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Advances in Laser Treatment Options for East Asian Patients: A Review

Ashley Liau

Irvine High School, Irvine, USA
Email: ashleyhliau@gmail.com

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Abstract

Research Background: Laser treatments are commonly used for various dermatological concerns. East Asian patients are typically classified as Fitzpatrick skin types III - V, characterized by increased melanin content. This results in a higher risk of complications such as post-inflammatory hyperpigmentation (PIH) following laser treatment. Despite the growing use of lasers in aesthetic dermatology, few studies have focused specifically on the efficacy and safety of laser modalities for East Asian populations. **Methods:** A comprehensive review of the literature was conducted on PubMed for each laser, focusing on Fitzpatrick skin types III - V among East Asian patients only. **Results:** The Alexandrite and Er:YAG lasers appeared to be the most promising modalities for treating pigmentation and scarring in East Asian skin, with minimal side effects and favorable safety profiles. The picosecond Nd:YAG laser was found to be beneficial for pigmentation reduction, offering lower treatment discomfort and faster healing compared to the Q-switched Nd:YAG model. The CO_2 laser, while effective for scarring and texture improvement, was associated with a higher risk of post-inflammatory complications in patients with darker skin types. **Conclusion:** The Alexandrite and Er:YAG lasers are recommended for East Asian patients due to their safety and efficacy for pigmentation and scarring. Clinicians should consider these lasers for treating East Asian skin to optimize outcomes and minimize adverse effects. Further studies are needed to explore alternative or synergistic treatments and to include more diverse patient cohorts for broader applicability.

Keywords

Lasers, Dermatology, East Asian Skin, Health Disparities, Laser Skin Treatments, CO_2 Lasers, Alexandrite Lasers, Er:YAG, Nd:YAG

1. Introduction

East Asian patients face disparities in terms of laser treatments [1]. There are

many existing laser options suitable for lighter-skinned patients [2]; however, there is a more limited understanding of optimal laser therapies for East Asian skin [3]. Therefore, it is essential that we explore different laser types to identify ones that are most optimal for East Asian patients.

East Asian patients are typically within skin types III - V on the Fitzpatrick scale and are rarely highlighted in cutaneous disorders or laser surgery publications [4]. Skin types III - V differ from lighter skin types because of increased epidermal melanin from increased melanocytes [5]. The increased ability to produce melanin in response to environmental stressors also leads to aberrant pigmentation, leading many to seek laser treatments [6]. Elevated reactive fibroblast responses are also described for the melanated skin of East Asian patients compared to the skin of Caucasian patients [7]. Reactive fibroblasts participate in tissue repair by producing different matrix components, growth factors, and enzymes in response to an injury or stimulus. Reactive fibroblasts also increase collagen production in disturbed areas.

The success rate of skin laser therapies is lower among East-Asian patients when compared to their Caucasian counterparts [8]. Laser treatments on Asian skin often cause side effects, the most common being post-inflammatory hyperpigmentation (PIH), which darkens the skin in response to injury or inflammation [9]. These therapies require careful device selection and treatment parameters to minimize the increased risk of post-treatment complications.

Laser therapy is largely based on the principle of selective photothermolysis, a precise microsurgery that uses a laser to heat and destroy tissue in a targeted area while leaving the surrounding tissue unharmed [10]. The sparing of peripheral tissues is achieved as different laser wavelengths directly correlate with penetration depth. Common laser types that are now available include the Er:YAG, Nd:YAG, CO_2, and Alexandrite (see **Table 1**).

Table 1. Summary of all laser types.

Laser Type	Typical Procedure	Average Wavelength	Concerns Addressed
CO_2	Ablative	10600 nm	Birthmarks Photodamage Pigmentation Scars Skin Tone Texture Wrinkles
Er:YAG	Ablative	2940 nm	Atrophic Acne Scars Benign and Malignant Lesions Pigmentation Skin Tone Texture Wrinkles

Continued

Nd:YAG	Non-Ablative	1064 nm	Acne Vulgaris Birthmarks Ephelides Hair Removal Photodamage Pigmentation Rosacea Skin Tone Texture Wrinkles
Alexandrite	Non-Ablative	755 nm	Benign and Malignant Lesions Hair Removal Melasma Photodamage Pigmentation Tattoo Removal Vascular Lesions Inflamed Blood Vessels

The rise in popularity of laser technology continues to increase research and innovation in this field, expanding treatment options for patients [11] [12]. Laser therapy has evolved from purely addressing aesthetic cosmetics to targeting dermatologic concerns such as melasma, facial telangiectasias, striae distensae, acne scars, and removing pre-cancerous skin growths. For example, pulsed dye lasers and diode lasers can target telangiectasias (dilated blood vessels) in childhood hemangiomas. Many other laser treatments, including the non-invasive YAG laser family, can target and treat spider veins. In melasma treatment, pulsed dye lasers (PDL) and copper bromide lasers target the vascular component of melasma lesions. Left unresolved, these problems can exacerbate self-image and mental health issues, affecting a patient's physical, psychological, and social well-being [13].

