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The role of microneedling in treatment of melasma

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Abstract
Background: Melasma is a chronic, recurrent hyperpigmentary disorder with multifactorial etiopathogenesis involving genetic, hormonal, vascular, and environmental influences. Conventional therapies such as hydroquinone, retinoids, chemical peels, and lasers often yield incomplete or transient improvement. Microneedling, a minimally invasive collagen induction therapy, has recently gained attention for its ability to remodel dermal structures and enhance transdermal drug delivery. This review explores the role of microneedling as a drug delivery system in melasma treatment, focusing on its mechanisms, safety, efficacy, and potential clinical advantages.
Methods: This structured literature search was conducted from August 2025 to the present, utilizing terms such as "microneedling, " "melasma, " and "drug delivery" in PubMed, Scopus, Web of Science, and Google Scholar. Clinical trials, observational studies, and reviews that evaluated the efficacy of microneedling in the treatment of melasma were incorporated. Data on therapeutic outcomes, relapse rates, and adverse events were synthesized narratively.
Conclusion: Evidence suggests that microneedling enhances drug penetration, stimulates collagen and elastin synthesis, and facilitates melanin elimination, making it an effective adjuvant in melasma therapy. Combination approaches with topical agents, particularly triple combination regimens, show superior pigment reduction and relapse prevention compared to conventional treatments alone. Although generally safe with minimal adverse effects, additional randomized controlled trials with standardized protocols are required to verify its long-term efficacy and safety.

Keywords: Microneedling, melasma, drug delivery system, collagen induction therapy, hyperpigmentation

Introduction
A skin hyperpigmentation disorder that is intractable, melasma is distinguished by the presence of light brown to dark macules on sun-exposed areas of the body, particularly the face. There are numerous fundamental factors that influence melasma, including genetics, pregnancy, ultraviolent radiation, and hormonal changes [1]. Melasma is prevalent in all racial groups, with a particular prevalence among individuals with skin types IV and V who live in regions with high ultraviolet radiation. Additionally, it is recognized that melasma has a significant effect on the psychological well-being of the participants [2].
In comparison to perilesional skin, melasma lesions exhibit a higher volume of fibroblasts and mast cells, as well as a higher degree of vascularization and solar elastosis. This suggests that melasma development is significantly influenced by altered dermal structures. [3].
Microneedling is a minimally invasive non-ablative therapy for skin rejuvenation [4]. It is also called collagen induction therapy. By sterile needle injury to collagen dermal strands, The activation of inflammatory responses, immune cell activation, and the release of cytokines and growth factors such as endothelial growth factor, fibroblast growth factor-2 in superficial blood vessels and platelet-derived growth factor, are all enhanced, resulting in the formation of new collagen and fibroblast [5]. Microneedling can create micro channels through the skin and improve the efficacy of transdermally applied therapeutic agents [6].
The purpose of this review is to evaluate the efficacy, safety, mechanisms, and potential benefits of microneedling as a drug delivery system in melasma treatment when used in conjunction with topical and systemic therapeutic agents.

Methodology of the review
Up to August 2025, a comprehensive narrative review was conducted by conducting searches of the PubMed, Web of Science, Scopus, and Google Scholar databases. Key terms

included "microneedling, " "collagen induction therapy, " "drug delivery, " "melasma, " "hyperpigmentation, " and "skin rejuvenation." Eligible studies included clinical trials, randomized controlled trials, case series, and review articles that evaluated microneedling either as a monotherapy or as an adjuvant to topical or systemic drugs in melasma. Articles focusing on microneedling in other dermatological conditions were included only if they provided mechanistic or comparative insight relevant to melasma. Non-English studies, conference abstracts without full data, and duplicate publications were excluded. Data were extracted on study design, patient demographics, treatment protocols, outcomes (e.g., MASI/mMASI reduction), relapse rates, and adverse events.

Melasma

The development of brown to bluish-gray patches with well-defined or ill-defined borders and bilateral distribution is a defining characteristic of melasma, a skin pigmentation disorder that affects sun-exposed areas, particularly the face. It is also known as chloasma or the "mask of pregnancy" (which is no longer in use) [7]. In women with this challenging hyperpigmentation disorder, etiopathogenetic factors that are typically observed include, pregnancy, genetic influences, pharmacological agents, and sun exposure oral contraceptive use. [8]. Melasma is characterized by three primary patterns: centrofacial, malar, and mandibular [9]. Melasma is classified as epidermal, dermal, or mixed type based on the location of the pigment in Wood's illumination examination [10].

Epidemiology

Melasma is a common condition worldwide, affecting both genders and all races, though it predominantly occurs in females (90%), especially those with intermediate to dark skin phototypes. Its prevalence varies with ethnicity, sunlight exposure, and skin type, being more frequent in Fitzpatrick types III-VI [11]. Populations in the Middle East, East Asia, India, Pakistan, the Mediterranean, and Africa have been found to have higher rates, with Southeast Asia experiencing rates as high as 40% [12].

