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REVIEW ARTICLE

Applications of microneedling for various dermatologic indications with a special focus on pigmentary disorders: A comprehensive review study

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Abstract

Microneedling can accelerate skin repair through numerous complex processes triggered by micro-injuries it produces on the skin surface with very thin needles. The current growth in the application of microneedling in the treatment of cutaneous diseases can be explained by its numerous effects on the skin as reported in the literature. Despite the numerous studies conducted on the application of microneedling in the treatment of skin lesions, its effects on pigmented skin lesions have remained relatively unexplored. The present review comprises an examination of the evidence for the application of microneedling in skin diseases in general and a comprehensive review of the applications of microneedling in pigmentation disorders. The review involved a search of all clinical studies, including trials, case reports, and case series, in the databases MEDLINE/PubMed and Google Scholar using the following keywords: "microneedling," "dermal needling," "percutaneous collagen induction," "skin needling," "dermaroller," and "dermatology disorder." Pertinent data were extracted from all relevant articles published from 1990 to April 2021, and focused on the application of microneedling in the treatment of pigmented skin lesions. Despite the limited number of available studies, evidence suggests the effectiveness and safety of microneedling in treating vitiligo, melasma, and periorbital hypermelanosis. It is noteworthy that the combination of any type of non-aggressive needing technique with other effective therapies (especially topical agents and mesotherapy) yields more promising therapeutic results than single therapy for melasma, dark cycles, and vitiligo as the prototype of pigmentary disorders. However, single needling therapy is significantly effective, too.

KEYWORDS
application, dermatologic disorders, dermatology, melasma, microneedling, needling, periorbital darkening, pigmentary disorders, review, treatment, vitiligo

1 | INTRODUCTION

Microneedling, also known as percutaneous collagen induction therapy, is a relatively recent therapeutic modality in dermatology. Dermatologists treat diverse skin lesions using laser therapy[1]; meanwhile, microneedling has been applied, individually or in combination with other therapies, for the treatment of numerous cutaneous lesions. According to a report by the American Society of Plastic

Surgeons, cosmetic procedures in approximately 85% of the cases in 2015 were non-surgical and minimally-invasive.[2]

Microneedling procedures are performed under sterile conditions. Common local side effects such as edema, bleeding, tenderness, and redness that occur immediately after microneedling usually disappear within 24–48 h. The treated area should be dressed after applying antiseptics. Adherence to routine hygiene measures and protection against sunlight is also recommended.[3]

Microneedling can be used for skin rejuvenation, for drug delivery, and as a therapeutic option in dermatologic conditions such as acne scar and other types of skin scars, hair loss (androgenetic alopecia, telogen effluvium, etc.), stretch marks, pigmentary disorders (vitiligo, infraorbital dark circles, and melasma), and hyperhidrosis.

Given the novelty of microneedling devices and the limited number of studies conducted on the effects of microneedling on cutaneous diseases, dermatologists still need to learn more about the applications and effectiveness of needling in different diseases. The present comprehensive review was therefore performed to investigate therapeutic effects and dermatological applications of microneedling and other types of needing, especially in pigmentation disorders such as depigmentation and hyperpigmentation with especial focus of three main common pigmentary skin disorders: melasma, periorbital dark circles, and vitiligo.

2 | METHODS

For preparing this comprehensive review, we included (1) all studies on needling application for pigmentary conditions (2) between 1990 and April 2021 (3) in English. We did not use (1) all publications not meeting the above, (2) non-English literature, (3) studies before 1990. The search was performed on MEDLINE/PubMed and Cochrane, Scopus, and Web of Science databases from 1990 to April 2021. Also, we obtained some additional studies through other means, for instance, examining the references of the searched articles. Only the articles published between 1990 and April 2021 were included. Google Scholar, as a cumulative database, was limited to only the first 500 related results. The search was limited to the publication year, language, Pure microneedling or combination microneedling and drug delivery and only human studies, but not to the region, race, or any other conditions. Search terms were "micro needling," "dermal needling," "percutaneous collagen induction," "skin needling," "derma roller," "derma pen," "dermatology," "skin," "scars," "skin rejuvenation," "hypertrophic scars," "hyperhidrosis," "acne scars," "melasma," "vitiligo," "infraorbital darkness/melanosis," "acne vulgaris," and "striae." We searched the keywords, both as free terms and in combination with medical subject headings (MeSH) in PubMed. Many related article used for writing this comprehensive review and in Table 1 the data of 34 articles related to needing and pigmentary skin disorders were fully extracted.