There has not been a recent comprehensive review of literature concerning lasers most suitable for East Asian patients. Clinicians are responsible for providing patients with appropriate recommendations, so a more comprehensive guide of suitable laser therapies for East Asian skin will help better address the needs of East Asian patients. In this paper, we review the laser types Er:YAG, Nd:YAG, CO_2, and alexandrite lasers and their efficacies in treating primary skin concerns of East Asian populations to gain a greater understanding of laser treatment disparities and appropriate usages on East Asian skin.

2. Methods

A systematic literature search was conducted exclusively through the PubMed database to identify peer-reviewed articles evaluating the efficacy, safety, and clinical outcomes of laser treatments for East Asian patients. The search was limited to studies published between January 1, 1998, and March 30, 2024, with no language

restrictions. Search terms were selected to encompass a wide range of laser modalities and relevant dermatologic indications. The following exact search strings were used individually and in combination with Boolean operators: ("laser treatment" AND "Asian skin"), ("laser therapy" AND "Fitzpatrick III - V"), ("Nd:YAG laser" AND "East Asian skin"), ("Er:YAG laser" AND "East Asian skin"), ("picosecond laser" AND "ethnic skin"), ("pulsed dye laser" AND "Asian"), ("carbon dioxide laser" AND "East Asian skin"), ("fractional laser" AND "Asian skin"), ("Alexandrite laser" AND "East Asian skin"), ("melasma laser" AND "Asian population"), ("nonablative laser" AND "Asian skin"), ("synergistic laser treatment" AND "Fitzpatrick III - V"), and ("ablative laser" AND "Asian skin"). Only studies that included patients of Chinese, Japanese, Korean, and other East Asian ethnicities were included in the results section. A few studies of ethnic skin falling outside of Fitzpatrick skin types III - V were used in the wider search but not included in my results. All paper types (*i.e.*, clinical trials, review papers, meta-analyses, etc.) were included. Systematic literature reviews were included in the wider search and included in the results. All search results were screened manually in two phases. In the first phase, titles and abstracts were reviewed to assess relevance to laser use in Fitzpatrick skin types III - V, specifically in East Asian populations. In the second phase, full-text reviews were conducted to confirm inclusion based on relevance to clinical outcomes, treatment protocols, safety profiles, and East Asian skin considerations. A total of 76 studies met inclusion criteria and were included in this review. A PRISMA flow diagram [14] [15] was created to show the selection process, from initial search results to final study inclusion (see **Figure 1**). Studies were further categorized by laser type: CO_2 (n = 16), Er:YAG (n = 17), Nd:YAG (n = 17), Alexandrite (n = 12), synergistic (combination) laser treatments (n = 5), and other (n = 9).

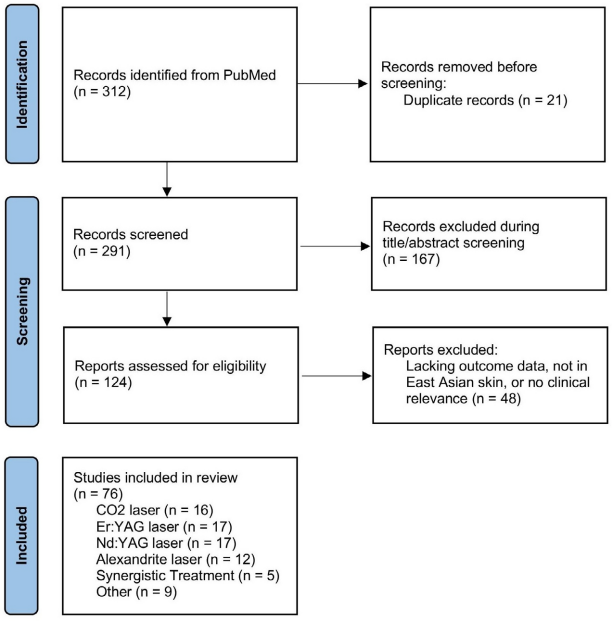

Figure 1. Flow diagram.

To assess the quality and reliability of the included studies, a simple risk of bias analysis was completed for the included studies. Studies were evaluated based on design type, randomization and blinding procedures, outcome reporting, and potential confounding factors following guidelines by Cornell University Library [16]. Randomized controlled trials (RCTs), including split-face and double-blinded designs, were generally considered to have a low risk of bias due to their methodological rigor. These studies demonstrated clear randomization protocols, blinding of assessors, and objective outcome measures, which reduced the likelihood of biases. Prospective cohort studies and observational trials were categorized as having a moderate risk of bias. Although these studies typically reported complete outcome data and employed standardized treatment protocols, the absence of randomization, blinding, and control groups introduced a greater potential for selection and confounding bias. Narrative reviews, expert commentaries, and case series were considered high risk because of their descriptive nature and lack of systematic methodology. These sources were included to provide clinical context but were not weighed heavily in the analysis of treatment efficacy or safety outcomes.

3. Laser Terminology

The following terms are the laser-specific language utilized throughout this review (see Table 2).

Table 2. Terminology and definitions.

