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Role of microneedling in vitiligo

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Abstract
Vitiligo isn't only a cosmetic illness; it is accompanied by social ostracism and stigmatisation, resulting in a significant psychological burden for those afflicted. A range of therapeutic modalities has been employed, exhibiting varying re-pigmentation rates, such as: intralesional, systemic and topical corticosteroids; psoralen ultraviolet A photochemotherapy and narrow-band ultraviolet B phototherapy; monochromatic excimer light laser; calcineurin inhibitors; afamelanotide; prostaglandin F2 alpha analogue (Latanoprost); erbium laser-assisted dermabrasion; CO_2 fractional laser; and surgical procedures. However, an adequate therapy for vitiligo remains elusive. A method utilising needling in vitiligo demonstrated positive levels of re-pigmentation. It may be accomplished with basic injection needles or microneedling (MN) apparatuses, including manual rollers, automated needle pen devices, dermarollers, and MN fractional radiofrequency devices. The recovery rates after treatment with MN have enhanced patient satisfaction and professional knowledge of this prevalent therapy for vitiligo.

Keywords: Vitiligo, microneedling

Introduction
The inception of Microneedling (MN) occurred in 1995 when Orentreich and Orentreich [1] introduced dermal needling as a subcision technique for scar remediation, followed independently in 1997 by plastic surgeons Camirand and Doucet [2], who employed tattoo guns devoid of ink to alleviate tension from post-surgical scarring [3].
The MN method was refined by cosmetic surgeon Fernandes in 2006 [4], who created a drum-shaped device including many small protrusion needles for percutaneous induction of collagen.

Methods of microneedling
The primary device utilized in MN is sometimes referred to as a 'dermaroller.' A dermaroller is a straightforward, manual device with a handle and a cylinder embedded with sterilized tiny, stainless-steel needles measuring 0.5-2 mm in length, uniformly spaced apart [5]. The dermaroller is applied to the skin in various directions to provide a therapeutic effect. These MNs induce little pinpoint injuries that typically heal within 2 to 3 days without any recorded post-treatment complications [6].
Automated devices typically consist of a pen-shaped instrument, handpiece, and disposable needle cartridge. The majority include a gauge of adjustable needle length and various speed settings. Automated MN devices are designed for a stamping action, facilitating perpendicular insertion of the needles into the skin and preventing skin laceration. Certain devices promote a dragging action of the needles over the skin, potentially resulting in minute rips and abrasions [7].
A benefit when employing an automated device is its capacity for treating tiny regions, especially those around the nose, mouth, and eyes, owing to the diminutive of the needle tip size. Adjustable depth and velocity of needle may be used to ensure sufficient penetration in these regions [8].

Various instruments and techniques
1. Dermaroller
Home-care dermarollers (C-8) are utilized by participants independently, with a length of

needle of fewer than 0.15 mm. They are designed to diminish size of pores, fine wrinkles, and production of sebum, in addition to facilitating the transdermal distribution of compounds like lipopeptides and other anti-aging formulations. They may be utilized two to three times weekly for a maximum of 100 applications. Post-usage, the rollers must be cleansed with hot tap water and then shook dry (Figure 1) [9].

Fig 1: Dermaroller [9]

2. Derma-stamp

Derma-stamps, which are tiny versions of dermarollers, are utilised for treating localised parts of the body, such as the eye region, the area above the upper lip, individual scarring, and stretch marks. The narrow diameter of the shaft guarantees accurate operation, facilitating access to challenging regions (Figure 2) [10].

Fig 2: Derma-stamp (McCrudden *et al.*, 2015) [10]

3. Dermapen

The Dermapen is a spring-loaded microneedling device that functions as an electrical-driven pen, executing stamp-like movements on the skin.

Numerous commercial iterations of this device are available, all depending on identical concepts. Skin puncturing is performed by the automated, pulsing motion of needles extending from the interchangeable tip. The reduced quantity of needles, the capacity to modify their length (0.25-2.5 mm), and the rapid ejection enhance the device's use while simultaneously improving accuracy and precision. This allows for comprehensive treatment of all skin regions without altering the instrument. (Figure 3) [7].

Fig 3: Dermapen devices of different companies [7]

4. DermaFrac

DermaFrac therapy is a recent enhancement of MN that integrates microdermabrasion, MN, concurrent deep tissue infusion of serum, and light-emitting diode therapy. DermaFrac therapies address ageing and uneven skin tone, sun-damaged skin, large pores, acne, fine lines, wrinkles, hyper-pigmentation, and superficial scarring. The whole face therapy takes roughly 45 minutes when all four methods are utilized. This non-invasive, cost-effective therapy offers the benefit of minimal downtime, with personalised infusion serum selection (figure 4) [11].

Fig 4: DermaFrac **(11)**

5. Microneedle delivery systems

They are a technique for transdermal delivery of medication whereby solid MNs penetrate the skin, thus allowing for the injection of topical medication. Alternatively, pharmaceuticals may be administered into the dermis directly using hollow needles [12]. In 2011, Fluzone® Intradermal vaccine for influenza virus (Sanofi Pasteur, Swiftwater, PA, USA) was the initial and only MN-based product given approval by the FDA for this use [12].