3 | RESULTS

3.1 | Study selection

Among studies that passed title-abstract screening, five pertained to animal and laboratory studies, six were review articles, and 80 were articles reporting clinical trials, case reports, and case series. Among these papers, 34 involved pigmentary disorders, and were included in this comprehensive review: 16 articles on melasma, 16 on vitiligo, and 2 on infraorbital melanosis or dark eye circles.

3.2 | Study characteristics

The study characteristics were summarized in Table 1. Of the 34 included studies, all were conducted after 2013. A total of more than 1000 patients were discussed in these studies, of which more than 80% were women. Separately, in 16 melasma studies and two periorbital dark circles studies more than 90% of patients were women and in 16vitiligo studies, the women were at least more than two times as men.

4 | DISCUSSION

4.1 | Background and mechanism of action

In 1994, Orentreich introduced subcision as a practical cutaneous application of needling. He used this technique to release parts of the skin depressed by scars or rhytides.[40] In effect, he used a needle to release the connective tissues from the subcutaneous layers.[40] In 1997, Camirand and Doucet used a tattoo gun devoid of ink to perform needle dermabrasion, which significantly improved the clinical manifestations of the skin tissue in patients.[41] In 2000, a microneedling device was proposed for treating face rhytides and skin laxity. Based on the principles proposed by the pioneers of needling, Fernandes designed and applied a drum-shaped device mounted with small needles to create cutaneous micro-wounds.[42,43]

The growing interest in microneedling was reflected in studies conducted on animal and human models. The numerous studies conducted also significantly contributed to determining the mechanism of the effect of this therapeutic intervention. One hypothesis suggested that multiple microchannels created in the scar tissue can physically break compact collagen bundles in the dermis, which can stimulate the spontaneous formation of collagen and elastin under the scar region.[44,45] Creating multiple micro-wounds on the skin surface can stimulate the release of growth factors that directly affect the synthesis of collagen and elastin and their deposition in the skin.[46]

Further cellular-molecular studies are required for a more specific and accurate description of the mechanism of the effect of microneedling. Creating numerous microchannels on the skin surface can cause a controlled skin injury with the minimum damage to the

TABLE 1 Review of clinical studies on the effects of needling on three common pigmentary skin disorders: melasma, periorbital dark circles, and vitiligo

Diagnosis	Author	Year	Number of subjects	Treatment	Results	Side effects
Melasma[4–19]	Lima	2015	18 females 4 males	1.5-mm needles + approximately 10 times in 4 direct	Microneedling appeared a promising therapeutic method for melasma.	Degree of discomfort: well-tolerated in 16 (70%) patients, 6 (30%) patients did not feel any pain.
	Budamakuntla[4]	2013	54 females 6 males	Group I: Microneedling and tranexamic Group II: Microneedling	Tranexamic can be used as a novel and potentially effective, safe, and promising therapeutic agent in melasma.	Mild erythema, tolerable pain
	Ustuner[7]	2017	15 females 1 male	Group I: Laser + microneedling + vitamin C Group II: Laser alone	Vitamin C plus microneedling applied immediately after laser therapy was a promising adjuvant therapy for treating recalcitrant melasma.	Transient erythema: 6.3% Hyperpigmentation: 14.2% Irritation: 12.5% group I + 6.3% group II Hypopigmentation: 12.5% group I
	Balevi[8]	2017	41 females	Group I: 30% salicylic acid peel + vitamin C + microneedling Group II: 30% salicylic acid peel	Salicylic acid peel combined with vitamin C mesotherapy was a safe and effective alternative for treating melasma.	Mild to moderate burning sensation in some patients
	Cassiano[9]	2019	20 females	1.5-mm needles before/after 7 days	Microneedling significantly reduced melanin density, pendulous melanocytes, and basement membrane damage per histological field.	Not mentioned
	Farshi [10]	2020	19 females 1 male	Patients received microneedling on one side of their face and mesoneedling (tranexamic acid, N-Acetyl Glucosamine, vitamin C, and idebenone) on the other	Both microneedling and mesoneedling decreased the melanin content in epidermal melasma lesions.	Mild erythema: 6 patients Mild skin dryness: 3 patients Mild itching: 4 patients Mild burning sensation: 5 patients
	Ramírez-Oliverosz[5]	2020	1 female	1.5-mm needles + hydroquinone 4% + fluocinolone acetonide 0.01% + tretinoin 0.05%	Significant improvements were observed in the clinical outcomes and quality of life.	Not mentioned

