picosecond pulses may be relevant to metallic particle disruption as well. However, the rarity of the condition and the combined treatment design make it impossible to isolate the picosecond contribution. The report is valuable mainly as a proof-of-concept application (Level 4).

Lueangarun et al. [48] described a novel application of a 1064-nm picosecond Nd:YAG laser for male androgenetic alopecia. This preliminary report is one of the most unconventional studies in the present review. The authors suggested that fractional picosecond treatment may promote hair regrowth, possibly through wound-healing and regenerative signaling rather than pigment-selective mechanisms. The study is noteworthy because it reflects the broader migration of picosecond platforms into biostimulatory indications. However, evidence remains extremely limited, and the report should be viewed as exploratory. Before such use can be recommended, controlled studies are needed to establish efficacy, mechanism, optimal treatment density, and durability relative to established medical therapies (Level 4).

Byun et al. [49] retrospectively compared picosecond and Q-switched Nd:YAG lasers for various pigmentary disorders in Korean patients. The study supports the impression that picosecond treatment can be effective in Asian skin and may offer practical advantages over conventional Q-switched approaches for selected lesions. Because the paper addressed multiple pigmentary diagnoses, its findings are clinically broad but also inherently heterogeneous. This design reflects everyday laser practice but limits lesion-specific conclusions. Even so, the article contributes important comparative real-world data and reinforces the theme that picosecond utility is strongest in pigmentary disease, especially when the balance between clearance and dyspigmentation risk is carefully managed (Level 4).

Lu et al. [50] performed a retrospective analysis comparing low-fluence 1064-nm picosecond Nd:YAG laser with 532-nm Nd:YAG laser for pigmented lesions in Chinese patients. The study concluded that low-fluence picosecond 1064-nm treatment was a promising and safe modality, implying that deeper-penetrating, lower-fluence strategies may be advantageous in selected Asian populations. This article is relevant because it emphasizes that treatment success does not always depend on aggressive fluence; controlled photoacoustic targeting may suffice for some lesions while potentially reducing adverse effects. As with other retrospective comparisons, the strength of inference is limited. Nevertheless, it supports thoughtful parameter minimization rather than assuming that more energy yields better outcomes (Level 2b).

Zhou et al. [51] investigated the safety and efficacy of a 755-nm picosecond alexandrite laser combined with topical tranexamic acid for melasma. The study aligns with the growing movement toward combination therapy for a condition that rarely responds durably to monotherapy. By pairing a pigment-targeting device with a topical agent aimed at vascular and plasmin-related pathways, the article reflects a multidimensional therapeutic model. Reported outcomes were favorable, suggesting clinical benefit without major safety concerns. However, because melasma is chronic and relapse-prone, early improvement should be interpreted cautiously. The study supports combination therapy as a rational direction but does not settle whether the laser component meaningfully improves long-term control (Level 2b).

Jung et al. [52] evaluated skin rejuvenation using topical indocyanine green with diffractive optical element mode of a 785-nm picosecond laser in Asian females. The study is interesting because it combines a chromophore-assisted approach with fractional-like picosecond delivery, aiming to enhance rejuvenative effects in photoaged skin. The authors reported promising clinical improvement, suggesting that nontraditional adjuncts may expand the versatility of picosecond systems beyond pigment removal. This work also highlights the growing interest in wavelength-specific picosecond rejuvenation rather than default reliance on 1064 nm platforms. Still, the absence of broad comparative data and likely limited sample size mean the findings should be considered preliminary (Level 4).

Nguyen et al. [53] presented conference data on follow-up visualization of in vivo colored tattoo particles after picosecond laser treatment using multiphoton tomography. Although this was not a therapeutic outcome study in the conventional sense, it is highly relevant methodologically. The paper addresses a longstanding limitation in tattoo laser research: poor in vivo visualization of pigment fragmentation and clearance over time. By applying advanced imaging, the authors provided a window into the biological aftermath of picosecond treatment. The work is exploratory and preclinical-clinical in character, but it may ultimately help refine treatment intervals, endpoint assessment, and comparative mechanistic understanding between tattoo colors and wavelengths (Level 4).

Zawodny et al. [54] evaluated the efficacy of a single 755-nm picosecond laser treatment for pigmented skin lesions using photographic analysis with polarized light. The study found significant improvement in lesion size and visual features after only one session, emphasizing the strong immediate performance that can sometimes be achieved in superficial pigmentary disease. This paper is clinically appealing because single-session benefit has practical implications for cost, patient satisfaction, and procedural burden. However, the study also raises familiar questions: which lesion subtypes respond best, how durable is a one-session response, and what is the true risk of delayed dyspigmentation? As such, the paper is encouraging but not definitive (Level 4).

