

The Management of Atrophic Acne Scars: Overview and New Tools

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Abstract

Acne is a common disorder with a high prevalence among adolescents. Acne can cause atrophic scars that are a very unpleasant marker and it may have a negative psychological impact on social life and relationships. The distress generated by acne scars is sometimes very strong among adolescents. General dermatologists have, often, the key role to evaluate atrophic scars and to suggest different treatments. The aim of this paper is to review the different therapeutic options for atrophic scars such as chemical peels, tretinoin-iontophoresis, dermabrasion/microdermabrasion, tissue augmentation, laser treatment, punch excision techniques, subcision, and percutaneous collagen induction by skin needling.

Introduction

Acne is a common disorder with a high prevalence among adolescents and often it causes atrophic scars [1-3]. The prevalence and severity of acne scars in the population is not well known. Goulden et al. [4] reported an incidence rate of 11% in men and of 14% in women while patients interviewed by Poli et al. [5] believed to have acne scars in 49% of cases. Layton et al. found that facial scarring affects both sexes equally and occurs quite in 90% of patients with acne. The pathogenesis of atrophic acne scarring is not completely understood, but it is most likely related to inflammatory mediators and enzymatic degradation of collagen fibers. Literature also demonstrated that the incidence of scars is sometimes correlated to the severity of acne but it is strictly correlated also to the delay of starting acne treatment and the duration of inflammatory response [6]. Genetic factors, which can determine differences in the process of cell-mediated immune response and in the capacity to respond to tissue damage, are the main factors influencing scar formation [7].

The scarring process can occur at any stage of acne; however, it is uniformly believed that early therapy in inflammatory and nodulocystic acne is the most effective way to prevent post-acne scarring [8].

Severe scarring caused by acne is associated with considerable psychological distress, mainly in adolescents associated to poor self esteem, depression, anxiety, body image alterations, embarrassment, anger, low academic performance, and unemployment [9-11]. The appearance of scars often worsens with normal aging or photodamage [12].

General dermatologists often have the key role in evaluation atrophic scars and in providing treatment. The aim of this paper is to review the different therapeutic options for atrophic scars such as chemical peels, dermabrasion/microdermabrasion, laser treatment, punch excision techniques, percutaneous collagen induction by skin needling.

Scars Evaluation

Evaluation of scar type and its severity is a very important step to select the most appropriate therapeutic option among the currently available ones. There have been several approaches to classify acne scars in order to evaluate objectively type and severity. Unfortunately, the consensus concerning acne scar evaluation is still lacking.

Atrophic acne scars are traditionally classified into ice pick, boxcar, and rolling scars (Figure 1). The ice pick scars, which represents almost the 60%-70% of atrophic scars, are usually punctiform, sharp and deep

and have a "V shape" in longitudinal section. The boxcar ones are round or oval shape, from 1.5 through 4.0 mm in diameter, wide at the surface and the base, showing "U" shape and representing 20%-30% of total atrophic scars. Finally, the rolling scars have "M" shape and, therefore, give a rolling appearance to the skin; they usually have a diameter of 4-5mm and represent from 15 through 25% of atrophic scars [13].

Sometimes in the same patient we can observe all these types of atrophic scars and it can be very difficult to differentiate between them. For this reason several classifications and evaluation scales have been proposed by other authors. Goodman and Baron proposed a qualitative scale and then presented a quantitative scale [14,15]. Dreno et al. introduced the ECCA scale (Echelle d'Evaluation Clinique des Cicatrices d'Acné) [16].

