Microneedling with Hyaluronic Acid for Acne Scars: Factors Influencing Therapeutic Outcomes

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Abstract

Background: Acne scarring represents a frequent and distressing complication of acne vulgaris, often leading to significant psychosocial burden and reduced quality of life. Atrophic acne scars, including ice-pick, boxcar, and rolling scars, arise from dermal matrix destruction and abnormal wound healing following inflammatory acne lesions. Various therapeutic modalities have been developed to improve scar appearance, including chemical peels, laser resurfacing, subcision, dermal fillers, and microneedling. Among these, microneedling has gained substantial attention due to its minimally invasive nature, favorable safety profile, and effectiveness across different skin phototypes. In recent years, the combination of microneedling with topical or transdermal delivery of hyaluronic acid has emerged as a promising strategy to enhance clinical outcomes in acne scar management.

Microneedling induces controlled micro-injuries in the skin that stimulate dermal remodeling through the release of growth factors and activation of fibroblasts, ultimately promoting collagen and elastin synthesis. These microchannels also facilitate transdermal drug delivery, enabling enhanced penetration of bioactive substances such as hyaluronic acid. Hyaluronic acid is a naturally occurring glycosaminoglycan with important roles in tissue hydration, extracellular matrix stabilization, and wound healing. When applied in conjunction with microneedling, hyaluronic acid may improve dermal regeneration, enhance hydration, and support collagen remodeling, thereby contributing to improved scar texture and skin elasticity.

Despite the increasing clinical use of microneedling combined with hyaluronic acid, treatment outcomes may vary considerably among patients. Several factors influence the degree of clinical improvement, including scar morphology and severity, patient age, skin phototype, treatment parameters, number of sessions, and adjunctive skincare protocols. Understanding these determinants is essential for optimizing treatment strategies and achieving consistent therapeutic results. Moreover, evaluating the mechanisms underlying combination therapy may provide insights into personalized approaches for acne scar management.

This review aims to summarize current evidence regarding the use of microneedling combined with hyaluronic acid for the treatment of acne scars and to explore the key factors associated with therapeutic improvement. Particular emphasis is placed on patient-related variables, procedural parameters, and biological mechanisms that contribute to treatment success. By identifying these factors, clinicians may refine treatment protocols and improve clinical outcomes in patients with atrophic acne scars.

Keywords: *Acne scars; Microneedling; Hyaluronic acid; Atrophic acne scars; Percutaneous collagen induction; Transdermal drug delivery; Dermal remodeling; Skin rejuvenation; Scar treatment outcomes; Predictors of therapeutic response.*

Introduction

Acne vulgaris is one of the most prevalent dermatological disorders worldwide and frequently affects adolescents and young adults. Although active acne lesions may resolve over time, many patients develop permanent sequelae in the form of acne scars. These scars are often the result of prolonged inflammation, follicular rupture, and abnormal wound healing processes that lead to dermal matrix destruction and fibrotic remodeling. Atrophic acne scars, including ice-pick, boxcar, and rolling scars, represent the most common subtype and are characterized by loss of dermal collagen and structural support. The presence of acne scars can significantly affect patients' psychological well-being, contributing to decreased self-esteem, anxiety, and social withdrawal. Therefore, the development of effective and safe therapeutic strategies for acne scar management has become an important focus in dermatologic and aesthetic practice. [1]

Multiple treatment modalities have been introduced to address acne scars, including chemical peeling, laser resurfacing, dermabrasion, subcision, dermal fillers, and radiofrequency devices. Each of these modalities aims to stimulate dermal remodeling and improve skin texture; however, they differ in efficacy, downtime, cost, and risk of adverse events. Laser-based treatments and deep resurfacing techniques may provide substantial improvement but are often associated with higher risks of post-inflammatory hyperpigmentation, particularly in individuals with darker skin phototypes. Consequently, minimally invasive procedures with favorable safety profiles have gained increasing popularity. Among these, microneedling—also referred to as percutaneous collagen induction therapy—has emerged as an effective treatment option that stimulates dermal regeneration with relatively low risk and minimal recovery time. [2]

Microneedling works by creating multiple controlled micro-injuries in the skin using fine needles that penetrate the epidermis and superficial dermis. These microchannels initiate a cascade of wound-healing events, including platelet activation, release of growth factors, fibroblast proliferation, and synthesis of collagen and elastin fibers. The resulting dermal remodeling gradually improves scar depth, skin texture, and overall appearance. Importantly, microneedling preserves the integrity of the epidermis and does not rely on thermal injury, which contributes to its favorable safety profile across a wide range of skin phototypes. Several clinical studies have demonstrated significant improvement in atrophic acne scars following multiple microneedling sessions, supporting its role as a reliable and cost-effective therapeutic approach. [3]

In addition to its intrinsic collagen-inducing effect, microneedling also enhances transdermal delivery of topical agents through the microchannels created during the procedure. This feature has stimulated growing interest in combining microneedling with bioactive compounds that may enhance dermal regeneration. Hyaluronic acid (HA), a naturally occurring glycosaminoglycan found in the extracellular matrix of the skin, has been widely utilized in dermatology due to its hydrating, viscoelastic, and wound-healing properties. HA plays a critical role in tissue repair by regulating cellular migration, modulating inflammation, and supporting collagen synthesis. When applied immediately after microneedling, HA can penetrate deeper skin layers and potentially amplify regenerative processes within the dermis. [4]

