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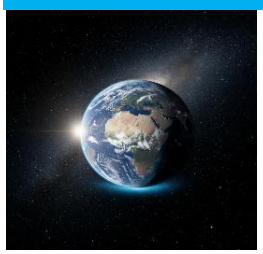

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Current strategies in the management of melasma: pathogenesis, risk factors and comprehensive treatment approaches

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Abstract

Melasma is an acquired pigmentary disorder characterized by symmetric hyperpigmented macules and patches on sun-exposed facial areas. Its multifactorial pathogenesis includes melanocyte hyperactivity, dermal melanophages, vascular and inflammatory components, oxidative stress and hormonal drivers. Because of its chronic, relapsing nature and high risk of recurrence, melasma management requires individualized, multimodal approaches combining strict photoprotection, topical agents, systemic medications when indicated, and procedure-based therapies for refractory or mixed cases. This review summarizes current knowledge of pathomechanisms and precipitating factors, evaluates therapeutic options (topical, systemic and procedural), compares modalities, and proposes practical algorithms for management and maintenance.

Keywords: melasma, hyperpigmentation, hydroquinone, tranexamic acid, lasers, microneedling, management

Introduction

Melasma is a common cause of facial hyperpigmentation worldwide. It predominantly affects women of reproductive age but also occurs in men and in older populations. The condition can be psychologically distressing, significantly reducing quality of life. Treatment remains

challenging: responses are variable, recurrences are common, and darker phototypes (Fitzpatrick IV–VI) have higher risk of post-inflammatory hyperpigmentation (PIH) after invasive procedures. Improved understanding of melasma pathogenesis in recent years — notably recognition of vascular, inflammatory and dermal contributions — informs an evolving multimodal therapeutic strategy(1, 2,16,17).

1. Definition

Melasma is an acquired chronic hypermelanosis characterized by symmetric brown to gray-brown macules and patches on sun-exposed facial areas, typically the cheeks, forehead, upper lip and chin(1,2,3,16,17).

1.1 Clinical patterns:

Centrofacial pattern: forehead, cheeks, nose, upper lip and chin (most common).
Malar pattern: cheeks and nose.
Mandibular pattern: jawline.

1.2 Histologic / type classification

Epidermal melasma: increased epidermal pigment, better response to topical agents.
Dermal melasma: dermal melanophages and deeper pigment, generally more refractory.
Mixed melasma: features of both. Diagnostic aids include Wood's lamp, dermoscopy and sometimes reflectance confocal microscopy or histology.

1.3 Melanocyte hyperactivity and melanogenesis

Melasma skin shows increased melanocyte activity, upregulated melanogenic enzymes (e.g., tyrosinase), and increased melanosome transfer to keratinocytes. This drives the hyperpigmented appearance in epidermal melasma and represents a primary therapeutic target for topical tyrosinase inhibitors and combination creams.

1.4 Dermal involvment and melanophages

In some patients melanin is found in the dermis interspersed with melanophages. Dermal pigment is less responsive to topical depigmenting agents, explaining incomplete response and higher recurrence. Dermal remodeling therapies (fractional lasers, microneedling) can help in selected cases.

1.5 Epidemiology

Prevalence varies with ethnicity, geographic latitude and sun exposure. Populations with darker phototypes report higher prevalence. Female sex predominates (female:male ratios reported widely), with pregnancy and hormonal therapies strongly associated with onset.

2. Pathogenesis — detailed mechanisms

Melasma is a multifactorial pigmentary disorder caused by UV and visible-light exposure, hormonal triggers (pregnancy, contraceptives, menopause), inflammation and genetic susceptibility. These factors increase melanocyte activity and melanogenesis via enzymes and mediators such as tyrosinase, tyrosinase-related proteins and melanocyte-stimulating pathways, and dermal/vascular changes and inflammation further sustain the pigmentation(1,2,16,17,18,30).