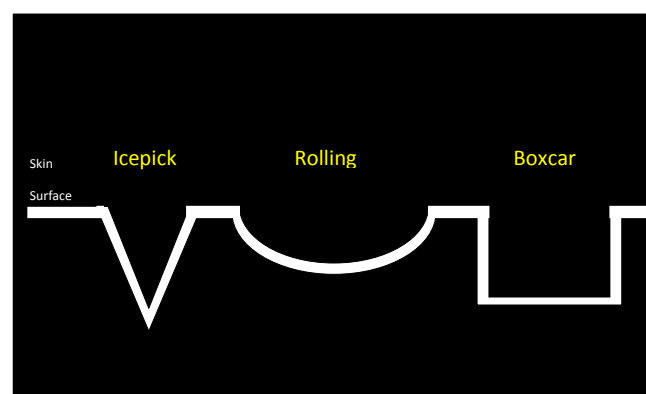


Figure 1: Acne scars subtypes.

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Received November 30, 2011; Accepted April 10, 2012; Published April 17, 2012

Citation: Fabbrocini G, Vita VD, Cozzolino A, Marasca C, Mazzella C, et al. (2012) The Management of Atrophic Acne Scars: Overview and New Tools. J Clin Exp Dermatol Res S5:001. doi:10.4172/2155-9554.S5-001

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The qualitative scarring grading system proposed by Goodman and Baron [14,15] is simple and universally accepted. According to this classification, four different grades can be used to identify an acne scar, as shown in Table 1. Different patterns can be simultaneously present and may be difficult to differentiate. For these reasons, the same authors subsequently, suggested a quantitative numeric grading system based on lesion counting (1 point for a number of lesions < 10, 2 points between 11 and 20, 3 points >20) and severity (1 point for milder atrophic scarring, 2 points for moderate atrophic scarring, 3 points for severe atrophic scarring, 2 or 6 point for hyperplastic scarring). The lesion counting score is then multiplied for the lesion severity score. The final score depends on the addition of points assigned to each respective category and reflects disease's severity, ranging from a minimum of 0 to a maximum of 84 (Table 2) [15]. In 2006 Dreno et al. proposed a semiquantitative scale, the ECCA (Echelle d'Evaluation clinique des Cicatrices d'acné), based on the sum of individual types of scars and their numerical extent. In particular, this type of scale detected six types of scars and assigned them a score indicating the disfiguring impact: the weighting factor. The higher the disfiguring effect, the higher the weighting factor assigned (Table 3). The ECCA has also shown a good interinvestigator reliability [16].

Scars Management

Several therapeutic options are currently available for atrophic acne scars treatment. If a patient presents different scars, two or more different procedures can be necessary in order to achieve the best clinical result. In literature it is stated that none of the currently available treatments can achieve complete resolution of the scar.

Chemical Peeling

Chemical peeling can be considered an effective therapeutic for scars treatment. Peeling produces a controlled, partial-thickness chemical exfoliation of the epidermis and dermis, accelerating the skin repair process [17,18].

Chemical peeling is recommended to treat skin aging, dyschromias, wrinkles, and acne scars are the major clinical indications for facial chemical peeling [19,20].

Before peeling, the skin should be cleaned by alcohol or acetone in order to remove the hydro-lipidic film and obtain optimal penetration. Salicylic acid, glycolic acid, pyruvic acid, trichloroacetic acid are all hydroxy acids that may be used as peeling agents. The choice of concentration depends on the peeling agent used, on the skin areas treated and on the severity of acne scarring. A total sun block between peeling sessions and 4 weeks after the last session is necessary in order to avoid hyperpigmentation. Chemical peelings may worsen papulopustular acne and some patients develop active papules and pustules in the immediate post-peeling period [21].