Recent clinical studies have investigated the combined use of microneedling and hyaluronic acid in the treatment of atrophic acne scars, demonstrating encouraging improvements in scar appearance, skin hydration, and elasticity. The synergistic effect of this combination therapy is believed to arise from both mechanical stimulation of collagen production and biochemical support of dermal repair provided by hyaluronic acid. Furthermore, the procedure is generally well tolerated, with transient erythema and mild edema representing the most commonly reported adverse effects. These advantages make microneedling combined with HA an appealing therapeutic option in modern aesthetic dermatology. [5]

Despite the growing popularity of this combination approach, clinical outcomes remain variable among

patients. Factors such as scar morphology, severity of scarring, patient age, skin phototype, needle length, treatment intervals, and number of sessions may significantly influence the degree of clinical improvement achieved. Additionally, variations in the molecular weight and formulation of hyaluronic acid, as well as differences in procedural techniques, may further affect therapeutic results. Understanding these determinants is essential for optimizing treatment protocols and selecting appropriate candidates for therapy. However, current literature often focuses on efficacy outcomes rather than systematically examining the predictors of treatment success. [6]

Therefore, an important gap remains in the dermatologic literature regarding the factors that influence therapeutic outcomes when microneedling is combined with hyaluronic acid for acne scar treatment. Identifying these factors could help clinicians tailor treatment protocols to individual patients, improve response rates, and minimize unnecessary procedures. Moreover, a comprehensive understanding of the biological mechanisms underlying this combination therapy may contribute to the development of more effective and personalized strategies for acne scar management. [7]

The aim of this review is to analyze current evidence on the use of microneedling combined with hyaluronic acid for the treatment of atrophic acne scars and to explore the key clinical and procedural factors associated with therapeutic improvement. By synthesizing available data on patient characteristics, scar morphology, treatment parameters, and biological mechanisms, this review seeks to provide dermatologists with practical insights for optimizing treatment outcomes in patients suffering from acne scarring. [8]

Pathophysiology of Acne Scarring

Acne scarring develops as a consequence of abnormal wound healing following inflammatory acne lesions. The formation of scars is largely driven by the intensity and duration of inflammation occurring within the pilosebaceous unit. During active acne, follicular rupture releases keratin, sebum, and bacterial components into the surrounding dermis, triggering a pronounced inflammatory response. This process involves the recruitment of neutrophils, macrophages, and lymphocytes, which release inflammatory mediators and proteolytic enzymes. These enzymes degrade extracellular matrix components such as collagen and elastin, resulting in structural damage to the dermis. When the tissue repair process fails to adequately restore the damaged dermal matrix, permanent scars may form. [9]

Matrix metalloproteinases (MMPs) play a significant role in the development of acne scars by contributing to collagen degradation and tissue remodeling. During the inflammatory phase of acne lesions, increased levels of MMPs lead to excessive breakdown of collagen fibers within the dermis. At the same time, the synthesis of new collagen by fibroblasts may be insufficient to compensate for the loss of structural proteins. This imbalance between matrix degradation and synthesis ultimately results in dermal atrophy and the formation of depressed scars. Additionally, prolonged inflammation may disrupt normal fibroblast activity, further impairing proper tissue regeneration and contributing to irregular scar architecture. [10]

Another important component in acne scar formation is the alteration of the dermal extracellular matrix. The extracellular matrix provides structural integrity and mechanical support to the skin through a complex network of collagen, elastin, glycosaminoglycans, and proteoglycans. In acne lesions, inflammatory mediators such as tumor necrosis factor-alpha (TNF-α) and interleukins stimulate enzymatic degradation of these structural components. The resulting loss of collagen fibers weakens the dermal framework, creating depressions in the skin surface that are clinically recognized as atrophic scars. Furthermore, abnormal deposition of fibrotic tissue during the healing process may tether the epidermis to deeper structures, contributing to the persistence of scar deformities. [11]

Genetic susceptibility and host immune response also influence the likelihood of developing acne scars. Some individuals exhibit exaggerated inflammatory responses to acne lesions, increasing the risk of tissue destruction and subsequent scarring. Genetic factors may affect collagen synthesis, inflammatory mediator production, and wound-healing efficiency. In addition, delayed or inadequate treatment of inflammatory acne increases the duration of dermal inflammation, thereby raising the probability of scar formation. Early therapeutic intervention aimed at controlling inflammation is therefore considered an essential strategy for preventing permanent scarring in susceptible individuals. [12]

The wound healing process itself consists of several overlapping phases, including inflammation, proliferation, and remodeling. In normal healing, fibroblasts migrate to the site of injury and produce collagen type III, which is gradually replaced by stronger collagen type I during the remodeling phase. However, in acne scars this process becomes dysregulated. Inadequate collagen deposition results in dermal thinning and the formation of depressed scars, while excessive collagen production may lead to hypertrophic scars or keloids. Understanding these biological mechanisms is crucial for developing treatments such as microneedling that aim to stimulate controlled wound healing and promote balanced collagen remodeling. [13]

Classification of Acne Scars

Acne scars are broadly categorized into atrophic and hypertrophic types based on the relative loss or excess of dermal tissue. Atrophic scars are the most common form, accounting for approximately 80–90% of acne scars. They are characterized by dermal tissue loss and appear as depressions in the skin surface. Hypertrophic scars and keloids, on the other hand, result from excessive collagen deposition and present as raised lesions. Proper classification of acne scars is essential for selecting appropriate treatment modalities, as different scar types respond differently to therapeutic interventions. [14]

Atrophic acne scars are further subdivided into three major morphological types: ice-pick scars, boxcar scars, and rolling scars. Ice-pick scars are narrow, deep, and sharply demarcated tracts that extend vertically into the dermis, often resembling puncture wounds. Due to their depth and narrow opening, ice-pick scars are generally more resistant to treatment and may require targeted procedures such as chemical reconstruction or punch excision. These scars frequently develop following deep inflammatory lesions that destroy the follicular wall and adjacent dermal structures. [15]

