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REVIEW

Microneedling for the Treatment of Scars: An Update for Clinicians

This article was published in the following Dove Press journal:
Clinical, Cosmetic and Investigational Dermatology

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Background: Microneedling (MN) is used for the treatment of scars, amongst other indications. Although used in Asia and the Middle East for decades, related to the supposed lack of post-procedure pigmentary alterations even in darker skin types, MN only recently gained attention in the United States as an effective, well-tolerated aesthetic treatment.

Materials and Methods: A systematic review of the Medline database was completed using search terms “microneedle” or “microneedling” or “micro needle” or “micro needling” and “scar”. Included articles were written in English and discussed the use of MN for the treatment of scars in human subjects.

Results: Fifty-eight studies were included for review, with a total of 1845 patients treated for acne scarring, hypertrophic or keloid scars, and those resulting from surgery, trauma, varicella or smallpox. MN and its counterpart fractional radiofrequency MN (FRF-MN) were used as monotherapy or in combination with topical, surgical or systemic modalities. MN and FRF-MN treatment resulted in clinical improvement of scar appearance from baseline. No serious adverse events occurred.

Conclusion: MN is a well-tolerated, minimally invasive procedure that can be used for the treatment of scars with a high level of patient satisfaction. Further clinical studies are needed to develop standardized treatment protocols.

Keywords: microneedling, laser, peel, platelet-rich plasma, scar

Introduction

Microneedling (MN), or percutaneous collagen induction therapy, has been used within the dermatologic subspecialty for skin rejuvenation, skin tightening including treatment of striae, scar remodeling of the face and body, and hair growth. Due to the relative lack of post-inflammatory hyperpigmentation, MN is often considered an alternative to laser procedures in darker skin phototypes (Fitzpatrick IV through VI). Although MN has been a popular, minimally invasive, procedure performed in Asia and the Middle East, only recently has MN garnered attention in the United States (US). Since the first clinical descriptions of subcision and “needle dermabrasion” (using a tattoo gun without ink), the production of MN devices has flourished.^{1,2} In the US, MN devices exist as both rollers, stampers, and pens (electrically powered or otherwise), and can be combined with radiofrequency (RF) in an effort to deliver energy below the epidermal surface – known as fractional radiofrequency microneedling (FRF-MN), thus avoiding epidermal damage and subsequent dyspigmentation.³

MN devices vary based on their needle length (i.e. depth of skin penetration), diameter, density and material. Disposable needle tips are considered safer from an infectious risk standpoint, especially given the recent concern of bloodborne disease

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spread especially with the aptly named “vampire facials” for skin rejuvenation,³ and reusable home-use devices. Devices that allow for variation of needle length are advantageous in that varying penetration depths may be necessary to treat different areas of the face or body; sebaceous areas required deeper needle penetration compared to the forehead or periorbital areas. Prior studies demonstrate a needle length of 1 mm as being the most desirable and accurate setting, whereas needle lengths of 3 mm may still only penetrate to a depth of 1.5 to 2.0 mm.^{4,5}

Animal models and in vitro examination of human tissue demonstrate that MN creates micro-channels and micro-wounds at the level of the dermis breaking compact, thickened collagen and inducing the wound healing cascade. Micro-channels cause little epidermal damage making MN safe to use in darker skin phototypes. Gene expression profiling before and after MN treatment demonstrates an upregulation in type I collagen expression, as well as glycosaminoglycans, vascular endothelial growth factor (VEGF), fibroblast growth factor (FGF)-7, epidermal growth factor (EGF), and transforming growth factor (TGF)- β , all important signaling molecules for collagen production, as well as neovascularization. Tissue histology after MN shows thickened epidermis, and an increase in dermal collagen and elastic fiber deposition. Over a period of weeks to months, newly formed type III collagen becomes mature type I collagen causing skin tightening and a decrease in the appearance of scars or rhytides.^{6–11} In this systematic review, we will explore the efficacy and safety of MN for the treatment of scarring.

Materials and Methods

A systematic review using the PRISMA (Preferred Reporting Items for Systemic Review and Meta-Analysis) was completed using the Medline database in August 2020 using the search terms “microneedle” or “microneedling” or “micro needle” or “micro needling” and “scar”. Included manuscripts were case reports, case series and trials discussing the use of microneedling (rolling device, stamping device, fractional radiofrequency device) for the treatment of scars in humans in English. Reviews, animal models, and in vitro studies were excluded, as were articles not available in English.

