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Introduction to Microneedling

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Introduction

Microneedling is a minimally invasive procedure that uses fine needles to puncture the epidermis. The microwounds created stimulate the release of growth factors and induce collagen production. The epidermis remains relatively intact during the procedure.

Microneedling initially was utilized as a collagen induction therapy for facial scars and skin rejuvenation, but it is now widely used for multiple indications, including transdermal delivery system for therapeutic drugs and in combination therapies. The indications for microneedling have grown as research and clinical applications have expanded widely in dermatology and dermatologic surgery.

In this textbook, the authors highlight the constantly evolving research and developments in microneedling techniques and instruments, along with microneedling's applications in dermatology and aesthetic medicine. We are honored to provide a comprehensive and global perspective from key opinion leaders in dermatology and plastic surgery from around the world.

History

Microneedling, or percutaneous collagen induction therapy, was introduced in the 1990s for the treatment of scars, striae, and laxity [1]. The use of needles for non-ablative skin treatment was first described by Orentreich and Orentreich in 1995

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Figure 1.1 Original microneedling roller created by Dr. Desmond Fernandes in 2001. Fixed needle length of 3.0 mm multiuse roller; designed for reuse on a single patient for approximately six treatment sessions. The original rollers were not able to be autoclaved at that time. They were sterilized by soaking in instrument cleaning fluid. *Source:* Dr. Desmond Fernandes.

as subcision surgery, which is the release of depressed scars and wrinkles with a needle from their attachment to the underlying skin. This controlled trauma leads to the formation of connective tissue to fill the created gap.

In 1996, skin needling using a roller device was introduced by Fernandes at the International Society of Aesthetic Plastic Surgery (ISAPS) congress in Taipei [2]. In 1997, Camirand and Doucet introduced dry tattooing without pigment as needle dermabrasion and proposed it as a technique to improve the appearance of scars [3].

Fernandes, in 2001, developed the original percutaneous collagen induction dermaroller with needles. His pilot roller device was a drum-shaped tool, with a cylinder and 3 mm needles that reach the fibroblasts deep in the reticular layer (see Figure 1.1).

Zeitter et al. confirmed Fernandes's findings and made a modified roller. They concluded that 1 mm needles show similar results to 3 mm needles, with the advantage of less downtime, swelling, and pain [3, 4].

Mechanism of action

The mechanism of action is thought to be a disruption of the epidermis and dermis. Micropunctures are created using microneedles, which produce a controlled skin injury without damaging the epidermis. The mechanical microinjury results in the classic wound-healing cascade and stimulates cellular proliferation and migration through the stimulation of growth factors (see Figure 1.2).

These microinjuries lead to minimal superficial bleeding and set up a wound-healing cascade with release of various growth factors, such as platelet-derived growth factor (PDGF), transforming growth factor alpha and beta (TGF α and TGF β), connective tissue activating protein, connective tissue growth factor, and fibroblast growth factor (FGF) [5]. The needles also break down the scar strands



Figure 1.2 The electric pen-shaped device has adjustable settings to control the speed and depth of needle penetration. *Source:* skvalval/Shutterstock.

and allow them to revascularize. Neovascularization and neocollagenesis are initiated by migration and proliferation of fibroblasts and laying down of an intercellular matrix [6, 7]. A fibronectin matrix forms five days after injury and determines the deposition of collagen, resulting in skin tightening persisting for five to seven years in the form of collagen III. The depth of neocollagenesis has been found to be 5–600 μm with a 1.5 mm length needle. Histological examination of the skin treated with four microneedling sessions one month apart shows up to 400% increase in collagen and elastin deposition at six months postoperatively, with a thickened stratum spinosum and normal rete ridges at one year postoperatively [8]. Collagen fiber bundles appear to have a normal lattice pattern rather than parallel bundles as in scar tissue [9].

The devices used create transient epidermal and dermal openings ranging in size from 25 to 3000 μm in depth as a microinjury, with the goal of stimulating the inherent skin repair mechanisms. These microwounds or microinjuries initiate the release of growth factors, which trigger and stimulate collagen and elastin formation in the dermis. That leads to healthier skin with improved texture. The microwounds are microchannels and heal following the classic wound-healing cascade: inflammation, proliferation, and remodeling. This cascade is brought on by the needles' disruption of the stratum corneum; the endothelial lining and the subendothelial matrix recruits platelets and neutrophils to the site of injury. Needling exposes thrombin and collagen fragments, which attract and activate platelets. The platelets form a plug and initiate the clotting cascade, which involves local platelet aggregation, inflammation, and blood coagulation through increased levels of thrombin and fibrin.

