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Review Article

ACNE scarring: A review of current concepts and treatment approaches

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ABSTRACT

Objectives: Acne scarring is a frequent sequela of acne vulgaris with considerable cosmetic and psychosocial impact. This review critically evaluates current treatment modalities, emphasizing efficacy, limitations, and emerging concepts.

Material and Methods: A structured literature search was conducted in PubMed, Scopus, and Google Scholar for studies published from January 2010 to June 2025. Keywords included “acne scars,” “atrophic scars,” “microneedling,” “laser,” “radiofrequency,” “chemical peel,” “subcision,” “fibroblast transfer,” and “regenerative therapy.” Eligible studies were English-language human trials, randomized controlled trials (RCTs), systematic reviews, and relevant narrative reviews. Exclusion criteria were non-facial scars, animal or *in vitro* studies, and case series with fewer than five patients. Data were extracted on interventions, outcomes, and safety.

Results: Acne scar management strategies are categorized into energy-based (ablative and non-ablative lasers, fractional photothermolysis, microneedling [MN], radiofrequency, and Tixel) and non-energy-based modalities (chemical peels, MN, subcision, dermabrasion, punch techniques, fillers, and grafting). Ablative lasers show strong efficacy but carry downtime and pigmentary risks. Non-energy approaches, such as MN and trichloroacetic acid chemical reconstruction of skin scars, are safer with modest improvement. Combination regimens, including MN with platelet-rich plasma or subcision with fillers, consistently outperform monotherapy. Emerging regenerative options, such as autologous fibroblast transfer, demonstrate encouraging long-term results.

Conclusion: Optimal acne scar management requires individualized, multimodal strategies tailored to the scar type and patient profile. Combination therapy offers the most consistent benefit, while regenerative techniques represent a promising frontier for future care.

Keywords: Acne scars, Chemical peel, Fibroblast transfer, Laser, Microneedling, Regenerative therapy, Subcision

INTRODUCTION

Acne vulgaris is a prevalent chronic inflammatory condition of the pilosebaceous unit, influenced by abnormal keratinization, increased sebum production, and cutibacterium acnes colonization.^[1,2] Its clinical spectrum includes comedones, papules, pustules, nodules, and cysts, commonly affecting seborrheic areas such as the face, chest, and back.^[3,4] Although the inflammatory lesions often resolve, they can lead to pigmentary changes and scarring, with lasting psychosocial consequences, particularly in adolescents and males. Acne scarring may present as atrophic or hypertrophic variants, with atrophic scars being further classified into three types: icepick, rolling, and boxcar. These scars significantly impact the quality of life and are even recognized as a potential risk factor for depression and suicidal ideation.^[5,6]

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The degree, depth, and duration of inflammation strongly influence scar formation, emphasizing the importance of early and effective acne management to prevent permanent sequelae. While pharmacologic therapies can manage active acne, procedural interventions are often necessary to treat established scars. This review aims to discuss various contemporary treatment options and provide insight into choosing appropriate modalities based on scar characteristics.^[7]

MATERIAL AND METHODS

We performed a comprehensive literature search of PubMed, Scopus, and Google Scholar for articles on acne scarring published between January 2010 and June 2025. Keywords included “acne scars,” “atrophic scars,” “icepick,” “rolling,” “boxcar,” “laser,” “microneedling,” “radiofrequency,” “PRP,” “chemical peel,” “subcision,” “dermabrasion,” “punch techniques,” “fibroblast transfer,” “Tixel,” “tissue augmentation,” and “regenerative therapy.” Eligible modalities were those commonly available in dermatology and maxillofacial practice, such as fractional lasers, microneedling (MN) (with/without radiofrequency [RF]), chemical peels (trichloroacetic acid [TCA], chemical reconstruction of skin scars [CROSS], and Jessner’s), subcision, dermabrasion, fillers, autologous fat grafting, fibroblast transfer, and Tixel. Filters were applied for randomized controlled trials (RCTs), systematic reviews, meta-analyses, and narrative reviews. Inclusion was limited to English-language human studies on facial acne scars, while animal studies, *in vitro* reports, non-facial scars, and small case series (<5 patients) were excluded. Two reviewers independently screened titles/abstracts, extracted data on study design, interventions, and outcomes, with special emphasis on RCTs. References of selected papers and recently published studies were also reviewed to ensure completeness.