Lee et al. [55] described treatment of a refractory allergic reaction to a red tattoo using a combination of picosecond Nd:YAG laser, fractional carbon dioxide laser, and intralesional corticosteroids. Tattoo allergy is a difficult therapeutic problem because treatment may worsen inflammation if pigment disruption releases additional antigenic material. The

reported case suggests that carefully sequenced combination therapy can improve both the allergic reaction and tattoo burden. For picosecond practice, the case is important not because it proves efficacy, but because it illustrates a nuanced nontraditional indication where risk-benefit assessment is more complex than standard cosmetic tattoo removal. Broader validation, however, remains absent (Level 4).

Lee et al. [56] reported a case of tattoo removal optimized with picosecond laser treatment, topical perfluorodecalin, and subsequent fractional CO_2 laser. The article focuses on procedural enhancement, aiming to improve clearance while reducing blistering and other common adverse effects. This is a useful reminder that picosecond outcomes depend not only on pulse duration and wavelength, but also on adjunctive techniques that influence epidermal whitening, treatment stacking, and post-laser tissue response. As a single case, the study cannot establish best practice, yet it provides practical insight into how clinicians are modifying procedural workflows to improve efficiency in tattoo removal (Level 4) (Table 1).

Table 1. Summary of Literature on Clinical Application of Picosecond Laser.

Author/Year	Study Design	Key Findings	Evidence Level
Sethi et al., 2026 [10]	Prospective case series	In patients with skin of color, 755-nm picosecond alexandrite laser produced substantial improvement in lichen planus pigmentosus and pigmentary demarcation lines with minimal adverse effects.	4
Alrubaiaan et al., 2026 [11]	Systematic review and meta-analysis	In nevus of Ota, pooled data showed moderate excellent response rates with relatively low frequencies of post-inflammatory hyperpigmentation and hypopigmentation, supporting clinical utility but not definitive superiority over older platforms.	2a
Abdul-Rahman et al., 2026 [12]	Systematic review	Picosecond lasers appeared effective and generally safe in skin of color when conservative parameters were used, though evidence remained heterogeneous and limited across indications.	2a
Chua et al., 2026 [13]	Systematic review and meta-analysis of randomized controlled trials	In melasma, 755-nm picosecond alexandrite laser did not outperform triple combination cream, and post-inflammatory hyperpigmentation appeared more frequent than with topical therapy.	1a
Chebotareva et al., 2026 [14]	Non-comparative clinical report/reviewed treatment protocol	Proposed a comprehensive melasma strategy combining alexandrite picosecond laser with dermal polyrevitalization, emphasizing multimodal management rather than laser monotherapy.	4
Shimojo et al., 2026 [15]	Theoretical analysis with limited clinical validation	Demonstrated that optimal spot size depends on lesion depth and wavelength; large spots may favor dermal targets and smaller spots may better suit epidermal lesions in Asian skin.	4
Lin et al., 2026 [16]	Retrospective comparative study	A 730-nm picosecond laser was more effective and safer than a 532-nm Q-switched Nd:YAG laser for facial pigmented disorders, supporting wavelength-specific targeting.	2b
Lê et al., 2026 [17]	Case series	In bilateral nevus of Ota, 1064-nm picosecond Nd:YAG laser achieved progressive improvement with good-to-complete clearance in most patients after serial sessions and no severe adverse events.	4
Aljoaib et al., 2026 [18]	Systematic review and meta-analysis	Laser- and light-based therapies improved melasma overall, but picosecond platforms did not show clear superiority over established non-laser regimens.	1a
Rutnin et al., 2026 [19]	Split-face randomized controlled trial	In lichen planus pigmentosus, 1064-nm picosecond laser was well tolerated but did not significantly outperform control in pigment reduction at six months.	2b
Tzermias, 2026 [20]	Book chapter	Discussed future integration of laser technologies and artificial intelligence in dermatology, including potential roles in treatment planning, image analysis, and safety optimization.	4