Laser Toning	Non-invasive cosmetic procedure that uses laser energy to break down excess melanin, improve skin tone and texture, and stimulate collagen production.
Facial Resurfacing	Cosmetic procedure addressing wrinkles, scars, and sun damage by ablating the outer layers of damaged skin.
Fractional Laser	Non-invasive treatment device that delivers a laser beam divided into microscopic treatment zones to create controlled micro-injuries on the skin's surface, stimulating the natural healing process and collagen production.
Full-Field Treatment	Laser skin resurfacing technique that uses a laser to treat the entire surface area of the skin.
Long-Pulsed Mode	Laser technique that emits light in the form of pulses with durations ranging from milliseconds to microseconds. These pulses are longer than short-pulse lasers (in nanoseconds or picoseconds), and energy is delivered more continuously. Allows for deeper penetration of the laser energy into dermal tissue.
Q-Switching Mode	Laser technique that generates short, high-energy pulses by rapidly modulating the Q-factor of the laser resonator. This is achieved by using a device to rapidly switch the laser on and off, creating a pulsed output instead of a continuous wave in nanoseconds.
Picosecond Mode	Laser technique that emits light pulses lasting between 1 and 100 picoseconds. Higher precision and reduced thermal effects compared to nanosecond counterparts.

4. CO_2 Laser

CO_2 lasers use carbon dioxide to create an infrared beam of light. This light is well-absorbed by water, which makes up a large percentage of human tissue, making it useful in medical treatments. CO_2 laser treatments may not be suitable for patients with skin types above type IV on the Fitzpatrick scale because the laser light can damage melanocytes and cause discoloration [17]. **Table 3** summarizes all CO_2 laser studies used in this section.

Table 3. Summary of CO_2 Laser.

Patient Concern	Laser Type	Key Findings and Conclusions	Overall Risk of Bias	Citation
Atrophic acne scars	Ablative fractional CO_2	37% of patients attained more than 50% improvement in scar appearances	Moderate	[18] Alajlan *et al.*, 2011
	Ablative fractional CO_2	Average improvement of 52.5% and 50% of patients experienced temporary erythema and post-inflammatory hyperpigmentation	Moderate	[23] Huang, 2013
	Ablative fractional CO_2	Greater than moderate improvement for both acne scars and wrinkles with no serious side effects 3 months post-procedure	Moderate	[19] Hwang *et al.*, 2013
	Ablative fractional CO_2	66.4% reported texture improvement, with 15% of patients experiencing adverse events	Moderate	[22] Ochi *et al.*, 2017
	Ablative fractional CO_2	All patients had erythema post-treatment. Other side effects include post-inflammatory hyperpigmentation and acne flare-ups.	Moderate	[21] Fang *et al.*, 2022
Pigmentation	Ablative fractional CO_2	Significant improvement in pigmentation reduction. Post-inflammatory hyperpigmentation rate was 55.5% and 11.1% at 1 and 6 months post-treatment	Low	[27] Chan *et al.*, 2010
	Ablative fractional CO_2	Treatment of photoaging concerns showed to have continued efficacy for up to 5 years	Moderate	[26] Tan *et al.*, 2014

Continued

	Ablative fractional CO_2	8% of the patients treated with the CO_2 laser had excellent results for pigmentation improvement	Moderate	[25] Vachiramon *et al.*, 2016
	Ablative fractional CO_2	Above moderate improvement in both acne scar and wrinkle appearances	Moderate	[19] Hwang *et al.*, 2013
	Ablative fractional CO_2	Significant decrease in the number of enlarged pores at a mean of 28.8% decrease. Increase in collagen fibers and expression of transforming growth factor-β1.	Moderate	[28] Kwon *et al.*, 2018
Tone, texture, wrinkles	Ablative fractional CO_2	Excellent improvement of wrinkles for 12% of patients, significant in 40%, and moderate in 28%. Adverse effects: transient pain, erythema, and edema.	Moderate	[29] Lee *et al.*, 2009
	Ablative fractional CO_2	CO_2 lasers are effective in treating photoaged skin and its effects have continued efficacy for up to 5 years	Moderate	[26] Tan *et al.*, 2014
	Ablative fractional CO_2	Significant improvement in wrinkles, skin texture, and elasticity	Moderate	[24] Gao *et al.*, 2021

Of patients with mainly type IV skin treated with the CO_2 laser, 37% of patients attained more than 50% improvement in acne scars [18]. Despite superior clinical outcomes, this particular treatment modality has been associated with lengthy recovery time and a high risk of side effects and complications, especially in Asian patients who have greater than type II - III skin on the Fitzpatrick scale [19] [20]. When used to treat atrophic acne scars, the CO_2 laser resulted in all patients having erythema post-treatment. The patient pool consisted of Asians with Fitzpatrick skin types III - IV. 19.51% of patients experienced erythema for over 3 months following treatment. 73.17% of patients also had post-inflammatory hyperpigmentation, with it lasting longer than 3 months in 31.71% of those patients. 9.76% of patients experienced acne flare-ups, and 1 patient experienced hypopigmentation. Post-laser scars occurred in 2 patients [21]. In another patient pool of 107 East Asian men and women, 15% experienced adverse events including hyperpigmentation (6.4%), blistering (4.0%), crusting (2.9%), aggravation of inflammatory acne lesions (1.7%), and scarring (0.6%) [22].

