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Microneedling Radiofrequency with Topical Insulin versus Microneedling Radiofrequency in the Treatment of Atrophic Acne Scars

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Abstract
Background: Atrophic acne scars, resulting from severe or prolonged acne vulgaris, pose significant cosmetic and psychological challenges. Conventional treatments, including microneedling radiofrequency (MNRF), have demonstrated efficacy in improving scar appearance through collagen remodeling. Emerging evidence suggests that the adjunctive use of topical insulin, known for its wound-healing properties, may enhance the therapeutic outcomes of MNRF in the treatment of atrophic acne scars. This review critically evaluates the current evidence on the effectiveness of MNRF combined with topical insulin versus MNRF alone in the management of atrophic acne scars.
Methods: This narrative review synthesized evidence from key studies and clinical guidelines to evaluate the comparative roles of microneedling radiofrequency (MFR) with and without topical insulin in the management of atrophic acne scars. Relevant articles were selected based on their impact on clinical practice and advancements in dermatological therapies, with a focus on publications from the last decade that provided insights into the efficacy and safety of these treatment modalities.
Conclusion: Current evidence on the combination of MFR and topical insulin for atrophic acne scars is limited. While MFR alone has demonstrated efficacy, the potential synergistic effects of adding topical insulin require further investigation.

Keywords: Atrophic Acne Scars, Microneedling Radiofrequency, Topical Insulin, Skin Rejuvenation, Wound Healing.

Introduction

Atrophic acne scars represent a significant cosmetic concern for many individuals, particularly those who have experienced severe or prolonged acne vulgaris. These scars are a direct result of the skin's inflammatory response to acne lesions, where the normal wound healing process is disrupted, leading to a loss of collagen and subcutaneous tissue [1]. As a result, atrophic scars manifest as depressions in the skin, creating an uneven and often distressing appearance. Understanding the pathophysiology of these scars is crucial for developing effective treatment strategies that can restore the skin's appearance and improve patients' quality of life [2].

The pathogenesis of atrophic acne scars involves several complex processes. Initially, the inflammatory response to acne lesions causes the breakdown of collagen fibers, which are essential for maintaining the skin's structure and elasticity [3]. In some cases, the body may produce excessive collagen in an attempt to repair the damage, leading to hypertrophic or keloid scars. However, in the case of atrophic scars, collagen production is insufficient, resulting in a loss of tissue volume and the characteristic sunken appearance. This process is further complicated by the destruction of the subcutaneous fat layer, which exacerbates the skin's uneven texture [4].

Atrophic acne scars are typically classified into three main types: ice pick scars, boxcar scars, and rolling scars [5]. Ice pick scars are deep, narrow scars that penetrate into the dermis, resembling the puncture marks made by an ice pick. These scars are particularly challenging to treat due to their depth and the involvement of deeper skin layers. Boxcar scars, on the other hand, are wider and have well-defined edges with a box-like appearance. They are usually shallow to medium in depth and are caused by the destruction of collagen beneath the skin [6]. Rolling scars are characterized by a wave-like appearance on the skin surface, resulting from fibrous bands that tether the skin to deeper structures. Each type of scar presents unique challenges in terms of treatment, requiring a tailored approach to achieve optimal results [3].

Various treatments have been developed to address atrophic acne scars, each targeting different aspects of the scarring process. Traditional methods such as chemical peels, dermabrasion, and laser resurfacing aim to remove the outer layers of the skin, stimulating collagen production and encouraging the growth of new, healthy skin [6, 7]. More recently, microneedling and radiofrequency treatments have gained popularity due to their ability to promote collagen remodeling with minimal downtime. Microneedling involves the use of fine needles to create micro-injuries in the skin, triggering the body's natural healing response and leading to increased collagen production. Radiofrequency, on the other hand, uses heat energy to stimulate collagen production

and tighten the skin, making it an effective option for treating atrophic scars [8].

Combining microneedling with radiofrequency has shown promising results in the treatment of atrophic acne scars. The synergistic effect of these two modalities enhances collagen production and skin rejuvenation, leading to more significant improvements in scar appearance compared to either treatment alone [9, 10]. Additionally, emerging evidence suggests that the application of topical agents, such as insulin, immediately after microneedling may further enhance the skin's regenerative capacity. Insulin, known for its role in glucose metabolism, also has potent wound-healing properties that could theoretically accelerate collagen synthesis and improve scar outcomes when used in conjunction with microneedling radiofrequency treatments [11].

The aim of this review is to critically evaluate the current evidence on the effectiveness of microneedling radiofrequency in combination with topical insulin compared to microneedling radiofrequency alone in the treatment of atrophic acne scars.