Table 1. *Cont.*

Author/Year	Study Design	Key Findings	Evidence Level
Zhang et al., 2026 [21]	Prospective randomized trial	Fractional 1064-nm picosecond laser improved photoaging, pigmented spots, and skin lightness, with superior effects versus IPL for periorbital fine lines and T-zone pores.	2b
Hang and Lim, 2026 [22]	Commentary	Highlighted biologic plausibility and clinical relevance of hypopigmentation after picosecond laser treatment, especially in melasma and skin of color, urging cautious parameter selection.	5
Chebotareva et al., 2026 [23]	Randomized controlled trial	In melasma, alexandrite picosecond laser combined with dermal polyrevitalization achieved better outcomes than laser alone, supporting combination-based management.	2b
Rebelo-Marques, 2026 [24]	Hybrid review	Positioned picosecond lasers within the broader ecosystem of aesthetic devices for pigmentation and rejuvenation, emphasizing integrative use rather than head-to-head proof of superiority.	4
Arenas et al., 2026 [25]	Case report	Multimodal treatment of facial atrophic acne scars incorporating picosecond laser improved scar appearance, texture, and skin quality without major complications.	4
Zou et al., 2026 [26]	Retrospective clinical study	Picosecond laser combined with sodium hyaluronate injection significantly reduced MASI scores in mixed-type melasma with high patient satisfaction and only mild transient adverse effects.	2b
Wang et al., 2026 [27]	Preclinical animal study	In a porcine model, picosecond laser induced melanosome disruption, macrophage-mediated pigment clearance, reduced tyrosinase expression, and collagen remodeling, supporting both pigment reduction and rejuvenation mechanisms.	4
Arenas et al., 2026 [28]	Case report	A personalized multimodal laser protocol including 1064-nm picosecond laser improved occupational photodamage, skin texture, and pigmentation with sustained benefit.	4
Zhang et al., 2026 [29]	Retrospective comparative study	Fractional 1064-nm picosecond laser produced faster and greater early mMASI reduction than low-fluence Q-switched Nd:YAG in melasma, with similar overall safety.	2b
Kroma-Szal et al., 2025 [30]	Comprehensive review	Reviewed non-tattoo uses of picosecond lasers, including acne scars, pigmentary disorders, striae, and photoaging, and supported broad versatility while acknowledging limited high-level comparative evidence.	4
Haji Mohammadi et al., 2025 [31]	Systematic review of comparative clinical trials	In scar therapy, outcomes depended strongly on scar phenotype and combination strategy; picosecond lasers appeared promising but adjunctive rather than universally superior.	2a
Jing et al., 2025 [32]	Prospective randomized split-face trial	For post-acne erythema, 1064-nm picosecond Nd:YAG with fractional micro-lens array outperformed electro-optical synergy in erythema reduction and improved some texture-related measures.	2b
Shimojo et al., 2025 [33]	In-silico-supported meta-analysis	For nevus of Ota, clinical outcomes were closely associated with irradiation parameters, suggesting that treatment success depends heavily on technical optimization rather than device category alone.	2a

Table 1. *Cont.*

Author/Year	Study Design	Key Findings	Evidence Level
Ma et al., 2025 [34]	Observational clinical study	Supported the safety and effectiveness of 1064-nm picosecond Nd:YAG laser for nevus of Ota and emphasized the importance of appropriate treatment parameters.	2b
Zhang et al., 2025 [35]	Scoping review	In benign pigmented lesions, picosecond lasers showed growing utility, especially for selected dermal and mixed lesions, but response varied substantially by diagnosis and skin type.	4
Chen et al., 2025 [36]	Observational pediatric study	1064-nm picosecond Nd:YAG laser was effective and safe for nevus of Ota in children, supporting its use in selected pediatric patients.	2b
Hang and Lim, 2025 [37]	Case series	Reported hypopigmentation following picosecond laser treatment for melasma, highlighting a clinically significant complication that may offset cosmetic benefit in some patients.	4
Zhao et al., 2025 [38]	Retrospective study	Picosecond alexandrite laser was effective and safe for acquired bilateral nevus of Ota-like macules in children, extending evidence for pediatric dermal melanocytosis.	2b
Castro et al., 2025 [39]	Case report	A combined laser protocol including variable-pulse picosecond technology improved traumatic facial atrophic scars, supporting multimodal scar remodeling strategies.	4
Luo et al., 2025 [40]	Clinical study	Picosecond laser combined with Shumin Star showed favorable efficacy in melasma and suggested that skin barrier function may be a useful additional treatment outcome marker.	2b
Suh et al., 2025 [41]	Case series	Among four picosecond tattoo-removal protocols, the R20-style approach appeared to achieve the most impressive improvement in this small case series.	4
Su et al., 2025 [42]	Clinical study	1064-nm picosecond Nd:YAG laser showed promising efficacy and acceptable safety in xanthelasma palpebrarum, suggesting a tissue-sparing lesion-directed option.	2b
Hameed et al., 2025 [43]	Mini review	Framed picosecond lasers as part of a broader precision-medicine trend in ophthalmology and dermatology, emphasizing high-precision minimally invasive energy delivery.	4
Chandrashekar et al., 2025 [44]	Comprehensive review	Reviewed laser treatment in nail disorders; picosecond lasers had only a peripheral role, illustrating how enthusiasm for newer technologies often exceeds condition-specific validation.	4
Wu et al., 2025 [45]	Preclinical animal study	In a nude mouse model of photodamage, 755-nm picosecond laser combined with bioactive polymer dots enhanced skin repair and reversed photoaging-related changes more effectively than expected from laser alone.	4
Jia et al., 2025 [46]	Clinical study	Dual-wavelength 1064/532-nm picosecond Nd:YAG laser was effective and well tolerated in facial atrophic acne scars, supporting its role in scar remodeling and associated dyschromia management.	2b
Kim et al., 2025 [47]	Case report	Combination treatment with low-fluence Q-switched Nd:YAG and picosecond laser improved generalized argyria, suggesting proof-of-concept utility for exogenous dermal deposition disorders.	4