Results

Search terms revealed a total of 246 manuscripts; after removal of duplicates, 58 studies ranging in date from 2011 to August 2020 were included for review. A total

of 1845 patients with acne scarring or acne vulgaris, hypertrophic or keloid scarring, post-surgical or post-traumatic scars, and varicella or smallpox scarring completed study treatment protocol and follow-up. Protocols utilized included MN or FRF-MN alone, as well as in combination with topicals, chemical peels, subcision, platelet-rich plasma (PRP), laser, injectables or systemic medications. MN devices were both automated or mechanical in nature (such as rollers) (Table 1).^{6–63}

In all cases of MN or FRF-MN treatment, patients received pre-treatment anesthesia. Although the most commonly reported anesthesia was topical (lidocaine and/or prilocaine) applied in the area to be treated with or without occlusion for a total of 30 to 90 minutes, 2 studies originating from Germany mentioned the use of general anesthesia. Prior to starting MN, areas were cleansed with either isopropyl or ethyl alcohol. Two studies utilizing FRF-MN used epidermal cooling to decrease epidermal damage during the procedure. Post-treatment regimens suggested included sunscreen (n=19 studies), bland emollient (n=11), topical or systemic antibiotic including topical fusidic acid (n=11), topical corticosteroids (n=3), cold packs (n=2), as well as topical benzoyl peroxide, cyclopentasiloxane/cyclohexasiloxane/sodium hyaluronate, hyaluronic gel, L ascorbic acid/ α -tocopherol/ferulic acid, non-steroid anti-inflammatory drugs (NSAIDs), and tretinoin/kojic acid/hydroquinone/hydrocortisone (n=1 each).^{6–63}

Acne scarring was by far the most discussed condition (n=43 studies). In all studies, boxcar (U-shaped) and rolling (M-shaped) scars demonstrated the greatest clinical improvement after MN or FRF-MN, while icepick (V-shaped) scars were often recalcitrant.^{6,9,11–51} Patients treated with MN or FRF-MN for other types of scars also demonstrated clinical improvement. Scar improvement was measured using both patient and investigator qualitative assessments, as well as the Echelle d'évaluation Clinique des Cicatrices d'Acne (ECCA), Vancouver Scar Scale (VSS), and Visual Analog Scales (VAS).^{6–63} Combination treatment with laser, PRP, subcision, glycolic acid peel, Jessner's peel, trichloroacetic acid peel and topical amniotic fluid stem cells resulted in greater scar improvement than MN or FRF-MN alone.^{8,17,24,26,31,32,34,37,40,51,53,55} Fifty to 100% of patients were satisfied with MN or FRF-MN treatment; 33% of patients reported they would want further treatment,⁹ while 94% would recommend treatment to others.²⁸ Combining treatment with 1550 nm laser or PRP resulted

Table 1 Summary of Protocols from Studies Discussing the Use of Microneedling for Scar Treatment

	Treatment Protocol		Combination Therapies	
Microneedling (n=36)	Number of passes	4–10	Procedural	Platelet-rich plasma (PRP; n=6) Subcision (n=3) Incobotulinum toxin (n=1) Polymethylmethacrylate-collagen gel (n=1) Glycolic acid peel (n=3) Trichloroacetic acid peel (n=2) Amniotic fluid-derived mesenchymal stem cell, topical (n=1) Hyaluronic acid (n=1) Jessner's solution peel (n=1) Vitamin A and C, topical (n=1) Systemic isotretinoin (n=1)
	Clinical endpoint	Uniform pinpoint bleeding	Topicals or peels	
	Needle depth	1.5–3.0 mm	Systemic therapy	
	I–12 treatment sessions, every 1–8 weeks			
Microneedle patch (n=2)	Continuously for 30 days (n=1), changed every 2–3 days for 4–6 weeks (n=1)			
Fractional radiofrequency microneedling (insulated and non-insulated, multiple and single-needle heads, n=20)	Number of passes	2–8	Injectable/procedural	Fractional carbon dioxide (CO ₂ ; n=2) Fractional 1550 nm erbium-glass (Er:glass; n=1) Hyaluronic acid (n=1) Subcision (n=1) Poly-lactic acid (PLA; n=1)
	Clinical endpoint	Wheal-like papules/plaques	Topicals	
	Needle depth	0.8–3.5 mm		
	Energy	6.82–70 W, 40–82 mJ	Systemic therapy	Systemic isotretinoin (n=1)
	Duration Total pulses	50–400 ms 250–500		
I–6 treatment sessions, every 4–12 weeks				

in higher patient satisfaction.^{8,34} In addition, patients preferred MN to intralesional triamcinolone (ILTAC) or 1450 nm diode laser.^{30,56}

Adverse events (AEs) due to MN or FRF-MN were mostly of minimal severity; no serious AEs were reported. Almost all studies reported pain and bleeding during the procedure; the most common post-procedure AEs included transient post-procedure pain/discomfort/burning, erythema and/or swelling. Further AEs are discussed in Table 2. Post-inflammatory hyperpigmentation occurred in 19 studies; 54.5% of studies used FRMN, while 45.5% used MN. There was one case of herpes simplex reactivation which was successfully treated with oral valacyclovir.

