



Systematic Review Article

LASER AND LIGHT-BASED THERAPIES FOR MELASMA: A SYSTEMATIC REVIEW

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ABSTRACT

Background: Melasma is a chronic facial hyperpigmentation disorder commonly affecting women of reproductive age, driven by ultraviolet and visible light exposure, hormonal factors, and dermal changes, with frequent recurrence. Although hydroquinone-based triple combination therapy remains first-line treatment, lasers and intense pulsed light (IPL) are increasingly used. This systematic review evaluates the efficacy and safety of laser and light-based therapies for melasma. The objective is to determine the most effective and safest laser modalities, compare outcomes across technologies and protocols, and identify research gaps to inform future studies and guide evidence-based clinical decision-making in melasma management.

Materials and Methods: This systematic review was conducted according to PRISMA guidelines. PubMed, Scopus, Web of Science, and Google Scholar were searched using predefined keywords related to melasma and laser/light-based therapies. Randomized controlled trials and observational studies, review articles, meta-analysis were included. Two reviewers independently screened studies and extracted data. Owing to heterogeneity, results were synthesized qualitatively.

Results: Laser and light-based therapies demonstrated variable efficacy in melasma management. Q-switched Neodymium-doped Yttrium Aluminium Garnet (Nd:YAG) showed temporary improvement but was associated with recurrence and pigmentary adverse effects. Fractional lasers and IPL provided moderate benefit, with combination IPL therapies enhancing outcomes. Picosecond lasers, particularly with diffractive lens arrays, showed superior efficacy, better patient satisfaction, and favorable safety profiles. Combination approaches improved long-term outcomes but increased the risk of mild adverse events.

Conclusion: Picosecond lasers and combination-based strategies appear to offer the most promising balance of efficacy and safety. However, recurrence and procedure-related pigmentary changes remain concerns, highlighting the need for standardized protocols and larger controlled trials to optimize long-term melasma management.

Keywords: Melasma, Laser therapy, Picosecond laser, Q-switched Nd:YAG, Fractional laser, Ablative laser, Non-ablative laser, Intense pulsed light (IPL), Combination therapy.

INTRODUCTION

Melasma is a chronic, acquired hyperpigmentation disorder characterized by symmetrical brown-to-gray macules and patches, predominantly affecting sun-exposed facial areas.

Melasma is a common acquired hyperpigmentation disorder, affecting up to 30% of women of

reproductive age in certain populations. It presents as symmetrical, light-to-dark brown patches with irregular borders, typically worsening during summer due to increased sun exposure. Traditionally, melasma has been classified as epidermal, dermal, or mixed based on Wood's lamp findings (Passeron T & Picardo M, 2018).^[1]

Reflectance confocal microscopy (RCM) enables real-time, near-histologic imaging and is particularly suited for pigmentary disorders due to melanin's strong optical contrast (Kang HY et al., 2010).^[2]

Marked facial pigmentation or blemishes, regardless of cause, can substantially impair women's quality of life. This impact is partly influenced by psychological factors, particularly those related to self-image and social self-expression (Balkrishnan R et al., 2006).^[3]

The exact pathogenesis of melasma remains unclear, though multiple mechanisms have been proposed. Increased vascularity within lesions suggests a contributory role of dilated blood vessels. Both internal factors, such as sex hormones, and external triggers, particularly ultraviolet radiation, may alter the cutaneous microenvironment and promote mediator release, leading to melanocyte activation. Additionally, melanocytes in affected individuals may exhibit heightened intrinsic sensitivity to these stimuli (Kang HY & Ortonne JP, 2010).^[4]

Melasma is challenging to manage due to its dermal involvement and high recurrence rate. Strict use of broad-spectrum (UVA [Ultraviolet A] and UVB [Ultraviolet B]) sunscreen is essential. Topical hydroquinone remains the mainstay of therapy, with other agents such as tretinoin and azelaic acid also used. Combination regimens—typically hydroquinone, a retinoid, and a corticosteroid—tend to be more effective than single-agent treatment. Additional depigmenting compounds have been explored, but require stronger evidence before routine use. Procedural options, including chemical peels, lasers, and intense pulsed light, are also employed in selected cases (Gupta AK et al., 2006).^[5]