Table 1. *Cont.*

Author/Year	Study Design	Key Findings	Evidence Level
Lueangarun and Tempark, 2024 [48]	Preliminary report/case-based study	Reported a novel use of 1064-nm picosecond Nd:YAG laser for male androgenetic alopecia, suggesting possible regenerative and wound-healing effects, though evidence remained highly exploratory.	4
Byun et al., 2024 [49]	Retrospective case series	In Korean patients with pigmentary disorders, picosecond lasers compared favorably with Q-switched Nd:YAG lasers and appeared effective across multiple lesion types.	4
Lu et al., 2024 [50]	Retrospective comparative analysis	Low-fluence 1064-nm picosecond Nd:YAG laser was a promising and safe option for pigmented lesions in Chinese patients when compared with 532-nm Nd:YAG laser.	2b
Zhou et al., 2024 [51]	Clinical study	In melasma, 755-nm picosecond alexandrite laser combined with topical tranexamic acid produced favorable outcomes, supporting multidimensional combination therapy.	2b
Jung et al., 2024 [52]	Clinical study	Topical indocyanine green combined with diffractive optical element mode of a 785-nm picosecond laser improved skin rejuvenation outcomes in Asian females.	4
Nguyen et al., 2024 [53]	Conference study/mechanistic imaging report	Multiphoton tomography enabled in vivo follow-up visualization of colored tattoo particles after picosecond laser treatment, providing a novel method for mechanistic assessment.	4
Zawodny et al., 2024 [54]	Clinical observational study	A single 755-nm picosecond laser treatment significantly improved pigmented skin lesions based on polarized photographic analysis, suggesting strong early efficacy in selected lesions.	4
Lee et al., 2024 [55]	Case report	A refractory allergic reaction to a red tattoo improved with combination treatment using picosecond Nd:YAG laser, fractional CO_2 laser, and intralesional corticosteroids.	4
Lee et al., 2024 [56]	Case report	Tattoo removal was optimized by combining picosecond laser, topical perfluorodecalin, and subsequent fractional CO_2 laser, suggesting procedural enhancement of clearance and tolerability.	4

4. Discussion

The year 2024–2026 literature confirms that picosecond laser technology has matured from a niche tattoo-removal platform into a broadly applied dermatologic tool, but the expansion of indications has outpaced the maturation of the evidence base. Across this review, the most convincing signals of benefit were seen in selected pigmented lesions, dermal melanocytoses, and some rejuvenation and acne-related indications, whereas melasma remained notably controversial. A central theme emerging from the recent literature is that picosecond lasers should not be viewed as uniformly superior to older devices; rather, their value appears to depend on diagnosis, wavelength selection, treatment parameters, skin phototype, and whether they are used alone or as part of a combination strategy [15,18,23,33].