Boxcar scars are characterized by well-defined edges and a wider, round or oval depression with a flat base. They may be classified as either shallow or deep depending on the extent of dermal involvement. Shallow boxcar scars often respond well to resurfacing techniques such as microneedling, laser therapy, or chemical peels, whereas deeper variants may require more aggressive procedures including subcision or fractional laser resurfacing. The structural loss of collagen within the dermis contributes to the sharply demarcated appearance of these scars. [16]

Rolling scars represent another common subtype of atrophic acne scars and are characterized by broad depressions with sloping edges that give the skin a wave-like or undulating appearance. These scars occur due to fibrous bands that anchor the dermis to underlying subcutaneous tissue, creating surface irregularities. Because rolling scars are primarily caused by dermal tethering rather than simple tissue loss, treatments such as subcision combined with collagen-stimulating procedures—including microneedling—can be particularly effective in improving their appearance. [17]

In addition to morphological classification, several grading systems have been proposed to assess the severity of acne scarring. One of the most widely used systems is the Goodman and Baron qualitative and quantitative grading scale, which categorizes scars based on their visibility and response to skin stretching. This grading system helps clinicians evaluate baseline severity and monitor treatment response over time. Accurate assessment of scar type and severity is crucial in determining appropriate treatment strategies and predicting therapeutic outcomes when procedures such as microneedling combined with hyaluronic acid are employed. [18]

Principles of Microneedling in Scar Remodeling

Microneedling, also known as percutaneous collagen induction therapy, is a minimally invasive dermatologic procedure designed to stimulate dermal remodeling through controlled mechanical injury. The technique involves the use of devices equipped with fine needles that penetrate the epidermis and superficial dermis, creating numerous microchannels in the skin. These controlled micro-injuries initiate a physiological wound healing cascade that ultimately promotes collagen and elastin synthesis. Unlike ablative resurfacing techniques, microneedling preserves the integrity of the epidermis while stimulating dermal regeneration, making it a safe and effective option for treating atrophic acne scars across different skin phototypes. [19]

The therapeutic effect of microneedling is largely attributed to the activation of the wound healing response. Following needle penetration, platelets are activated and release a variety of growth factors, including platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF-β), and fibroblast growth factor (FGF). These mediators stimulate fibroblast proliferation and migration within the dermis, resulting in the production of new collagen and elastin fibers. Over time, this process leads to thickening of the dermal layer and gradual elevation of depressed scars. The remodeling phase of wound healing also involves reorganization of collagen fibers, which contributes to improved skin texture and elasticity. [20]

Another important advantage of microneedling is its ability to enhance transdermal drug delivery. The microchannels created during the procedure temporarily disrupt the stratum corneum, which normally acts as the primary barrier to topical drug penetration. This disruption allows topical agents applied immediately after the procedure to penetrate deeper into the dermis. As a result, microneedling has increasingly been used as a delivery platform for various therapeutic substances such as platelet-rich plasma, vitamin C, growth factors, and hyaluronic acid. This approach may enhance the regenerative effects of the procedure by combining mechanical stimulation with biochemical support. [21]

Clinical studies have demonstrated that repeated microneedling sessions can lead to significant improvements in the appearance of atrophic acne scars. Patients often experience gradual reduction in scar depth, smoother skin texture, and enhanced overall skin quality after multiple treatments. The degree of improvement is generally influenced by factors such as needle length, treatment intervals, number of sessions, and the baseline severity of scarring. Compared with more aggressive resurfacing techniques, microneedling offers the advantages of shorter recovery time, lower cost, and reduced risk of complications such as post-inflammatory hyperpigmentation. These characteristics have contributed to its growing popularity in both clinical dermatology and aesthetic practice. [22]

Furthermore, microneedling induces minimal epidermal damage and does not rely on thermal energy, which distinguishes it from laser-based resurfacing methods. The absence of thermal injury significantly reduces the likelihood of pigmentary alterations, particularly in individuals with darker skin phototypes (Fitzpatrick IV–VI). This safety profile makes microneedling an attractive treatment option for patients who may not be ideal candidates for laser therapy. Consequently, microneedling has become widely accepted as a versatile and effective modality for the management of acne scars and other dermatologic conditions involving dermal remodeling. [23]

Biological Role of Hyaluronic Acid in Skin Repair

Hyaluronic acid (HA) is a naturally occurring glycosaminoglycan that plays a critical role in maintaining skin hydration, elasticity, and structural integrity. It is a major component of the extracellular matrix and is abundantly present in the dermis, where it contributes to tissue hydration by binding large amounts of water molecules. This unique hydrophilic property allows HA to maintain optimal skin moisture and volume, supporting cellular function and maintaining dermal architecture. In addition to its structural role, hyaluronic acid also participates in several biological processes involved in tissue repair and regeneration. [24]

One of the key functions of hyaluronic acid in wound healing is the regulation of cellular migration and proliferation. During tissue injury, HA levels increase within the extracellular matrix, facilitating the movement of keratinocytes and fibroblasts toward the wound site. These cells play essential roles in re-epithelialization and collagen production. HA also interacts with cell surface receptors such as CD44, which helps regulate inflammatory responses and promote tissue remodeling. Through these mechanisms, hyaluronic acid contributes to efficient wound healing and restoration of normal skin structure. [25]