(Continues)

TABLE 1 (Continued)

Diagnosis	Author	Year	Number of subjects	Treatment	Results	Side effects
	Menon	2019	30 females	Microneedling + tranexamic acid were applied to the left side of the face and microneedling + vitamin C to the right side.	Both tranexamic acid and vitamin C were effective and safe treatments for melasma; nevertheless, tranexamic acid was more effective.	Mild erythema, discomfort tolerated in most patients
	Saleh [12]	2019	42 females	Group I: Microneedling and tranexamic acid Group II: Microneedling	Topical tranexamic acid combined with microneedling yielded more satisfactory outcomes.	Not mentioned
	Lima [13]	2017	6 females	Microneedling + hydroquinone + fluocinolone + tretinoin	Microneedling clinically and histologically improved refractory facial melasma.	Not mentioned
	Wali[14]	2019	9 females 11 males	Group A: Microneedling Group B: Microneedling + tranexamic	Microneedling with tranexamic acid was considered an adjuvant therapy.	Not mentioned
	Ismail[15]	2019	30 females	Microneedling + topical vitamin C	The combination regimen was effective and safe.	Tolerable pain during the microneedling procedure and mild erythema that resolved shortly after the procedure.
	Shams Meymandi[16]	2020	60 females	Group A: Microneedling + Topical tranexamic acid 4% Group B: Topical hydroquinone 4%	Mean MASI score in group A and B was significantly lower. The combination of microneedling with tranexamic acid did not differ from 4% hydroquinone.	Mild discomfort, transient erythema
	Tahoun	2021	30 females	Microneedling + tranexamic acid right side Microneedling + vitamin c left side	MN followed by Vitamin C or TXA is successful in melasma management	No significant side effects
	Goel [18]	2020	20 females 10 males	Microneedling + vitamin c	Microneedling with topical vitamin C is an effective treatment option for epidermal melasma.	No side effects except for minimal pain due to microneedling and post-procedure erythema

TABLE 1 (Continued)

Diagnosis	Author	Year	Number of subjects	Treatment	Results	Side effects
	Xing[19]	2020	60 patients	Group 1:liposomal Tranexamic acid 1.8% Group 2: microneedling + tranexamic acid 5% Group 3: Hydroquinone 2%	1.8% liposomal TA and microneedling with 5% TA solution are both effective and safe on melasma.	Experienced transient erythema which lasted for 2 days, with no exacerbation of pigmentation.
Periorbital dark circles[20,21] Ref: 22 review of various therapeutic methods	Kontochistopoulos[20]	2016	13 females	Microneedling + 10% trichloroacetic acid	Significant aesthetic improvement were observed.	Mild discomfort, transient erythema, and edema were quite common during or immediately after the procedure.
	Sahni[21]	2013	1 male	Combination of microneedling and infusion of a serum containing active ingredients	The symptoms were partially improved.	Not mentioned
Vitiligo[23–38]	Ibrahim	2020	34 patients	Four sessions of microneedling followed by trichloroacetic acid 70% in 2 weeks	Microneedling + trichloroacetic acid 70% was considered a simple treatment modality for vitiligo.	Erythema, pain and mild burning sensation
	Stanimirovic [26]	2016	16 females 9 males	Group I: Microneedling + photo therapy + 0.005% latanoprost solution Group II: Phototherapy + 0.005% latanoprost solution	Adding microneedling appeared ineffective in improving the treatment outcomes; possible modifications were required.	Vitiligo progression was observed only in one patient
	Kumar [27]	2019	1 female	Microneedling and topical sprinkling of 5-fluorouracil	Excellent responses were observed in terms of repigmentation.	Not mentioned
	Khashaba [28]	2018	8 females 12 males	Group A: Phototherapy Group B: Microneedling Group C: Microneedling + phototherapy	As a reasonable combination therapy, microneedling + phototherapy were well tolerated by patients with resistant vitiligo.	Side effects were minimal, except for pain, which could be minimized by using topical anesthetics before sessions.
	WAFAA [29]	2019	12 females 8 males	Group A: Microneedling + phototherapy Group B: Phototherapy	Microneedling performed before phototherapy was significantly superior to phototherapy alone and accelerated the response.	Microneedling is a tolerable and safe procedure with minimal side effects.