2.1 UV Radiation

UV Radiation Solar radiation, especially UVB, is the main environmental trigger of melasma. UVB and visible light cause keratinocytes, fibroblasts and endothelial cells to release factors that stimulate melanocytes to make melanin. Sun exposure activates several photobiological pathways that increase melanin-stimulating receptors (MSRs) on melanocytes; when MSRs are activated by MSH, they boost melanin production and promote transfer of melanin to keratinocytes, causing visible pigmentation. After UVB exposure, keratinocytes and fibroblasts also secrete stem cell factor (SCF), which can increase melanocyte proliferation; higher SCF expression and raised levels of melanogenesis genes have been found in the dermis of melasma lesions. Keratinocyte-derived VEGF may further support melanocytes and is linked to the greater vascularity seen in affected skin. Overproduction of nitric oxide at the dermal–epidermal junction may stimulate tyrosinase activity and increase vascularity in melasma. Finally, UVB raises reactive oxygen species, which promote melanogenesis; oxidative stress markers are higher in melasma patients than in healthy controls.

2.2 Vascular component

Recent studies show increased vascularity and upregulation of angiogenic factors (e.g., VEGF) in melasma lesions. Cross talk between the dermal microvasculature and melanocytes (via paracrine factors such as endothelin-1) may amplify melanogenesis. This has therapeutic implications: interventions that target vascular elements (vascular-targeted lasers, tranexamic acid with anti-angiogenic effects) can be beneficial adjuncts.

2.3 Inflammation and cytokine milieu

Subclinical inflammation with elevated cytokines (IL-1, IL-6, TNF-α) and activation of inflammatory pathways promotes melanogenesis and melanosome transfer. Invasive procedures risk exacerbating PIH through inflammatory mechanisms; careful preconditioning and anti-inflammatory strategies are essential.

2.4 Oxidative stress and mitochondrial dysfunction

Oxidative stress markers are elevated in melasma; reactive oxygen species may activate melanogenic pathways. Antioxidants (topical oral) are an investigated adjunct.

2.5 Hormonal influences

Estrogen and progesterone modulate melanocyte function; pregnancy and oral contraceptives are well established triggers. Receptors for sex hormones are expressed in melanocytes, supporting a hormonal basis in many cases.

2.6 Genetic predisposition and environmental triggers

Family history is often positive. UV exposure (UVA, UVB) and visible light are strong exacerbating factors; medications and cosmetic irritants may precipitate or worsen the condition.

Predisposing and precipitating factors

UV and visible light exposure (principal trigger).

Pregnancy, estrogen/progesterone therapies.

Genetic predisposition, darker phototypes.

Cosmetics, chronic irritation, and prior procedures causing PIH.

Thyroid dysfunction and some systemic conditions have been associated in observational studies.

3. Clinical assessment and monitoring

3.1 History, examination and objective scoring

Obtain onset, evolution, hormonal history, previous treatments, sun exposure, and psychosocial impact. Use photography for baseline and serial monitoring.

The Melasma Area and Severity Index (MASI) and modified or hemi-MASI are common for objective monitoring. Standardized lesion photography (same light conditions) helps longitudinal assessment(1,2,26,30).

3.2 Investigations

Noninvasive tools — Wood's lamp, dermoscopy and reflectance confocal microscopy (RCM) — can help characterize depth and microstructure of pigmentation, although diagnosis is usually clinical and biopsy is rarely required(1,2,20,30).

4. Management principles (1,2,16,17).

4.1 Education

Explain chronicity, expected course, need for maintenance, and relapse risk.

4.2 Photoprotection

Strict photoprotection is non-negotiable: broad-spectrum sunscreens (UVA, UVB) and visible light protection (tinted sunscreens with iron oxides) are essential. Reapply every two hours in daytime exposure

4.3 Preconditioning

Before procedures, preconditioning with topical depigmenting regimens reduces risk of PIH and improves outcomes.

4.4 Individualization

Tailor treatment by type (epidermal vs dermal vs mixed), skin phototype and patient preferences/contraindications.

Therapeutic modalities — detailed review

5. Treatment methods

Common melasma treatments target three goals: stop melanocyte overgrowth, reduce melanosome formation, and speed up melanin breakdown.

5.1 Topical therapy (first-line)

Topical drugs, oral agents and procedures achieve this by blocking melanin production, removing existing pigment, or breaking melanosomes.

5.1.1 Hydroquinone (HQ)

HQ (2–4%) remains the benchmark topical depigmenting agent.

Mechanism: reversible inhibition of tyrosinase and interference with melanosome formation.

Efficacy: robust in epidermal melasma; often used in combination.

Safety: irritation, paradoxical exogenous ochronosis with prolonged use at high concentrations — recommended cyclic use and monitoring (17,22,26,27).