Salicylic acid

Salicylic acid is one of the best peeling agents for the treatment of acne scars [22]. It is a beta hydroxy acid agent which has a peculiar characteristic of lipophilicity. Its lipophilicity lets the penetration in the superficial layers of the epidermis and sebaceous glands so that it removes intercellular lipids that are covalently linked to the cornified envelope surrounding cornified epithelioid cells. The most

Grades of Post Acne Scarring	Level of disease	Clinical features
1	Macular	These scars can be erythematous, hyper- or hypopigmented flat marks. They do not represent a problem of contour like other scar grades but of color.
2	Mild	Mild atrophy or hypertrophy scars that may not be obvious at social distances of 50 cm or greater and may be covered adequately by makeup or the normal shadow of shaved beard hair in men or normal body hair if extra facial.
3	Moderate	Moderate atrophic or hypertrophic scarring that is obvious at social distances of 50 cm or greater and is not covered easily by makeup or the normal shadow of shaved beard hair in men or body hair if extrafacial, but is still able to be flattened by manual stretching of the skin (if atrophic).
4	Severe	Severe atrophic or hypertrophic scarring that is evident at social distances greater than 50 cm and is not covered easily by makeup or the normal shadow of shaved beard hair in men or body hair if extrafacial and is not able to be flattened by manual stretching of the skin.

Table 1: Qualitative scarring grading system (adapted from [21]).

Grade or Type	Number of Lesions 1(1-10)	Number of Lesions 2(11-20)	Number of Lesions 3(>20)
A) Milder scarring (1 point each) Macular erythematous pigmented Mildly atrophic dish-like	1 point	2 points	3 points
B) Moderate scarring (2 points each) Moderately atrophic, dish like Punched out with shallow bases small cars (<5mm) Shallow but broad atrophic areas	2 points	4 points	6 points
C) Severe scarring (3 points each) Punched out with deep but normal bases, small scars (<5mm) Punched out with deep but abnormal bases, small scars (<5mm) Linear or troughed dermal scarring Deep, broad atrophic areas	3 points	6 points	9 points
D) Hyperplastic Papular scars Keloidal/Hypertrophic scars	2 points Area<5mm 6 points	4 points Area 5-20 cm ² 12 points	6 points Area>20 cm ² 18 points

Table 2: Goodman's quantitative global acne scarring grading system.

Description	Weighting factor (a)	Semiquantitative score (b)	Grading (axb)
V-shaped atrophic scars, diameter < 2 mm, and punctiform	15	0 = no scar 1 = few scars 2 = limited number of scars 3 = many scars	I_/_
U-shaped atrophic scars, diameter of 2-4 mm, with sheer edges	20	0 = no scar 1 = few scars 2 = limited number of scars 3 = many scars	I_/_
M-shaped atrophic scars, diameter > 4mm, superficial and with irregular surface	25	0 = no scar 1 = few scars 2 = limited number of scars 3 = many scars	I_/_
Superficial elastolysis	30	0 = no scar 1 = few scars 2 = limited number of scars 3 = many scars	I_/_
Subgrading 1			
Hypertrophic inflammatory scars, scar of less than 2 years of age	40	0 = no scar 1 = few scars 2 = limited number of scars 3 = many scars	I_/_
Keloid scars and hypertrophic scars that are more than 2 years of age	50	0 = no scar 1 = few scars 2 = limited number of scars 3 = many scars	I_/_
Subgrading2			
Global score (Subgrading 1+2)			I_/_

Table 3: Echelle d'Evaluation clinique des Cicatrices d'acné (ECCA).

used concentration for acne scars is 30% in multiple sessions, 3–5 times, every 3-4 weeks [23,24]. Possible side effects of salicylic acid peeling are mild and temporary; they include mainly erythema and dryness. Persistent postinflammatory hyperpigmentation or scarring are extremely infrequent and for this reason it is considered very safe for all skin phototypes [25]. Salicylic acid is also available in combination with resorcinol and lactic acid in 95% ethanol. Resorcinol is structurally and chemically similar to phenol. It disrupts the weak hydrogen bonds of keratin and enhances-penetration of other agent [26]. Lactic acid is an alpha hydroxy acid which causes corneocyte detachment and subsequent desquamation of the stratum corneum [27]. Combination of salicylic acid with resorcinol and lactic acid in 95% ethanol is known as Jessner's peels. General contraindications include active inflammation, dermatitis or infection of the area to be treated, isotretinoin therapy within 6 months before the peeling sessions. Allergic contact dermatitis and systemic allergic reactions to resorcinol are the main contraindications [28,29].