In recent years, low-fluence, large spot size, multi-pass Q-switched 1,064 nm Nd:YAG (Neodymium-doped Yttrium Aluminium Garnet) laser “toning” has become popular in Asian countries for non-ablative rejuvenation and melasma treatment (Chan NP et al., 2010).^[6]

Modified Kligman's triple combination (hydroquinone, tretinoin, fluocinolone) is the standard treatment for melasma. Laser therapy is used cautiously, as thermal injury may worsen pigmentation, especially in darker skin. Melasma is now viewed as a complex photoaging disorder with dermal inflammation and structural changes, which may explain treatment resistance and laser-induced aggravation. Low-fluence Q-switched 1,064 nm Nd:YAG “laser toning” became popular in Asia for melasma treatment. It uses multiple low-energy sessions to reduce melanin selectively, producing controlled depigmentation with minimal cellular damage (Lee YS et al., 2022).^[7]

Ultraviolet radiation is a major trigger for melasma relapse, making strict photoprotection essential. However, recurrences often occur despite effective UV sunscreen use. Recent evidence suggests that visible light can also increase pigmentation, particularly in darker skin types, with studies

showing pigment changes comparable to those induced by UVA exposure (Passeron T, 2013).^[8]

Given the expanding range of laser and light-based technologies and heterogeneity in reported efficacy and safety outcomes, a comprehensive synthesis of current evidence is warranted. This systematic review aims to critically evaluate the effectiveness, safety, and long-term outcomes of laser and light-based therapies for melasma and to identify gaps that may guide future research and clinical practice.

Objectives: To identify the most effective and safest laser modalities, compare treatment outcomes across different technologies and protocols, and highlight gaps in existing literature to guide future research. I believe this work will contribute meaningfully to evidence-based clinical practice and may assist clinicians in selecting appropriate treatment strategies for melasma.

MATERIALS AND METHODS

This systematic review conducted in accordance with the PRISMA guidelines. A comprehensive literature search was performed using databases including PubMed, Scopus, Web of Science, and Google Scholar using key words Melasma, Laser therapy, Picosecond laser, Q-switched Nd:YAG, Fractional laser, Ablative laser, Non-ablative laser, Intense pulsed light (IPL), Combination therapy. Eligible study designs included randomized controlled trials, cohort studies, case-control studies, and cross-sectional studies, review articles. Articles without extractable data, Lacked clear outcome measures or evaluable results were excluded.

Titles, abstracts, and full texts were independently screened by two reviewers, with disagreements resolved by consensus. Data extraction and quality assessment were performed independently using standardized tools appropriate to study design. Due to heterogeneity among studies, a qualitative synthesis was conducted.

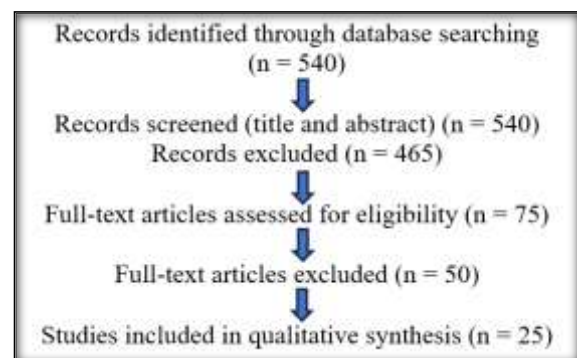


Figure 1: PRISMA Flow chart of Study Selection Process

RESULTS

The study by Mahmoud BH et al., 2010, evaluated the effects of visible light versus UVA1 on pigmentation

in individuals with skin types IV–VI. Both radiation types induced pigmentation, but visible light produced darker and longer-lasting changes, while no pigmentation occurred in skin type II. Differences were noted in pigment characteristics between the two sources. These findings highlight the role of visible light in photoaggravated pigmentary disorders and have implications for sunscreen use and treatment strategies.^[9]