6. Fractional radiofrequency (RF)

The integration of MN with RF has broadened the potential applications of this technology. Insulated needles penetrate the skin to deliver RF currents from their tips, creating hot zones in the dermal structural elements and accessory glands while preserving the integrity of the overlying epidermis. This initiates prolonged dermal remodelling,

neo-collagenesis and neo-elastogenesis [13]. It doesn't harm the epidermis and is hence suitable for darker skin types. The indications involve scarring therapy, tightened skin, rejuvenation, hyperhidrosis, and further applications [14].

7. Light emitting microneedling device

It integrates titanium MNs with light-emitting diodes to address wrinkling and scars [7].

Mechanism of action

The micro-puncture technique induces controlled inflammation in the skin by many microprisms formed by condensed punctures with tiny needles. Penetrating the skin with suitably sized needles may harm superficial blood vessels, leading to microbleeds. This initiates a process comparable to the wound healing mechanism. MN induces minute ruptures in the blood vessels located directly under the epidermis. During this process, blood platelets, which facilitate coagulation, are released, and the synthesis of elastin, collagen, and GFs is stimulated [7]. MN triggers a sequence of cutaneous responses categorised by three primary phases: inflammation, proliferation, and remodelling [10].

1. The phase of inflammation

The inflammatory stage is brief (lasting up to 72 hours post-injury) and encompasses formation of clots, influx of cytokines and GFs into the injured region, along with the activation of immune cells [15]. The primary mechanism linked to MN is platelet activation due to the cessation of blood flow in arteries. This results in the release of several growth factors that significantly encourage fibroblasts to synthesise elastin and collagen [16].

Immune cells (neutrophils, leukocytes, macrophages) eliminate potential pollutants and microorganisms from the wounded site. Within one-week post-injury, these cells experience apoptosis, resulting in a significant alteration of the wound environment [17].

2. The phase of proliferation

The primary mechanisms occurring during the proliferative phase, that lasts 2-3 weeks, are epithelialisation and the substitution of the fibrin clots with granulation tissues (15). Recently formed granulation tissue mostly consists of collagen, fibroblasts, and hyaluronic acid. The fibroblasts secretion and migration, together with the restoration of the extracellular matrix (ECM), are controlled by matrix metalloproteinases, interleukins, and GF [18].

Collagen is a crucial protein synthesised in the formation of new tissues. The expansion of keratinocytes facilitates the accumulation of collagen Types IV and VII, while fibroblasts promote the synthesis of collagen Types I and III. Collagen Types I and III, deposited on fibronectin, contribute to the restoration of defects of tissues, enhancing its extensibility. Collagen type III is predominant in granulation tissues, that is characteristic of the rebuilding process following mechanical trauma [3].

Concurrent with neo-collagenesis, angio-genesis (The creation of new blood vessels) transpires, resulting in enhanced oxygenation of the skin [17].

3. The phase of remodeling

Throughout the remodelling phase, the ECM undergoes further transformation. Initially, collagen Type III is mostly synthesised, but it subsequently transitions into collagen Type I. The skin thickens and becomes more resilient, restoring its proper colour and texture [4]. Histopathological analysis of the skin post-MN reveals a notable augmentation in the epidermis granular layer thickness, while the dermal thickness remains unchanged [19].

Application of microneedling in dermatology [20]

1. Skin aging symptoms.
2. Scars.
3. Acnea vulgaris, Rosecea.
4. Androgenetic alopecia and alopecia areata.
5. Melasma.
6. Periorbital melanosis.
7. Hyperhidrosis.
8. Verruca.
9. Actinic keratosis.
10. Transdermal delivery of drug.
11. Stretch marks.

Role of microneedling in vitiligo

The needling therapy for vitiligo is predicated on the ideas of activating existing melanocytes in the afflicted region or repopulating it with functional melanocytes. The purpose of the needling method is to transfer and propel the active melanocytes located in the pigmented perimeter of lesions into the centre hypopigmented area [13]. It enhances the epidermal fibroblast proliferation and replication rate and the control of MMP in the upper dermis. The healing of the epidermis and upper dermis induced by MN may result in a reorganization of the microenvironment, triggering vitiligo. The reverse Köbner phenomenon may potentially play a role in vitiligo pigmentation [21].

Moreover, MN induce microinjuries that trigger the cascade for healing of the wounds, resulting in the release of several factors, which includes platelet-derived GF, transforming GF α, transforming GF β, connective tissue activating protein and GF, and fibroblast GF. These substances augment fibroblasts to introduce collagen and promote the migration of melanocytes to depigmented areas [22].

Another significant therapeutic impact of MN is its ability to form tiny channels that improve the administration of topical medicinal medicines. The microchannels exhibit reversible characteristics and occlude after a few hours, contingent upon the MN length. The reversible characteristic of microchannels is beneficial for the regulated administration of topically administered therapies. The amalgamation of MN with several topical treatment agents for vitiligo has been shown to provide more favourable results than any of them alone [23].

Conflict of Interest

Not available

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