5.1.2 Triple combination creams (HQ + retinoid + topical steroid)

Combination formulations (e.g., hydroquinone 4% + tretinoin + corticosteroid) accelerate depigmentation and are often used as initial therapy (8–12 weeks). Long-term steroid exposure risks (atrophy, telangiectasia) require transitioning to maintenance regimens after initial clearance(17,19,20,26).

5.1.3 Alternatives and adjuncts

Azelaic acid (20%): effective and safer in pregnancy/lactation.

Kojic acid, arbutin, niacinamide, cysteamine — used as adjuncts.

Topical tranexamic acid (TA): antifibrinolytic and anti-angiogenic effects; studies show promise as adjunctive topical therapy with excellent tolerability (4,9,12,13,17,19,20,26).

5.2 Systemic therapy

5.2.1 Oral tranexamic acid (TA)

Mechanism: inhibition of plasminogen activation reduces melanogenic mediators and angiogenesis.

Evidence: multiple RCTs and meta-analyses demonstrate efficacy for recalcitrant melasma.

Safety: thromboembolic risk — avoid in patients with personal/family history of thrombosis, pregnancy, active thromboembolic disease; screen patients and use shortest effective course(4,9,12,13,17).

5.2.2 Other oral agents

Polypodium leucotomos: oral antioxidant with photoprotective properties; can be adjunctive.

Oral isotretinoin and hormonal manipulation have limited and selective indications(2,16,17,28,30).

5.3 Chemical peels

Superficial peels (glycolic acid 20–70%, salicylic acid, Jessner's) can improve epidermal pigmentation when combined with topical therapy.

Risk: PIH in darker phototypes — preconditioning and careful technique reduce risk(19,20,26,27).

5.4 Microneedling and microneedling-assisted delivery

Microneedling increases transdermal delivery of depigmenting agents and promotes dermal remodeling. Evidence supports its utility as an adjunct to topical therapy, particularly for mixed or recalcitrant melasma, with relatively low risk when performed appropriately(2,12,16,17,28,30).

5.5 Energy-based therapies

5.5.1 Overview and rationale

Lasers and intense pulsed light (IPL) can target pigment and vascular components. Because of the PIH risk and frequent relapse, energy-based therapies are generally reserved for refractory cases and used in combination with rigid topical maintenance and pre/post care (3,7,11,17,21,23,25,26,29).

5.5.2 Q-switched Nd:YAG (1064 nm) — low fluence ("laser toning")

Used to fragment pigment (photomechanical effect). Low-fluence protocols aim to mitigate thermal damage. Evidence: mixed; combination with topical regimens improves outcomes. Careful parameter selection is critical to reduce PIH(3,7,11,17,21,24,28).

5.5.3 Picosecond lasers

Picosecond devices produce photomechanical disruption of pigment with shorter pulse widths; emerging evidence shows promise in refractory cases but comparative superiority remains to be established(6,11,21).

5.5.4 Fractional ablative and non-ablative lasers

Fractional lasers can remodel dermal architecture and potentially reduce dermal pigmentation but carry higher PIH risk. Reserved for selected, experienced centers with rigorous preconditioning(7,11,17,21).

5.5.5 Intense Pulsed Light (IPL)

IPL targets both pigment and vessel components and has been used, often in combination with topical therapy, especially when a vascular component is suspected. Patient selection and conservative settings are imperative(6,7,8,14,15,17,24,25).

5.5.6 Broadband light (BBL)

BBL is commonly used for epidermal and dermal pigmentary disorders and can help in refractory melasma. Epidermal lesions respond better to BBL than dermal ones. In our study, improvements in texture and wrinkles may reflect BBL effects, but we used low-fluence BBL combined with low-fluence Er:YAG. Marked textural improvement appeared 2–4 weeks after the first combined session, so low-fluence Er:YAG alone or together with BBL likely drove the rejuvenation seen(3,17,30).

5.6 Intradermal and injectable modalities

5.6.1 Tranexamic acid mesotherapy

Intradermal injection of TA has shown favorable results in small trials as adjunctive therapy(2,4,17,30).

5.6.2 Intradermal botulinum toxin A (BoNT-A)

Recent randomized split-face trials indicate intradermal microinjections of BoNT-A may reduce pigmentation (Hemi-MASI reductions reported). Proposed mechanisms: modulation of neurogenic inflammation, decreased sebum or vascular effects, and indirect suppression of melanogenic signaling. Data are preliminary but promising(2,5,10).