Glycolic acid

Glycolic acid is an alpha-hydroxy acid, soluble in alcohol, derived from fruit and milk sugars, which acts by thinning the stratum corneum, promoting epidermolysis and dispersing basal layer melanin. It increases dermal hyaluronic acid and collagen gene expression by increasing secretion of IL-6. The procedure is well tolerated and patient compliance is excellent. Contraindications include: contact dermatitis, pregnancy, and glycolate hypersensitivity. Side effects, such as temporary hyperpigmentation or irritation, are not very significant. Some studies showed that the level of skin damage with glycolic acid peel increases is time related. The most used protocols include 5-6 of 70% glycolic acid sessions every 2 weeks [30,31].

Pyruvic acid

Pyruvic acid is an alpha-ketoacid, with strong antimicrobial effect. It seems to promote collagen synthesis and formation of elastic

fibers. The use of 40%–70% pyruvic acid has been proposed for the treatment of moderate acne scars, but its effects are higher in active papular-pustular acne and rosacea. Side effects include desquamation, crusting, intense stinging, and a burning sensation during treatment. Pyruvic acid has stinging and irritating vapors for the upper respiratory mucosa, and adequate ventilation during application is usually used [32,33].

Trichloroacetic acid

Trichloroacetic Acid (TCA) is a peeling agent, it causes protein denaturation, well-known as keratocoagulation, [34]. It is mixed with 100 mL of distilled water to create the desired concentration. TCA peeling has high efficacy on acne scar treatment, but it is not indicated for dark skin for hyperpigmentation's risk [35]. 10-20% TCA concentration causes a very superficial peel with no penetration below the stratum granulosum; a concentration of 25%–35% produces a superficial peel with diffusion in the epidermis; 40%–50% TCA can produce injury to the papillary dermis and higher concentration than 50% extends injury over the reticular dermis. Consequently, the use of TCA in concentrations higher than 35% should be limited to treatment of isolated icepick scars [36]. In 2002 Lee et al. reported the use of high-concentration (65% and 100%) trichloroacetic acid (TCA) applied locally in the atrophic acne scars, known as Chemical Reconstruction Of Skin Scars (CROSS) [37,38].

According to several authors [39-41] CROSS technique has high efficacy in the case of few isolated scars on healthy skin. TCA is applied for a few seconds by a wooden applicator until the scar displays a white frosting. No local anesthesia or sedation is generally needed, especially at lower concentrations. Emollients and high photoprotection is required. The procedure should be repeated at 4-week intervals, and each patient should receive a total of 3-4 treatments. Fabbrocini et al. showed that a lower TCA concentration (50%) has similar results respect to higher concentration (90%) but lower adverse reactions [42].

This technique reduces the risk of scarring and hypopigmentation by sparing the adjacent normal skin and adnexal structures.

Tretinoin-iontophoresis

Stratum corneum is the main barrier layer for transdermal delivery of drugs. Different approaches to enhance the transdermal penetration of drugs have been proposed: iontophoresis is one of them. Iontophoresis is a non invasive method able to enhance transdermal drug delivery using a small electrical current applied by a iontophoretic chamber containing a similarly charged active agent and its vehicle [43]. Schmidt et al. proposed the use of iontophoresis with 0.025% tretinoin gel in atrophic acne scars [44,45].

The authors performed Iontophoresis with tretinoin gel twice weekly for 20 min over a period of 3 months. Clinical improvement in terms of a decrease in scar depth was recorded in 94% of patients. Collagenogenesis stimulated by tretinoin may explain the efficacy of this technique on acne scarring. Tretinoin-iontophoresis is a non invasive treatment of atrophic acne scars and its side-effects are minimal. Erythema and stinging are sometimes recorded.

