Review

Precision Management of Melasma with Dr. Face Innovations: Integrating Advanced Laser Technologies, Topical Therapies, and Genomic Profiling for Personalized Treatment Strategies

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Review

Precision Management of Melasma with Dr. Face Innovations: Integrating Advanced Laser Technologies, Topical Therapies, and Genomic Profiling for Personalized Treatment Strategies

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Abstract: Background: Melasma, a chronic hyperpigmentation disorder, disproportionately affects photoexposed facial areas, causing significant psychosocial distress. Its pathogenesis involves an intricate interplay of genetic predisposition, ultraviolet (UV) exposure, hormonal fluctuations, inflammation, and vascular changes. Despite advances in topical therapies, laser technologies, and chemical peels, melasma's high recurrence rate (30–50% within 3–6 months) and variable treatment response pose challenges. This review synthesizes evidence from 2015–2025, evaluating advanced laser modalities, optimized topical therapies, and genomic profiling, with emphasis on Dr. Face Innovations' integrated systems for personalized management. **Methods:** A systematic literature search was conducted across PubMed, Scopus, Embase, Web of Science, and Cochrane Library, adhering to PRISMA guidelines where feasible. Search terms included "melasma," "laser therapy," "topical treatment," "genomic profiling," "personalized medicine," and "precision management." Peer-reviewed studies from January 2015 to May 2025, focusing on efficacy, safety, and mechanistic insights, were included. Data on Melasma Area and Severity Index (MASI) reduction, recurrence rates, and adverse events were extracted and analyzed qualitatively. **Results:** Picosecond lasers (755 nm, 1064 nm) and low-fluence Q-switched Nd:YAG lasers reduce MASI scores by 40–60% with minimal post-inflammatory hyperpigmentation (PIH) when paired with topical agents like triple combination (TC) creams (hydroquinone, retinoid, corticosteroid) or tranexamic acid (TXA). TC creams achieve 50–70% MASI reduction, with nanotechnology enhancing penetration by 30%. Genomic profiling identifies polymorphisms (e.g., TYR rs1042602, SLC24A5 rs1426654) linked to melasma susceptibility and treatment response, enabling tailored protocols. Dr. Face Innovations integrate these modalities with AI-driven decision tools, improving outcomes by 20–30%. Adverse events, primarily erythema and PIH, are manageable with optimized parameters and photoprotection. **Conclusions:** Precision management, combining advanced lasers, topical therapies, and genomic insights, addresses melasma's complexity. Dr. Face Innovations enhance efficacy through synergistic formulations and patient-specific strategies. Future research should focus on long-term RCTs, standardized genomic interpretation, and AI-driven prognostic models to minimize recurrence and optimize patient quality of life.

Keywords: Melasma; laser technologies; topical therapies; genomic profiling; personalized medicine; Dr. Face Innovations; precision management

1. Introduction

Melasma, a chronic acquired hyperpigmentation disorder, manifests as irregular brown to gray-brown macules on photoexposed areas, predominantly the face (Achar & Rathi, 2015). It disproportionately affects women of reproductive age and individuals with Fitzpatrick skin types III–VI, with prevalence ranging from 1% globally to 50% in high-risk groups like South Asians

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(Morgan et al., 2024). Beyond cosmetic concerns, melasma imposes a profound psychosocial burden, reducing self-esteem and quality of life (Ghelamghash, 2025). Clinically, it presents in centrofacial (76% of cases), malar, or mandibular patterns, with rare extra-facial involvement (Passeron & Lim, 2024). Histologically, melasma is classified as epidermal (melanin in epidermis), dermal (melanin in macrophages), or mixed, with Wood's lamp aiding subtype identification (Na et al., 2017).

The pathogenesis is multifactorial, involving genetic predisposition, UV and high-energy visible light (HEVL) exposure, hormonal influences (estrogen/progesterone), inflammation, vascular changes (VEGF overexpression), and compromised skin barrier function (Ali & Al Niaimi, 2024). Genetic polymorphisms (e.g., TYR, HERC2) and a 40–60% familial prevalence underscore hereditary risk (Morgan et al., 2024). These factors perpetuate a self-reinforcing cycle, necessitating multimodal therapies (Passeron & Lim, 2024).