Among pigmentary disorders, nevus of Ota and related dermal melanocytoses currently represent the most coherent and clinically reliable indications. The systematic review and meta-analysis by Alrubaiaan et al. supported the efficacy of the 755-nm picosecond alexandrite laser, while also showing that excellent responses are not universal and that post-inflammatory hyperpigmentation and hypopigmentation remain relevant adverse events [11]. This tempered but positive conclusion is strengthened by multiple observational studies reporting favorable outcomes in Asian populations, including bilateral nevus of Ota treated with 1064-nm picosecond Nd:YAG laser, pediatric nevus of Ota, and acquired bilateral nevus of Ota-like macules in children [17,36,38]. Importantly, Shimojo et al. went beyond clinical reporting by linking outcomes to irradiation parameters in an in-silico-supported meta-analysis, reinforcing that response variability is driven not simply by whether a laser is picosecond, but by how it is used [33]. Ma et al. reached similar conclusions, emphasizing parameter dependence in clinical practice [34]. Taken together, these studies suggest that dermal melanocytosis is one of

the strongest present indications for picosecond treatment, but they also underscore that protocol optimization remains fundamental to success.

A related strength of the recent literature is its growing attention to wavelength- and spot-size-specific treatment logic. Shimojo et al. proposed that large-spot picosecond treatment may be preferable for deeper dermal targets, whereas smaller spots may better suit more superficial lesions, particularly in Asian skin [15]. Comparative retrospective studies also suggest that newer wavelength choices may provide practical advantages over traditional approaches. Lin et al. found the 730-nm picosecond laser to be more effective and safer than 532-nm Q-switched Nd:YAG for facial pigmented disorders [16], while Lu et al. reported that low-fluence 1064-nm picosecond Nd:YAG compared favorably with 532-nm Nd:YAG in Chinese patients [50]. Byun et al. similarly supported the real-world usefulness of picosecond systems over Q-switched Nd:YAG lasers across pigmentary disorders in Korean patients [49]. These comparative studies are not definitive because they are largely retrospective and diagnostically heterogeneous, but they collectively suggest that the contemporary advantage of picosecond technology may lie less in pulse duration alone than in improved tailoring of wavelength, depth targeting, and fluence minimization [15,33,50].

Abdul-Rahman et al. concluded that picosecond lasers can be both safe and effective in darker phototypes when used cautiously, but also highlighted the overall heterogeneity and incompleteness of the evidence [12]. Several of the most clinically relevant recent studies were conducted in Asian patients or other skin-of-color populations, including work on lichen planus pigmentosus, pigmentary demarcation lines, melasma, nevus of Ota, facial rejuvenation, and pediatric dermal melanocytoses [10,29,36,49,50]. This is a major strength of the newer literature, because it aligns with the populations in whom pigmentary complications are especially consequential. Yet the same body of evidence also underscores a persistent safety paradox: picosecond devices are often promoted as less thermally damaging, but pigmentary disturbance has by no means been eliminated. The commentary by Hang and Lim and their earlier case series on hypopigmentation after picosecond treatment for melasma serve as important warnings that reduced thermal diffusion does not translate into absence of melanocyte-related injury [22,37]. Thus, conservative parameters, lesion-specific endpoint recognition, and thorough counseling remain essential, especially in darker phototypes.

Melasma remains the clearest example of a gap between procedural enthusiasm and evidentiary certainty. The strongest available recent synthesis, the meta-analysis of randomized controlled trials by Chua et al., did not show superiority of 755-nm picosecond alexandrite laser over triple combination cream and suggested a greater risk of post-inflammatory hyperpigmentation relative to topical treatment [13]. This conclusion is consistent with the broader systematic review by Aljoaib et al., which found that laser-based treatments can improve melasma but did not establish clear dominance of picosecond platforms over established non-laser therapy [18]. These higher-level findings are important because several lower-level studies reported encouraging early efficacy, including retrospective comparison against low-fluence Q-switched Nd:YAG, combination with sodium hyaluronate, combination with Shumin Star, and addition of topical tranexamic acid [26,40,51]. Moreover, Chebotareva et al. reported improved outcomes when alexandrite picosecond laser was combined with dermal polyrevitalization rather than used alone [23], echoing their broader multimodal therapeutic framework [14]. The overall interpretation is therefore nuanced: picosecond lasers may improve melasma, particularly in combination protocols, but current evidence does not support regarding them as first-line monotherapy or as clearly superior to established medical management [13,18,51].

The discordant data in lichen planus pigmentosus further illustrate why diagnosis-specific interpretation is necessary. Sethi et al. described substantial improvement in lichen planus pigmentosus and pigmentary demarcation lines in patients with skin of color treated with a 755-nm picosecond alexandrite platform [10]. However, Rutnin et al., in a split-face randomized controlled trial using a 1064-nm picosecond laser, found no significant benefit over control for lichen planus pigmentosus despite acceptable tolerability [19]. These divergent results may reflect differences in wavelength, lesion biology, chronicity, endpoint selection, or sample characteristics, but they also highlight a larger issue in picosecond research: positive case series can generate early optimism that is not consistently confirmed under controlled conditions. For inflammatory dyschromias in particular, device effects may be less predictable than in stable dermal melanocytosis.