Microdermabrasion/Dermabrasion

Microdermabrasion and dermabrasion are facial resurfacing techniques that mechanically ablate damaged skin in order to promote reepithelialisation. They are particularly effective in the treatment of scars and can perform clinical significant improvement in skin appearance [46]. Microdermabrasion removes the outer layer of the epidermis, accelerating the natural process of exfoliation [47,48]. Dermabrasion, with respect to microdermabrasion, completely removes the epidermis and exposes the papillary or reticular dermis, inducing remodeling of the skin's structural proteins [46]. Microdermabrasion is usually painless, it does not require anesthesia and multiple sessions are frequently required. A variety of microdermabraders are available. All microdermabraders include a pump that generates a stream of aluminum oxide crystals with a hand piece and vacuum [49]. Occasionally, sodium chloride, sodium bicarbonate, or magnesium oxide crystals are used. Although they are cheaper, these crystal alternatives are not as abrasive and are less efficacious than aluminum oxide crystals [50,51].

In comparison to dermabrasion, microdermabrasion has a lower efficacy and it shouldn't be used to treat deep scars but it is associated with a low risk of side effects. They usually include temporary stripping of the treatment area, bruising, burning or stinging sensation, photosensitivity, and occasional pain.

Dermabrasion is performed under local or general anaesthesia. It usually uses highspeed brush, diamond cylinder, fraise, or manual silicone carbide sandpaper. Side effects are frequent and include prolonged erythema, bacterial or viral infection, hypertrophic or keloidal scarring, sun-sensitivity, transitory or permanent hypopigmentation or hyperpigmentation, especially in dark skin patients.

Subcision

Subcision is a nonoperative technique to manage depressed scars by percutaneously releasing scar bands within the dermis and subcutaneous tissue. It was initially described by Orentreich in 1995 [52]. The entire area to be subcised is marked and local anesthetic is administered. Once anesthesia is obtained, a needle is used to release the fibrous septa within the scar, resulting in the formation of new connective tissue underneath the scar. When subcision was first introduced, it was performed using a tri-beveled hypodermic needle.

Then sharp hypodermic needles, usually 19 to 21-G, were used. Bleeding and nodule formation are the main side effects. Nodule formation can be improved with low-dose intralesional steroid injections, but often resolves without treatment in 2 to 3 months [13].

Percutaneous Collagen Induction by Skin Needling

Skin needling is a recently proposed technique that involves using a sterile roller comprised of a series of fine, sharp needles to puncture the skin. At first, facial skin must be disinfected, and then a topical anaesthetic is applied. 90 minutes after anaesthetic cream application, patients can undergo the skin needling session. The procedure consists of rolling a performing instrument on the cutaneous areas affected by acne scars, several times, at least four-six times, in four directions: horizontally, vertically and diagonally right and left. The needles penetrate about 1.5 to 2mm into the dermis. As expected, the skin bleeds for a short time, but that soon stops.

The efficacy of the above described technique depends on its capacity to stimulate the neo-collagenogenesis process. Skin microinjures induced by the roller stimulate the wound healing process, with the consequent increase in the synthesis of growth factors that finally stimulate collagen production. Histology shows thickening of skin and a dramatic increase in new collagen and elastin fibers. Neo-collagenogenesis process starts from 5 days after wounding and continue slowly over a long time period. The formation of new collagen reaches its peak in about 12 weeks after treatment. The complete results are visible after 32 weeks from the last session of treatment. Clinical results vary between patients, but all patients achieve some improvements [53].