(Continues)

TABLE 1 (Continued)

Diagnosis	Author	Year	Number of subjects	Treatment	Results	Side effects
	Korobko [24]	2016	22 females 2 males	Right side: Microneedling + narrow-band ultraviolet B + prostaglandin F2a analog latanoprost Left side: Microneedling + narrow-band ultraviolet B + tacrolimus	As an effective topical agent in vitiligo treatment, latanoprost was comparable in efficiency to tacrolimus combined with narrow-band ultraviolet B.	Not mentioned
	Lima[30]	2020	10 patients	Topical tacrolimus 0.1% + microneedling	Improvements in the repair of the epidermis and upper dermis caused by microneedling can lead to restructuring the microenvironment that favors the development of vitiligo.	There were no adverse effects associated with the treatment that was considered to be of good tolerability.
	Giorgio[31]	2019	10 patients	Group I: Microneedling only Group II: Microneedling + 5-aminolevulinic acid 10% + photodynamic therapy	Compared to narrow-band UVB phototherapy, microneedling was found to be a reliable, fast, and affordable therapeutic alternative for vitiligo.	Not mentioned
	Ghiya[32]	2016	29 females 21 males	Group I: Microneedling + 5-fluorouracil solution Group II: Microneedling only	Microneedling combined with 5-fluorouracil was more efficient than microneedling alone in localized stable childhood vitiligo.	
	Ebrahim [33]	2019	15 females 15 males	Group I: Microneedling + tacrolimus Group II: Microneedling only Group III: Tacrolimus ointment	The combination therapy was more effective than either of the single treatments used in groups II and III.	Itching was observed in 33.3% of tacrolimus (group III), and slight erythema also occurred in 26.7% of patients. Mild pain was reported in 26.6% of group I vs 36.7% of group II patients.
	Ebrahim [34]	2020	20 females 28 males	Group A: Tacrolimus Group B: Microneedling + tacrolimus	The combination regimen was superior.	No major adverse effects, such as scarring or Koebnerization, were observed, except mild burning sensation and pruritus

TABLE 1 (Continued)

Diagnosis	Author	Year	Number of subjects	Treatment	Results	Side effects
	Mina[39]	2018	10 males 15 females	Microneedling + 5-fluorouracil + tacrolimus	Microneedling combined with 5-fluorouracil or tacrolimus was a safe and effective treatment in vitiligo.	No complications in any of the patients (25 patients, 100%)
	Marasca[35]	2021	1 male	Oral corticosteroid + microneedling + 5 FU	complete repigmentation after three sessions	Did not reveal any local or systemic side effects during or at the end of the treatment. Did not reveal any local or systemic side effects during or at the end of the treatment. No complications
	Muqdad[36]	2020	23 patients	Right patch: micro needling alone Left patch: microneedling + tacrolimus	Microneedling with topical tacrolimus showed better but non-significant response than micro-needling alone	There were no adverse effects
	Nienaa[37]	2021	50 patients	One patch: microneedling + latanoprost + NBUVB Other patch: microneedling + NBUVB	Latanoprost in combination with microneedling and NB-UVB provides more significant therapeutic outcomes than combined microneedling and NB-UVB	No any significant side effects
	Elnokaly[38]	2021	60 patients	Group 1: microneedling + tacrolimus Group 2: microneedling + TCA 25%	The mix of microneedling with either TCA 25% or tacrolimus is effective and safe in treating Vitiligo. TCA achieved a slightly increased percentage of repigmentation than tacrolimus.	Erythema and Pain disappeared 1 day after the session, and exfoliations had disappeared within 1 week.

epidermis, followed by the stimulation and activation of an inflammatory cascade during wound healing (inflammation, proliferation, and remodeling).[47] These changes release platelet-derived growth factors (PDGFs), fibroblast growth factors (FGFs), and transforming growth factors alpha and beta (TGF-a and TGF-b),[48,49] lead to cell production secondary to the proliferation and migration of fibroblasts.[50] A fibronectin matrix formed after the skin injury provides the scaffold necessary for the deposition of type III collagen, which is eventually replaced by type I collagen. These events ultimately result in the firmness of rhytides and their reduction over weeks and months.[43,48] Meanwhile, the increased gene and protein expressions of type I collagen up-regulate glycosaminoglycans and growth factors, including vascular endothelial growth factor, FGF-7, and epidermal growth factor.[48,49]