In Egypt, melasma prevalence is particularly high among women of childbearing age. The condition is aggravated by intense ultraviolet (UV) radiation due to the country's sunny climate [13]. Genetic predisposition plays a significant role, with 40.3% of patients reporting a positive family history, while sun exposure was implicated in 26.4% of cases [14]. These discoveries emphasize that melasma is a multifactorial disorder in Egypt, influenced by hormonal, environmental factors and genetic.

Social impact of melasma

According to reports, patients' general health is adversely affected by melasma, a facial disfiguring lesion. Quality of life studies have demonstrated that melasma has an impact on interpersonal interactions, particularly due to its impact on an individual's appearance. Melasma frequently leads to deleterious psychosocial consequences for patients and reduces their life quality. As a consequence of chronic contingencies that are associated with social stigma and diminished self-esteem, patients with melasma may experience anxiety and depression. Patients frequently encounter shame, low self-esteem, dissatisfaction, dissatisfaction, and a lack of social motivation [15].

Etiopathogenesis

Melasma presents with a multifactorial and intricate pathogenesis that encompasses genetic predisposition, inflammation, hormonal fluctuations, and Ultraviolet (UV) radiation exposure [16].

1. Hormones

Melasma typically develops after puberty, suggesting a strong link with female hormones. It mainly affects women of childbearing age and can be induced or aggravated by pregnancy, oral contraceptives, oestrogen creams, and drugs like prosexol for prostate cancer (Chen *et al*., 2024). Hormonal studies show increased serum oestrogen (E2), FSH, and LH in patients with melasma. Lesional skin demonstrates higher expression of progesterone receptors and oestrogen receptors (ER-α, ER-β) compared with adjacent normal skin [17]. Oestrogen contributes to pathogenesis by stimulating melanocytes via ER-β and upregulating tyrosinase (TYR), the key enzyme in melanin synthesis [18]. Through elevated levels of placental and pituitary hormones, including FSH, LH, and MSH, pregnancy further enhances pigmentation, particularly during the third trimester [17].

Although less common, melasma also occurs in men, often associated with hormonal imbalances. Cases have been reported with hypogonadism (high LH/FSH, low testosterone), gonadotropic stimulants that increase LH, and finasteride use, which reduces DHT but increases peripheral oestrogen conversion [19]. The role of thyroid hormones remains unclear, though pigmentary changes are reported in thyroid dysfunction, especially hyperthyroidism. ACTH and MSH may also contribute by activating melanocortin receptors on melanocytes, promoting melanogenesis [20].

2. Ultraviolet Radiation (UVR)

Ultraviolet Radiation (UVR) is the most critical factor in melasma pathogenesis. This is because UVR upregulates melanocortin-1 receptors (MC1R), which in turn enhances hormone binding and melanin production, thereby increasing melanin synthesis. UVR has been recognized as a significant factor in the development and progression of melasma since its initial association in 1953 [21].

Microphthalmia-Associated Transcription Factor (MITF) regulates the survival of melanocytes and the transport of melanin to keratinocytes. It also plays a significant role in pigmentation following UV exposure. Furthermore, MITF regulates tyrosinase (TYR) and other melanogenic enzymes. Therapeutic approaches targeting MITF, including MITF-siRNA and Tranexamic Acid (TA), have shown promise in reducing melanin synthesis and melanocyte activity [22]. Stem Cell Factor (SCF), which is secreted by keratinocytes and fibroblasts, is another UV-induced pathway that activates the c-kit receptor, thereby promoting melanocyte proliferation. Chronic UV exposure increases SCF expression through inflammation and fibroblast activation, further enhancing melanogenesis in melasma [23].

3. Genetics

Melasma shows higher prevalence among Asians, Indians, Latin Americans, and African Americans, with genetics playing a key role. Familial susceptibility is strong, as 41-61% of patients report a family history, and a case-control study in Indonesia reported an odds ratio of 35 for family history [24]. Studies also suggest dominant inheritance

patterns, particularly in populations with African ancestry. MC1R polymorphisms, such as Val92Met (common in South Asians), are linked to increased risk, and epigenetic studies demonstrate reduced DNA hypermethylation in melasma lesions [25, 26].

Emerging genetic and molecular evidence highlights the role of non-coding RNAs and altered gene expression in melanogenesis. The functional analyses indicate that miRNA-675, H19 RNA, MITF, and WNT inhibitory factor 1 are involved. Expression studies indicate that SOD2, EDN3, WNT3A, and ESR2, are upregulated, while COL4A1, DKK3, and TIMP4 are downregulated, indicating a proinflammatory, repair-deficient phenotype [27]. Exosomal transcriptomics and H19 RNA may serve as disease markers. Reduced DNA methyltransferase-1 expression after treatment with niacinamide and retinoic acid suggests that epigenetic changes may influence treatment response and represent therapeutic targets [28].