Q-Switched Nd:YAG Laser (1,064 nm)

After five sessions, the laser-treated side showed significant improvement in colorimetric values and modified Melasma Area and Severity Index (mMASI) scores compared with baseline and control. Relative lightness improved by 92.5% and mMASI by 75.9% on the treated side, versus modest changes on the control side. However, mottled hypopigmentation occurred in three patients, rebound hyperpigmentation in four, and all patients eventually experienced recurrence (Wattanakrai P et al., 2010).^[10]

Low-fluence Q-switched 1,064 nm Nd:YAG laser toning for melasma and rejuvenation may lead to mottled depigmentation, sometimes after only a few sessions. As its use increases, this complication may be encountered more often and can be cosmetically distressing, particularly in patients with pre-existing melasma. Further research is needed to enhance safety and improve treatment outcomes (Chan NP et al., 2010).^[6]

In a study by Hong JK et al., 2022, both treatment groups demonstrated significant clinical improvement and reduction in mMASI scores from baseline, with no significant differences between the two techniques at any time point. Melanin index, patient satisfaction, and Visual Analog Scale (VAS) scores were comparable in both groups. Overall, the 1,064 nm picosecond Nd:YAG laser was as safe and effective as the conventional Q-switched 1,064 nm Nd:YAG laser, without showing superior results.^[11]

Fractional Lasers (Non-ablative and Ablative)

In a study by Katz TM et al., 2010, at the final session, over half of the patients showed more than 50% clinical improvement, with sustained benefit observed in five cases during follow-up. Recurrence occurred in three patients, and no major adverse effects were reported. Fractional photothermolysis appeared to be a safe and effective option for refractory melasma, offering prolonged remission in some patients.^[12]

Erbium Doped Yttrium Aluminum Garnet Laser (Er:YAG) and CO₂ lasers have shown benefit in small melasma studies, particularly with short pulses and low energy to reduce post-inflammatory hyperpigmentation (PIH) risk. Both appear safe when combined with depigmenting agents, but no direct comparisons exist and optimal parameters remain unclear (Morais OO et al., 2013).^[13]

Combined ablative fractional laser (AFL) plus topical therapy significantly improved Melasma Area and Severity Index (MASI) scores and physician global assessment compared with drug therapy alone,

though patient self-assessment showed no significant difference. As monotherapy, AFL was not superior to other laser modalities. Adverse effects were generally mild and transient, with occasional reversible post-inflammatory hyperpigmentation. Overall, AFL appears to be a useful option, particularly for refractory or severe melasma, with better outcomes seen when combined with medical therapy (Zhao S et al., 2024).^[14]

Intense Pulsed Light (IPL)

At Week 16, the intense pulsed light (IPL) group showed a 39.8% reduction in melanin index versus 11.6% in controls ($p < 0.05$), with over 50% improvement in 35% of treated patients compared to 14% of controls. Two patients developed temporary post-inflammatory hyperpigmentation, and partial repigmentation occurred by 24 weeks. Overall, IPL was effective and generally safe for refractory melasma, though maintenance sessions may be necessary (Wang CC et al., 2004).^[15]

Weekly fractionated IPL was demonstrated to be non-inferior to biweekly conventional IPL, as the lower bound of the 95% confidence interval for the difference in MASI score change (2.61) exceeded the predefined non-inferiority margin (-2.68 ; $P < 0.025$). The fractionated IPL group showed a steady decline in modified MASI scores, whereas the conventional IPL group experienced a rebound increase during treatment (Yun WJ et al., 2015).^[16]