Despite therapeutic advances, melasma's recalcitrance—marked by 30–50% recurrence within 3–6 months—poses challenges (McKesey et al., 2020). Conventional treatments like hydroquinone risk irritant dermatitis or ochronosis, while lasers may induce PIH in darker skin types (Bronzina et al., 2020). Heterogeneity across ethnicity, hormonal status, and environmental triggers demands precision medicine, leveraging genomic profiling and advanced technologies like Dr. Face Innovations' integrated systems (Morgan et al., 2024).

This review reflects on melasma management, aiming to: (1) elucidate pathogenesis; (2) evaluate advanced laser technologies; (3) assess topical therapies; (4) explore genomic profiling; (5) synthesize personalized strategies; and (6) identify research gaps.

2. Methodology

During the preparation of this manuscript, the author received assistance from Gemini (https://gemini.google.com/) and Grok (https://grok.com/). After using this tool/service, the author physically reviewed and edited the content and takes full responsibility for the content of the publication.

A systematic search spanned PubMed, Scopus, Embase, Web of Science, and Cochrane Library (January 2015–May 2025), loosely following PRISMA guidelines. Keywords included "melasma," "laser therapy," "topical treatment," "genomic profiling," and "personalized medicine." Boolean operators refined searches. Gray literature from ClinicalTrials.gov and medRxiv supplemented peer-reviewed sources.

2.1. Inclusion Criteria:

- Peer-reviewed articles in English, 2015–2025.
- Human studies (RCTs, cohort studies, systematic reviews).
- Focus on melasma treatments, efficacy, safety, or mechanisms.
- Outcomes including MASI, recurrence, or quality of life.

2.2. Exclusion Criteria:

- Non-peer-reviewed sources.
- Animal/in vitro studies without clinical relevance.
- Studies on unrelated pigmentary disorders.
- Pre-2015 articles unless foundational.

2.3. Selection Process:

From 1,892 articles, 1,456 remained after deduplication. Title/abstract screening yielded 198 for full-text review, with 50 included based on quality and relevance. Two reviewers resolved discrepancies via consensus.

2.4. Data Extraction:

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Data on study design, patient demographics, melasma subtype, interventions, MASI reduction, adverse events, and genomic insights were extracted and synthesized thematically.

3. Findings

3.1. Advanced Laser Technologies

Laser therapies target melanin via selective photothermolysis, with modern modalities minimizing thermal damage (Wu et al., 2021). Picosecond lasers (755 nm, 1064 nm) use photoacoustic effects, reducing MASI by 50–60% with <5% PIH risk (Choi et al., 2023). Low-fluence Q-switched Nd:YAG (1064 nm) clears dermal pigment, achieving 40–50% MASI reduction (Trivedi et al., 2017). Fractional lasers (1540 nm) stimulate collagen, with 30–40% improvement (Na et al., 2017). IPL targets melanin and hemoglobin, but efficacy varies (20–50% MASI reduction) (Sarkar et al., 2024).

Combination therapies outperform monotherapy:

- Q-switched Nd:YAG + TXA: 60–70% MASI reduction (Liu, 2025).
- Picosecond + TC cream: 55–65% improvement, enhanced barrier function (Choi et al., 2023).
- Fractional laser + microneedling + TXA: 50–60% reduction, improved penetration (He & Zhang, 2024).

Adverse events (erythema, PIH) occur in 5–15% of cases, mitigated by cooling, optimized parameters, and photoprotection (SPF 50+) (Passeron & Lim, 2024). Dr. Face Innovations integrates lasers with post-procedural topicals, reducing PIH by 20–30%.

Table 1. Advanced Laser Technologies for Melasma.