The number of treatments required depends on the individual collagen response and on the desired results. Most patients require 3-4 treatments approximately every 4 weeks. More recently, Fabbrocini et al. have proposed the combined use of skin needling and Platelet-Rich Plasma (PRP). PRP contains autologous growth factors, especially epidermal growth factor, platelet-derived growth factor, transforming growth factor beta and vascular endothelial growth factor that are very useful to accelerate wound healing and tissue repair. Its application on the skin immediately before the treatment with the microneedles (Figure 2) showed that the combined use of skin needling and PRP is more effective in improving acne scars than skin needling alone [54]. Skin needling can be safely performed on all skin phototypes. The risk of postinflammatory hyperpigmentation is very low respect to other procedures, such as dermabrasion, chemical peelings, and laser resurfacing. Main contraindications are: anticoagulant drugs assumption, bleeding disorder, active skin infections, collagen injections, and injectable fillers in the previous six months, personal or familiar history of hypertrophic and keloidal scars [55,56].

Punch Excision Techniques

Punch excision is mainly indicating for ice-pick or boxcar scars. According to diameter, depth and shape of scar, a biopsy punch of appropriate size is used to excise the scar and, then, closure or elevation or grafting is possible options to perform.

Punch excision and closure

Scar is excised and sutured after undermining, in a parallel direction to the relaxed skin tension lines. The goal is to trade a larger, deeper scar for a smaller, linear closure that will hopefully be less noticeable.

Punch incision and elevation

If the depressed scar has a normal surface texture, it is incised up



Figure 2: Application of PRP on the skin immediately before the treatment with the microneedles.

to the subcutaneous tissue and its base is elevated and, then, sutured to the level of the surrounding skin.

Punch excision and grafting

Scar is excised and replaced with an autologous, full-thickness punch graft. The postauricular region or the buttock are the most used donor sites [57,58].

Tissue Augmenting Agents

Augmentation is a further alternative for management of acne scarring. Several filler materials are currently available. An ideal filler material has to be hypoallergenic and safe, painless and easy to inject, inexpensive and long lasting. Although close, none of the treatments available meet all of the criteria completely.

Hyaluronic acid is the recommended one [59].

Laser Treatment

All patients with box-car scars or rolling scars are candidates for laser treatment. Both ablative and non ablative lasers are successfully employed in treating acne scars, even if they act through two different mechanisms: ablative lasers, such as Carbon dioxide laser and Erbium YAG laser resurface the skin by removing outer layers and damaged scar tissue, through vaporization or evaporation. On the contrary, non ablative lasers, such as Nd YAG and Diode lasers, mainly stimulate new collagen formation, without removing epidermis [60].

Ablative effect is due to the high laser selectivity for water which is further expressed by Erbium technologies. CO₂ laser, instead, presents a lower selectivity for water adding two main effects: protein denaturation in the tissues surrounding the ablation, and a thermal stimulus for dermal protein, which result in an amplified production of matrix proteins and fibroblasts, promoting wound healing process [61].

In previous clinical studies CO₂ showed 50%-80% improvement. Laser skin resurfacing is avoided for active acne. Herpes virus infection is the main contraindication for laser treatment. Patients with dark skin phototype may develop postinflammatory hyperpigmentation.

All ablative lasers showed high risk of complications and side effects. Possible adverse reactions may be acute (temporary pain, redness, infections) or chronic (hyperpigmentation, scarring, swelling) [62,63].

Nonablative skin remodeling systems are now more popular for the treatment of facial wrinkles and acne scars because they decrease the risk of side effects and postoperative care. The most used non ablative technologies are Nd YAG (1450 nm diode, 1320 and 1064 nm neodymium-doped yttrium aluminum garnet) and 1540 nm Erbium glass.

Several clinical trials have demonstrated that diode laser is efficacy to improve atrophic scars. The 1,320 nm Nd:YAG (CoolTouch, CoolTouch Corp., Auburn, CA, USA) and 1,450 nm diode (Smoothbeam) lasers were compared by Tanzi and Alster. These authors demonstrated clinical improvement with the 1,450 nm diode system respect to 1,320. Skin surface texture was improved by the both systems, but the 1,450 nm diode laser induced more significant change, at the 6 months following [64]. More recently, Wada et al. [65] evaluated efficacy and safety of a low-energy double-pass 1450-nm diode laser for the treatment of acne scars. After five treatment sessions, seventy-five percent of the subjects showed at least 30% improvement of acne scars. At the 3-month follow-up evaluation, 92.9% of the subjects with >30% improvement maintained the effectiveness. Vesicle formation and transient hyperpigmentation also occurred in one case [65].