Eight studies comprising 215 patients were analyzed. IPL-based combination therapy significantly improved outcomes, demonstrating a greater reduction in MASI scores (Standardized Mean Difference [SMD] = 0.61; 95% Confidence Interval [CI] 0.42–0.80; $P < 0.0001$) and higher patient-rated improvement on a four-point scale (Risk Ratio [RR] = 1.44; 95% CI 1.17–1.76; $P = 0.0004$) (Yi J et al., 2020).^[17]

Picosecond Lasers

The report by Maredia H et al., 2025 found picosecond laser to be well tolerated and effective for hyperpigmentation disorders such as hydroxychloroquine-induced hyperpigmentation (HH) and Lichen planus pigmentosus (LPP). Unlike Q-switched lasers, picosecond devices deliver energy through ultra-short pulses with photoacoustic effects, minimizing thermal damage and reducing the risk of post-inflammatory hyperpigmentation. Comparative studies in other pigmentary conditions have shown improved outcomes and less discomfort with picosecond lasers, making them a promising and potentially safer option, particularly for patients with darker skin types.^[18]

In a study by Chen YT et al., 2019, physician assessment showed good improvement in 40% and moderate improvement in 40% of cases. Mean MASI scores significantly decreased from 9.0 ± 4.8 to 6.5 ± 3.7 ($p < 0.001$). VISIA analysis demonstrated significant reductions in forehead spots ($p = 0.007$) and porphyrins ($p = 0.032$). Adverse effects were mild and transient, including erythema (25%), pruritus (20%), and scaling (20%). One patient (5%)

developed mild post-inflammatory hyperpigmentation, which resolved within three weeks.^[19]

In a randomized control trial by Liang S et al., 2023, fifty-nine patients were analyzed. All groups showed significant MASI reduction over 24 weeks. The non-fractional picosecond Nd:YAG laser (PSNYL) group achieved greater improvement than non-fractional picosecond alexandrite laser (PSAL) (p = 0.016) and 2% hydroquinone (HQ) (p = 0.018), while PSAL was

comparable to HQ. Patient satisfaction was highest with PSNYL. Recurrence occurred in 6.8%, and adverse effects were mild and transient.^[20]

After six picosecond Alexandrite laser sessions, Melasma Severity Index (MSI) improved more with the diffractive lens (75.7%) than the flat optic (57.2%) at 6 months. Recurrence was lower with the diffractive lens (5% vs. 16%), and transient hyperpigmentation occurred only in the flat optic group (21%) (Polnikorn N & Tanghetti E, 2020).^[21]

Table 1: Summary of Laser and Light-Based Therapies for Melasma: Key Clinical Findings

Type of Therapy	Author (Year)	Key Findings
Q-Switched Nd:YAG (1,064 nm)	Wattanakrai P et al., 2010	92.5% relative lightness and 75.9% mMASI improvement after five sessions; mottled hypopigmentation (3), rebound hyperpigmentation (4), recurrence in all patients.
Low-fluence Q-Switched Nd:YAG (1,064 nm)	Chan NP et al., 2010	May cause mottled depigmentation, sometimes after few sessions; cosmetically distressing; further research needed.
Picosecond vs Q-Switched Nd:YAG (1,064 nm)	Hong JK et al., 2022	Significant mMASI reduction in both groups; no significant difference; comparable melanin index, satisfaction, and VAS Score.
Fractional Photothermolysis	Katz TM et al., 2010	>50% improvement in over half; sustained benefit in some; recurrence in three; no major adverse effects.
Er:YAG and CO ₂ Lasers	Morais OO et al., 2013	Benefit with short pulses and low energy; safe with depigmenting agents; optimal parameters unclear.
Ablative Fractional Laser + Topical	Zhao S et al., 2024	Improved MASI and physician assessment vs drug therapy alone; mild transient adverse effects; reversible PIH.
Intense Pulsed Light (IPL)	Wang CC et al., 2004	39.8% melanin reduction vs 11.6% controls; temporary PIH; partial repigmentation by 24 weeks.
Fractionated vs Conventional IPL	Yun WJ et al., 2015	Weekly fractionated IPL non-inferior; steady MASI decline vs rebound increase with conventional IPL.
IPL-based Combination Therapy	Yi J et al., 2020	Greater MASI reduction (SMD 0.61) and higher patient-rated improvement (RR 1.44).
Picosecond Laser	Maredia H et al., 2025	Well tolerated; photoacoustic effect reduces thermal damage and PIH risk; promising for darker skin types.
Picosecond Laser	Chen YT et al., 2019	MASI reduced from 9.0 ± 4.8 to 6.5 ± 3.7; good improvement in 40% and moderate improvement in 40% of cases, mild transient adverse effects.
Picosecond Nd:YAG vs Alexandrite and HQ	Liang S et al., 2023	PSNYL superior to PSAL and HQ; highest satisfaction; recurrence 6.8%; mild transient adverse effects.
Picosecond Alexandrite (Diffractive lens vs Flat Optic)	Polnikorn N & Tanghetti E, 2020	Greater MSI improvement with diffractive lens (75.7%); lower recurrence (5% vs 16%); transient hyperpigmentation only with flat optic (21%).