4. Oxygen free radicals

Oxidative stress in the skin is induced by exposure to UV radiation, respiration, and air pollution, resulting in reactive oxygen species production. Excessive free radicals and lipid peroxidation damage cell membranes, enhance melanin synthesis, and despite the fact that antioxidant enzymes like GSH-PX, GSH, CAT, and SOD typically scavenge ROS to maintain homeostasis, they contribute to the development of melasma. Melasma's pathogenesis and persistence are significantly influenced by oxidative stress, particularly UVR-induced oxidative stress, according to empirical evidence [29].

5. Vascular factors

Dermoscopy and reflectance confocal microscopy have demonstrated that melasma is associated with increased vascularization, as well as elevated expression of VEGF in lesions. Melanocyte survival and activity are facilitated by VEGF, which is produced by keratinocytes in response to UV injury. Additionally, UV-induced angiogenesis contributes to vascular changes [30]. Endothelial cells release endothelin peptides, prostaglandins, and nitric oxide, which activate melanogenesis through EDNRB and MAPK/ERK pathways. Additionally, SCF/c-kit signaling and other paracrine interactions between endothelial cells and melanocytes enhance pigmentation, whereas factors like TGF-β and clusterin may reduce it. Tranexamic acid mitigates these effects by reducing VEGF and endothelin-1, thereby decreasing vascularization in melasma [31].

6. Inflammation

Melasma is distinguished by a generalized state of inflammation in the epidermis, as confirmed by the increased inflammatory mediators expression such as VEGF, iNOS, and EDN1.An elevated mast cell count, leukocyte infiltration, upregulation of melanogenic cytokines, and increased vascularity are common manifestations of UV-damaged skin. The pigmented lesional dermis of patients with melasma exhibits an increase in mast cells, which are critical mediators of acute inflammation [32].

7. Impairment of the skin barrier

a) Damage to the skin permeability barrier

The principal barrier against Trans-Epidermal Water Loss (TEWL) and external insults is the epidermis. Histopathologic studies have documented stratum corneum impairment, solar elastosis, and In lesional skin significant epidermal atrophy in comparison to perilesional areas, indicating that this barrier is compromised in melasma. Furthermore, lesional skin demonstrates delayed barrier recovery and elevated TEWL, which is indicative of impaired barrier function [33].

Damage to the microbial skin barrier

Compared to the normal control group, the gastrointestinal microbiota structure of patients with melasma is distinct. The reduced abundance of Propionibacterium in melasma lesions may be attributed to the increased abundance of exogenous pigmented Micrococcus and gram-negative bacteria, as well as the decreased abundance of this resident defensive bacterium. Furthermore, this implies that the pathogenesis of melasma is also associated with the regulation of the gut-skin axis [34].

Clinical characteristics

The face is the primary site of melasma, a chronic acquired hyperpigmentation disorder that is characterized by a light to dark brown color, symmetrical deposition, and irregular borders. The majority of patients develop melasma in their thirties or forties. In addition, 20% of instances arise during the peri-pregnancy period, and 10% occur after menopause. Melasma develops gradually, persists for 10 to 20 years, and has its most severe symptoms during the summer [35]. Wood's lamp, a capillary microscope, and the fragment pressure diagnostic method were implemented to classify melasma into four clinical types:

- The type M (pigmented)
- The type V (vascular)
- The type M>V (pigmented advantage), and
- The type V>M (vascular advantage) [36].

Wood's light classification

The following forms of melasma are classified using Wood's lamps in conjunction with histopathological analyses:

1) **Epidermal type:** Demonstrates a significant color contrast under Wood's lamp, and histopathological analysis has disclosed pigment deposition in the basement layer and the upper portion of the basement layer [37].
2) **Dermatological type:** In this type, no color contrast is observed between the lesions and the normal skin under Wood's lamp, and histopathological examination discovered melanophages presence around dermis blood vessels (upper and middle) [38].
3) **Mixed type:** Histopathological analysis demonstrated that pigments are present in both epidermis and dermis, despite the fact that the color contrast of specific areas of the same patient during Wood's lamp examination is apparent. [38].
4) **The fourth type:** Variety is prevalent among dark skin patients. The melasma of these patients is not confidential under Wood's lamp. The dermis is the primary site of pigment deposition, as indicated by histopathological analysis [39].

Dermoscopy of melasma

Dermoscopy is an advantageous approach for the assessment of melasma, as it facilitates the objective

classification of the condition based on melanin deposition depth in the skin layers, besides the comprehensive modifications to the treatment monitoring protocol and the visualization of the vascular component [40]. Brown (associated with melanin in the basal layer of the epidermis or superficial dermis) and gray (associated with melanin in the papillary dermis) are the dermoscopic colors observed in melasma [41]. Characterization of perifollicular and eccrine findings in melasma through dermoscopy: Diffuse brown structureless areas with ostial sparing (brown pseudonetwork) are present in the epidermal pigmentation on histology, as well as gray pseudonetwork and interostial particles that relate to the dermal component of melasma [42].