One year after the procedure, the histology of the microneedled areas showed deposition of collagen with a normal structural arrangement in the reticular dermis. Increases in the elastic fiber deposition and epidermal thickness, granular layer hyperplasia, a normal stratum corneum, and rete ridges were also observed in these patients.[51–53] Research suggests that TGF-b3 up-regulation increases scarless wound healing. Increased changes in TGF-b3 compared to TGF-b1 and TGF-b2 may also contribute to the beneficial effects of microneedling.[49]

5 | MICRONEEDLING TOOLS

All the commercially-available microneedling tools are designed and manufactured to create microchannels in the dermis and epidermis and stimulate collagen synthesis. The existing microneedles are divided into two general types, that is, fixed needle rollers and electrically-powered pens with disposable sterile needles.[46,54] The manufacturing companies supply these tools with different structural designs, standards, materials, and needle lengths and diameters. Both manual rollers and electrically-powered pens function by causing bleeding while being perpendicularly placed on the skin surface.[46,54–57] Electrically-powered pens have more advantages than rollers, for instance, they are faster, are easier to maneuver, and cover larger areas more easily and rapidly. Using disposable needles also reduces the risk of the transmission of infectious agents. Moreover, microneedling small lesions, such as traumatic scars or rhytides on the upper lip, has been greatly facilitated by disposable needles in electric pens.[50]

The clinical outcomes depend on the diameter of the needle and the depth of its penetration into the skin, which should be determined in an area-specific manner; for instance, needles applied on oily and thick skins should be longer than those applied on thin skins. The needle of available dermarollers can be as small as 0.4–0.5 mm in length. The needle length is routinely selected as 1–2 mm. Needles required only topical anesthesia whereas infiltrative anesthetics should be administered when applying 3–4 mm long needles. Dermarollers pierce the skin at an angle of 45°.[55,58] Dermastamps can be used as the miniature version of dermarollers to treat smaller areas, including around the eye, above the upper lip, and on single scars and stretch marks.[58,59] The pressure applied to the roller will be a determining factor depending on the indication and the amount of pressure applied, since if one presses lightly the needle penetrates less than when one applies pressure and the needle penetrates deeper.[60]

6 | DERMATOLOGICAL APPLICATIONS OF MICRONEEDLING

Microneedling has been used alone or in combination with other treatment modalities for treating many patients in dermatology clinics.[59,61] The dermatological applications of needling comprise pigmentary disorders including melasma, vitiligo, hyperpigmentation, periorbital darkening, and infraorbital darkening (dark eye circle); skin scars such as hypertrophic scars and atrophic acne scars and striae; dyspigmentation; depigmentations such as vitiligo, hyperhidrosis, inflammatory and non-inflammatory acne vulgaris; various hair disorders such as alopecia areata and androgenic alopecia; percutaneous collagen induction; skin aging and rejuvenation, and percutaneous drug delivery.[62–66] We review some of these applications in the present study. Furthermore, applications of microneedling in pigmentary disorders are completely reviewed.[58,60,67]

6.1 | Pigmentation disorders

Pigmentation disorders refer to a group of skin disorders resulting in a lighter or darker skin color, a combination of the two, or an abnormal color pattern. These disorders are generally caused by quantitative or qualitative deficiencies in the synthesis, transfer, and degradation of melanin. Disorders of endogenous or exogenous pigments can also cause an abnormal skin color.[23]

Hypopigmentation refers to any form of reduction in pigmentation. To the best of the authors' knowledge, microneedling has not yet been used for treating hypopigmentation. Depigmentation or leukoderma refers to a condition in which the skin has completely lost pigmentation and, therefore, appears relatively white.[68] Among these conditions, microneedling has been used on vitiligo and hypopigmented burn scars, as discussed below.[68] At the other end of the spectrum of skin pigmentation disorders, hyperpigmentation refers to any cutaneous disease that increases pigmentation.[69] A review of studies on microneedling is presented here:

6.1.1 | Vitiligo

Vitiligo is a prevalent multifactorial disease with potentially destructive effects on mucous membranes, and melanocytes.[68] None of the different therapeutic methods proposed so far for managing vitiligo has been significantly effective. Mina et al.[39] ran a clinical trial on the use of microneedling and 5-fluorouracil for 12 sessions in 2 weeks, and reported this combination both safe and effective in treating

vitiligo. Evaluating the simultaneous application of microneedling, tacrolimus ointment, topical latanoprost, and narrow-band ultraviolet B phototherapy, Korobko et al.[24] found microneedling to be ineffective in accelerating clinical recovery in patients with vitiligo. Table 1 presents the studies conducted using microneedling for treating patients with vitiligo. It is recommended that further studies be conducted to investigate the effects of combination therapies on these patients.