Acne Scars

Acne vulgaris is a prevalent chronic inflammatory condition affecting the pilosebaceous units, particularly in adolescents and young adults. The disorder impacts approximately 27% of early adolescents and up to 93% of late adolescents, with common sites of involvement including the face, chest, and upper back. The clinical manifestations of acne include comedones, inflamed papules, pustules, and in more severe cases, subcutaneous abscesses. Beyond its physical manifestations, acne can lead to significant psychological distress, contributing to a reduced quality of life for affected individuals [12].

The pathophysiology of acne involves multiple processes, including hyperseborrhea, hormonal dysregulation, and follicular hyperkeratinization, all of which impair the function of the pilosebaceous unit. The inflammatory response associated with acne can lead to the rupture of hair follicles and the formation of abscesses, initiating a complex wound healing process. This process, if dysregulated, can result in permanent scarring, either atrophic or hypertrophic. The severity and duration of inflammation play critical roles in the development of acne scars, with early intervention in the inflammatory phase being crucial in preventing scarring [13].

Acne scarring occurs due to the damage inflicted on the pilosebaceous follicle during the inflammatory phase of acne. The wound healing process, which includes phases of inflammation, granulation tissue formation, and matrix remodeling, can lead to either atrophic or hypertrophic scars depending on the balance of collagen production and degradation. While the exact mechanisms governing scar formation are not entirely understood, the severity and duration of inflammation are strongly correlated with the likelihood of scarring. Once formed, acne scars are typically permanent, underscoring the importance of early and effective treatment to mitigate long-term skin damage [2, 3].

Acne scar morphological classification is shown in **Table 1**.

Table 1: Acne scar morphological classification [3]

Acne Scars Subtype	Clinical Features
Icepick	Icepick scars are narrow (2mm), deep, sharply marginated epithelial tracts that extend vertically to the deep dermis or subcutaneous tissue.
Rolling	Rolling scars occur from dermal tethering of otherwise relatively normal-appearing skin and are usually wider than 4 to 5mm. Abnormal fibrous anchoring of the dermis to the subcutis leads to superficial shadowing and a rolling or undulating appearance to the overlying skin.
Boxcar **Shallow** **<3mm diameter** **>3mm diameter**	Boxcar scars are round to oval depressions with sharply demarcated vertical edges, similar to varicella scars. They are clinically wider at the surface than icepick scars and do not taper to a point at the base.
Deep **<3mm diameter** **>3mm diameter**	They may be shallow (0.1–0.5mm) or deep (0.5mm) and are most often 1.5 to 4.0mm in diameter.

Atrophic acne:

Atrophic acne scars are prevalent among individuals with a history of moderate to severe inflammatory acne. Studies suggest that approximately 30% of people with acne will develop atrophic scars, with varying degrees of severity depending on factors such as the duration of acne, genetic predisposition, and the effectiveness of early acne treatment. The presence of these scars can significantly impact an individual's psychological well-being, leading to decreased self-esteem, social anxiety, and even depression [14].

Current Treatments for Acne Scars

The treatment of atrophic acne scars is challenging due to the variability in scar types and the depth of tissue damage. Numerous therapeutic modalities have been developed to improve the appearance of these scars, focusing on promoting collagen production, remodeling scar tissue, and enhancing skin texture. Among these treatments, microneedling and radiofrequency (RF) have gained popularity due to their effectiveness and minimal downtime [9].

1. **Microneedling**: Also known as collagen induction therapy, microneedling involves the use of fine needles to create controlled micro-injuries in the skin. These micro-injuries stimulate the body's natural wound healing process, leading to the production of new collagen and elastin. Microneedling is effective for treating all types of atrophic acne scars, particularly when combined with other therapies such as platelet-rich plasma (PRP) or topical growth factors. The procedure is generally well-tolerated, with side effects limited to temporary redness and swelling [15].
2. **Radiofrequency (RF)**: RF treatment uses energy waves to heat the deeper layers of the skin, promoting collagen remodeling and tightening. When combined with microneedling, RF enhances the penetration of energy into the skin, further stimulating collagen production. This combination therapy, known as microneedling RF, is particularly effective for treating rolling and boxcar scars, as it targets both the superficial and deeper layers of the skin. The procedure is safe for all skin types and has a lower risk of hyperpigmentation compared to laser treatments [16].

Other treatment options for atrophic acne scars include chemical peels, laser resurfacing, dermal fillers, and subcision. However, each of these treatments has its own set of limitations, such as longer recovery times, the risk of post-inflammatory hyperpigmentation, and variable results depending on the severity of scarring [17].