Histological changes

Solar elastosis, flattening of the rete ridges, and an increase in melanin in the suprabasal and basal layers were the defining characteristics of melasma. Melasma patients' basal basement membranes exhibit a vacuolar structure within keratinocytes and contain a significant number of solitary, non-aggregated melanosomes [43].

Treatment of melasma

The complex pathology and recurring nature of melasma make it challenging to target therapeutically, necessitating the development of novel approaches. Topical agents, such as hydroquinone (which inhibits tyrosinase), tretinoin, and corticosteroids, have been the traditional treatment for melasma. UV radiation and visible light must be avoided and protected in order to maintain the effective management of melasma. Consequently, it is recommended that all melasma patients use a broad-spectrum UVA/UVB sunscreen with a high sun protection factor (SPF 30+) and high protection against UVA1 and HEVL for the duration of the year. A sunscreen that incorporates broad-spectrum UVA and UVB filters and visible light blockers, such as iron oxide, is advised. Compared to broad-spectrum UV filters alone, this combination has exhibited superior results in the prevention of melasma flares [44].

1. Hydroquinone (HQ)

Hydroquinone (HQ) is the most frequently employed topical treatment for melasma, as it frequently induces transient enhancements. HQ induces melanocyte injury by inhibiting tyrosinase, which inhibits the conversion of DOPA to melanin, thereby suppressing melanosome formation. This is achieved by interfering with the synthesis of RNA and DNA [45]. The best treatment for melasma is Modified Kligman's Formula (0.05% tretinoin, 0.01% fluocinolone acetonide, and 4% HQ). This is because of the synergistic depigmenting effect that is achieved by combining HQ with retinoic acid and corticosteroids. [46].

2. Topical retinoids

By inhibiting the transcription of tyrosinase and melanin synthesis, they prevent the activation of the matrix metalloproteinase, which in turn reduces oxidative stress. In addition, the exfoliative properties and increased turnover of keratinocytes result in the acceleration of melanin loss and the reduction of melanosome transfer to keratinocytes. Utilized in conjunction, they may facilitate the transepidermal penetration of additional topical medication [47].

3. Niacinamide

It has been demonstrated that niacinamide (4%), either alone or in combination with retinoic acids, can inhibit melanosome transmission to keratinocytes and reduce pigmentation in melasma within eight weeks [48].

4. Antioxidants

Through its interaction with copper ions at the tyrosinase-active site, vitamin C inhibits the tyrosinase enzyme. Melanin formation, particularly the perifollicular melanin, is reduced by this action. Antioxidant activity is evident in polypodium leucotomos, grape seed extract, pycnogenol, vitamin E, phytic acid, silymarin, amino fruit acids, and zinc [49].

5. Laser therapy

Laser- and light-based therapies, such as intensive pulsed light, non-ablative fractional lasers, Q-switched low-fluency lasers, and picosecond lasers, can expedite the removal of melanin, leading to a more rapid improvement in patients. However, since they do not have any direct or indirect effect on melanin synthesis, none of these methods are causative. The risk of recurrence and post-inflammatory hypopigmentation or hyperpigmentation, which is associated with specific techniques, must be explicitly communicated to patients [50].

6. Platelet-Rich Plasma (PRP)

In melasma, platelet-rich plasma functions by unleashing a variety of bioactive ances that are present in the alpha granules of platelets for therapeutic purposes. The delayed activation of extracellular signal-regulated kinase is the mechanism by which transforming growth factor (TGF)-β and epidermal growth factor significantly inhibit melanin synthesis. Additionally, they inhibit tyrosinase activity and block the expression of prostaglandin [51].

7. Chemical peel

Melasma is frequently treated with chemical peels, which effectively eliminate pigment through chemical exfoliation. Peels are classified as superficial, medium-depth, and extensive peels. When the concentrations are titrated appropriately, superficial peels are considered safe and effective for epidermal melasma of Fitzpatrick skin type IV-VI. In contrast, chemical exfoliation is not suitable for dermal pigmentation, notably in skin types IV-VI. Glycolic acid and lactic acid function by desquamating keratinocytes, stimulating new cell growth in the basal layer, and reducing corneocyte cohesion [52].

Microneedling

Controlled superficial skin puncturing with fine needles, also known as microneedling or percutaneous collagen induction therapy, is a technique that promotes wound healing, extracellular matrix proliferation, and dermal remodeling while maintaining the integrity of the epidermis [53]. Initially designed to address acne scarring and skin laxity, it was subsequently discovered to enhance post-inflammatory hyperpigmentation and melasma. In comparison to TC alone, microneedling resulted in a 48% reduction in mMASI and improved relapse prevention when combined with broad-spectrum sunscreen and Triple Combination (TC) therapy [54].