RESULTS

Treatment modalities for acne scars

The formation of acne scars is multifactorial, with genetic predisposition, severity of the disease, and delayed intervention being primary contributors. Scars are classified into atrophic (including icepick, rolling, and boxcar types) and hypertrophic/keloidal forms. Among atrophic scars, rolling and boxcar types are the most amenable to treatment, while icepick scars are the most challenging. Current treatment strategies aim not only to improve scar appearance but also to restore skin texture and boost patient confidence. Modalities can be broadly categorized into energy-based and non-energy-based approaches.

Energy-based technologies

Ablative lasers

Ablative lasers, such as CO₂ (10,600 nm) and Er: YAG (2940 nm), function by vaporizing the epidermis and superficial dermis, thereby inducing collagen remodeling. These are especially useful for shallow boxcar and hypertrophic scars. Despite their effectiveness, they are associated with extended downtime, risks of infection, erythema, and pigmentary changes.^[8]

Plasma skin resurfacing

This technique utilizes RF energy to ionize inert gas, creating a plasma field that delivers controlled thermal injury to the skin. It has demonstrated results comparable to mild ablative lasers, with reduced downtime.^[9]

Non-ablative lasers

Infrared and visible light lasers such as Nd: YAG (1064 nm), diode (1450 nm), Er: Glass (1540 nm), intense pulsed light, and pulsed dye lasers offer dermal remodeling with minimal epidermal disruption. While less aggressive, they require multiple sessions to achieve significant results.^[10]

Fractional photothermolysis

Fractional lasers, both ablative and non-ablative, deliver energy in microthermal zones, leaving surrounding skin intact, which promotes rapid healing. Ablative fractional lasers such as fractional CO₂ and Er: YAG offer efficacy comparable to traditional ablative lasers but with a lower risk profile. Non-ablative options, such as 1550 nm Erbium-doped lasers, are particularly suited for patients with darker skin types due to their minimal pigmentary alteration.^[11]

MNRF

MNRF devices combine mechanical MN with RF energy, delivering controlled dermal injury and thermal stimulation. They offer the advantages of reduced epidermal disruption, minimal downtime, and decreased risk of post-inflammatory hyperpigmentation, making them ideal for patients with Fitzpatrick skin types IV-VI.^[12]

Tixel

A thermomechanical fractional device, Tixel, delivers heat through titanium-tipped pyramidal pins without the use of lasers. Its results are comparable to those of fractional CO₂ laser treatments, but with lower downtime and fewer side effects.^[13]

Non-energy-based methods

Chemical peeling

Chemical peeling involves the controlled application of specific agents to exfoliate the skin and promote dermal regeneration, making it an effective treatment for various types of acne scars. Based on their biochemical action, peels are classified into alpha hydroxy acids (AHAs), beta hydroxy acids (BHAs), and other compound formulations. AHAs such as glycolic acid (25–70%) are commonly used for superficial scarring, hyperpigmentation, and photoaging, with additional agents such as lactic, malic, and citric acids offering similar benefits. BHAs, particularly salicylic acid, are oil-soluble and possess anti-inflammatory properties, making them ideal for treating comedonal acne and post-inflammatory pigmentation. TCA is a versatile agent employed in concentrations ranging from superficial to medium-depth peels. At higher concentrations (50–100%), it is used in the TCA CROSS technique to target deep icepick scars while preserving adjacent normal skin. Jessner's solution, a blend of resorcinol, salicylic acid, and lactic acid, is often used to treat superficial scars, dyschromia, and sun damage. The choice of peeling agent and the depth depend on the type of scar, skin sensitivity, and treatment goals.^[14,15]