The needles carry an electric potential that stimulates fibroblast proliferation [10]. The mechanical injury triggers the release of potassium and proteins that

alter intercellular resting potential, drawing in fibroblasts and stimulating neocollagenesis and revascularization [6].

Research has shown up-regulation of TGF β 3, a cytokine that prevents aberrant scarring; increased gene expression for collagen type I; and elevated levels of vascular endothelial growth factor, fibroblast growth factor, and epidermal growth factor [11–13]. Histological studies have shown huge variation in epidermal thickness. Randomized murine studies have reported statistically significant epidermal thickening from 140% up to 685% after microneedling plus topical vitamins A and C when compared to control [13, 14]. This is thought to be one of the reasons microneedling is effective for scar therapy and notable skin rejuvenation.

A human study of 480 patients treated with microneedling plus topical vitamins A and C reported thickening of the stratum spinosum lasting up to one year [8, 15].

Increased collagen types I, III, and VII and tropoelastin in human biopsies were found after six sessions of microneedling, ten with elevated levels of collagen type I and elastin persisting at six months. The number of melanocytes was unchanged postprocedurally.

These results support the safe use of this modality in patients with darker skin types [8, 15]. Having a safe and effective treatment modality for all skin types is advantageous in an aesthetic practice.

The devices

Modern microneedling devices consist of rollers, stamps, and pens. Needling devices have evolved over the past decade through a variety of advancements. Currently, there are multiple devices based on needle length, drum size, and automation. To date, there are five FDA-approved pen devices. Physicians and providers need to consider important factors like needle length, needle material, and clinical indications in selecting which device to utilize [9].

Pens

Most pens utilize sterile single-use cartridges and variable needle length to be able to customize the treatment depending on the unique characteristics of the patient's skin and the area being treated. They are automated and the physician has the ability to adjust the needle length for customized treatment options and the pressure and depth during treatment can be more uniform (see Figure 1.3) [16].

The pen itself is reusable, and most pens have a protective disposable sleeve. The needle tips are the disposable/consumable in these devices. Because of their size the tips are able to treat curved and small areas such as the nasal ala and the

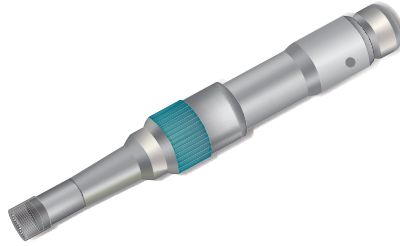


Figure 1.3 Pen: Single-use cartridge with adjustable frequency and needle length. *Source:* Sakurra/Shutterstock.

periocular and perioral areas. Most devices have a rechargeable battery that operates in two modes: high speed mode (700 cycles/minute) and low speed mode (412 cycles/minute) in a vibrating stamp-like manner [17].

The devices contain multiple fine needles, ranging from 0.5 to 1.5 mm in length, that are rolled onto the skin. Needles between 1.5 and 3.0 mm are available but are preferred for the use of scars and damaged skin. The roller device is a drum-shaped tool with a cylindrical head that is rolled back and forth to induce thousands of tiny pores in the stratum corneum and papillary dermis.

The length of needle selected for an individual patient depends upon the indication for microneedling and on the thickness of epidermis and dermis of the skin being treated. For treating acne and other scars, on average a needle length of 1.5–2 mm is utilized. When microneedling is used as a procedure to treat skin aging and wrinkles, a needle length of 0.5 mm or 1.0 mm is recommended [18]. The frequency interval for microneedling depends upon the indication for which the procedure is being done as well as the needle length of the dermaroller device used. Microneedling generally requires more than one session and a series of treatments is usually recommended.

Five basic types of medical dermarollers, which are registered with the FDA, have been described in the dermaroller series by Anastassakis and most dermarolling devices are adopted from these elementary types [19].

Stamps

Stamps were popular in the late 1990s and have made a resurgence recently. The stamps currently offered have attached microchambers which have the ability to directly administer a form of mesotherapy using the stamping device. Stamps have different needle lengths (0.2–3 mm) and a diameter of 0.12 mm. These are useful in the administration of treatment to scars and anatomically small surface areas such as the perioral, periocular, and nasal regions where greater control is beneficial, and may be used on isolated scars and wrinkles (see Figure 1.4) [3, 20–22].