Combination Therapies

Combination therapy showed no significant effect at 4 weeks but produced significant improvement by 8–16 weeks (SMD -0.55), suggesting a cumulative benefit. Moderate heterogeneity was reduced after sensitivity analysis, with consistent efficacy findings. However, adverse events were significantly more frequent in the combination group (Odds Ratio [OR] 8.96), mainly erythema and post-inflammatory hyperpigmentation. Evidence certainty was moderate for efficacy and very low for safety (Fithria RF et al., 2026).^[22]

In a study by Wang, J et al., 2025, a total of 160 patients were randomized to receive either laser alone (n = 80) or laser combined with topical tranexamic acid (n = 80). The combination group demonstrated significantly greater reductions in melasma area and depth, improved skin quality scores, and better long-term control at 6 and 12 months (P < 0.05). It also showed fewer adverse effects and higher patient satisfaction compared to laser monotherapy. Overall, combining laser with topical tranexamic acid proved more effective and better tolerated than laser alone.^[23]

In this randomized split-face study of 37 patients, 755-nm picosecond alexandrite laser combined with topical tranexamic acid showed greater improvement in hemi-MASI and dyschromia at 1 and 3 months compared with laser alone (p < 0.05). Both treatments significantly improved pigmentation and skin texture, with no serious adverse events. Laser monotherapy caused less short-term redness and sensitivity. Overall, combination therapy demonstrated superior efficacy with acceptable safety (Li Y et al., 2022).^[24]

In a study by Wang YJ et al., 2020, twenty-nine patients were randomized to three laser sessions (A1), five laser sessions (A2), or topical triple combination cream (B). By week 20, MASI scores improved significantly in all groups, with improvement rates of 53% (A1), 38% (A2), and 50% (B). VISIA analysis showed significant enhancement in spots, pores, and pigmentation after laser treatment. A2 demonstrated greater overall improvement than A1, with a significant reduction in red areas. Adverse effects were mild and resolved within 1–3 months.^[25]

Table 2: Summary of combination Therapies for Melasma: Key Clinical Findings

Author (Year)	Study Design	Key Findings
Fithria RF et al., 2026	Combination therapy vs control	No significant effect at 4 weeks; significant improvement at 8–16 weeks (SMD -0.55), showing cumulative benefit but higher adverse events (OR 8.96).
Wang J et al., 2025	Laser alone vs laser + topical tranexamic acid	Combination achieved greater melasma reduction, better long-term control, fewer adverse effects, and higher satisfaction, proving more effective and better tolerated.
Li Y et al., 2022	Randomized split-face (755-nm picosecond alexandrite laser ± tranexamic acid)	Combination showed greater hemi-MASI improvement with no serious adverse events, demonstrating superior efficacy with acceptable safety.
Wang YJ et al., 2020	3 sessions vs 5 sessions vs triple combination cream	By week 20, MASI scores improved significantly in all groups, All groups improved (53%, 38%, 50%)