Mechanism of action of micro-needling

Microneedling's mechanism in melasma is not entirely

understood; nevertheless, it induces physiological changes, including the upregulation of genes involved in wound healing, , immune cell recruitment, epithelial proliferation and the downregulation of proinflammatory cytokines. Melanin elimination is facilitated by early keratinocyte proliferation, and basal membrane restoration, photoaging features, and safety in skin of color have been enhanced [55]. Microneedling, which was initially investigated for acne scarring, has demonstrated histologic advantages, including increased epidermal thickness, improved rete ridges, increased collagen (types I-IV and VII) and fibronectin expression, and denser elastin fibers in the upper dermis [56]. It has been applied to a variety of conditions, including hypertrophic and keloid scars, traumatic scars, burn contractures, stretch marks, androgenic alopecia, and melasma. The benefits of this treatment are associated with the normalization of the extracellular collagen matrix and better cutaneous remodeling [57].

Microneedling in the treatment of melasma

Through a variety of mechanisms, microneedling improves melasma by enhancing the transcutaneous delivery of topical agents through microchannels, stimulating wound-healing responses that promote fibroblast proliferation, neocollagenesis, neoelastogenesis, and epidermal thickening, and facilitating melanin elimination [58]. Topical therapies used in conjunction with microneedling typically target tyrosinase to inhibit melanogenesis, angiogenic growth factors to reduce vascularization, or proinflammatory cytokines to suppress inflammation [59].

When combined with topical drugs, microneedling enhances drug penetration into the epidermis and dermis while carrying a low risk of post inflammatory hyperpigmentation [60]. It has been shown to stimulate fibroblast proliferation, boost collagen synthesis, and improve drug delivery, thereby reducing melasma pigmentation [61]. Microneedling and mesoneedling have both been shown to be effective in reducing the amount of epidermal melanin in melasma lesions [62].

Microneedling in scar treatment

Micro needling, which is one of the collagen inductions therapies, is regarded as both safe and efficacious. The technique involves the superficial penetration of the epidermis with sterilized microneedles, which activates an inflammatory response, thereby stimulating the synthesis of new collagen and the deposition of collagen. In the remodeling stage, skin micro-needling induces normal wound recovery, during which collagen is formed in the dermis over a period of 12 to 18 months [63].

Microneedling in androgenic alopecia treatment

Particularly when administered in conjunction with other medications, microneedling has been shown to have advantageous therapeutic effects on AGA. Microneedling, also known as collagen induction therapy, is a minimally invasive procedure that entails the insertion of numerous extremely fine needles into the epidermis to create micropunctures. This procedure is designed to induce the expression of Wnt proteins, facilitate neovascularization, and release growth factors. The release of platelet-derived and epidermal growth factors is the mechanism by which microneedling achieves its effect. This process facilitates skin regeneration through perforations, the activation of stem cells in the bulb, and the expression of genes associated with hair growth [64].

Microneedling in vitiligo treatment

A medication delivery method through the stratum corneum is the principle behind microneedling. Vitiliginous pigmentation is brought about by the transfer of melanocytes from pigmented regions to depigmented regions through the use of a needle. Additionally, Microneedling (Mn) induces processes such as wound healing, which generate cytokines and growth factors that aid in repigmentation, as a result of skin perforation. As a consequence of mechanical trauma, melanocytes migrate from pigmented regions to vitiliginous lesions, leading to additional melanocytic autoinoculation events. Damage to the basal cell layer may also result in the enhancement of cutaneous melanophages and hyperpigmentation by microtrauma. All of these contribute to the process of melanogenesis [65].

Microneedling in drug delivery

In comparison to intralesional injections, microneedling is generally innocuous and facilitates uniform drug administration. It enhances drug delivery through the epidermis by directly inserting the drug into the vascularized dermis [66].

Instruments of microneedling

There are numerous microneedling devices available on the market, such as [67]:

1) Standard medical derma roller
2) Home care derma roller
3) Derma-stamp
4) Dermapen
5) DermaFrac
6) Microneedle delivery systems
7) Fractional radiofrequency microneedling

Contraindication and adverse events of micro-needling

Microneedling is a contraindication for patients with bleeding disorders, those on anticoagulants, and those with conditions such as warts, eczema, impetigo, herpes labialis, skin cancer, lesions, solar keratosis, high keloidal tendency, or during chemotherapy or radiation therapy. Through koebnerization, it has the capacity to exacerbate dermatoses like psoriasis and lichen planus. Common adverse effects include transient erythema and irritation. Acne exacerbation, post-inflammatory hyperpigmentation, hypersensitivity, granulomatous reactions, and local infections are, however, less common risks when nonsterile devices are employed [68].

Conclusions

Microneedling represents a promising minimally invasive strategy for enhancing drug delivery in melasma management. By creating controlled dermal microchannels, it augments penetration of topical agents, promotes collagen remodeling, and facilitates melanin clearance. Current evidence supports its use as an adjunct to standard therapies, yielding superior pigment reduction and relapse prevention compared with conventional treatments alone. However, standardized protocols, larger randomized controlled trials, and long-term follow-up are required to establish its optimal role in clinical practice.