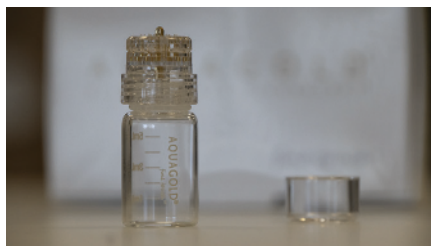


Figure 1.4 Microneedling stamp: fixed needle length with customizable vial for needling infusion.
Source: Aquavit Pharmaceuticals, Inc.

Rollers

Rollers have many fine-gauged needles that are on a cylindrical surface that pierces the skin on an angle. The rollers are fixed; the parameters are uniform for each device that you use. Unlike pens, you can not mechanically adjust rollers. The quality of rollers is also critical. Patients are seeking at-home rollers but the quality of the needles is paramount. Needles that are dull or loose may cause tears in the skin and foreign body reactions, including but not limited to granulomas.

The most important factor is needle length. A high ratio of tip length to diameter (13:1) is an important property of good needles [9]. The length of needle selected for an individual patient depends upon the indication for microneedling. For treating acne and other scars as a routine, a needle length of 1.5–2 mm is usually used. When microneedling is used as a procedure to treat aging skin and wrinkles, a needle length of 0.5 mm or 1.0 mm is usually recommended [19]. The needle length to use will also depend on the thickness of the epidermis and dermis of the skin for optimal results.

Given their design and mechanics, rollers are able to pierce the skin deeper when at a 90-degree angle or perpendicular to the skin. Fernandes showed that with the use of rollers you have an intact epidermis with microchannels spaced out with about a four-cell width distribution [4]. The provider's technique with these devices is critical. Tearing of the epidermis may occur if performed incorrectly, with too much pressure, or at an increased speed. The needle rollers themselves are variable based on the materials used, needle length and diameter, and total number of needles. The quality of the rollers is also critical to evaluate.

Needle length is generally 0.2–3.00 mm, with a diameter of > 0.25 mm and the materials are variable: stainless steel, titanium, or silver and gold. Stainless steel is the most common type of needle, silver and gold offer antimicrobial properties and carry less of a risk of allergic reactions, and titanium needles usually stay sharper longer (see Figure 1.5).



Figure 1.5 Current rollers with fixed needle length; some current models are autoclavable. *Source:* marcinm111/Shutterstock.

DermaFrac

DermaFrac treatment is a newer modification of microneedling combining microdermabrasion, microneedling, simultaneous deep tissue serum infusion, and light emitting diode (LED) therapy. DermaFrac treatments target aging and sun damaged skin, acne, enlarged pores, uneven skin tone, wrinkles, fine lines, hyperpigmentation, and superficial scars. It takes approximately 45 minutes to complete a full face treatment when all four modalities are used. This noninvasive, cost-effective treatment carries the advantage of having no downtime, with individualized selection of serums for infusion (see Figure 1.6) [22].



Figure 1.6 DermaFrac™: Microneedling device combining simultaneous customized infusion followed by LED light therapy. *Source:* Genesis Biosystems, Inc.

Clinical considerations

Microneedling is not only used for rejuvenation of the skin. Its use in dermatology and aesthetic medicine has expanded to include the treatment of acne scars, alopecia, dyspigmentation, alopecia, striae, and for many other indications. It can be utilized alone or in combination with other treatment modalities, such as chemical

peels, platelet-rich plasma, radiofrequency, subcision, punch elevation, and lasers. It is often used in conjunction with a topical formulation to enhance its penetration and action.

Microneedling is safely used for enhanced drug delivery to the deeper epidermis and dermis by bypassing the stratum corneum. This strategy has been utilized for burn patients and for rejuvenation, allowing cosmeceuticals to be delivered more deeply. Caution is necessary in deciding which topicals to use during delivery, as inflammation may occur and granulomas have been noted.

Conclusion

Microneedling is a popular treatment in dermatology and aesthetic medicine. Since the development of the first dermaroller over 20 years ago, a variety of new microneedling devices have been introduced. Accordingly, the applications of microneedling in dermatology and aesthetic medicine have expanded indications over the past several years.

Evidence-based treatment of the skin for a variety of indications have been shown to be safe on all skin types. Microneedling is an effective modality of treatment, especially in patients with Fitzpatrick's IV and V skin types because it overcomes the side effects of scarring and hyperpigmentation resulting from other procedures in which the epidermis is compromised. It certainly promises to be a valuable technique with its numerous applications and its ever-expanding modifications.

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