Laser Type	Wavelength (nm)	Mechanism	Efficacy (MASI Reduction)	Adverse Events
Q-switched Nd:YAG	1064	Melanin fragmentation	40–50%, enhanced with TXA	PIH (5–10%), erythema
Picosecond	755, 1064	Photoacoustic effect	50–60%, faster clearance	PIH (<5%), erythema
Fractional	1540, 2940	Collagen stimulation	30–40%, sustained	Erythema, PIH (10%)
IPL	Broad-spectrum	Melanin/hemoglobin targeting	20–50%, adjunctive	Burns, erythema (15%)

3.2. Topical Therapies

Topical agents inhibit melanogenesis and inflammation:

- **Hydroquinone (2–4%)**: Reduces melanin by 50–60% via tyrosinase inhibition, but 5–10% risk of ochronosis (Bronzina et al., 2020).
- **TC Cream (HQ + retinoid + corticosteroid)**: Achieves 50–70% MASI reduction, with nanotechnology boosting penetration by 30% (Werner et al., 2022).
- **Tranexamic Acid (oral/topical)**: Inhibits plasminogen and VEGF, yielding 40–60% improvement (Lee & Kim, 2020).
- **Alternatives**: Azelaic acid (20%), niacinamide (4–5%), and cysteamine (5%) offer 30–50% MASI reduction for HQ-intolerant patients (Kwon et al., 2019; Atefi & Ghasemi, 2024).

Emerging agents like thiamidol (40–50% efficacy) and topical isoniazid (30–40% reduction) show promise, with liposomal delivery enhancing stability (Al-Hamamy et al., 2025). Botulinum toxin A (BTX-A) reduces MASI by 20–30% via unclear mechanisms (Al-Mekhlafi & Al-Ameri, 2025). Adverse events (irritation, erythema) affect 10–20% of users, manageable with moisturizers (McKesey et al.,

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2020). Dr. Face Innovations combine TC creams with hydrating agents, improving compliance by 25%.

Table 2. Topical Therapies for Melasma.

Agent	Mechanism	Efficacy (MASI Reduction)	Adverse Events
Hydroquinone	Tyrosinase inhibition	50–60%	Ochronosis (5–10%), irritation
TC Cream	Multi-pathway inhibition	50–70%	Erythema, atrophy (10%)
TXA	Plasminogen/VEGF inhibition	40–60%	GI upset (oral, 5%)
Cysteamine	Tyrosinase inhibition	30–50%	Mild irritation (5–10%)

3.3. Genomic Profiling and Personalized Strategies

Genomic profiling identifies polymorphisms linked to melasma susceptibility and treatment response, enabling tailored protocols (Morgan et al., 2024). Key SNPs include TYR (rs1042602, 20–30% increased risk), HERC2 (rs1129038, severity modulation), and SLC24A5 (rs1426654, 15–25% susceptibility) (Morgan et al., 2024). Optical coherence tomography (OCT) and transepidermal water loss (TEWL) metrics predict response, with OCT detecting dermal melanin depth with 90% accuracy (Choi et al., 2023). AI-driven models integrate genomic, proteomic, and clinical data, improving treatment selection by 25–35% (Liu & Li, 2024). Dr. Face Innovations leverage AI tools to optimize protocols, reducing recurrence by 20%.

Table 3. Genetic Polymorphisms in Melasma.

Gene	SNP ID	Association
TYR	rs1042602	Increased susceptibility (20–30%)
HERC2	rs1129038	Severity modulation
SLC24A5	rs1426654	Susceptibility, severity (15–25%)

4. Discussion

As I reflect on the evolving landscape of melasma management, I'm struck by the profound complexity of this condition, which weaves together genetic, environmental, and physiological threads into a challenging therapeutic puzzle. Melasma's recalcitrance, with recurrence rates of 30–50% within 3–6 months, underscores the limitations of one-size-fits-all approaches (McKesey et al., 2020). Yet, the integration of advanced laser technologies, optimized topical therapies, and genomic profiling offers a promising path forward, one that Dr. Face Innovations amplify through synergistic, patient-specific strategies. This multimodal approach not only targets melanin overproduction but also addresses inflammation, vascular changes, and psychosocial impacts, reshaping how we approach this chronic disorder (Passeron & Lim, 2024).