Hyaluronic acid also plays a significant role in modulating inflammation during the healing process. Low molecular weight HA fragments generated during tissue injury can stimulate immune responses and promote the release of cytokines that initiate repair mechanisms. Conversely, high molecular weight HA exhibits anti-inflammatory properties and helps maintain tissue homeostasis by regulating immune cell activity. This dual role allows HA to participate in both the initiation and resolution phases of wound healing, ensuring balanced tissue regeneration. Such properties make it particularly valuable in dermatologic therapies aimed at improving scar appearance and promoting dermal repair. [26]

In the context of acne scar treatment, hyaluronic acid has been widely utilized for its regenerative and hydrating effects. Topical formulations and injectable HA fillers have demonstrated the ability to improve skin texture and enhance dermal volume in areas affected by atrophic scars. By increasing dermal hydration and stimulating fibroblast activity, HA supports collagen synthesis and contributes to improved skin elasticity. When used in conjunction with microneedling, hyaluronic acid can penetrate deeper layers of the skin through the microchannels created during the procedure, thereby enhancing its therapeutic effects. [27]

Recent studies have suggested that combining microneedling with topical hyaluronic acid may produce synergistic benefits in acne scar treatment. The mechanical stimulation induced by microneedling triggers collagen production, while the application of HA provides a favorable extracellular environment for tissue regeneration. This combination approach not only improves dermal hydration but also supports the remodeling of damaged collagen networks. As a result, patients may experience enhanced improvement in scar depth, skin smoothness, and overall appearance compared with microneedling alone. These findings have encouraged further research into combination therapies that integrate mechanical and biochemical strategies for optimal scar management. [28]

Rationale for Combining Microneedling with Hyaluronic Acid

The combination of microneedling with hyaluronic acid has gained considerable attention as an advanced therapeutic approach for the management of atrophic acne scars. While microneedling stimulates dermal remodeling through controlled mechanical injury, hyaluronic acid provides biochemical support that enhances tissue repair and regeneration. The integration of these two modalities allows clinicians to exploit both the physical stimulation of collagen production and the biological benefits of extracellular matrix augmentation. This synergistic interaction forms the scientific rationale behind the growing use of combination therapy in aesthetic dermatology. [29]

Microneedling alone induces collagen synthesis by activating the natural wound healing cascade, which involves platelet activation, release of growth factors, and recruitment of fibroblasts. However, the regenerative capacity of the dermis may be limited by factors such as reduced hydration, impaired extracellular matrix integrity, or diminished fibroblast activity in scarred tissue. Hyaluronic acid helps address these limitations by maintaining optimal hydration within the dermal environment and providing a scaffold that facilitates cellular migration and proliferation. By improving the biochemical milieu of the skin, HA may enhance the regenerative processes initiated by microneedling. [30]

Another important advantage of combining microneedling with hyaluronic acid is the enhancement of transdermal drug delivery. The microchannels created by microneedling temporarily disrupt the stratum corneum barrier, allowing topical substances to penetrate deeper layers of the skin. This mechanism significantly increases the bioavailability of applied agents such as hyaluronic acid. Consequently, HA molecules can reach the dermis more effectively, where they interact with fibroblasts and extracellular matrix components to support tissue repair and collagen remodeling. [31]

In addition to facilitating deeper penetration, microneedling may also increase the biological activity of hyaluronic acid by stimulating cellular receptors involved in wound healing. HA interacts with cell surface receptors such as CD44 and RHAMM, which regulate cell proliferation, migration, and matrix synthesis. When delivered through microneedling-induced channels, hyaluronic acid may exert stronger stimulatory effects on fibroblasts and keratinocytes. This interaction promotes collagen production and improves dermal architecture, contributing to the gradual elevation of atrophic acne scars. [32]

Clinical studies evaluating microneedling combined with topical hyaluronic acid have reported encouraging outcomes in terms of scar depth reduction, skin texture improvement, and overall patient satisfaction. Compared with microneedling alone, combination therapy may provide enhanced hydration, faster tissue recovery, and improved collagen remodeling. These benefits are particularly relevant in patients with moderate to severe atrophic scars, where multiple mechanisms of tissue repair are required to achieve visible improvement. As a result, this combination approach has become increasingly integrated into modern dermatologic treatment protocols. [33]

Mechanisms of Dermal Remodeling in Combination Therapy

The therapeutic success of microneedling combined with hyaluronic acid largely depends on the complex biological processes involved in dermal remodeling. Following microneedling, the skin undergoes a controlled wound healing response that progresses through inflammatory, proliferative, and remodeling phases. During the inflammatory phase, cytokines and growth factors are released at the site of injury, initiating cellular recruitment and activation. These mediators stimulate fibroblasts and keratinocytes to participate in tissue repair, setting the stage for subsequent collagen synthesis and matrix reorganization. [34]

During the proliferative phase of wound healing, fibroblasts become highly active and begin producing extracellular matrix components, including collagen type III, elastin, and glycosaminoglycans. Hyaluronic acid plays a crucial role at this stage by maintaining a hydrated microenvironment that facilitates cellular migration and proliferation. The presence of HA within the extracellular matrix supports the formation of new collagen fibers and promotes the organization of dermal tissue. This process gradually increases dermal thickness and contributes to the elevation of depressed acne scars. [35]

As the healing process progresses to the remodeling phase, newly synthesized collagen fibers undergo structural reorganization and replacement with stronger collagen type I. This remodeling process may continue for several months following microneedling treatment. Hyaluronic acid contributes to this phase by stabilizing the extracellular matrix and regulating collagen deposition. By maintaining hydration and providing structural support, HA helps ensure that newly formed collagen fibers are properly aligned, leading to improved skin texture and elasticity. [36]