All studies employed fractional ablative CO_2 lasers to treat atrophic acne scarring. Across studies, patients underwent between 1 to 3 sessions of full-face treatment, with energy and pulse parameters adjusted according to clinical judgment

and patient skin type. Consistent principles guided treatment protocols, including tailoring fluence and density to scar severity while minimizing thermal injury. Standardized pre-treatment protocols, such as topical anesthetic application and photo documentation, were common across studies. Outcomes were uniformly assessed via both physician evaluation and patient-reported satisfaction, typically measured 3 months post-procedure. Across all studies, safety monitoring included adverse events such as post-inflammatory hyperpigmentation, erythema, and scarring.

The CO_2 laser is moderately effective at addressing pigmentation and skin texture but involves a large probability of erythema and post-inflammatory hyperpigmentation in East Asian patients. 50% of patients experienced post-inflammatory hyperpigmentation for less than a month following treatment, with 9% of patients experiencing PIH for up to 3 months. Post-laser erythema was resolved within 1 month for 50% of patients; prolonged erythema experienced for up to 3 months was noted in 27% of cases [23]. However, the CO_2 laser significantly improves the appearance of static periorbital wrinkles, skin texture, and elasticity at a 3-month follow-up compared with baseline [24]. Comparatively, the Q-switched Nd:YAG is more promising than the fractional CO_2 laser for the treatment of solar lentigines. Only 8% of patients treated from the CO_2 laser group experienced excellent results in pigmentation improvement compared to 80% of the patients treated with the Nd:YAG having excellent results [25].

In the reviewed studies that showed a statistically significant reduction in pigmented lesions, the recurrence risk of pigmented lesions ranged from 5% to 25% after 3 to 5 years [26]. Factors such as lesion type, lesion height, and multicentricity can increase the risk of recurrence.

5. Er:YAG Laser

The Erbium-doped yttrium aluminium garnet (Er:YAG) laser is a solid-state laser generally emitting infrared light. Er:YAG lasers are widely used for superficial penetration, where the goal is to have controlled, layer-by-layer ablation of the skin. The depth of tissue ablation goes down to the epidermis while also causing controlled damage to the upper layers of the dermis to stimulate collagen production. Er:YAG lasers penetrate the granular layer after 1 pass, the basal cell layer after 2 passes, the papillary dermis after 3 to 4 passes, and deeper into the papillary and superficial reticular dermis after 5 to 6 passes [30]. The basal layer refers to the innermost layer of the epidermis, with the papillary dermis below it being the topmost layer of the dermis. A technical option when operating the Er:YAG includes the fractional technique. Fractional lasers deliver precise microbeams of laser light into deeper layers of skin, creating narrow columns of tissue coagulation with considerable depth. Coagulated tissue of the treatment area then stimulates a natural healing process, resulting in the rapid growth of healthy new tissue. A summary of laser modality, key findings, and relevant citations for Er:YAG laser treatments is presented in **Table 4**.

Table 4. Summary of Er:YAG laser.

Patient Concern	Laser Type	Key Findings and Conclusions	Overall Risk of Bias	Citation
Atrophic acne scars	2940-nm dual-mode Er:YAG	Moderate-to-severe facial acne scars treated successfully	Moderate	[38] Hu *et al.*, 2010
	2940-nm fractional Er:YAG in adjustable coagulation mode	Good to excellent patient satisfaction. Low incidence of postinflammatory hyperpigmentation.	Moderate	[34] Hu *et al.*, 2011
Pigmentation	2940-nm fractional Er:YAG	Significant reduction in pigmentation with minimal treatment-related pain or adverse events	Low	[37] Moon *et al.*, 2015
	532-nm Er:YAG	Effective improvement of pigmentation in pigmented lesions	Moderate	[39] Negishi *et al.*, 2018
	2040-nm Er:YAG	Effective elimination of solar lentigo lesions	Moderate	[33] Karabay *et al.*, 2020
Tone, texture, wrinkles	2940-nm short-pulsed Er:YAG	All treated acquired melanocytic nevi (AMN) and small congenital melanocytic nevi (CMN) showed complete removal of pigmentation.	Low	[40] Lee *et al.*, 2015
	2940-nm fractional Er:YAG	Significant reduction in uneven tone and erythema with minimal treatment-related pain or adverse events	Low	[37] Moon *et al.*, 2015
	2940-nm fractional nonablative Er:YAG	Successful clearance of ephelides after 1 treatment session	High	[36] Tian, 2017
	2940-nm low-fluenced Er:YAG	Effective treatment of pigmentation disorders with improvements in overall skin tone, texture, and wrinkles	Moderate	[41] Kim *et al.*, 2019

The Er:YAG laser is effective in targeting pigmentation and atrophic acne scarring concerns in East Asian skin. Though the Er:YAG laser is effective in improving skin laxity, skin texture, and scarring (see **Figure 1**), full-field treatment is usually limited to Fitzpatrick skin types I - II to reduce the occurrence of adverse

effects with Fitzpatrick skin types III - V treated using more conservative parameters [31]. For example, the full-field treatment approach operates on the entire area of interest, while fractionated treatments ablate microscopic vertical columns within focused treatment areas, leaving surrounding areas unaffected. East Asians typically fall in this Fitzpatrick skin type III - IV range and are recommended to undergo only fractionated treatments [32]. Er:YAG results from treatment targeting pigmented lesions last between 6 months and 2 years [33]. However, recurrence risk and duration of efficacy can be extended depending on patient factors such as skin type, age, and post-treatment practices.