5.7 Combination strategies

Because melasma is multifactorial, combination strategies generally outperform monotherapy. Typical combinations: topical depigmenting agents + sunscreen + (for refractory disease) oral TA or microneedling ± topical TA or low-fluence laser in selected cases. Preconditioning and maintenance therapy are crucial to minimize adverse effects and recurrences.

Practical management algorithm (concise)

Evaluate and classify (epidermal/mixed/dermal).

Educate and institute strict photoprotection (UVA/UVB + visible light protection).

Start topical therapy: triple combination or HQ-based regimen for 8–12 weeks (unless contraindicated).

Reassess; if partial response add topical TA or consider oral TA (after screening).

For refractory or mixed/deep disease consider adjunctive procedures (microneedling, low-fluence lasers) with preconditioning and ongoing topical maintenance.

Use long-term maintenance regimens (lower strength topical agents and continued photoprotection) to reduce relapse risk(2,16,17,28,30).

5.8 Comparative table

Lp	Method	Mechanism	Typical efficacy	Main adverse effects	Practical notes
1	Hydroquinone (2–4%) (HQ)	Tyrosinase inhibitor → reduced melanin synthesis	High (epidermal)	Irritation, ochronosis if prolonged	Use cyclically; monitor
2	Triple combination (HQ+retinoid+steroid)	Inhibition of melanogenesis + acceleration of turnover + anti-inflammatory effect	Very high +(short term)	Steroid side effects if prolonged	8–12 week initial therapy
3	Topical tranexamic acid (TA)	Anti-plasmin, anti-angiogenic	Moderate-high as adjunct	Mild irritation	Good option as an addition to lasers/microneedling
4	Oral tranexamic acid	Inhibits the plasminogen/plasmin pathway → reduces angiogenesis and melanogenesis	Moderate (refractory)	Thrombo-embolic risk (rare)	Screen for thrombotic risk; short courses

5	Chemical peels	Exfoliation, turnover	Moderate (epidermal)	PIH, irritation	Preconditioning recommended
6	Microneedling ± topical agents	Enhanced delivery, remodeling	Moderate-high (combination)	Erythema, rare PIH	Often used as an adjunct; good results when combined with TA/HQ
7	Q-switched Nd:YAG low-fluence	Photomechanical pigment targeting	Variable	PIH, recurrence	Use conservative parameters, combine with topicals, use with caution in phototypes IV–V
8	Picosecond lasers	Photomechanical destruction of pigment	Moderate	PIH, transient erythema	Often necessary to combine with topical therapy
9	Fractional lasers (non-ablative ablative)	Dermal /remodeling	Moderate (mixed/deep)	Higher PIH risk	Preconditio-ning and careful parameters; use in experienced hands
10	IPL	Pigment and vascular targeting	Moderate	PIH, erythema	Consider for vascular predominant lesions, effective in combination with topical methods
11	Intradermal BoNT-A	Modulates neurogenic inflammation	Preliminary RCTs show improvement (hemi-MASI)	Local injection effects	Experimental adjunct, need more scientific reaserch

6. Safety and special considerations

Darker phototypes require conservative approaches to procedures and more intensive preconditioning.

Oral TA contraindications: active thromboembolic disease, pregnancy, high thrombotic risk — screen patients.

Consider pregnancy/lactation-safe agents (azelaic acid, physical sunscreens).

Document baseline and informed consent prior to energy based interventions.

7. Prognosis and maintenance

Melasma commonly recurs; long-term maintenance with photoprotection and topical agents reduces relapse frequency and severity. Lifelong counseling about sun/visible light avoidance and adherence to maintenance regimens is often necessary.

8. Research needs and future directions

Long-term RCTs comparing combination protocols with standardized outcomes and prolonged follow-up.

Studies elucidating vascular and neurogenic pathways to design targeted therapies.

Head-to-head trials of energy devices across phototypes and standardized pre/post regimens.

Biomarkers predicting response and relapse.

9. Conclusion

Melasma demands chronic, individualized care addressing multiple pathogenic axes: melanocytic, dermal, vascular and inflammatory. Topical therapies remain the foundation of management; systemic options and procedural modalities are valuable for recalcitrant or dermal disease when used within an integrated plan, emphasizing photoprotection and maintenance. Emerging therapies (topical/intradermal TA, intradermal BoNT-A) hold promise but require more robust long-term data.