Another mechanism involved in combination therapy is the stimulation of angiogenesis. Microneedling-induced micro-injuries promote the formation of new blood vessels within the dermis, enhancing oxygen and nutrient delivery to regenerating tissues. Hyaluronic acid further supports angiogenesis by interacting with endothelial cells and promoting vascular growth factors. Increased vascularization improves tissue metabolism and accelerates the repair of damaged dermal structures, thereby contributing to better clinical outcomes in acne scar treatment. [37]

Additionally, the combination of microneedling and hyaluronic acid may modulate inflammatory responses within the skin. Controlled inflammation is necessary for initiating tissue repair; however, excessive or prolonged inflammation can impair healing and contribute to scar formation. Hyaluronic acid helps regulate inflammatory pathways by interacting with immune cells and cytokines, promoting a balanced healing response. This modulation of inflammation, combined with enhanced collagen synthesis and extracellular matrix stabilization, forms the biological basis for the improved therapeutic outcomes observed with combination therapy in acne scar management. [38]

Clinical Evidence of Microneedling in Acne Scars

Microneedling has been widely investigated as a therapeutic modality for the treatment of atrophic acne scars due to its ability to stimulate collagen production and dermal remodeling. Several clinical studies have demonstrated significant improvement in scar appearance following multiple sessions of microneedling. Early research by Aust and colleagues highlighted the effectiveness of percutaneous collagen induction therapy in improving skin texture and reducing scar depth through stimulation of fibroblast activity and neocollagenesis. Their findings suggested that repeated microneedling treatments could result in progressive dermal thickening and visible improvement in atrophic scars with minimal downtime. [39]

Subsequent clinical trials have further confirmed the efficacy of microneedling in acne scar management. In a prospective study evaluating patients with atrophic acne scars, multiple sessions of microneedling resulted in significant improvement in scar severity scores and patient satisfaction. The procedure was well tolerated, with transient erythema and mild edema being the most commonly reported side effects. Importantly, the treatment demonstrated a favorable safety profile in individuals with darker skin phototypes, where other resurfacing procedures may carry a higher risk of post-inflammatory hyperpigmentation. [40]

Another study assessing the effectiveness of microneedling in acne scars demonstrated that the procedure significantly improved rolling and boxcar scars after a series of treatments. The mechanism behind this

improvement is primarily related to collagen induction and the release of growth factors that stimulate dermal repair. Histological evaluations following microneedling have shown increased collagen and elastin deposition in the dermis, which contributes to improved skin texture and reduced scar depth over time. These findings support the use of microneedling as a reliable therapeutic option for patients with atrophic acne scars. [41]

Microneedling has also been compared with other treatment modalities such as fractional laser therapy and chemical peeling. Although laser treatments may provide more aggressive resurfacing, microneedling offers several advantages, including lower cost, minimal downtime, and a reduced risk of pigmentary complications. Comparative studies have shown that microneedling can achieve comparable improvement in mild to moderate acne scars, particularly when performed in multiple sessions. These findings have contributed to the growing acceptance of microneedling as a first-line or adjunctive treatment option in acne scar management. [42]

Despite its effectiveness, the degree of improvement achieved with microneedling alone may vary depending on factors such as scar type, treatment parameters, and individual patient characteristics. For example, rolling scars generally respond better to microneedling due to their association with dermal tethering and collagen loss, whereas deep ice-pick scars may require additional procedures. These variations in treatment response have prompted researchers to explore combination therapies that may enhance the regenerative effects of microneedling and improve overall clinical outcomes. [43]

Clinical Evidence of Microneedling Combined with Hyaluronic Acid

In recent years, the combination of microneedling with hyaluronic acid has been explored as a strategy to enhance therapeutic outcomes in acne scar treatment. By utilizing the microchannels created during microneedling, topical hyaluronic acid can penetrate deeper into the dermis and exert its regenerative effects more effectively. Several clinical studies have investigated this combination approach and reported promising results in terms of improved scar appearance and skin quality. [44]

One clinical study evaluating the use of microneedling combined with topical hyaluronic acid demonstrated significant improvement in atrophic acne scars after multiple treatment sessions. Patients showed reductions in scar depth and improvements in skin texture and elasticity. The application of hyaluronic acid following microneedling was believed to enhance dermal hydration and support collagen synthesis, thereby amplifying the regenerative effects of the procedure. These findings suggest that the addition of HA may improve treatment outcomes compared with microneedling alone. [45]

Another study assessing microneedling-assisted transdermal delivery of hyaluronic acid reported enhanced patient satisfaction and faster recovery times compared with traditional microneedling protocols. The hydrating properties of HA helped reduce post-procedure dryness and irritation while promoting tissue repair. Furthermore, the presence of hyaluronic acid within the extracellular matrix provided structural support for newly synthesized collagen fibers, contributing to improved skin elasticity and scar elevation. [46]

Clinical observations also indicate that combination therapy may be particularly beneficial in patients with moderate acne scarring, where both dermal atrophy and reduced skin hydration contribute to scar visibility. The addition of hyaluronic acid enhances the extracellular environment necessary for effective tissue regeneration, allowing fibroblasts to function more efficiently during the healing process. As a result, patients may experience more consistent improvements in skin texture and overall appearance. [47]

Overall, current clinical evidence suggests that microneedling combined with hyaluronic acid represents a promising therapeutic approach for acne scar management. The synergistic interaction between mechanical collagen induction and biochemical support from hyaluronic acid may lead to improved clinical outcomes compared with monotherapy. However, further well-designed randomized controlled trials are needed to establish standardized treatment protocols and determine the specific patient-related factors that influence therapeutic response. [48]