CONCLUSION

Low-fluence Q-switched 1,064 nm Nd:YAG laser toning, used for skin rejuvenation and melasma, may lead to mottled depigmentation. As the procedure becomes more common, this adverse effect may be seen more frequently in practice. Depigmentation can develop after only a few sessions and may be cosmetically distressing, particularly in patients with underlying melasma. Further research is needed to improve outcomes and reduce complications (Chan NP et al., 2010).^[6]

Overall, QS-Nd:YAG (Q-switched neodymium-doped yttrium aluminum garnet) laser provided only temporary benefit and was associated with notable adverse effects (Wattanakrai P et al., 2010).^[10]

Fractionated IPL provides moderate improvement in melasma and represents a suitable alternative to conventional IPL, with no evidence of disease worsening. It may also serve as an effective maintenance therapy (Yun WJ et al., 2015).^[16]

Combined IPL therapy effectively decreases melasma severity and enhances patient satisfaction, supporting its role as a beneficial treatment option (Yi J et al., 2020).^[17]

Three sessions of 755-nm picosecond alexandrite laser with a diffractive lens array were effective for treating melasma in Asian patients, with minimal and self-limiting side effects (Chen YT et al., 2019).^[19]

Non-fractional PSNYL was more effective than PSAL and 2% HQ, with similar safety profiles, making picosecond lasers a viable option for melasma in Fitzpatrick skin types (FST) III–IV patient (Liang S et al., 2023).^[20]

The picosecond Alexandrite laser is effective for melasma, with superior outcomes and fewer adverse effects using the diffractive lens array (Polnikorn N & Tanghetti E, 2020).^[21]

Combination therapy enhances melasma outcomes over time but carries a higher risk of side effects. Careful patient selection and monitoring are essential, and larger standardized trials are needed to confirm optimal protocols (Fithria RF et al., 2026).^[22]

Picosecond alexandrite laser with Diffractive Lens Array (DLA) provides efficacy comparable to triple combination cream, with added benefits in skin texture and pigmentation; additional sessions may

help patients with telangiectatic features (Wang YJ et al., 2020).^[25]

Overall, Low-fluence Q-switched Nd:YAG laser provides temporary improvement but carries a risk of depigmentation. IPL offers moderate improvement and can be used as maintenance therapy. Picosecond lasers, especially alexandrite with diffractive lens array, show better efficacy with fewer side effects. Combination therapies may improve outcomes, but standardized protocols and further studies are needed. Further research is needed to establish standardized treatment protocols and long-term outcomes.

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REFERENCES

- Passeron T, Picardo M. Melasma, a photoaging disorder. *Pigment Cell Melanoma Res.* 2018 Jul;31(4):461-465. doi: 10.1111/pcmr.12684. Epub 2018 Jan 12. PMID: 29285880.
- Kang HY, Bahadoran P, Suzuki I, Zugaj D, Khemis A, Passeron T, Andres P, Ortonne JP. In vivo reflectance confocal microscopy detects pigmentary changes in melasma at a cellular level resolution. *Exp Dermatol.* 2010 Aug;19(8):e228-33. doi: 10.1111/j.1600-0625.2009.01057.x. PMID: 20497220.
- Balkrishnan R, McMichael AJ, Hu JY, Camacho FT, Shew KR, Bouloc A, Rapp SR, Feldman SR. Correlates of health-related quality of life in women with severe facial blemishes. *Int J Dermatol.* 2006 Feb;45(2):111-5. doi: 10.1111/j.1365-4632.2004.02371.x. PMID: 16445498.
- Kang HY, Ortonne JP. What should be considered in treatment of melasma. *Ann Dermatol.* 2010 Nov;22(4):373-8. doi: 10.5021/ad.2010.22.4.373. Epub 2010 Nov 5. PMID: 21165205; PMCID: PMC2991712.
- Gupta AK, Gover MD, Nouri K, Taylor S. The treatment of melasma: a review of clinical trials. *J Am Acad Dermatol.* 2006 Dec;55(6):1048-65. doi: 10.1016/j.jaad.2006.02.009. Epub 2006 Sep 28. PMID: 17097400.
- Chan NP, Ho SG, Shek SY, Yeung CK, Chan HH. A case series of facial depigmentation associated with low fluence Q-switched 1,064 nm Nd:YAG laser for skin rejuvenation and melasma. *Lasers Surg Med.* 2010 Oct;42(8):712-9. doi: 10.1002/lsm.20956. PMID: 20848553.
- Lee YS, Lee YJ, Lee JM, Han TY, Lee JH, Choi JE. The Low-Fluence Q-Switched Nd:YAG Laser Treatment for Melasma: A Systematic Review. *Medicina (Kaunas).* 2022 Jul