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References

1. Ali L, Al Niaimi F. Pathogenesis of Melasma Explained. Int J Dermatol. 2025 Jul;64(7):1201-1212. doi: 10.1111/ijd.17718. Epub 2025 Feb 28. PMID: 40022484; PMCID: PMC12207721.

DOI: 10.1111/ijd.17718

2. Kania B, Lolis M, Goldberg D. Melasma Management: A Comprehensive Review of Treatment Strategies Including BTX-A. J Cosmet Dermatol. 2025 Feb;24(2):e16669. doi: 10.1111/jocd.16669. Epub 2024 Nov 12. PMID: 39533523; PMCID: PMC11845932.
DOI: 10.1111/jocd.16669

3. Kim H, Park J, Zheng Z, Cho SB. Low-fluenced erbium:yttrium-aluminium-garnet laser treatment in combination with broadband light pretreatment for various pigmentation disorders in Asian patients. J Cosmet Dermatol. 2019 Dec;18(6):1657-1664. doi: 10.1111/jocd.12897. Epub 2019 Mar 1. PMID: 30825265.
DOI: 10.1111/jocd.12897

4. Calacattawi R, Alshahrani M, Aleid M, Aleid F, Basamih K, Alsugair G, Alqahtani R, AlKhabbaz N, Algaidi Y, Alrakayan L, Almohanna A, Madkhali A, Aljohani S, Alotibi N. Tranexamic acid as a therapeutic option for melasma management: meta-analysis and systematic review of randomized controlled trials. J Dermatolog Treat. 2024 Dec;35(1):2361106. doi: 10.1080/09546634.2024.2361106. Epub 2024 Jun 6. PMID: 38843906.
DOI: 10.1080/09546634.2024.2361106

5. Pongklaokam J, Manuskiatti W, Wanitphakdeedecha R, Maneeprasopchoke P, Thongjaroensirikul P, Nokdhes Y, Abad-Constantino RMR, Bhorntarakcharoen W, Sittiwanaruk S, Techapichetvanich T. Efficacy and Safety of Letibotulinum Toxin A for the Treatment of Melasma in Two Different Dilutions: A Randomized Double-Blind Split-Face Study. Toxins (Basel). 2025 Jul 11;17(7):349. doi: 10.3390/toxins17070349. PMID: 40711160; PMCID: PMC12299615.
DOI:10.3390/toxins17070349

6. Chen J, Liu J, Wu J. Treatment of melasma by a combination of intense pulsed light with advanced optimal pulse technology and human-like collagen repair dressing: A case series study. Medicine (Baltimore). 2022 Aug 5;101(31):e29492. doi: 10.1097/MD.0000000000029492. PMID: 35945756; PMCID: PMC9351870.
DOI: 10.1097/MD.0000000000029492

7. Chehrara M, Tabavar A, Roohaninasab M, Jafary P, Mohammad AP, Mozafarpoor S, Alavi Rad E, Goodarzi A. The Efficacy of Laser Therapy in Melasma Treatment: A Systematic

Review and Meta-Analysis. J Cosmet Dermatol. 2025 Dec;24(12):e70602. doi: 10.1111/jocd.70602. PMID: 41378674; PMCID: PMC12696807.
DOI: 10.1111/jocd.70602.

8. Wang J, Wang X, Gu L, Shi Z, Xu Z, Shen S, Gu L, Chen L, Ju L, Jin C, Zhou B, Hua H. Efficacy of Intense Pulsed Light AOPT-LTL Technique in the Treatment of Melasma: An In Vivo and Clinical Study. J Cosmet Dermatol. 2025 Sep;24(9):e70443. doi: 10.1111/jocd.70443. PMID: 40916844; PMCID: PMC12415836.
DOI: 10.1111/jocd.70443.