The Er:YAG laser is shown to be effective for moderate to severe acne scars in Asian patients. In 34 patients with Fitzpatrick skin types III and IV, those who received 1 treatment and were followed for 3 months rated their satisfaction an average of 3 or 4 (good or excellent) on a 4-point scale. The incidence of postinflammatory hyperpigmentation following treatment was also low, at 3.0% [34]. In comparison, a study involving individuals with Fitzpatrick I - II skin saw a 10% rate of postinflammatory hyperpigmentation [35]. Er:YAG is also similarly effective in the clearance of ephelides in Fitzpatrick III and IV skin, with one study reporting 90% clearance and no development of hyperpigmentation, hypopigmentation, or recurrence after 6 months [36].

Compared to the CO_2 laser, Er:YAG is generally considered less likely to cause postinflammatory hyperpigmentation of treatment areas and, therefore, is considered to be a more suitable treatment option for photoaged skin in Asians [37]. The 2940-nm Er:YAG laser appears to yield the most satisfactory results for use on Fitzpatrick III - V skin, balancing both visual appeal and side effects.

6. Nd:YAG Laser

Neodymium-doped yttrium aluminum garnet (Nd:YAG) lasers use crystals as a lasing medium for the solid-state laser, emitting infrared light. Pulsed Nd:YAG lasers are typically operated in Q-switching mode, producing short pulses in nanoseconds with high peak powers in megawatts, allowing better and faster clinical results. Table 5 provides a summary of Nd:YAG laser treatments.

Table 5. Summary of Nd:YAG laser.

Patient Concern	Laser Type	Key Findings and Conclusions	Overall Risk of Bias	Citation
Atrophic acne scars	1320-nm Nd:YAG	Effective for atrophic acne scar improvement but requires a combination approach with another device to further enhance appearance	Moderate	[50] Chan *et al.*, 2004
	Fractional Q-switched 1064 nm Nd:YAG	Significant improvement in acne scars	Moderate	[1] Nisticò *et al.*, 2022
	Picosecond 1064-nm Nd:YAG	Compared to the Er:YAG, Nd:YAG had comparable improvement effect with more safety profiles	Low	[51] Dai *et al.*, 2023

Continued

Non-malignant pigmented lesions	Q-switched 532-nm Nd:YAG	Melanin average level was not significantly reduced	Low	[52] Noh *et al.*, 2015
	Q-switched 660-nm Nd:YAG	Average melanin level significantly reduced in solar lentigines	Low	[52] Noh *et al.*, 2015
	Picosecond 1064-nm Nd:YAG	Effective improvement in pigmentation and lesion reduction with minimal treatment discomfort	Low	[47] Ungaksornpairote *et al.*, 2020
	Picosecond 1064-nm Nd:YAG	Significant improvement of melasma lesions and decreased Melasma Area Severity Index scores	Low	[49] Hong *et al.*, 2022
	Q-switched 1064-nm Nd:YAG	Significant improvement of melasma lesions and decreased Melasma Area Severity Index scores	Low	[49] Hong *et al.*, 2022
Pigmentation	Long-pulse 1064-nm Nd:YAG	Moderate improvement in pigmentation. Adverse events were minor and rare.	Moderate	[53] Negishi *et al.*, 2016
	Low Fluence Q-Switched 532/1064-nm Nd:YAG	Satisfactory outcomes for both sole 1064-nm and combined 532/1064-nm therapy, with low incidence of PIH	Moderate	[54] Shen *et al.*, 2016
	Low-fluence Q-switched 1064-nm Nd:YAG	2.5% of patients showed excellent improvement, 35% good, 37.5% fair, 15% poor, and 10% no improvement in melasma pigmentation	Moderate	[48] Choi *et al.*, 2018
Telangiectasias	1064-nm Nd:YAG	Used for darker blue telangiectasias. Patient satisfaction was very high, including dermatologists' clinical evaluations	Moderate	[55] Bennardo *et al.*, 2022
	532-nm Nd:YAG	Used for red lesions caused by telangiectasias. Patient satisfaction was very high, including dermatologists' clinical evaluations	Moderate	[55] Bennardo *et al.*, 2022
	Long pulse 1064-nm Nd:YAG	Majority reported an excellent (80%) or mild (20%) disappearance of telangiectasia appearance	Moderate	[56] Cannarozzo *et al.*, 2023

Nd:YAG laser is best for skin types IV - VI because its longer wavelength can bypass melanin in the skin [42]. However, caution is still recommended for tanned or darker-skinned patients, as the laser can destroy melanin and cause white patches of skin. Hypopigmentation may appear as white macules that match the size and form of the laser spot within weeks of treatment with the Q-switching 1064/532 nm Nd:YAG laser [43]. The probability of hypopigmentation is associated with fluence (a measure of energy delivered per unit area) and treatment session frequency. The negative effects can be avoided by employing the appropriate fluence adjusted to the specific patient.

The long-pulse Nd:YAG laser with a minimal downtime technique should be considered as a treatment modality in Asian patients to address skin texture concerns. Good or superior results with minimal discomfort are achieved within 2 to

7 treatments of the long-pulse Nd:YAG laser every 3 - 4 weeks [44]. The Nd:YAG treatment improves wrinkles, skin laxity, skin texture, and fine lines [45]. An increase in the density of collagen fibers in the papillary dermis has been observed histopathologically [46].