- 14;58(7):936. doi: 10.3390/medicina58070936. PMID: 35888655; PMCID: PMC9323185.
8. Passeron T. Melasma pathogenesis and influencing factors - an overview of the latest research. *J Eur Acad Dermatol Venereol.* 2013 Jan;27 Suppl 1:5-6. doi: 10.1111/jdv.12049. PMID: 23205539.
 9. Mahmoud BH, Ruvalo E, Hexsel CL, Liu Y, Owen MR, Kollias N, Lim HW, Hamzavi IH. Impact of long-wavelength UVA and visible light on melanocompetent skin. *J Invest Dermatol.* 2010 Aug;130(8):2092-7. doi: 10.1038/jid.2010.95. Epub 2010 Apr 22. PMID: 20410914.
 10. Wattanakrai P, Mornchan R, Eimpunth S. Low-fluence Q-switched neodymium-doped yttrium aluminum garnet (1,064 nm) laser for the treatment of facial melasma in Asians. *Dermatol Surg.* 2010;36(1):76-87. doi: 10.1111/j.1524-4725.2009.01383.x. PMID: 20298254.
 11. Hong JK, Shin SH, Park SJ, Seo SJ, Park KY. A prospective, split-face study comparing 1,064-nm picosecond Nd:YAG laser toning with 1,064-nm Q-switched Nd:YAG laser toning in the treatment of melasma. *J Dermatolog Treat.* 2022 Aug;33(5):2547-2553. doi: 10.1080/09546634.2022.2033674. Epub 2022 Jan 31. PMID: 35067157.
 12. Katz TM, Glaich AS, Goldberg LH, Firoz BF, Dai T, Friedman PM. Treatment of melasma using fractional photothermolysis: a report of eight cases with long-term follow-up. *Dermatol Surg.* 2010 Aug;36(8):1273-80. doi: 10.1111/j.1524-4725.2010.01621.x. PMID: 20666816.
 13. Morais OO, Lemos ÉF, Sousa MC, Gomes CM, Costa IM, Paula CD. The use of ablative lasers in the treatment of facial melasma. *An Bras Dermatol.* 2013 Mar-Apr;88(2):238-42. doi: 10.1590/S0365-05962013000200009. PMID: 23739704; PMCID: PMC3750887.
 14. Zhao S, Wang M, Lai X, Yan Y. Efficacy and Safety of Ablative Fractional Laser in Melasma: A Meta-analysis and Systematic Review. *Lasers Med Sci.* 2024 Feb 21;39(1):71. doi: 10.1007/s10103-024-03972-w. PMID: 38379033.
 15. Wang CC, Hui CY, Sue YM, Wong WR, Hong HS. Intense pulsed light for the treatment of refractory melasma in Asian persons. *Dermatol Surg.* 2004 Sep;30(9):1196-200. doi: 10.1111/j.1524-4725.2004.30371.x. PMID: 15355358.
 16. Yun WJ, Lee SM, Han JS, Lee SH, Chang SY, Haw S, Lee JB, Won CH, Lee MW, Choi JH, Chang SE. A prospective, split-face, randomized study of the efficacy and safety of a novel fractionated intense pulsed light treatment for melasma in Asians. *J Cosmet Laser Ther.* 2015;17(5):259-66. doi: 10.3109/14764172.2015.1027227. Epub 2015 Jul 29. PMID: 25803571.
 17. Yi J, Hong T, Zeng H, Li P, Li P, Wang S, Chen J, Li P, Zhou J. A Meta-analysis-Based Assessment of Intense Pulsed Light for Treatment of Melasma. *Aesthetic Plast Surg.* 2020 Jun;44(3):947-952. doi: 10.1007/s00266-020-01637-x. Epub 2020 Feb 13. PMID: 32055937.