9. Heidary B, Meibodi GAH, Ardakani ME, Ramezani V, Heidari F. Randomized Clinical Trial on the Efficacy of Oral Tranexamic Acid Versus Topical Tranexamic Acid in Treatment of Melasma. J Cosmet Dermatol. 2025 Sep;24(9):e70428. doi: 10.1111/jocd.70428. Erratum in: J Cosmet Dermatol. 2025 Nov;24(11):e70516. doi: 10.1111/jocd.70516. PMID: 40923777; PMCID: PMC12418907.
DOI: 10.1111/jocd.70428

10. Chaijaras S, Boonpethkaew S, Chirasuthat S, Sakpuwadol N, Yongpisarn T, Anansiripun P, Vachiramon V. Efficacy of Botulinum Toxin A for the Management of Melasma: A Split-Face, Randomized Control Study. J Cosmet Dermatol. 2025 Aug;24(8):e70376. doi: 10.1111/jocd.70376. PMID: 40747795; PMCID: PMC12315078.
DOI: 10.1111/jocd.70376

11. Ma W, Gao Q, Liu J, Zhong X, Xu T, Wu Q, Cheng Z, Luo N, Hao P. Efficacy and safety of laser-related therapy for melasma: A systematic review and network meta-analysis. J Cosmet Dermatol. 2023 Nov;22(11):2910-2924. doi: 10.1111/jocd.16006. Epub 2023 Sep 22. PMID: 37737021.
DOI: 10.1111/jocd.16006

12. Feng X, Su H, Xie J. The efficacy and safety of microneedling with topical tranexamic acid for melasma treatment: A systematic review and meta-analysis. J Cosmet Dermatol. 2024 Jan;23(1):33-43. doi: 10.1111/jocd.15965. Epub 2023 Aug 16. PMID: 37584240.
DOI: 10.1111/jocd.15965

13. Guo L, Liu X, Liu Q, Xie X, Jiang X. Treatment of Melasma with Tranexamic Acid Essence Combined with Iontophoresis: A Randomized, Double-Blind, Placebo-Controlled Clinical Trial. Drug Des Devel Ther. 2024 Aug 20;18:3659-3666. doi: 10.2147/DDDT.S472922. PMID: 39185080; PMCID: PMC11344540.
DOI: 10.2147/DDDT.S472922

14. Zaleski L, Fabi S, Goldman MP. Treatment of melasma and the use of intense pulsed light: a review. J Drugs Dermatol. 2012 Nov;11(11):1316-20. PMID: 23135081.

15. Chung JY, Choi M, Lee JH, Cho S, Lee JH. Pulse in pulse intense pulsed light for melasma treatment: a pilot study. Dermatol Surg. 2014 Feb;40(2):162-8. doi: 10.1111/dsu.12414. Epub 2014 Jan 17. PMID: 24433388.
DOI: 10.1111/dsu.12414

16. Neagu N, Conforti C, Agozzino M, Marangi GF, Morariu SH, Pellacani G, Persichetti P, Piccolo D, Segreto F, Zalaudek I, Dianzani C. Melasma treatment: a systematic review. J Dermatolog Treat. 2022 Jun;33(4):1816-1837. doi: 10.1080/09546634.2021.1914313. Epub 2022 Mar 23. PMID: 33849384.
DOI: 10.1080/09546634.2021.1914313

17. Liu Y, Wu S, Wu H, Liang X, Guo D, Zhuo F. Comparison of the Efficacy of Melasma Treatments: A Network Meta-Analysis of Randomized Controlled Trials. Front Med (Lausanne). 2021 Sep 29;8:713554. doi: 10.3389/fmed.2021.713554. PMID: 34660626; PMCID: PMC8511390.
DOI: 10.3389/fmed.2021.713554

18. Ogbechie-Godec OA, Elbuluk N. Melasma: an Up-to-Date Comprehensive Review. Dermatol Ther (Heidelb). 2017 Sep;7(3):305-318. doi: 10.1007/s13555-017-0194-1. Epub 2017 Jul 19. PMID: 28726212; PMCID: PMC5574745.
DOI: 10.1007/s13555-017-0194-1

19. Maruma F, Dlova N, Mofokeng TRP, Ngwenya E. The effects and safety of sequential high concentration glycolic acid and trichloroacetic acid chemical peels in skin photo-type IV-VI, a retrospective cross-sectional monocentric review. Int J Womens Dermatol. 2025 Jul 3;11(3):e209. doi: 10.1097/JW9.0000000000000209. PMID: 40620441; PMCID: PMC12225990.
DOI: 10.1097/JW9.0000000000000209