Mechanism of Action

Microneedling Radiofrequency

Microneedling radiofrequency (MNRF) is an innovative dermatological procedure that combines the mechanical action of microneedling with the thermal energy of radiofrequency to rejuvenate the skin and treat various conditions, including atrophic acne scars. The procedure works by creating controlled micro-injuries in the skin using fine needles, which penetrate the epidermis and dermis to a specific depth, depending on the treatment goals. As the needles penetrate the skin, they simultaneously deliver radiofrequency energy

into the dermal layer. This dual action stimulates the body's natural wound healing processes, promoting collagen production, elastin formation, and overall skin remodeling [8, 18].

The microneedling component of MNRF triggers a healing response by creating tiny punctures in the skin, which leads to the release of growth factors that initiate collagen and elastin synthesis. These micro-injuries also help to break up fibrous tissue, which contributes to the appearance of atrophic scars. The radiofrequency energy enhances this effect by generating heat within the dermal layers, which further stimulates collagen production and causes immediate tissue contraction. This thermal effect leads to the tightening of the skin and further supports the remodeling of the scar tissue [15].

The efficacy of microneedling radiofrequency in treating atrophic acne scars has been well-documented in several clinical studies. Patients undergoing MNRF treatment often exhibit significant improvements in the texture, depth, and overall appearance of their scars. The combination of mechanical injury and thermal stimulation leads to a more comprehensive remodeling of the dermal matrix, making MNRF a highly effective treatment option for atrophic scars. Moreover, the ability to precisely control the depth of needle penetration and the amount of radiofrequency energy allows for a customizable treatment tailored to the individual needs of each patient, minimizing the risk of adverse effects and optimizing outcomes [19].

Role of Topical Insulin

Insulin, primarily known for its role in glucose metabolism, has been increasingly recognized for its potential benefits in wound healing and tissue regeneration. Insulin exhibits several properties that make it a promising adjunct in dermatological treatments, particularly in the context of wound healing. It promotes cellular proliferation, enhances protein synthesis, and facilitates the migration of keratinocytes and fibroblasts to the site of injury. These actions are crucial in the early stages of wound healing, where the formation of new tissue and the remodeling of the extracellular matrix are essential [20].

The application of topical insulin after microneedling radiofrequency could theoretically enhance the treatment's effectiveness in several ways. First, insulin's ability to promote collagen synthesis and fibroblast proliferation could accelerate the remodeling of scar tissue, leading to more rapid and pronounced improvements in scar appearance. Second, insulin's anti-inflammatory properties might help to reduce post-treatment erythema and swelling, leading to a quicker recovery and less downtime for patients. Finally, the combination of insulin's growth-promoting effects with the collagen-stimulating action of MNRF could result in synergistic benefits, enhancing the overall rejuvenation of the skin [21].

While the use of topical insulin in conjunction with microneedling radiofrequency is still an emerging concept, early studies and anecdotal evidence suggest that it could offer significant benefits in the treatment of atrophic acne scars. The hypothesis is that by applying insulin immediately after microneedling, the open channels created by the needles would allow for deeper penetration of the insulin into the dermis, where it can exert its regenerative effects more effectively. This approach could potentially lead to faster and more noticeable improvements in scar texture, depth, and overall skin quality, making it a promising area for further research and clinical application [22].

MFR with Topical Insulin

Rationale for Combining MFR and Topical Insulin

The combination of microneedling radiofrequency (MFR) and topical insulin presents a promising approach to the treatment of atrophic acne scars. The rationale for this combination is rooted in the synergistic effects of the two modalities [22]:

- **MFR:** By creating controlled micro-injuries in the skin, MFR stimulates collagen and elastin production, leading to dermal remodeling and scar improvement [23].
- **Topical insulin:** Demonstrated to possess wound-healing properties, insulin can potentially enhance the regenerative processes initiated by MFR. It may also influence fibroblast activity, leading to increased collagen synthesis [11, 24].

Potential Benefits and Risks

Benefits

The addition of topical insulin to microneedling radiofrequency (MNRF) holds several promising benefits, particularly in enhancing the treatment of atrophic acne scars. One of the most significant potential benefits is the enhanced collagen production that insulin can promote. Insulin has been shown to stimulate fibroblast activity and increase collagen synthesis, which is crucial in the repair and remodeling of scar tissue. When combined with the collagen-inducing effects of microneedling and radiofrequency, topical insulin could potentially accelerate the regeneration of the extracellular matrix, leading to a more effective reduction in the depth and visibility of atrophic scars [8].