Beyond pigmentation, the literature supports a meaningful but still evolving role for picosecond lasers in rejuvenation and acne-related sequelae. Zhang et al. demonstrated in a prospective randomized trial that fractional 1064-nm picosecond treatment was comparable to, and in some domains better than, intense pulsed light for facial rejuvenation, particularly regarding fine lines and pore appearance [21]. Jing et al. extended the utility of fractional picosecond treatment into post-acne erythema, showing superiority over electro-optical synergy in a split-face trial [32]. Jia et al. also reported favorable results with dual-wavelength picosecond Nd:YAG in facial atrophic acne scars [46]. Although still limited by modest sample sizes and short follow-up, these studies suggest that picosecond technology should no longer be regarded solely as a pigment-fragmentation device. Case reports of multimodal acne scar and traumatic scar management reinforce this view, showing how picosecond treatment may contribute to collagen remodeling and textural improvement when combined with resurfacing, radiofrequency, fillers, or other technologies [25,39]. However, the systematic review of scar therapies by Haji Mohammadi et al. appropriately cautions that no single laser modality is superior across all scar types, and that scar phenotype remains central to treatment selection [31].

Mechanistic work has helped explain this broadened clinical role. In a porcine model, Wang et al. showed that picosecond treatment induced melanosome disruption, macrophage-associated pigment clearance, reduced tyrosinase expression, collagen remodeling, and barrier-related protein changes [27]. These findings provide biologic plausibility for the dual clinical claims of pigment reduction and rejuvenation. Preclinical work combining 755-nm picosecond laser with bioactive polymer dots similarly suggested enhanced photodamage repair and anti-photoaging effects [45], while Jung et al. reported promising rejuvenation outcomes using topical indocyanine green with a 785-nm picosecond platform in Asian females [52]. Together, these data suggest that picosecond lasers may be increasingly relevant in biostimulatory and remodeling paradigms, not just selective photothermolysis analogs. Still, translational gaps remain substantial, and mechanistic plausibility should not be conflated with proven long-term clinical superiority.

Several exploratory applications also deserve mention because they illustrate the widening conceptual boundaries of picosecond practice. Promising early reports have appeared in xanthelasma palpebrarum [42], generalized argyria [47], and even male androgenetic alopecia [48]. In tattoo-related practice, recent reports have focused less on whether picosecond lasers work and more on how to optimize protocols, manage complications, and integrate adjuncts such as topical perfluorodecalin or fractional carbon dioxide laser [41,55,56]. Nguyen et al. added an important methodological dimension by visualizing in vivo tattoo particle changes after picosecond treatment with multiphoton tomography, potentially opening the way for more objective endpoint assessment in the future [53]. These emerging indications are intriguing, but at present they are best considered exploratory and should not yet be extrapolated into routine standard-of-care recommendations.

In practical terms, the current evidence supports a phenotype-specific approach. Picosecond lasers appear most dependable for dermal melanocytosis and selected pigmented lesions, promising as adjunctive tools for acne scarring and rejuvenation, and potentially valuable in carefully constructed multimodal protocols. By contrast, melasma should be approached with caution and realistic counseling, with preference for combination-based strategies and careful attention to rebound and hypopigmentation risk. The central message from the year 2024–2026 literature is therefore not that picosecond technology has solved pigmentary and textural disease, but that it has become an important precision tool whose success depends on thoughtful clinical matching rather than indiscriminate technological enthusiasm [11–13,33,37].

5. Conclusions

The literature from 2024 to 2026 confirms that picosecond lasers now occupy a broad clinical space extending well beyond tattoo removal. The strongest practical support is seen in benign pigmentary disorders, dermal melanocytoses, selected acne-scar and rejuvenation settings, and carefully chosen combination protocols. Melasma remains the most contentious indication: improvement is common, but durable superiority over established therapy has not been demonstrated, and pigmentary complications remain a real concern.

Overall, picosecond technology should be regarded as an important and versatile therapeutic platform, but not as a universally superior substitute for older lasers or multimodal care. Current best practice requires diagnosis-specific treatment selection, conservative use in skin of color, and realistic counseling regarding recurrence and dyspigmentation. The next phase of progress will depend less on device proliferation and more on higher-quality comparative research, standardized methodology, and precision-based treatment planning.

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