20. Atwa MA, Ahmed AH, Nada HA, Refaey SM, Jafferany M, Elsaie ML. Combined chemical peels versus trichloroacetic acid (TCA) for treating melasma: a split face study. J Dermatolog Treat. 2022 Mar;33(2):959-964. doi: 10.1080/09546634.2020.1793888. PMID: 32649234.
DOI: 10.1080/09546634.2020.1793888

21. Ma W, Gao Q, Liu J, Zhong X, Xu T, Wu Q, Cheng Z, Luo N, Hao P. Efficacy and safety of laser-related therapy for melasma: A systematic review and network meta-analysis. J Cosmet Dermatol. 2023 Nov;22(11):2910-2924. doi: 10.1111/jocd.16006. Epub 2023 Sep 22. PMID: 37737021.
DOI: 10.1111/jocd.16006

22. Charoo NA. Hyperpigmentation: Looking beyond hydroquinone. J Cosmet Dermatol. 2022 Oct;21(10):4133-4145. doi: 10.1111/jocd.14746. Epub 2022 Jan 12. PMID: 35020267.Chao JR, Porter JP, Hessler J. Cosmetic Treatments with Energy-Based Devices in Skin of Color. Facial Plast Surg. 2023 Oct;39(5):496-500. doi: 10.1055/s-0043-1772197. Epub 2023 Aug 9. PMID: 37557909.
DOI: 10.1111/jocd.14746

23. 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.
DOI: 10.1007/s00266-020-01637-x

24. Chen J, Yu N, Peng L, Li H, Tang Y, Ou S, Zhu H. Efficacy of low-fluence 1064 nm Q-switched Nd: YAG laser for the treatment of melasma: A meta-analysis and systematic review. J Cosmet Dermatol. 2022 Jul;21(7). doi: 10.1111/jocd.15126. Epub 2022 Jun 4. PMID: 35621242.
DOI: 10.1111/jocd.15126

25. Mehrabi JN, Bar-Ilan E, Wasim S, Koren A, Zusmanovitch L, Salameh F, Isman Nelkenbaum G, Horovitz T, Zur E, Song Lim T, Mashiah J, Artzi O. A review of combined treatments for melasma involving energy-based devices and proposed pathogenesis-oriented combinations. J Cosmet Dermatol. 2022 Feb;21(2):461-472. doi: 10.1111/jocd.14110. Epub 2021 Apr 16. PMID: 33794033. (PMID: 38720210).
DOI: 10.1111/jocd.14110

26. Suliman RS, Alhuwayshil J, Almuflehi AA, Al Zaghir AK, Alateqi HA, Mohamedin HE, Mohammed AE, Alghamdi SS. Emerging topical therapies for melasma: a comparative analysis of efficacy and safety. J Dermatolog Treat. 2025 Dec;36(1):2591502. doi: 10.1080/09546634.2025.2591502. Epub 2025 Nov 27. PMID: 41307217.
DOI: 10.1080/09546634.2025.2591502

27. Gan C, Rodrigues M. An Update on New and Existing Treatments for the Management of Melasma. Am J Clin Dermatol. 2024 Sep;25(5):717-733. doi: 10.1007/s40257-024-00863-2. Epub 2024 Jun 19. PMID: 38896402; PMCID: PMC11358250.
DOI: 10.1007/s40257-024-00863-2

28. Trujillo Ramírez L, Meza Corso MF, Gonzalez C, Amador JR, Holguín A, González C. High Resolution Ultrasound for the Assessment of Melasma: Experience With 1064 nm Q-Switched Nd:YAG Laser. Cureus. 2025 Dec 8;17(12):e98719. doi: 10.7759/cureus.98719. PMID: 41510434; PMCID: PMC12778035.
DOI: 10.7759/cureus.98719

29. Sheth VM, Pandya AG. Melasma: a comprehensive update: part I. J Am Acad Dermatol. 2011 Oct;65(4):689-697. doi: 10.1016/j.jaad.2010.12.046. PMID: 21920241.
DOI: 10.1016/j.jaad.2010.12.046

30. Jia Z, Tian K, Zhong Y, Wang X, Gao S, Xu W, Li K, Wu L. Effectiveness of combination therapy of broadband light and intradermal injection of tranexamic acid in the treatment of chloasma. J Cosmet Dermatol. 2023 May;22(5):1536-1544. doi: 10.1111/jocd.15632. Epub 2023 Jan 31. PMID: 36718828.
DOI: 10.1111/jocd.15632