References

1. Pandya A, Berneburg M, Ortonne JP, *et al*. Guidelines

for clinical trials in melasma. Pigmentation Disorders Academy. Br J Dermatol. 2006 Dec;156 Suppl 1:21-8.
2. Gupta AK, Gover MD, Nouri K, *et al*. The treatment of melasma: a review of clinical trials. J Am Acad Dermatol. 2006 Dec;55(6):1048-1065.
3. Kang HY, Ortonne JP. What should be considered in treatment of melasma. Ann Dermatol. 2010 Nov;22(4):373-378.
4. Singh A, Yadav S. Microneedling: Advances and widening horizons. Indian Dermatol Online J. 2016 Jul-Aug;7(4):244-254.
5. El Attar Y, Doghaim N, El Far N, *et al*. Efficacy and Safety of tranexamic acid versus vitamin c after microneedling in treatment of melasma: Clinical and Dermoscopic study. J Cosmet Dermatol. 2022 Jul;21(7):2817-2825.
6. Lim D-J, Kim H-J. Microneedles in action: microneedling and microneedles-assisted transdermal delivery. Polymers. 2022;14(8):1608.
7. Chen Y, Vellaichamy G, Schneider SL, *et al*. Exposure factors in the occurrence and development of melasma (Review). Exp Ther Med. 2024 Apr;27(4):131.
8. Bostan E, Cakir A. The dermoscopic characteristics of melasma in relation to different skin phototypes, distribution patterns and wood lamp findings: a cross-sectional study of 236 melasma lesions. Arch Dermatol Res. 2023 Sep;315(7):1927-1938.
9. Artzi O, Horovitz T, Bar-Ilan E, *et al*. The pathogenesis of melasma and implications for treatment. J Cosmet Dermatol. 2021 Nov;20(11):3432-3445.
10. Philipp-Dormston WG. Melasma: A Step-by-Step Approach Towards a Multimodal Combination Therapy. Clin Cosmet Investig Dermatol. 2024;17:1203-1216.
11. Pennitz A, Kinberger M, Avila Valle G, *et al*. Self-applied topical interventions for melasma: a systematic review and meta-analysis of data from randomized, investigator-blinded clinical trials. Br J Dermatol. 2022 Sep;187(3):309-317.
12. Sarkar R, Jagadeesan S, Basavapura Madegowda S, *et al*. Clinical and epidemiologic features of melasma: a multicentric cross-sectional study from India. Int J Dermatol. 2019 Nov;58(11):1305-1310.
13. Abd el-Sattar EM, Hussine OAB, Nassar A. Skin Changes during Pregnancy and their Impact on Pregnant Women. Zagazig University Medical Journal. 2025;31(8):4067-4075.
14. Abdelaziz MI, Attwa EM, Esawy AM, *et al*. Evaluation of the Serum Zinc Level in Adult Egyptian Patients with Melasma. Zagazig University Medical Journal. 2022;28(5):1036-1040.
15. Espósito MCC, Espósito ACC, Jorge MFS, *et al*. Depression, anxiety, and self-esteem in women with facial melasma: an Internet-based survey in Brazil. Int J Dermatol. 2021 Sep;60(9):e346-e347.
16. Jusuf NK, Putra IB, Mahdalena M. Is There a Correlation between Severity of Melasma and Quality of Life? Open Access Maced J Med Sci. 2019 Aug 30;7(16):2615-2618.
17. Goandal NF, Rungby J, Karmisholt KE. [The role of sex hormones in the pathogenesis of melasma]. Ugeskr Laeger. 2022 Feb 7;184(6).
18. Zhou Y, Zeng HL, Wen XY, *et al*. Selaginellin Inhibits Melanogenesis via the MAPK Signaling Pathway. J Nat Prod. 2022 Apr 22;85(4):838-845.