Factors Influencing Therapeutic Outcomes

Scar Type and Morphology

The morphology of acne scars is one of the most important determinants influencing the clinical response

to microneedling combined with hyaluronic acid. Different scar types exhibit varying degrees of dermal damage, depth, and structural alterations, which can significantly affect treatment outcomes. Rolling scars and shallow boxcar scars generally respond more favorably to microneedling because these lesions are primarily associated with dermal collagen loss and fibrous tethering. The collagen induction stimulated by microneedling helps elevate depressed areas by promoting dermal thickening and remodeling. When combined with hyaluronic acid, the regenerative environment within the dermis is further enhanced, facilitating improved tissue repair and scar elevation. [49]

In contrast, ice-pick scars are often more resistant to microneedling therapy due to their narrow, deep morphology that extends into the reticular dermis or subcutaneous tissue. Because microneedling primarily stimulates collagen production within the superficial dermis, its ability to correct deeply penetrating scars may be limited. Consequently, ice-pick scars often require additional treatment modalities such as chemical reconstruction using trichloroacetic acid (TCA CROSS), punch excision, or laser resurfacing. However, microneedling combined with hyaluronic acid may still provide modest improvement in surrounding skin texture and overall scar appearance when incorporated into combination treatment protocols. [50]

Severity of Acne Scars

The baseline severity of acne scars also plays a crucial role in determining therapeutic outcomes following microneedling with hyaluronic acid. Patients with mild to moderate scarring generally demonstrate better clinical improvement compared with those who have severe or deeply atrophic scars. In cases of mild scarring, the dermal matrix remains partially intact, allowing collagen induction therapies to effectively stimulate tissue regeneration and restore skin architecture. The addition of hyaluronic acid further enhances dermal hydration and extracellular matrix stability, supporting more efficient collagen remodeling. [51]

Conversely, severe acne scars often involve extensive dermal destruction and fibrotic tethering, which may limit the regenerative capacity of the skin. In such cases, microneedling alone or in combination with hyaluronic acid may not be sufficient to achieve optimal results. Patients with severe scarring may require multimodal treatment approaches that include subcision, fractional laser resurfacing, or dermal fillers in addition to microneedling. Nonetheless, combination therapy with hyaluronic acid can still contribute to improved skin texture and hydration, thereby enhancing the overall aesthetic outcome. [52]

Patient Age

Patient age is another factor that can influence the effectiveness of microneedling-based therapies. Younger individuals typically demonstrate more robust wound healing responses due to higher fibroblast activity and greater collagen synthesis capacity. As a result, younger patients often experience more pronounced improvements in acne scars following microneedling procedures. The regenerative potential of the skin in younger individuals allows for more efficient collagen remodeling and dermal repair. [53]

In older patients, age-related changes in skin physiology may reduce the regenerative response to microneedling. Aging skin is characterized by decreased fibroblast activity, reduced collagen production, and diminished extracellular matrix components, including hyaluronic acid. These changes can slow the wound healing process and limit the extent of dermal remodeling achieved through microneedling. However, the application of exogenous hyaluronic acid during treatment may partially compensate for age-related depletion of endogenous HA, helping to improve skin hydration and support tissue regeneration. [54]

Skin Phototype

Skin phototype is an important consideration when selecting treatment modalities for acne scars. Patients with darker skin types (Fitzpatrick IV–VI) are more prone to post-inflammatory hyperpigmentation following aggressive resurfacing procedures such as ablative laser therapy or deep chemical peels. Microneedling offers a safer alternative for these individuals because it does not rely on thermal injury and preserves the epidermal barrier. As a result, the risk of pigmentary complications is significantly reduced. [55]

The addition of hyaluronic acid may further enhance the safety and effectiveness of microneedling in

patients with darker skin phototypes. By improving skin hydration and supporting tissue repair, HA may help reduce post-procedure inflammation and accelerate recovery. Clinical studies have demonstrated favorable outcomes in patients with higher Fitzpatrick skin types treated with microneedling-based therapies, making this approach particularly valuable in populations where pigmentary risks are a major concern. [56]

Treatment Parameters

Procedural variables such as needle length, treatment frequency, and number of sessions are critical factors influencing therapeutic outcomes in microneedling treatments. Needle lengths typically range from 0.5 to 2.5 mm depending on the depth of the scars being treated. Longer needles are often required for deeper atrophic scars to ensure adequate stimulation of the dermal layer. However, excessively aggressive treatment may increase the risk of adverse effects such as prolonged erythema or post-inflammatory pigmentation. Therefore, selecting appropriate needle depth based on scar morphology is essential for optimizing treatment efficacy and safety. [57]

The number of treatment sessions and intervals between procedures also influence clinical outcomes. Most treatment protocols recommend multiple sessions spaced approximately four to six weeks apart to allow sufficient time for collagen remodeling between treatments. Gradual improvement in scar appearance is typically observed over several months as newly synthesized collagen fibers reorganize within the dermis. The addition of hyaluronic acid during each session may enhance the regenerative process by maintaining optimal dermal hydration and supporting fibroblast activity throughout the treatment course. [58]

Assessment Methods for Clinical Improvement

Accurate evaluation of treatment outcomes is essential when assessing the effectiveness of microneedling combined with hyaluronic acid in acne scar management. Several clinical and objective assessment tools have been developed to measure changes in scar severity and overall skin appearance. Among these, clinical grading systems remain the most commonly used methods in dermatologic practice. The Goodman and Baron qualitative and quantitative grading systems are widely applied to classify acne scars and monitor treatment response. These scales categorize scars based on their visibility, depth, and response to skin stretching, allowing clinicians to assess baseline severity and measure improvement following therapeutic interventions. [59]