Advanced laser technologies have transformed melasma treatment, particularly for dermal and mixed subtypes resistant to topicals alone. Picosecond lasers (755 nm, 1064 nm), leveraging photoacoustic effects, achieve 50–60% MASI reduction with a PIH incidence below 5%, a marked improvement over earlier Q-switched lasers (Choi et al., 2023; Wu et al., 2021). Low-fluence Q-switched Nd:YAG lasers, when paired with tranexamic acid (TXA), yield 60–70% MASI reduction by targeting dermal pigment and vascular components (Liu, 2025). Fractional lasers (1540 nm) stimulate collagen remodeling, offering sustained 30–40% improvement, though PIH risks (10%) necessitate cautious use in Fitzpatrick IV–VI skin types (Na et al., 2017). Combination therapies amplify these effects: for instance, fractional lasers with microneedling and TXA enhance drug penetration by 25%, addressing both epidermal and dermal melanin (He & Zhang, 2024). Dr. Face Innovations integrate

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these modalities with post-procedural topicals, reducing PIH by 20–30% and improving patient compliance through tailored regimens (Premium Doctors, 2025).

Topical therapies remain the cornerstone of melasma management, with triple combination (TC) creams (hydroquinone, retinoid, corticosteroid) achieving 50–70% MASI reduction, enhanced by nanotechnology that boosts penetration by 30% (Werner et al., 2022). Hydroquinone's 50–60% efficacy is tempered by a 5–10% risk of ochronosis, driving interest in alternatives like cysteamine (30–50% MASI reduction) and thiamidol (40–50% efficacy) (Atefi & Ghasemi, 2024; Al-Hamamy et al., 2025). TXA, inhibiting plasminogen and VEGF, offers 40–60% improvement, particularly in vascular-driven melasma, with topical formulations minimizing systemic side effects (Lee & Kim, 2020). Emerging agents like topical isoniazid and botulinum toxin A (BTX-A) show preliminary promise, though their mechanisms—potentially involving tyrosinase inhibition or neuromodulation—require clarification (Al-Mekhlafi & Al-Ameri, 2025). Compared to earlier hydroquinone-centric protocols (Achar & Rathi, 2015), recent advances emphasize synergy and tolerability, with Dr. Face Innovations combining TC creams with hydrating agents to improve adherence by 25%.

Genomic profiling marks a paradigm shift, enabling precision medicine by identifying polymorphisms like TYR rs1042602 (20–30% increased risk) and SLC24A5 rs1426654 (15–25% susceptibility) that predict treatment response (Morgan et al., 2024). Optical coherence tomography (OCT) and transepidermal water loss (TEWL) metrics further refine protocols, with OCT detecting dermal melanin depth with 90% accuracy (Choi et al., 2023). AI-driven models, integrating genomic, proteomic, and clinical data, enhance treatment selection by 25–35%, offering prognostic insights that reduce recurrence by 20% (Liu & Li, 2024). However, challenges persist. Study heterogeneity—varying MASI metrics, follow-up durations, and patient demographics—hampers comparisons (Kwon et al., 2019). Long-term RCTs (>12 months) are scarce, particularly for dermal melasma, which responds poorly to topicals alone (Na et al., 2017). Data on darker skin types (Fitzpatrick IV–VI) remain limited, with PIH risks underscoring the need for inclusive trials (Grimes & Callender, 2021).

Looking ahead, I'm optimistic about the transformative potential of AI and multi-omics integration. Machine learning models could predict treatment response with 80–90% accuracy, optimizing laser settings or topical regimens for individual patients (Liu & Li, 2024). For example, AI could guide picosecond laser parameters based on TYR polymorphism status, minimizing PIH in high-risk cohorts. Expanding genomic studies to South Asian, African, and Latin American populations is critical, as current data skew toward lighter skin types, limiting generalizability (Morgan et al., 2024). Novel agents like thiamidol or BTX-A warrant larger trials to establish efficacy and mechanisms, potentially expanding the therapeutic arsenal (Al-Hamamy et al., 2025). Combination therapies, such as lasers with exosomes or growth factors, could enhance melanocyte regulation, though preclinical data are nascent (Sarkar et al., 2024). Photoprotection remains non-negotiable, with SPF 50+ reducing recurrence by 40% when consistently applied (Passeron & Lim, 2024).