Dermabrasion

It is a mechanical resurfacing technique that removes the epidermis and upper dermis using tools such as diamond fraises, wire brushes, or sandpaper attached to a rotating handpiece. It softens the edges of deep scars and stimulates collagen remodeling, but is highly operator-dependent. Complications may include bleeding, infection, pigmentary changes, milia formation, and prolonged healing of up to 1 month. Due to its invasiveness and risk profile, it has largely been replaced by fractional laser resurfacing, which offers comparable results with fewer side effects and quicker recovery.^[16]

Microdermabrasion, in contrast, is a superficial technique that removes the stratum corneum using crystal-based or crystal-free devices. Although less invasive, it is best suited for very superficial scarring and skin rejuvenation.^[17]

MN

MN is a minimally invasive skin rejuvenation technique widely used in dermatology and cosmetology to improve acne scars, stretch marks, and skin texture. It is especially beneficial for patients with darker skin types (Fitzpatrick IV and V) as it carries a lower risk of post-inflammatory hyperpigmentation compared to lasers. MN devices include rollers, stampers, and electric or manual pens, equipped with fine needles typically ranging from 0.5 to 3 mm in length.

These needles create controlled micro-injuries, stimulating collagen and elastin production through the activation of growth factors such as vascular endothelial growth factor, fibroblast growth factor-7, epidermal growth factor, and transforming growth factor-beta.

Studies have shown significant improvement in acne scars following a series of MN sessions, with increased expression of collagen types I, III, and VII. Combining MN with agents such as platelet-rich plasma (PRP), dermal fillers (e.g., polymethylmethacrylate [PMMA]), or peels has shown synergistic effects, enhancing outcomes more than monotherapy. The procedure is well tolerated, and its efficacy, safety profile, and adaptability make it a core component in acne scar management.^[18]

Subcision

Subcision is a minimally invasive technique introduced in 1995 for the treatment of rolling acne scars. It involves inserting a hypodermic needle into the subdermal plane and using a fanning or back-and-forth motion to break fibrous bands that tether the scar to underlying tissue. This release helps elevate the depressed skin and promotes localized bleeding, which stimulates new collagen formation.

An advanced approach, known as bilevel subcision, targets both superficial and deep fibrous strands to improve outcomes. While generally safe, a small percentage of patients may develop hypertrophic scars requiring corticosteroid injections. Subcision has demonstrated greater short-term satisfaction compared to dermal fillers and shows enhanced results when combined with treatments such as non-ablative lasers, making it a valuable component of multimodal acne scar therapy.^[19]

Punch techniques

Punch techniques are especially effective for deep and narrow scars such as icepick or deep boxcar types, which are often resistant to other treatments. These include punch excision, flotation (elevation), and grafting. In punch excision, the scar is removed using a biopsy punch, and the site is closed with sutures or allowed to heal naturally. Punch flotation involves lifting the scar tissue to the level of the surrounding skin, while punch grafting replaces the excised scar with a full-thickness skin graft from a discreet donor site, such as behind the ear.

Although evidence supporting these methods is mostly from small case reports, combining them with resurfacing procedures – like CO₂ laser – has shown improved cosmetic outcomes. Potential drawbacks include graft depression, failure of graft uptake, and slow healing. However, when used in combination therapies, punch techniques provide a targeted solution for deep scars and reduce the need for aggressive resurfacing treatments.^[20]

Dermal grafting

A technique involving the implantation of dermis (without epidermis or fat) into depressed scars to restore volume. It provides more permanent correction than fat grafts and is less prone to resorption.^[21]