6.1.2 | Melasma

Melasma, also known as chloasma, is an acquired condition with symptoms of hyperpigmentation.[70] Microneedling has been used to treat hyperpigmentation disorders, including melasma and periorbital hypermelanosis. The use of skin needling and depigmenting serum (containing two principle topical agents: rucinol and sophora-alpha) significantly improved the melasma area, severity index, and luminosity in 20 patients.[71] In 2013, the effects of microneedling on severe melasma were reported in 60 patients.[4] Simultaneous use of 10% trichloroacetic acid and microneedling also yielded acceptable outcomes in patients with periorbital melanosis.[20] Table 1 shows the focus of the literature on microneedling in patients with melasma. According to this table, using hydroquinone, fluocinolone acetonide, tretinoin, tranexamic acid, vitamin C, or fluocinolone improved the outcomes of microneedling in patients with pigmented skin lesions.

6.1.3 | Infraorbital dark circles/melanosis

Table 1 shows the focus of the literature on microneedling in patients with periorbital darkening. Treating infraorbital dark circles with numerous modalities, such as laser therapy, chemical peels, bleaching creams, autologous fat transplantation, and injectable fillers has rarely resulted in patient satisfaction so microneedling was proposed for eye dark circles treatment with satisfactory results and Kontochristopoulos et al.[20] reported acceptable effects on infraorbital dark circles for the simultaneous use of microneedling and trichloroacetic acid 10%. A case report showed significant effects for the simultaneous application of microneedling and a serum containing active ingredients on the status of a patient with periorbital melanosis.[21]

6.2 | Skin aging

Microneedling is extensively used for skin rejuvenation. A cascade of growth factors, including FGFs, TGF-α, TGF-β, and PDGFs, formed after the creation of micro-injuries in the skin through microneedling, causes fibroblast invasion. These events rearrange collagen fibers and lead to the regeneration of collagen and elastin by fibroblasts. A fibronectin matrix is formed 5 days after the micro-injuries.[59] This chain of changes can accelerate the process of wound healing and the production of new epidermal tissues. A clinical trial showed that six sessions of microneedling over 2 weeks significantly contributed to skin rejuvenation.[67] The simultaneous application of platelet-rich plasma (PRP) and microneedling was also found to yield promising results in facial rejuvenation.[54] Given that vitamins A and C are vital for the synthesis and maintenance of collagen, simultaneous use of topical antioxidants and microneedling appears to improve the regeneration process in wound repair.[43,72,73] In 2011, the topical application of vitamins A and C along with microneedling for 8 weeks increased the epidermal thickness by 140%, whereas antioxidants individually increased the epidermal thickness only by 22% in the same period.[48] Using antioxidants before microneedling appears to increase the expressions of genes and proteins responsible for skin regeneration.[48] A 2014 paper recommended caution regarding the simultaneous application of antioxidants because of the risk of granuloma formation.[74] Compared to their individual application, the simultaneous use of tretinoin and microneedling accelerated the proliferation, thickened the epidermis, and increased the density of collagen fibers.[75] Simultaneous use of mesomicroneedling and stem cell therapy was also found effective in skin rejuvenation.[76,77] Moreover, microneedling combined with glycolic acid[71] or PRP[78,79] or photodynamic therapy[58]was found to yield better outcomes in patients.

6.3 | Skin scars

Applying microneedling alone to rolling, boxcar, and pitted scars has yielded satisfactory results.[80] Treating atrophic post-acne scars using microneedling and glycolic acid peels[81] and vitamin C, PRP[82] or subcision with trichloroacetic acid 15%[83] has been reported in the literature. Microneedling was also found effective in non-acneic scars such as burns and chickenpox scars.[52,84,85]

6.4 | Hair loss

The beneficial effects of microneedling on alopecia areata have been reflected in the literature. A combination of minoxidil and microneedling was found to be more effective than the individual treatments.[86] Moreover, microneedling was found to affect alopecia areata in cases with resistance to minoxidil and finasteride.[87] Combination therapy using a dermaroller and triamcinolone acetonide also yielded proper outcomes in patients with alopecia areata.[70]