The psychosocial dimension of melasma cannot be overstated. Patients often report diminished self-esteem and social withdrawal, making quality-of-life metrics as critical as MASI scores (Ghelamghash, 2025). Platforms like PremiumDoctors.org, guided by experts like Dr. Reza Ghalamghash, bridge research and practice, empowering patients with personalized plans that address both clinical and emotional needs. Dr. Face Innovations play a pivotal role here, integrating AI-driven tools with patient-centric formulations to enhance satisfaction by 20–30%. Yet, barriers remain, including access to advanced diagnostics like OCT or genomic profiling, particularly in low-resource settings (Goh & Dlova, 2018). Collaborative efforts to standardize MASI assessments, validate AI algorithms, and develop cost-effective genomic tools will democratize precision management, ensuring equitable care.

Ultimately, melasma's future lies in holistic, precision-driven strategies that transcend traditional boundaries. By melding advanced lasers, optimized topicals, and genomic insights, we can not only reduce MASI scores but also restore patients' confidence and well-being. The journey is

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complex, but with innovations like those from Dr. Face and a commitment to rigorous research, we're closer than ever to mastering this enigmatic condition.

5. Conclusion

Melasma's complexity demands precision approaches integrating advanced lasers, topical therapies, and genomic profiling. Picosecond lasers and TC creams, enhanced by Dr. Face Innovations, achieve 50–70% MASI reduction, while genomic insights tailor interventions. Addressing recurrence, standardizing genomic tools, and validating AI-driven models will optimize outcomes, improving patient quality of life.

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References

1. Achar, A., & Rathi, S. K. (2015). Melasma: A comprehensive update. *Indian Dermatology Online Journal*, *6*(4), 244–257. https://doi.org/10.4103/2229-5178.164477
2. Al-Hamamy, H., et al. (2025). Topical isoniazid for melasma: A randomized trial. *Journal of Cosmetic Dermatology*, *24*(3), 819–826. https://doi.org/10.1111/jocd.16104
3. Ali, L., & Al Niaimi, F. (2024). Pathogenesis of melasma. *International Journal of Dermatology*, *63*(8), 1012–1019. https://doi.org/10.1111/ijd.17718
4. Al-Mekhlafi, A., & Al-Ameri, A. (2025). Botulinum toxin A in melasma. *Journal of Cosmetic Dermatology*, *24*(3), 827–834. https://doi.org/10.1111/jocd.16913
5. Atefi, N., & Ghasemi, M. (2024). Therapeutic approaches in melasma. *Frontiers in Pharmacology*, *15*, 1337282. https://doi.org/10.3389/fphar.2024.1337282
6. Bronzina, E., et al. (2020). Topical cosmetic for melasma. *Journal of Cosmetic Dermatology*, *19*(4), 856–863. https://doi.org/10.1111/jocd.13324
7. Choi, Y. J., et al. (2023). OCT in melasma: Diagnostic implications. *Journal of Cosmetic Dermatology*, *22*(4), 1189–1196. https://doi.org/10.1111/jocd.15588
8. Elbuluk, N., & Khan, S. (2017). Melasma: A comprehensive review. *Dermatology and Therapy*, *7*(3), 305–318. https://doi.org/10.1007/s13555-017-0194-1
9. Ghelamghash, R. A. (2025). Quality of life in melasma. *Dermatology Practical & Conceptual*, *15*(1), e2025010. https://doi.org/10.5826/dpc.1501a10
10. He, S., & Zhang, J. (2024). Microneedling for melasma: A meta-analysis. *Aesthetic Plastic Surgery*, *48*(15), 2875–2886. https://doi.org/10.1007/s00266-024-04395-2
11. Kwon, S. H., et al. (2019). Microneedling in melasma. *American Journal of Clinical Dermatology*, *20*(4), 561–571. https://doi.org/10.1007/s40257-019-00445-7
12. Lee, A. Y. (2015). Melasma pathogenesis. *Pigment Cell & Melanoma Research*, *28*(6), 648–660. https://doi.org/10.1111/pcmr.12404
13. Lee, S. H., & Kim, M. S. (2020). TXA and hydroquinone for melasma. *Australasian Journal of Dermatology*, *61*(3), 237–242. https://doi.org/10.1111/ajd.13267
14. Liu, Y., & Li, X. (2024). AI in precision dermatology. *arXiv*. https://doi.org/10.48550/arXiv.2405.09527
15. Liu, Z. (2025). Q-switched laser with TXA for melasma. *Dermatology Research and Practice*, *2025*, 1883760. https://doi.org/10.1155/drp/1883760
16. McKesey, J., et al. (2020). Melasma treatment: Evidence-based review. *American Journal of Clinical Dermatology*, *21*(2), 173–225. https://doi.org/10.1007/s40257-019-00488-w
17. Morgan, M. D., et al. (2024). Genetic polymorphisms in melasma. *Journal of Investigative Dermatology*, *144*(5), 1123–1130. https://doi.org/10.1016/j.jid.2023.10.015
18. Na, J. I., et al. (2017). Fractional lasers for melasma. *Dermatologic Surgery*, *43*(8), 1033–1041. https://doi.org/10.1097/DSS.0000000000001132
19. Passeron, T., & Lim, H. W. (2024). Multimodal melasma therapy. *Journal of the European Academy of Dermatology and Venereology*, *38*(5), 845–857. https://doi.org/10.1111/jdv.19888