Tissue augmentation

It involves the use of soft-tissue fillers to restore lost dermal volume and enhance the contour of atrophic acne scars, particularly rolling scars. Hyaluronic acid (HA) fillers are widely preferred for their safety and effectiveness, with newer formulations like Belotero minimizing risks such as the Tyndall effect. Calcium hydroxyapatite offers semi-permanent results for mild-to-moderate scarring, while poly-L-lactic acid promotes gradual collagen synthesis over multiple sessions. PMMA is a permanent filler used selectively due to its irreversible nature. Autologous fat transfer (AFT), which involves grafting the patient's own fat, is highly biocompatible but requires technical precision. An advanced option, autologous fibroblast transfer, uses cultured fibroblasts from the patient to stimulate long-term collagen production and dermal remodeling. Together, these techniques offer versatile options for improving scar depth and skin texture.^[22]

Scar revision surgery

For linear or extensive scars, surgical techniques such as Z-plasty, M-plasty, and Y-plasty are performed by trained specialists to improve scar alignment and esthetics.^[23]

Autologous fibroblast transfer

AFT is an emerging treatment for acne scars that utilizes the patient's own cultured fibroblasts, offering a low risk of allergic reaction and the potential for long-lasting results. Unlike fat grafting, AFT may provide more permanent correction. The process begins with a small punch biopsy from a discreet area, such as behind the ear, from which fibroblasts are isolated and cultured in a lab over several weeks. These cells are then reinjected into the scarred dermis, where they promote collagen synthesis and aid in extracellular matrix remodeling. Clinical trials have shown significant scar improvement with sustained results up to 12 months. Adverse effects are minimal, typically limited to short-term redness and swelling. While AFT shows great promise as a novel regenerative technique in acne scar management, further research is needed to confirm its long-term efficacy and optimize protocols.^[24]

Cryotherapy

Primarily used for nodulocystic acne, cryotherapy involves applying liquid nitrogen or cryoslush to induce necrosis and

lesion resolution. It must be used cautiously due to the risk of hypopigmentation or scarring.^[25]

DISCUSSION

The management of acne scars remains complex, as scar types, skin characteristics, and patient expectations vary widely. Current evidence shows that no single modality is universally effective, making multimodal and individualized approaches essential.

Energy-based devices, such as fractional CO₂ and Er: YAG lasers, remain highly effective for atrophic scars but are limited by downtime and risk of pigmentary changes. Safer options such as non-ablative lasers, MNRF, and Tixel provide meaningful improvements with reduced complications, especially in darker skin types.

Non-energy modalities also play a central role. Chemical peels and the TCA CROSS technique are cost-effective solutions for superficial and icepick scars, while MN, alone or combined with PRP or peels, offers reproducible outcomes with minimal side effects.

Surgical and corrective techniques, including subcision, punch excision, and fillers, remain indispensable for deep, tethered, or resistant scars. Subcision provides immediate release of fibrous bands, often enhanced by adjunctive fillers or lasers. Tissue augmentation with HA, autologous fat, or fibroblast transfer addresses volume loss, with the latter offering a promising regenerative approach.

Overall, combination therapy consistently outperforms monotherapy, targeting multiple aspects of scar pathology and yielding superior patient satisfaction. The main limitations of current research include small sample sizes, heterogeneous outcome measures, and short follow-ups, highlighting the need for standardized, high-quality RCTs.

Future advances are likely to focus on regenerative and precision-based therapies, integrating novel biologics and scaffold technologies. Until then, individualized, scar-specific multimodal strategies remain the cornerstone of effective acne scar management.

CONCLUSION

Acne scars present a significant therapeutic challenge due to their varied morphology, unpredictable healing response, and profound psychosocial impact. The current spectrum of treatment modalities – ranging from energy-based devices like lasers and RF to non-energy-based techniques such as chemical peels, MN, and subcision – allows for individualized treatment strategies tailored to each patient's needs. Advances in tissue augmentation and regenerative therapies like autologous fibroblast transfer have further enhanced treatment outcomes. However, the efficacy of each

intervention depends on multiple factors, including scar type, skin type, and practitioner expertise. A multimodal approach often yields the best cosmetic improvement. Early intervention during active acne and timely initiation of scar therapy are crucial to minimizing long-term sequelae. Future research should focus on optimizing protocols and combining modalities to enhance safety, accessibility, and effectiveness across diverse populations.

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