19. Kanwal S, ur Rehman F, Qureshi SW, *et al*. Evaluation of Serum Estrogen, Progesterone, Prolactin and Testosterone in Patients of Melasma. Pakistan Armed Forces Medical Journal. 2023;73(3):654.
20. Sastrini Sekarnesia I, Sitohang IBS, Agustin T, *et al*. A comparison of serum zinc levels in melasma and non-melasma patients: a preliminary study of thyroid dysfunction. Acta Dermatovenerol Alp Pannonica Adriat. 2020 Jun;29(2):59-62.
21. Khanna R, Nowah A, Morris D, *et al*. Pathogenesis of melasma. Dermatological Reviews. 2023;4(1):12-16.
22. Xing X, Xu Z, Chen L, *et al*. Tranexamic acid inhibits melanogenesis partially via stimulation of TGF-β1 expression in human epidermal keratinocytes. Exp Dermatol. 2022 Apr;31(4):633-640.
23. Kapoor R, Dhatwalia SK, Kumar R, *et al*. Emerging role of dermal compartment in skin pigmentation: comprehensive review. J Eur Acad Dermatol Venereol. 2020 Dec;34(12):2757-2765.
24. Suryaningsih BE, Sadewa AH, Wirohadidjojo YW, *et al*. Association between heterozygote Val92Met MC1R gene polymorphisms with incidence of melasma: a study of Javanese women population in Yogyakarta. Clin Cosmet Investig Dermatol. 2019;12:489-495.
25. Desai S, Ayres E, Bak H, *et al*. Effect of a Tranexamic Acid, Kojic Acid, and Niacinamide Containing Serum on Facial Dyschromia: A Clinical Evaluation. J Drugs Dermatol. 2019 May 1;18(5):454-459.
26. Campuzano-García AE, Torres-Alvarez B, Hernández-Blanco D, *et al*. DNA Methyltransferases in Malar Melasma and Their Modification by Sunscreen in Combination with 4% Niacinamide, 0.05% Retinoic Acid, or Placebo. Biomed Res Int. 2019;2019:9068314.
27. Jin S, Chen L, Xu Z, *et al*. 585 nm light-emitting diodes inhibit melanogenesis through upregulating H19/miR-675 axis in LEDs-irradiated keratinocytes by paracrine effect. J Dermatol Sci. 2020 May;98(2):102-108.
28. Jung JM, Noh TK, Jo SY, *et al*. Guanine Deaminase in Human Epidermal Keratinocytes Contributes to Skin Pigmentation. Molecules. 2020 Jun 5;25(11).
29. Katiyar S, Yadav D. Correlation of Oxidative Stress with Melasma: An Overview. Curr Pharm Des. 2022;28(3):225-231.
30. Zhu JW, Ni YJ, Tong XY, *et al*. Activation of VEGF receptors in response to UVB promotes cell proliferation and melanogenesis of normal human melanocytes. Exp Cell Res. 2020 Feb 15;387(2):111798.
31. Ayhan E. Intralesional tranexamic acid in treatment of telangiectasia: reversible effect and resistance to therapy. Clin Exp Dermatol. 2019 Jul;44(5):e209-e210.
32. Phansuk K, Vachiramon V, Jurairattanaporn N, *et al*. Dermal Pathology in Melasma: An Update Review. Clin Cosmet Investig Dermatol. 2022;15:11-19.
33. Gautam M, Patil S, Nadkarni N, *et al*. Histopathological comparison of lesional and perilesional skin in melasma: A cross-sectional analysis. Indian J Dermatol Venereol Leprol. 2019 Jul-Aug;85(4):367-373.
34. Yan S. Skin barrier and melasma. Dermatology Bulletin. 2022;39(5):430-434.
35. Zheng H, Pei Q, Yao M. Understanding Melasma: From pathogenesis to innovative treatments. Dermatologic Therapy. 2024;2024(1):2206130.
36. Flori E, Mastrofrancesco A, Mosca S, *et al*. Sebocytes