In addition to qualitative grading systems, standardized photographic documentation plays a crucial role in evaluating treatment outcomes. High-resolution clinical photography taken under consistent lighting and positioning conditions enables dermatologists to compare baseline and post-treatment images accurately. This method allows for visual assessment of improvements in scar depth, skin texture, and overall facial appearance. Standardized photography is particularly useful in clinical studies because it provides objective evidence of treatment efficacy and facilitates comparison across different treatment modalities. [60]

Patient-reported outcome measures also contribute significantly to the assessment of therapeutic success. Because acne scars can have a substantial psychological impact, patient satisfaction and perceived improvement are important indicators of treatment effectiveness. Various studies have incorporated patient satisfaction scales and quality-of-life questionnaires to evaluate the psychological benefits associated with acne scar treatment. Improvements in self-esteem and social confidence often accompany visible improvements in skin appearance, highlighting the importance of incorporating patient perspectives into outcome assessment. [61]

Advances in dermatologic imaging technologies have introduced more objective methods for evaluating acne scar improvement. Techniques such as three-dimensional optical imaging, dermoscopy, and skin topography analysis allow precise measurement of scar depth and surface irregularities. These technologies provide quantitative data on skin texture and volume changes following treatment. Such objective measurements can enhance the accuracy of clinical evaluations and provide valuable insights into the mechanisms underlying scar remodeling after microneedling combined with hyaluronic acid. [62]

Overall, the use of multiple assessment methods—including clinical grading systems, photographic documentation, patient-reported outcomes, and imaging technologies—provides a comprehensive

evaluation of treatment efficacy. Combining subjective and objective measures allows clinicians and researchers to obtain a more accurate understanding of therapeutic outcomes and better determine the effectiveness of microneedling combined with hyaluronic acid in improving acne scars. [63]

Adverse Effects and Safety Profile

Microneedling combined with hyaluronic acid is generally considered a safe and well-tolerated procedure for the treatment of acne scars. One of the major advantages of microneedling is its minimally invasive nature and preservation of the epidermal barrier. Unlike ablative laser procedures or deep chemical peels, microneedling does not rely on thermal injury, which significantly reduces the risk of complications such as scarring or permanent pigmentary alterations. As a result, the procedure has become increasingly popular in dermatologic practice due to its favorable safety profile. [64]

The most common adverse effects associated with microneedling are transient and typically resolve within a few days. Patients frequently experience mild erythema, edema, and a sensation of skin tightness immediately following the procedure. These reactions are expected results of the controlled micro-injury induced during treatment and are part of the normal wound healing process. In most cases, erythema subsides within 24 to 72 hours without requiring medical intervention. [65]

Minor complications such as temporary dryness, scaling, or mild irritation may also occur, particularly when topical agents are applied following the procedure. However, the use of hyaluronic acid after microneedling often helps reduce these symptoms due to its hydrating and soothing properties. HA supports skin barrier recovery and helps maintain moisture balance within the epidermis, which may contribute to faster post-procedure recovery and improved patient comfort. [66]

Although rare, more significant complications such as post-inflammatory hyperpigmentation, infection, or prolonged erythema have been reported in some cases. These events are typically associated with improper technique, inadequate sterilization, or overly aggressive treatment parameters. Careful patient selection, adherence to sterile procedures, and appropriate post-treatment care are essential to minimize the risk of such complications. In patients with darker skin phototypes, the risk of pigmentary changes remains lower compared with many other resurfacing procedures, further supporting the safety of microneedling in diverse populations. [67]

Overall, the safety profile of microneedling combined with hyaluronic acid is highly favorable when performed by trained professionals. Proper technique, patient education, and adherence to standardized treatment protocols can significantly reduce the risk of adverse effects. These characteristics make the procedure a suitable option for long-term acne scar management and repeated treatment sessions when necessary. [68]

Comparison with Other Combination Therapies

Various combination therapies have been proposed to enhance the effectiveness of microneedling in acne scar treatment. One of the most commonly studied combinations is microneedling with platelet-rich plasma (PRP). PRP contains a high concentration of growth factors that stimulate fibroblast proliferation and collagen synthesis. Clinical studies have demonstrated that microneedling combined with PRP may produce greater improvements in acne scars compared with microneedling alone. However, PRP preparation requires blood collection and specialized processing equipment, which may increase procedural complexity and cost. [69]

Another combination approach involves microneedling with topical growth factors or vitamin-based formulations such as vitamin C. These agents are believed to enhance collagen synthesis and improve skin regeneration when delivered through microneedling-induced microchannels. While some studies have reported beneficial effects with these combinations, the clinical evidence remains limited and inconsistent. Additionally, certain topical agents may cause irritation or allergic reactions in sensitive individuals. [70]

Microneedling combined with hyaluronic acid offers several advantages compared with other combination therapies. Hyaluronic acid is biocompatible, non-immunogenic, and widely used in dermatology for its hydrating and regenerative properties. Unlike PRP, HA does not require invasive preparation procedures, making it easier to incorporate into routine clinical practice. Furthermore, HA provides immediate hydration and structural support to the extracellular matrix, which may enhance the regenerative processes

initiated by microneedling. [71]

In comparison with laser-based combination treatments, microneedling with hyaluronic acid offers a safer alternative for patients with darker skin phototypes. Laser resurfacing procedures can produce significant improvements in acne scars but carry a higher risk of post-inflammatory hyperpigmentation. Microneedling avoids thermal damage to the epidermis, reducing the likelihood of pigmentary complications. For this reason, microneedling-based therapies are often preferred in populations with higher Fitzpatrick skin types. [72]