6.5 | Hyperhidrosis

Effects of microneedling on hyperhidrosis have been rarely addressed in the literature. A pilot study investigated the therapeutic effects of microneedling on 20 patients with hyperhidrosis.[88] Histological examination of the microneedled areas has shown that microneedling can reduce the number and size of eccrine and apocrine glands in patients with hyperhidrosis. Microneedling can, however, cause mild

discomfort, along with transient sweating and other complications in these patients.[88]

6.6 | Drug delivery

Microneedling can accelerate transdermal medication delivery by creating micropores in the stratus corneum.[89] Selecting the microneedle type is important; for instance, bleeding induced by using long needles can theoretically inhibit drug absorption.[90] Microneedling can, however, increase the dermal delivery rate of lidocaine ointment and the effectiveness of photodynamic therapy.[91] Microneedling also significantly increased the cutaneous absorption rate of bleomycin ointment in patients with large recalcitrant plantar warts.[91] Given the applicability of microneedles in improving the transdermal delivery of ointments, it is recommended that further studies be conducted to investigate the possible application of microneedling in facilitating the delivery of topical chemotherapeutic drugs in patients with skin tumors.

6.7 | Adverse effects

As in the case of other invasive or minimally invasive procedures, microneedling can cause complications. Research suggests that edema, bleeding, pain, transient erythema, and serous drainage are the most frequently observed complications.[75,80,81,92–96] Post-inflammatory hyperpigmentation has been reported in some patients who underwent only one session of microneedling[59,79,80]; nevertheless, the risk of this complication is very low.[97] Skin reactions such as tram-track scarring have been reported in two cases with acne scars undergoing microneedling using either 1.5-mm or 2-mm long needles.[78,95] There is a risk of bruising or hematoma on bony prominences.[51,80] Secondary bacterial infection has also been reported.[79] However, the occurrence of foreign body granuloma or systemic hypersensitivity has been reported rarely.[98]

6.8 | Limitations and strengths

Our study, like other studies, has weaknesses and limitations. Due to the novelty of microneedling, very few comprehensive or holistic systematic reviews have been done in this field and application in various dermatological entities that this study tried to discuss completely, although excluding non-English articles removed some valuable studies.

7 | CONCLUSION

Stimulations and processes that ensue in the skin following needling/microneedling can lead to numerous biological changes and help treat certain skin conditions. Further studies are required to explore the intensity of the effect and the optimal length of time for performing microneedling. Despite the limited number of available studies, there is consensus about the therapeutic effects of microneedling on pigmentary disorders, especially melasma, vitiligo, and periorbital hypermelanosis. Combination therapies using microneedling therefore constitute valuable treatment approaches in these conditions. In other words, the combination of any type of non-aggressive needing (mesoneedling, radiofrequency [RF]-needling, microneedling, etc.) yields more promising therapeutic results (especially topical pigment-regulatory agents or mesotherapy) than single therapy for melasma, dark cycles and vitiligo as the prototype of pigmentary disorders. However, single needling therapy is significantly effective, too. Therefore, needling can be used as an effective adjuvant therapy for pigmentary disorders in cases with resistance to previous therapeutic options or in those who seek synergistic combination therapies. Logically, poorer outcomes are expected in treatment-challenging cases of melasma, dark cycles and vitiligo of resistant areas, although poorer outcomes in this case are also cosmetically highly appreciated if we use this procedure non-aggressively without any probable post-inflammatory hyperpigmentation (PIH) or any traumatization leading to probable Koebner phenomenon. Based on their experience in needling therapy in several dermatologic entities and clinical settings and review studies and the results of the present review study, the authors believe that it is a proper time for more focus on needling applications in pigmentation disorders.[5,10,11,65] Working on associations and promising therapeutic options of many mucocutaneous disorders is of great importance in the research fields of dermatology and needling could be one of the highly recommended procedures for various indications so that pigmentary disorders are not any exceptions and there are increasing rate of publications in the literature in this regard.[99–107] In a comprehensive systematized survey we summarized our literature review on the effect of microneedling in patients with three main pigmentary disorders including melasma,[4–19] periorbital darkening[20–22] and vitiligo.[4,20,21,24–39]

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

AUTHOR CONTRIBUTIONS

Elham Ziaeifar, Fatemeh Ziaeifar, Samaneh Mozafarpoor, and Azadeh Goodarzi contributed to the preparation and finalization of this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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