Non-ablative 1550-nm erbium laser has also been effectively used to treat acne scars. Kim et al. compared the efficacy of 1,550 nm Erbium fractional laser and chemical reconstruction of skin scar (TCA CROSS) method in the treatment of acne scars [66]. They found that in rolling type the objective and subjective improvement rates were significantly higher in the sides treated with laser than CROSS method, while in icepick type there were no statistically significant differences between the two treatment sides. Laser treatment produced grades of pain significantly higher than that produced by CROSS method. However, downtimes and lasting days of erythema were significantly longer in the sides treated with CROSS method [66].

Fractional Photothermolysis (FP) showed its usefulness in the treatment of acne scars [67] because it avoids potential negative side effects, mainly regarding post inflammatory hyperpigmentation [62]. The combination of an ablative 30 W CO₂ laser with FP system produces the "Ablative Fractional Resurfacing" (AFR) which ensures, at the same time, the efficacy of ablative techniques and the safety of FP methods, with the advantage of a faster recovery time [68]. Topographic analysis performed by some authors has showed that the depth of acne scars has quantifiable objective improvement ranging from 43% to 80% with a mean level of 66.8% [69]. The different experiences of numerous authors in this field have shown that, by combining ablative technology with FP, AFR treatments constitute a safe and effective treatment modality for acne scarring. Rapid re-epithelization from surrounding undamaged areas allows a reduced downtime with no adverse effects [68,70]. Na Ji et al. has recently showed that application of autologous PRP is an effective method to enhance wound healing and reducing transient adverse effects after ablative fractional carbon dioxide laser resurfacing [71]. Pigmentation abnormalities following laser treatment are ones of the most frequent side effects. Alster and West reported a significant higher incidence of hyperpigmentation (36%) with conventional CO₂ resurfacing respect to patients treated with AFR treatments [72].

A relatively new modality uses fractionated bipolar Radiofrequency (RF) for the treatment of acne scars. This type of treatment provides a coagulative (nonablative) effect limited to the mid-dermis in addition to an ablative injury to less than five percent of the epidermis. The advantages of this modality are reduced down time, lack of interaction with melanin, and low side-effect profile. Forman et al. [73] underwent their patients to five treatments, at four-week intervals, with subablative fractional bipolar radiofrequency and bipolar radiofrequency combined with diode laser. Acne scars improved significantly one month after three treatments and the improvement persisted for at least 12 weeks after the fifth treatment. Adverse effects were limited to transient erythema and edema [73]. Also Peterson et al. evaluated the effect of

fractional laser with radiofrequency and fractionated radiofrequency on the improvement of acne scars. Their patients received five treatments at 30-day intervals. A 72.3% decrease ($p < .001$) was observed on the acne scar scale from day 1 to 210. From day 30 to 210, investigator-rated changes in scarring, texture, and pigmentation improved 68.2% ($p < .001$), 66.7% ($p < .001$), and 13.3% ($p = .05$), respectively [74].

Conclusions

None of the currently available treatments can achieve complete resolution of atrophic acne scars. The best method to prevent scarring is to treat acne early enough to minimize the extent and duration of inflammation. Combining different methods we can improve the efficacy. Guidelines are necessary to quantify the benefits of single treatment and to establish the duration of the effects, the cost-effective ratio of different treatments, and to evaluate the psychological improvement and the quality of life of these patients.

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This article was originally published in a special issue, [Advances in Skin therapies and Therapeutics](#) handled by Editor(s). Dr. Camile Hexsel, Henry Ford Hospital, USA; Dr. Anetta Reszko, Cornell University, USA