 18. Maredia H, Wyles SP, Cantwell HM, Sartori-Valinotti JC. Picosecond laser to treat complex pigmentary disorders. *JAAD Case Rep.* 2025 Mar 21;60:22-25. doi: 10.1016/j.jcdr.2025.02.040. PMID: 40353092; PMCID: PMC12063027.
 19. Chen YT, Lin ET, Chang CC, Lin BS, Chiang HM, Huang YH, Lin HY, Wang KY, Chang TM. Efficacy and Safety Evaluation of Picosecond Alexandrite Laser with a Diffractive Lens Array for Treatment of Melasma in Asian Patients by VISIA Imaging System. *Photobiomodul Photomed Laser Surg.* 2019 Sep;37(9):559-566. doi: 10.1089/photob.2019.4644. Epub 2019 Aug 14. PMID: 31411549.
 20. Liang S, Shang S, Zhang W, Tan A, Zhou B, Mei X, Li L. Comparison of the efficacy and safety of picosecond Nd:YAG laser (1,064 nm), picosecond alexandrite laser (755 nm) and 2% hydroquinone cream in the treatment of melasma: A randomized, controlled, assessor-blinded trial. *Front Med (Lausanne).* 2023 Mar 28;10:1132823. doi: 10.3389/fmed.2023.1132823. PMID: 37056729; PMCID: PMC10086227.
 21. Polnikorn N, Tanghetti E. Treatment of Refractory Melasma in Asians With the Picosecond Alexandrite Laser. *Dermatol Surg.* 2020 Dec;46(12):1651-1656. doi: 10.1097/DSS.0000000000002612. PMID: 32932271.
 22. Fithria RF, Supranoto YTN, Liu Z, Peng J. Laser and light-based therapies combined with topical agents for melasma: A systematic review and meta-analysis. *Medicine (Baltimore).* 2026 Jan 9;105(2):e46579. doi: 10.1097/MD.00000000000046579. PMID: 41517728; PMCID: PMC12795099.
 23. Wang, J., Luo, H., Zhao, X. et al. Clinical study on the effectiveness of laser combined with topical tranexamic acid in the treatment of melasma. *Lasers Med Sci* 40, 368 (2025).
 24. Li Y, Yao C, Zhang H, Li L, Song Y. Efficacy and safety of 755-nm picosecond alexandrite laser with topical tranexamic acid versus laser monotherapy for melasma and facial rejuvenation: a multicenter, randomized, double-blinded, split-face study in Chinese patients. *Lasers Med Sci.* 2022 Sep;37(7):2879-2887. doi: 10.1007/s10103-022-03566-4. Epub 2022 May 1. PMID: 35501519.
 25. Wang YJ, Lin ET, Chen YT, Chiu PC, Lin BS, Chiang HM, Huang YH, Wang KY, Lin HY, Chang TM, Chang CC. Prospective randomized controlled trial comparing treatment efficacy and tolerance of picosecond alexandrite laser with a diffractive lens array and triple combination cream in female asian patients with melasma. *J Eur Acad Dermatol Venereol.* 2020 Mar;34(3):624-632. doi: 10.1111/jdv.15934. Epub 2019 Oct 17. PMID: 31494973.