The Nd:YAG laser has also been effective in improving the appearance of atrophic acne scars when scaled on Goodman and Baron's Quantitative Global Acne Scarring Grading System. The Goodman quantitative post-acne scarring grading system is a photographic assessment reporting a global severity score from 0 to 84 points. This system assesses scar appearance by measuring vascularization, pigmentation, and thickness, with higher scores indicating more scarring. No side effects for the Nd:YAG laser have been observed other than some instances of minor erythematous reactions such as erythema, edema, and exfoliation that resolved within 10 days [1].

For pigmented lesions in East Asians, the picosecond Nd:YAG laser is shown to be more promising than the Q-switched Nd:YAG laser. Both the picosecond and Q-switched laser variations use short pulse durations to target endogenous pigmentation, emitting a short pulse of light that's absorbed by the skin's pigment, which breaks them apart into smaller pieces for the body's immune system to clear away the fragments. The picosecond laser, however, has a pulse duration of picoseconds while the Q-switched has a pulse duration of nanoseconds. A study of 14 subjects with lentigines and acquired bilateral nevus of Ota-like macules was treated with a picosecond laser on one side of the face and a Q-switched laser on the other side. 85.7% of picosecond sites and 57.2% of Q-switched laser sites showed >50% improvement at 6 months, with no significant difference in their side effect profiles [47]. The picosecond laser was significantly associated with lower treatment discomfort, according to patient reports. Generally, the picosecond 1064-nm Nd:YAG laser is preferred when treating East Asian skin in the Fitzpatrick III - V range.

Nd:YAG laser treatment for pigmented lesions can offer long-lasting results. Most pigmented lesions can be treated in 1 to 2 sessions, and the treated areas typically lighten significantly within a few months. The results from Nd:YAG treatment last from several months to over a year. Studies report recurrence rates ranging from 40% to 65% within 3 - 9 months after treatment for pigmented lesions [48]. Higher recurrence risk is correlated with deeper lesion depth. Melasma is particularly prone to recurrence following Nd:YAG laser treatment [49]. Recurrence may be due to melanocytes remaining active in the treated area or at the margins of the treated area.

7. Alexandrite Laser

The alexandrite laser uses a green gemstone to create a laser in the wavelength that is known to be effective in penetrating red spots. They are also used for removing brown spots, freckles, and other pigmented lesions, commonly used in melasma treatments and dermal pigmentation concerns in East Asian patients

[57]. The alexandrite laser is used to target melasma-related pigmented lesions, such as the commonly acquired facial hypermelanosis characterized by irregular brownish macules and patches. A comprehensive summary of studies is compiled in Table 6.

Table 6. Summary of alexandrite laser.

Patient Concern	Laser Type	Key Findings and Conclusions	Overall Risk of Bias	Citation
Pigmentation	Long-pulsed 755-nm Alexandrite	Statistically significant improvement in pigmentation	Moderate	[8] Kono *et al.*, 2016
	Picosecond 755-nm Alexandrite	42.5% of patients experienced excellent (<60%) improvement in melasma pigmentation	Moderate	[63] Cheng *et al.*, 2017
	Picosecond 755-nm Alexandrite	Effective treatment of melasma with fewer adverse events	Moderate	[61] Lee *et al.*, 2017
	Picosecond 755-nm Alexandrite	Successful treatment and improvement of melasma pigmentation	Moderate	[64] Polnikorn *et al.*, 2020
	Picosecond 755-nm Alexandrite	88.89% of patients achieved improvement in dermal pigmentation	Moderate	[57] Hu *et al.*, 2020
Tone, texture, wrinkles	Picosecond 755-nm Alexandrite	More than 76% removal of ephelides with no scarring, pigmentary, or textural changes post-treatment	Moderate	[58] Jang *et al.*, 2000
	Q-switched 755-nm Alexandrite	All patients experienced improvement in ephelides and lentigines	Low	[59] Wang *et al.*, 2006
	Long-pulsed 755-nm Alexandrite	Lower risk of adverse effects for the removal of ephelides and lentigines	Moderate	[8] Kono *et al.*, 2016

The alexandrite laser also successfully targets ephelides for East Asian patients with minimal post-treatment side effects [58]. The long-pulsed alexandrite laser carries a lower risk of adverse effects when compared to the nanosecond alexandrite laser for removing ephelides and lentigines in darker skin types [8], and is relatively quick and effective. In a study involving 15 patients with ephelides and 17 patients with lentigines of East Asian ethnicity, ephelides achieved greater improvement after treatment with the Q-switched alexandrite laser than with intense pulsed light (IPL). Postinflammatory hyperpigmentation had developed in 1 pa-

tient with ephelides and 8 patients with lentigines after alexandrite laser treatment, but no postinflammatory hyperpigmentation occurred after IPL [59]. The results of alexandrite laser treatment are more favorable than IPL, but include minor side effects [60]. Another study saw that a skin model exposed to the picosecond 755-nm alexandrite laser showed a decrease in epidermal keratinocyte necrosis (death of individual skin cells) compared to the 532-nm Q-switched Nd:YAG treatment, yet decreased melanin content [61]. The probability of adverse events such as post-inflammatory hyperpigmentation is noticeably lower for Alexandrite lasers during all 8 weeks of the follow-up period. The 755-nm Alexandrite laser appears most promising for use on East Asian skin [62].