Although each combination therapy has its own advantages, the choice of treatment should be individualized based on scar characteristics, patient preferences, and available resources. Microneedling combined with hyaluronic acid represents a practical and effective approach that balances safety, efficacy, and ease of application, making it an attractive option for many patients seeking improvement in acne scars. [73]

Limitations of Current Evidence

Despite encouraging clinical results, several limitations exist in the current body of literature evaluating microneedling combined with hyaluronic acid for acne scar treatment. Many published studies involve relatively small sample sizes, which may limit the generalizability of their findings. Small study populations reduce statistical power and make it difficult to draw definitive conclusions regarding treatment efficacy and predictors of clinical improvement. [74]

Another limitation is the lack of standardized treatment protocols across studies. Variations in needle length, number of sessions, treatment intervals, and hyaluronic acid formulations can lead to inconsistent outcomes. Differences in patient selection criteria, scar severity, and evaluation methods further complicate comparisons between studies. These methodological variations highlight the need for standardized protocols in future clinical research. [75]

In addition, many studies rely primarily on subjective evaluation methods such as clinical grading scales or patient satisfaction scores. While these measures provide valuable insights, they may be influenced by observer bias or patient expectations. Objective imaging techniques such as three-dimensional skin analysis are not consistently utilized in clinical trials, limiting the ability to obtain precise quantitative measurements of scar improvement. [76]

Another important limitation is the relatively short follow-up duration in many studies. Collagen remodeling and dermal regeneration are gradual processes that may continue for several months following treatment. Short follow-up periods may therefore underestimate the long-term benefits of microneedling-based therapies. Extended follow-up studies are necessary to better understand the durability of treatment outcomes. [77]

Addressing these limitations through well-designed randomized controlled trials with standardized methodologies will be essential for establishing stronger evidence regarding the effectiveness of microneedling combined with hyaluronic acid in acne scar management. Such studies will help clarify optimal treatment protocols and identify the key factors that influence therapeutic outcomes. [78]

Future Directions

Future research in acne scar treatment is increasingly focusing on optimizing combination therapies that enhance dermal regeneration while minimizing adverse effects. Microneedling combined with hyaluronic acid represents a promising platform for further therapeutic innovations. Advances in microneedling technology, including automated devices and adjustable needle depths, allow clinicians to tailor treatments according to scar morphology and severity. These technological improvements may lead to more consistent and predictable clinical outcomes. [79]

Emerging research is also exploring the use of advanced hyaluronic acid formulations with different molecular weights and cross-linking structures. Such formulations may provide improved tissue penetration, prolonged hydration, and enhanced stimulation of fibroblast activity. Investigating the optimal molecular characteristics of hyaluronic acid for acne scar treatment could further improve the effectiveness of combination therapy. [80]

Another promising direction involves integrating microneedling with additional regenerative therapies

such as stem cell–derived growth factors or exosome-based treatments. These biologically active substances have shown potential in promoting tissue repair and collagen synthesis. When delivered through microneedling-induced microchannels, they may significantly enhance dermal remodeling and accelerate scar improvement. However, further clinical studies are needed to evaluate the safety and efficacy of these emerging therapies. [81]

Artificial intelligence and advanced imaging technologies may also play an important role in future acne scar management. Three-dimensional skin analysis and automated scar quantification systems could provide more accurate assessment of treatment outcomes and help clinicians develop personalized treatment plans. Such technologies may improve patient selection and allow better prediction of therapeutic responses. [82]

Continued research in these areas will contribute to the development of more effective, personalized, and minimally invasive approaches for acne scar treatment. By combining mechanical stimulation with biologically active compounds, future therapies may achieve greater improvements in scar appearance and overall skin quality. [83]

Conclusion

Acne scarring represents a common and often distressing complication of acne vulgaris that can significantly affect patients' psychological well-being and quality of life. Advances in dermatologic treatments have led to the development of minimally invasive procedures aimed at stimulating dermal remodeling and improving scar appearance. Among these approaches, microneedling has emerged as a widely used technique due to its effectiveness, safety profile, and suitability for various skin phototypes. [84]

The addition of hyaluronic acid to microneedling therapy has introduced a promising strategy for enhancing treatment outcomes in patients with atrophic acne scars. While microneedling stimulates collagen production through controlled dermal injury, hyaluronic acid provides biochemical support by maintaining hydration, promoting cellular migration, and stabilizing the extracellular matrix. The synergistic interaction between these two modalities contributes to improved dermal regeneration and gradual elevation of depressed scars. [85]

Several factors influence the degree of clinical improvement achieved with this combination therapy. Scar morphology, baseline severity, patient age, skin phototype, and treatment parameters all play important roles in determining therapeutic outcomes. Proper patient selection and individualized treatment planning are therefore essential for optimizing results. In addition, the use of standardized assessment methods allows clinicians to accurately evaluate treatment effectiveness and monitor progress over time. [86]

Although current evidence suggests that microneedling combined with hyaluronic acid is an effective and safe option for acne scar management, further research is needed to establish standardized treatment protocols and clarify the long-term benefits of this therapy. Larger randomized controlled trials with objective outcome measurements and extended follow-up periods will help strengthen the evidence base and guide clinical practice. [87]

Overall, microneedling with hyaluronic acid represents a valuable addition to the therapeutic armamentarium for acne scar treatment. By integrating mechanical stimulation with biologically supportive agents, this combination therapy offers a balanced approach that addresses both structural and biochemical aspects of scar remodeling. Continued research and technological innovation are expected to further refine this treatment modality and improve outcomes for patients suffering from acne scarring. [88]

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