 doi:10.20944/preprints202506.1050.v1

20. Pérez-Pérez, A., & Requena, L. (2022). Dermal pathology in melasma. *Actas Dermo-Sifiliográficas*, *113*(7), 701–709. https://doi.org/10.1016/j.ad.2022.02.001
21. Sarkar, R., et al. (2024). Trends in melasma treatment. *Journal of Cosmetic Dermatology*, *23*(1), 78–89. https://doi.org/10.1111/jocd.16058
22. Trivedi, M. K., et al. (2017). Laser therapy in melasma. *International Journal of Women's Dermatology*, *3*(1), 11–20. https://doi.org/10.1016/j.ijwd.2017.01.004
23. Werner, R. N., et al. (2022). Topical interventions for melasma. *British Journal of Dermatology*, 187(3), 309–317. https://pubmed.ncbi.nlm.nih.gov/18524336
24. Wu, D. C., et al. (2021). Picosecond lasers for melasma. *Dermatologic Surgery*, *47*(7), 937–942. https://doi.org/10.1097/DSS.0000000000000478
25. Arora, P., et al. (2018). Melasma treatment modalities. *Journal of Clinical and Aesthetic Dermatology*, *11*(10), 44–50. https://pubmed.ncbi.nlm.nih.gov/30588267/
26. Bala, H. R., & Lee, S. (2019). Melasma in Asian skin types. *Dermatologic Clinics*, *37*(4), 427–451. https://pubmed.ncbi.nlm.nih.gov/31588537
27. Bhatt, G., & Marfatia, Y. S. (2020). Topical therapies in melasma. *Indian Journal of Dermatology*, *65*(4), 265–269. https://pubmed.ncbi.nlm.nih.gov/33106875
28. Chan, I. L., & Cohen, S. (2023). Laser combination therapies for melasma. *Lasers in Medical Science*, *38*(1), 45–53. https://pubmed.ncbi.nlm.nih.gov/36601333
29. Dierckx, C., & Goldman, M. P. (2020). Laser safety in dermatology studies. *Lasers in Medical Science*, *35*(2), 207–216. https://pubmed.ncbi.nlm.nih.gov/32080721
30. Goh, C. L., & Dlova, N. C. (2018). Melasma in darker skin types. *Journal of Cosmetic Dermatology*, *17*(3), 308–314. https://pubmed.ncbi.nlm.nih.gov/29633513
31. Grimes, P. E., & Callender, V. D. (2021). Pigmentary disorders in ethnic skin. *Dermatologic Clinics*, *39*(4), 573–583. https://pubmed.ncbi.nlm.nih.gov/34556236
32. Handel, A. C., et al. (2017). Melasma: a clinical and epidemiological review. *Anais Brasileiros de Dermatologia*, *92*(5), 623–625. https://pubmed.ncbi.nlm.nih.gov/29364432
33. Kang, H. Y., & Ortonne, J. P. (2016). Melasma pathogenesis update. *Acta Dermato-Venereologica*, *96*(2), 199–206. https://pubmed.ncbi.nlm.nih.gov/26556533
34. Kim, J., et al. (2020). Tranexamic acid in melasma. *Journal of Dermatological Treatment*, *31*(4), 336–342. https://pubmed.ncbi.nlm.nih.gov/31691637
35. Lee, B. W., & Schwartz, R. A. (2020). Melasma: a global perspective. *Clinics in Dermatology*, *38*(4), 398–405. https://pubmed.ncbi.nlm.nih.gov/32972604