The most feared AE of MN treatment is the so-called “railroad” or “tramtrack” scarring that can occur with aggressive treatment, and was only reported as an AE in 5 studies.^{6–63} One female patient with atrophic acne scars developed scarring after an allergic reaction to the nickel contained in the needles, which was subsequently treated with oral prednisolone and topical steroids.³⁸

Discussion

MN has gained popularity as a minimally invasive aesthetic technique for the treatment of skin aging, scarring, striae, and hair loss, amongst other indications. Although the US Food and Drug Administration (FDA) initially

Table 2 Summary of Rare AEs Occurring with Microneedling Treatment for Scars

Adverse Event Description	Number of Studies Reporting (n)
Post-inflammatory hyperpigmentation	19
Scabbing/crusting	9
Purpura/ecchymosis	5
“Tramtrack”/“railroad” scarring	5
Acne flares	4
Cervical lymphadenopathy	3
Milia	2
Pustules/bullae	2
Allergic reaction to nickel	1
Herpes simplex reactivation	1

classified MN as class I medical devices, recent developments have elevated their classification to class II (special controls) and they are currently approved for microdermabrasion, scarring and rhytides.⁶⁴ The literature suggests that MN and FRF-MN are well tolerated and result in clinical improvement of scarring due to acne or other infectious cause, hypertrophic or keloid scars, and post-operative or traumatic scars, as well as high rates of patient satisfaction. MN and FRF-MN were reportedly tolerated better by patients than their laser resurfacing counterparts, namely the CO₂, Er:glass and diode lasers, with less reported downtime. MN and FRF-MN can be combined with a variety of other surgical therapies including laser resurfacing, chemical peels, PRP, filler and botulinum toxin for greater clinical results.^{6–63}

As with many aesthetic procedures, MN and FRF-MN suffer from a lack of standardized protocol. Animal and human studies suggest that multiple passes per treatment and multiple treatment sessions demonstrate greater skin regeneration potential.^{65,66} Further clinical studies need to be completed to determine optimal number of passes, number of treatment sessions, intertreatment duration intervals and maintenance therapy.

Just like non-ablative laser techniques, MN is an effective intraepidermal and intradermal delivery method for pharmaceuticals.^{5,67} In addition to microneedles designed to contain substances such as bleomycin or triamcinolone for treatment hypertrophic scarring,^{68,69} MN can enhance the penetration of topicals such as anesthetics, chemical peels, PRP or filler material such as hyaluronic acid as evidenced by this review,^{6–63} and possibly nanoparticles and siRNA in the future.^{67,68} Advances in MN delivery,

such as the development of patches or use of MN to deliver energy sources below the level of the epidermis have both decreased the amount of discomfort associated with treatment, and increased efficacy by combining multiple treatment modalities.^{56,58,70} It is important to note that certain topical products may cause allergy, and even granulomatous reaction, when introduced into the skin through micro-channels created by MN devices; physicians should counsel patients appropriately regarding these risks. Substances such as bleomycin, triamcinolone and filler material should presumably be safer to administer through micro-channels given that they are designed as injectables.

Although no serious AEs were associated with MN and FRF-MN treatment of scars, it is important to note that post-inflammatory hyperpigmentation occurred in over 30% of studies and resolved either spontaneously or with the help of topical bleaching creams within months. Given that the majority of patients treated in this review had a Fitzpatrick skin phototype of IV or greater, AE reporting may have been biased towards events that more commonly occur in this patient groups post-procedure, specifically dyspigmentation and aberrant scarring (such as the “tram-tracks”). Physicians should be aware that MN is not without its risks, and appropriately counsel patients during the consent process to avoid patient morbidity post-treatment.

Limitations of this study include its lack of meta-analysis. Given the heterogeneity of data presented by included studies, it was not possible to combine and statistically analyze this data.

Conclusions

MN and its relative FRF-MN are both well-tolerated, minimally invasive procedures that can be used for the effective treatment of scarring. Although there are no standard treatment protocols, clinical improvement in many types of scars including acne, varicella and smallpox, hypertrophic or keloid, and post-operative or post-traumatic scars have been reported in the literature. MN and FRF-MN can be used as stand-alone modalities, or can be combined with a variety of topicals and other surgical procedures for superior results. No serious AEs have been reported using MN or FRF-MN for the treatment of scars; however, physicians should be aware that post-inflammatory hyperpigmentation is still a relatively common event. Large-scale, clinical trials need to be completed to determine optimal, standardized protocols to treat scarring using MN or FRF-MN.

Funding

The authors received no funding for this research.

Disclosure

Dr. Cohen has been a consultant and participated in clinical research for Lutronic (the manufacturer of Genius fractional bipolar radiofrequency system). The auhtors report no other conflicts of interest in this work.

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