contribute to melasma onset. iScience. 2022 Mar 18;25(3):103871.
37. de Abreu L, Ramos ESM, Quintella LP, *et al*. Dermoscopic classification of melasma: Concordance study and correlation with the melanophages count. J Cosmet Dermatol. 2022 Nov;21(11):5887-5894.
38. Khadka A, Bhattarai S. Clinico-dermoscopic study and comparative evaluation with Wood's Lamp as a diagnostic tool in patients with melasma. Pigment International. 2024;11(2):79-84.
39. Wang Z, Chen Y, Pan S, *et al*. Quantitative classification of melasma with photoacoustic microscopy: a pilot study. J Biomed Opt. 2024 Jan;29(Suppl 1):S11504.
40. Abdel Hay R, Mohammed FN, Sayed KS, *et al*. Dermoscopy as a useful tool for evaluating melasma and assessing the response to 1064-nm Q-switched Nd:YAG laser. Dermatol Ther. 2020 Jul;33(4):e13629.
41. Solanki V, Dongre A, Nayak C. A clinico-epidemiological study of different dermoscopic patterns in hyperpigmented facial lesions in a tertiary care centre. J Cutan Aesthet Surg. 2024 Apr-Jun;17(2):112-123.
42. Errichetti E, Ankad BS, Sonthalia S, *et al*. Dermoscopy in general dermatology (non-neoplastic dermatoses) of skin of colour: A comparative retrospective study by the International Dermoscopy Society. Eur J Dermatol. 2020 Dec 1;30(6):688-698.
43. Khunger N, Kandhari R, Singh A, *et al*. A clinical, dermoscopic, histopathological and immunohistochemical study of melasma and facial pigmentary demarcation lines in the skin of color. Dermatol Ther. 2020 Nov;33(6):e14515.
44. Zubair R, Lyons AB, Vellaichamy G, *et al*. What's New in Pigmentary Disorders. Dermatol Clin. 2019 Apr;37(2):175-181.
45. Saeedi M, Eslamifar M, Khezri K. Kojic acid applications in cosmetic and pharmaceutical preparations. Biomedicine & Pharmacotherapy. 2019;110:582-593.
46. Karrabi M, David J, Sahebkar M. Clinical evaluation of efficacy, safety and tolerability of cysteamine 5% cream in comparison with modified Kligman's formula in subjects with epidermal melasma: A randomized, double-blind clinical trial study. Skin Res Technol. 2021 Jan;27(1):24-31.
47. Dhaliwal S, Rybak I, Ellis SR, *et al*. Prospective, randomized, double-blind assessment of topical bakuchiol and retinol for facial photoageing. Br J Dermatol. 2019 Feb;180(2):289-296.
48. Morgado-Carrasco D, Piquero-Casals J, Granger C, *et al*. Melasma: The need for tailored photoprotection to improve clinical outcomes. Photodermatol Photoimmunol Photomed. 2022 Nov;38(6):515-521.
49. Babbush KM, Babbush RA, Khachemoune A. Treatment of melasma: a review of less commonly used antioxidants. Int J Dermatol. 2021 Feb;60(2):166-173.
50. Fritz K, Salavastru C. Laser treatment of pigmentation disorders. Hautarzt. 2020 Dec;71(12):920-925.
51. Patil NK, Bubna AK. A comparative evaluation of the efficacy of intralesional tranexamic acid versus platelet rich plasma in the treatment of melasma. Dermatol Ther. 2022 Jul;35(7):e15534.
52. Raka A, Brahmbhatt VU. Comparative study of efficacy of glycolic acid (50%) peel and lactic acid (92%) peel in the treatment of melasma. Int J Res Dermatol. 2019;5(2):370-375.
53. Alqam M, Wamsley CE, Hitchcock T, *et al*. Efficacy and Tolerability of a Microneedling Device for Treating Wrinkles on the Neck. Aesthet Surg J. 2022 Sep 14;42(10):1154-1160.
54. Bailey AJM, Li HO, Tan MG, *et al*. Microneedling as an adjuvant to topical therapies for melasma: A systematic review and meta-analysis. J Am Acad Dermatol. 2022 Apr;86(4):797-810.
55. Ferreira ADS, Aita DL, Muneratto MA. Microneedling: A review. Revista Brasileira de Cirurgia Plástica. 2023;35:228-234.
56. Iosifidis C, Goutos I. Percutaneous collagen induction (microneedling) for the management of non-atrophic scars: literature review. Scars Burn Heal. 2019 Jan-Dec;5:2059513119880301.
57. Nazarian RS, Farberg AS, Hashim PW, *et al*. Nonsurgical hair restoration treatment. Cutis. 2019 Jul;104(1):17-24.
58. Jung JW, Kim WO, Jung HR, *et al*. A Face-Split Study to Evaluate the Effects of Microneedle Radiofrequency with Q-Switched Nd:YAG Laser for the Treatment of Melasma. Ann Dermatol. 2019 Apr;31(2):133-138.
59. Shamsi Meymandi S, Mozayyeni A, Shamsi Meymandi M, *et al*. Efficacy of microneedling plus topical 4% tranexamic acid solution vs 4% hydroquinone in the treatment of melasma: A single-blind randomized clinical trial. J Cosmet Dermatol. 2020 Nov;19(11):2906-2911.
60. Wu SZ, Muddasani S, Alam M. A Systematic Review of the Efficacy and Safety of Microneedling in the Treatment of Melasma. Dermatol Surg. 2020 Dec;46(12):1636-1641.
61. Mekawy KMM, Sadek A, Seddeik Abdel-Hameed AK. Micro-needling versus fractional carbon dioxide laser for delivery of tranexamic acid in the treatment of melasma: A split-face study. J Cosmet Dermatol. 2021 Feb;20(2):460-465.
62. Farshi S, Mansouri P. Study of efficacy of microneedling and mesoneedling in the treatment of epidermal melasma: A pilot trial. J Cosmet Dermatol. 2020 May;19(5):1093-1098.
63. Mujahid N, Shareef F, Maymone MBC, *et al*. Microneedling as a Treatment for Acne Scarring: A Systematic Review. Dermatol Surg. 2020 Jan;46(1):86-92.
64. Faghihi G, Nabavinejad S, Mokhtari F, *et al*. Microneedling in androgenetic alopecia; comparing two different depths of microneedles. Journal of Cosmetic Dermatology. 2021;20(4):1241-1247.
65. Ebrahim HM, Elkot R, Albalate W. Combined microneedling with tacrolimus vs tacrolimus monotherapy for vitiligo treatment. J Dermatolog Treat. 2021 Dec;32(8):999-1004.
66. Avcil M, Çelik A. Microneedles in Drug Delivery: Progress and Challenges. Micromachines (Basel). 2021 Oct 28;12(11).
67. Wamsley CE, Kislevitz M, Barillas J, *et al*. A Single-Center Trial to Evaluate the Efficacy and Tolerability of Four Microneedling Treatments on Fine Lines and Wrinkles of Facial and Neck Skin in Subjects with Fitzpatrick Skin Types I-IV: An Objective Assessment

Using Noninvasive Devices and 0.33-mm Microbiopsies. Aesthet Surg J. 2021 Oct 15;41(11):Np1603-np1618.
68. Abdelmaged WM. Microneedling in treatment of vitiligo: A review article. Sohag Medical Journal. 2022;26(1):1-7.

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