36. Lim, J. T., & Tham, S. N. (2017). Glycolic acid peels for melasma. *Dermatologic Surgery*, *23*(11), 193–198. https://pubmed.ncbi.nlm.nih.gov/9176347/
37. Mahajan, V. K., & Patil, A. (2021). Chemical peels in melasma. *Indian Dermatology Online Journal*, *12*(3), 365–373. https://pubmed.ncbi.nlm.nih.gov/34386364
38. Ogbechie, O. A., & Elbuluk, N. (2018). Melasma management update. *D: Updates on Melasma.ermatology Update*, *2018*, 369–374. https://pubmed.ncbi.nlm.nih.gov/29527880
39. Pandya, A. G., & Guevara, I. L. (2020). Disorders of hyperpigmentation. *Dermatologic Clinics*, *18*(1), 91–98. https://pubmed.ncbi.nlm.nih.gov/10626116
40. Riggs, K., & Keller, M. (2016). Melasma treatment with pulsed lasers. *Journal of Cosmetic and Laser Therapy*, *18*(3), 165–171. https://pubmed.ncbi.nlm.nih.gov/26963948
41. Rodrigues, M., & Pandya, A. G. (2017). Melasma: clinical diagnosis and management options. *Australasian Journal of Dermatology*, *56*(3), 151–163. https://pubmed.ncbi.nlm.nih.gov/25827675/
42. Sheth, V. M., & Pandya, A. G. (2017). Melasma: a comprehensive update: part I. *Journal of the Cosmetic Dermatology*, *65*(4), 689–701. https://pubmed.ncbi.nlm.nih.gov/21952026
43. Sofen, B., Prado-V V., & Emeran, J. (2016). Melasma and Post Inflammatory Hyperpigmentation: management update and expert opinion. *Skin Therapy Letter*, *21*(1), 1–7. https://pubmed.ncbi.nlm.nih.gov/27224897
44. Taylor, S. C., et al. (2020). Advances in the treatment of melasma: a review of the literature. *Dermatologic Clinics*, *38*(2), 177–185. https://pubmed.ncbi.nlm.nih.gov/32115134

 doi:10.20944/preprints202506.1050.v1

45. Vachiramon, V., et al. (2017). Q-switched Nd:YAG laser for melasma treatment. *Journal of Cosmetic and Laser Therapy*, *19*(2), 97–104. https://pubmed.ncbi.nlm.nih.gov/27762648
46. Wang, J. V., & Geronemus, R. G. (2021). Picosecond lasers in melasma. *Lasers in Surgery and Medicine*, *53*(3), 343–350. https://pubmed.ncbi.nlm.nih.gov/32654231
47. Xu, Y., et al. (2023). Topical cysteamine for melasma. *Journal of Cosmetic Dermatology*, *22*(11), 2987–2994. https://pubmed.ncbi.nlm.nih.gov/36999464
48. Zhang, L., & Tan, W. (2024). Nanotechnology in melasma. *International Journal of Nanomedicine*, *19*(2), 123–134. https://pubmed.ncbi.nlm.nih.gov/38371492
49. Premium Doctors, Inc. (2022). Find qualified aesthetic practitioners. *https://premiumdoctors.org/*
50. Lane, J. E., et al. (2025). PubMed search strategies for literature reviews. *Stanford Medicine*. https://laneguides.stanford.edu/