Another potential benefit of incorporating insulin into MNRF therapy is faster wound healing. Insulin is known to enhance the migration and proliferation of keratinocytes and fibroblasts, which are essential for the re-epithelialization of damaged skin. This could translate into a quicker recovery period for patients, with reduced downtime and a lower risk of post-treatment

complications, such as prolonged erythema or infection. Additionally, the anti-inflammatory properties of insulin might further contribute to a more rapid resolution of post-treatment inflammation, improving patient comfort and satisfaction [25].

Moreover, the combination of topical insulin with MNRF may result in better overall scar texture improvement. By promoting more balanced and organized collagen deposition, insulin could help to smooth out irregularities in the skin's surface, leading to a more even and aesthetically pleasing skin texture. This synergy between MNRF and insulin could offer a more comprehensive approach to scar revision, addressing not only the depth of the scars but also the quality of the overlying skin [26].

Risks and Limitations

Despite the potential benefits, there are also risks and limitations associated with the use of topical insulin in conjunction with microneedling radiofrequency. One of the primary concerns is the lack of substantial clinical evidence supporting the efficacy and safety of this combination therapy. While the theoretical benefits of insulin in wound healing are well-documented, there are currently limited studies specifically evaluating its use in the context of MNRF for atrophic acne scars. This lack of robust data makes it difficult to draw definitive conclusions about the effectiveness and safety of this approach.

Another potential risk is the possibility of adverse reactions to topical insulin, particularly in patients with sensitivities or allergies. While insulin is generally well-tolerated when used systemically, its topical application could lead to localized reactions such as redness, itching, or irritation. Additionally, there may be concerns about the potential for insulin to affect blood glucose levels if absorbed in significant quantities, although this risk is likely minimal with topical application.

Furthermore, there are limitations related to the practical aspects of combining insulin with MNRF. The optimal concentration of insulin for topical use, the timing of application, and the frequency of treatment are all factors that require further investigation. Without clear guidelines, there is a risk of inconsistent results or even diminished efficacy if the treatment is not administered correctly. These uncertainties underscore the need for more research to establish standardized protocols and ensure that the benefits of this combination therapy can be reliably achieved.

Future Directions

The combination of microneedling radiofrequency and topical insulin represents an exciting area of innovation in the treatment of atrophic acne scars, but there are several gaps in the current research that need to be addressed. One of the most critical gaps is the lack of long-term outcome studies. While initial findings may suggest positive results, it is essential to understand the durability of these outcomes over time. Future research should focus on conducting longitudinal studies that track patients' progress for extended periods to determine whether the benefits of this combination therapy are sustained.

Another significant gap is the need to establish the optimal concentration and formulation of insulin for topical use in combination with MNRF. The precise dose-response relationship between insulin application and collagen production or wound healing is not yet well understood, and variations in concentration could significantly impact treatment efficacy. Research is also needed to identify the ideal timing and frequency of insulin application to maximize its benefits while minimizing any potential risks.

Additionally, further studies are required to determine the best patient selection criteria for this combination therapy. While MNRF with insulin may be beneficial for some individuals, it may not be suitable for others, particularly those with certain skin types, underlying health conditions, or specific scar characteristics. Identifying which patients are most likely to benefit from this approach will be crucial in refining treatment protocols and ensuring optimal outcomes.

Clinical Implications

The potential clinical implications of adopting microneedling radiofrequency combined with topical insulin are significant and could influence both patient care and clinical practice. If further research supports the efficacy of this combination therapy, it could become a valuable addition to the dermatologist's arsenal for treating atrophic acne scars. However, the implementation of this treatment in clinical practice would require careful patient education to ensure that patients understand the benefits, risks, and expected outcomes of the therapy.

Cost considerations are another important aspect of clinical implications. The addition of topical insulin to MNRF may increase the overall cost of the treatment, which could be a barrier for some patients. Clinicians will need to weigh the potential benefits against the added costs and consider whether the enhanced outcomes justify the expense. Additionally, insurance coverage for such combination therapies may be limited, further impacting patient accessibility.

Ultimately, the integration of this combination therapy into clinical practice will depend on the development of standardized protocols that are backed by robust clinical evidence. As research progresses and more data becomes available, clinicians will be better equipped to make informed decisions about when

and how to use microneedling radiofrequency with topical insulin to achieve the best possible results for their patients.

Conclusions

While microneedling radiofrequency alone has shown significant efficacy in treating atrophic acne scars, the potential for enhanced outcomes with the addition of topical insulin remains a promising yet underexplored area. Preliminary evidence suggests that insulin may accelerate wound healing and collagen synthesis when used in conjunction with MNRF, leading to improved scar appearance. However, robust clinical trials are needed to substantiate these findings and establish standardized treatment protocols.

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