Of studies specifically treating Nevus of Ota, recurrence rates after Alexandrite laser treatment range from 0.6% to 5.2% after 4 to 10 years. Recurrence rate is higher for melasma treatment, as Alexandrite laser only lessens the appearance of existing pigmentation. Alexandrite laser results typically last over a year but may require multiple treatments every 3 - 6 months.

8. Synergistic Treatments

The combined use of the Er:YAG and alexandrite laser is promising in treating moles and birthmarks, with the successful treatment of Korean patients with melanocytic nevi and small congenital nevi. This treatment used the short-pulsed Er:YAG laser followed by the long-pulsed alexandrite laser at 1-month intervals. 8 weeks after the final treatment of Er:YAG followed by long-pulsed alexandrite laser, all treated nevi showed complete removal of pigmentation [40]. **Table 7** details all studies related to synergistic laser treatment.

Table 7. Summary of synergistic treatments.

Patient Concern	Laser Types	Key Findings	Overall Risk of Bias	Citation
Nonmalignant pigmented lesion	Combined short-pulsed Er:YAG and long-pulsed alexandrite	Complete removal of pigmentation in all treated nevi	Low	[40] Lee *et al.*, 2015
Pigmentation	Q-switched alexandrite and ablative fractional CO_2	Improvement in lentigo senilis, moles, melasma, seborrheic keratosis, dermal melanocytosis, and ephelides.	Moderate	[66] Takekawa *et al.*, 2021
	2940-nm fractional Er:YAG and 1064-nm Q-switched Nd:YAG	Rapid improvement in melasma pigmented lesions	High	[68] Tian, 2016
	Nanosecond alexandrite and nanosecond 1064-nm Nd:YAG	Higher risk of hyperpigmentation recurrence	Moderate	[8] Kono *et al.*, 2016
Tone, texture, wrinkles	Ablative fractional CO_2 and Intense Pulsed Light (IPL)	Significantly increased elasticity, decreased pore size, reduced skin wrinkles, and improved skin texture with no side effects	Moderate	[67] Mei *et al.*, 2018

Er:YAG and Nd:YAG lasers are also used together to achieve greater improvement in targeting melasma in East Asian skin. In a study of Chinese patients with melasma, rapid improvement in 2 cases of melasma pigmentation in Chinese type III skin was shown within a month of treatment using the combined treatment of the Er:YAG and Nd:YAG laser [65]. Sustained results with no complications were shown at the 6-month follow-up.

Using the alexandrite and CO_2 laser treatments together is another effective option in targeting pigmentation. This result is shown in a study of 246 patients with lentigo senilis, 186 with moles, 79 with melasma, 53 with seborrheic keratosis, 17 with acquired dermal melanocytosis, and 16 with ephelides. Post-treatment, outcomes were excellent in 97 patients, good in 113 patients, fair in 17, and poor in 0 patients [66], with the improved pigmentation of ephelides being most responsive in this synergistic treatment. The CO_2 laser was used to ablate the skin for moles and benign skin tumors, and the Q-switched alexandrite laser was used for acquired dermal melanocytosis (ADM) and ephelides.

The combined alternating use of a nanosecond alexandrite and a nanosecond 1064-nm Nd:YAG laser in different treatment sessions was associated with a higher risk of complications. It is shown that using this synergistic treatment for clearing nevus of Ota had an estimated recurrence risk of 0.6% and 1.2% in East Asian patients [8]. Recurrence of nevus of Ota was seen even in patients who had experienced complete clearance.

Combining the CO_2 laser and Intense Pulsed Light (IPL) treatment is promising for treating photoaged skin in East Asian patients. Though aggressive CO_2 lasers with higher fluence values are associated with a higher risk of adverse effects, this study used less aggressive CO_2 fluences (84 mJ/pixel) in combination with IPL. The results showed that this combined therapy was not associated with severe adverse effects (*i.e.* infection, hypopigmentation, scarring) in all cases. Erythema had lasted for 7 - 14 post-therapy and disappeared spontaneously. The combined treatment of the ablative fractional CO_2 laser and IPL significantly increased elasticity, decreased pore size, reduced skin wrinkles, and improved skin texture [67].

9. Discussion

Er:YAG, Nd:YAG, and alexandrite lasers appear promising in addressing skin concerns in East Asian patients. The picosecond mode of the Nd:YAG laser is more effective for pigmentation reduction than the Q-switched Nd:YAG laser, yielding lasting results and improved patient-reported outcomes [47]. The CO_2 laser has shown efficacy in improving texture and pigmentation, producing notable results in skin resurfacing and acne scar treatment. The Er:YAG laser, while less aggressive than the CO_2 laser, is also effective in treating atrophic acne scars and improving skin texture in Fitzpatrick skin types III - IV. Alexandrite laser procedures are effective for addressing melasma and pigmentation disorders in Asian populations [69]. Clinicians may consider incorporating Alexandrite lasers for patients undergoing regular laser toning treatments. Laser toning, or laser fa-

cials, is increasingly popular for treating melasma in Asian countries. Treatments are on average 3 - 7 times a week, for 2 or more months [68] [70]. Laser toning breaks down pigmentation and stimulates collagen production, whereas laser facials (laser resurfacing) are more intense, targeting deeper skin layers for wrinkles and scars. Among the studies reviewed, the Er:YAG laser and Alexandrite laser may be promising options for pigmented lesions (e.g. melasma, Nevus of Ota, age spots, birthmarks, ephilides, moles, etc.), with lower recurrence rates than Nd:YAG laser treatment.

Each laser carries specific risks, since East Asian skin (Fitzpatrick III - V) is more prone to pigmentation [71]. The CO_2 laser is associated with significant post-treatment risks in East Asian patients, including prolonged erythema, hyperpigmentation, hypopigmentation, and scarring. Its deeper penetration and greater thermal damage poses a higher risk for post-inflammatory hyperpigmentation (PIH) in darker skin tones. In contrast, the Er:YAG laser seems to offer a better safety profile due to a controlled ablation depth and minimal thermal injury, reducing the risk of pigmentation. The picosecond Nd:YAG laser is associated with lower treatment discomfort and fewer adverse effects than its Q-switched counterpart. Alexandrite lasers, operated at lower wavelengths compared to other laser types, are the least invasive. This makes alexandrite laser treatment generally well tolerated with a low incidence of PIH, making it favorable for patients with sensitive skin or a history of post-inflammatory responses.

In current literature, social factors affect the demographics of laser studies and lead to the under-representation of certain groups. A majority of cosmetic studies are currently geared toward women, with limited clinical trials focusing on variation in sex and gender. Future studies could be done with a more gender-diverse patient cohort. This diversity is achieved in other areas of dermatology, such as acne and atopic dermatitis research [72], but is lacking for dermatologic laser treatments. A more inclusive sample would enhance generalizability, increase diversity, and improve understanding of new technologies across all skin types.

As the United States becomes more diverse, it is important to have a greater understanding of people of color in medical laser therapy. In the future, this review topic could be expanded to Fitzpatrick Type V - VI and other ethnic groups. Currently, the CO_2 laser is the most common laser modality for skin resurfacing [73]. Lasers are increasingly popular among the general populace, and more laser technologies are available. However, many clinicians choose to invest in CO_2 lasers primarily, limiting our understanding and usage of other lasers. The CO_2 laser is favored for purchase in clinics because it is versatile, addressing concerns across pigmentation, skin tone and texture, and skin tumor removal. Though the CO_2 laser is effective for individuals with lighter skin in the Fitzpatrick range I - II [74], prolonged hyperpigmentation, scarring, and erythema are noted for individuals of darker skin tones post-treatment. A more comprehensive review of patients with darker skin tones can identify optimal treatments for their Fitzpatrick skin type. Future directions can compare alternative cosmetic dermatology procedures

to laser treatment, such as microneedling or topical prescriptions. Adjunct topical therapies or synergistic treatments after laser treatment for darker skin tones are also promising directions of study. This is a promising avenue, as shown in studies by Angra *et al.* [75].

Limitations of this review include the number of papers used for data collection. The literature regarding East Asian skin and lasers is sparse, restricting our findings to a small sample size. Many studies had low participant numbers, limiting generalizability. Cosmetic outcomes reporting is potentially prone to observer bias. There is also underlying confirmation bias and reporting bias for studies involving patient-reported outcomes (*i.e.* appearance improvements). Any medication, topicals, or other health conditions of the individual that may influence patient results are also not collected or given by the data. These factors may be confounders.

Laser practitioners should explore using Er:YAG, Nd:YAG, and alexandrite lasers for the management of skin concerns in East Asian patients. Er:YAG lasers can target atrophic acne scars and skin tone, and the picosecond Nd:YAG laser can be considered for pigmented lesions. The alexandrite laser can be promising in improving pigmentation while reducing the risk of post-inflammatory responses in sensitive skin. Despite efficacy, cost remains a barrier to access, particularly in underinsured or resource-limited settings. Lasers are often classified as cosmetic and not covered by insurance, making them expensive, which exacerbates disparities in dermatological care [76]. Limited clinician familiarity with optimal laser settings for East Asian skin types may further contribute to inconsistent patient outcomes. Addressing these gaps improves accessibility and affordability by reducing repetitive or additional treatments post-laser therapy. By considering these suggestions, clinicians can take steps toward delivering optimal, equitable, and evidence-based care to East Asian patients.

10. Conclusion

East Asian patients experience distinct challenges with laser treatments due to their unique skin physiology and the underrepresentation in current literature. Among the modalities reviewed, the Er:YAG, Nd:YAG, and alexandrite lasers demonstrated safer profiles and effective clinical outcomes for treating common pigmentary and textural concerns. The Er:YAG laser is precise with minimal thermal damage, while the picosecond Nd:YAG and alexandrite lasers minimize the incidence of post-inflammatory hyperpigmentation. Those complications are commonly observed with higher-energy or ablative options, such as CO_2 lasers. Despite these advantages, gaps remain in clinician familiarity, accessibility of diverse laser technologies, and representation of East Asian patients in clinical trials. Expanding research efforts to include more ethnically diverse cohorts and exploring adjunct therapies may improve treatment outcomes and reduce disparities.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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