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Review Article

Current trends in the use of lasers for the management of Acne scars-A literature review

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Abstract

One of the most prominent side effects of acne is the formation of scars. It can have a detrimental effect on someone's psychological and physiological wellness as well as overall experience of living. Since acne is a complex condition, it can be managed in a variety of ways to reduce the production of scars, yet scarring can still occur occasionally for a variety of reasons. With advances in medical science, a variety of therapy techniques, including derma-peeling treatments, injectable implants, derma-planning, etc., have been proven to be helpful for both hypertrophic and atrophic scarring. Today, lasers have advanced and earned a unique position in the managerial hierarchy. Laser beams have demonstrated their effectiveness not only in the control of scars but also in treating cases of persistent acne. This analysis compares several laser treatment possibilities and focuses on the laser solution that is most appropriate for particular kinds of marks. It describes how lasers may be used efficiently and how using them in conjunction with other therapies may enhance their effectiveness. The chosen publications provide detailed information on particular laser patterns and their effects on different scar kinds. It involves addressing an individual entirely, using an integrated approach to medical treatment, involving managing pimples and scarring associated with them. In conclusion of the evaluation, it is possible to determine if lasers are a viable way to treatment for acne-related scarring than traditional techniques or whether further research is required before selecting them as a comprehensive solution.

Keywords: Acne; Dermatology; Laser treatment; Scarring; Skin care

Introduction

Acne is a dermal illness that affects predominantly teens but is also frequently observed in adults across the entire globe. It frequently leaves marks and has a detrimental societal and psychological impact on a person's life. Scarring is a typical reaction to the damage done to the skin, however, severe scarring can happen if the epidermis is repeatedly plucked and pressed

[1]. Because acne is a complex illness, its pathophysiology can vary from the development of microcomedones to swelling and inflammation that may be brought on by the growth of gram positive bacteria named *Propionibacterium acnes* [2]. Experiments on different kinds of marks from acne and innovative treatment practices have been carried out over time to assess their efficacy and results. Acne can result in keloidal scars, hypertrophic scars, atrophic scars, and other forms of scars [3].

The therapy choices for acne and associated scars are evolving with the progress the field of medicine. Whereas intermediate levels of acne may be treated with antibiotics administered orally, while earlier stages can be treated with applied medicines such as keratolytics, antimicrobial drugs, and retinoids. However, orally administered retinoids and an extensive monitoring strategy is required for more serious types like nodulocystic acne. At present, lasers are applied to acne and acne scars. Additionally, several forms of light-based therapies appear to have encouraged outcomes in the treatment of inflamed acne [2]. As a result, many laser types, with ablation or non-ablation procedures, are now being examined for therapy [3]. We can determine the most suitable lasers for particular kinds of scars after doing several trials. Although flashlamps are taken into consideration for treating hypertrophic scars, while CO_2 and Er.YAG-lasers with ablation characteristics are employed for boxed scars [1]. Intralesional steroids and silicone gel therapies can increase the efficacy of lasers. CO_2 laser treatment with ablative fractions can be improved by coupling it with a therapy like Protein Rich Plasma (PRP), according to a systematic review. Other investigations have indicated that the use of many therapies, including silicon, PRP, collagen induction therapy, surgical skin planing, punch elevation, intralesional steroids, and fractional lasers with dot peeling, can significantly improve the appearance of scars [3]. Because of its efficacy and much fewer drawbacks than alternative ablative and non-ablative lasers, thermolysis with the help of light is currently employed [2]. However, it might be difficult to cure aggressive acne and scarring. Continuous advancement can be demonstrated with the frequent application of lasers and further procedures. The person receiving treatment should be addressed properly as a result [2].

To conclude the most recent and efficient treatment of acne scarring using lasers and other approaches, this overview of the literature attempts to objectively examine several research carried out over time.

Acne vulgaris and acne scarring

Pathogenesis and clinical features

Acne vulgaris

A condition when the pilosebaceous glands in the epidermis are chronically inflamed. Dehydroepiandrosterone sulfate and free testosterone are both found in greater concentrations in extreme situations [4]. This condition is associated with aberrant regulation of androgen production. Acne affects both sexes and every race and ethnicity. However, adolescent and young adult prevalence is highest [5, 6].

Acne-causing susceptibility factors

Due to its multifactorial nature, multiple variables, including but not limited to those mentioned above, have been linked to the development of acne [5] as shown in (Fig. 1). Acne can be exacerbated by dairy and fatty foods, excessive cosmetics use, hormonal fluctuations, tension, and anxiety [7]. In addition, Acne may be made worse by hormonal imbalances or by malignancies of the adrenal glands or ovaries [5].

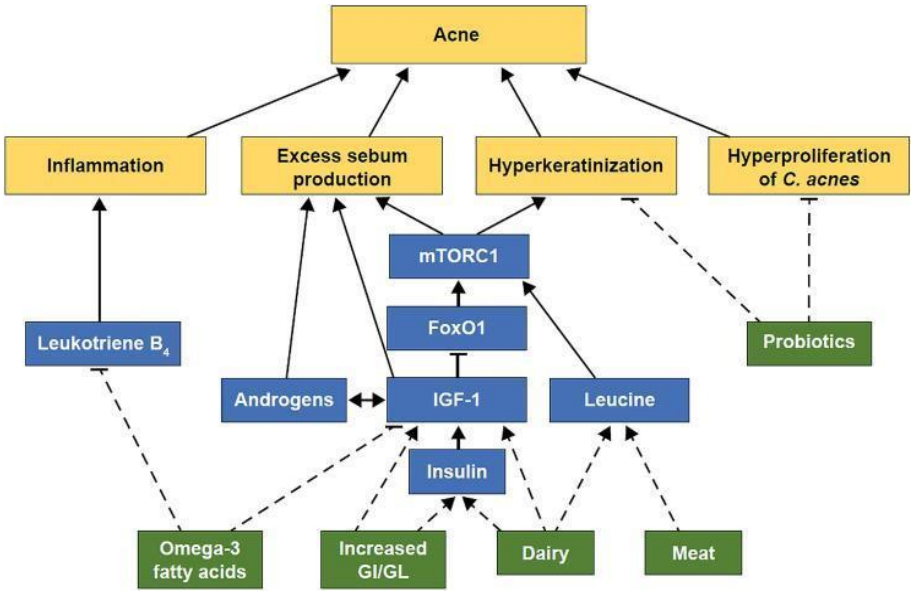

Figure 1. The effect of diet on the mammalian rapamycin target complex 1 (mTORC1) signaling. Entities under consideration in this overview are shown by broken lines. IGF-1 insulin-like growth factor-1, Glycemic index (GI), glycemic load (GL), and forkhead box class O transcription factor 1 (FoxO1) [8]

Distributional scope

Acne lesions often occur on the face, back, and upper torso. They can, however, range in severity and manifest as a variety of lesions [9].

Acne grading and diagnosis

Acne is diagnosed with a detailed inspection of the skin, which typically reveals visible comedones. As a result, it distinguishes itself from other folliculocentric. It may be classified into four types: comedonal (open and closed), tiny papular erythematous, pustules, and nodulocystic [7].

Pathogenesis

Comedones may form when the sebum secreted by a pilosebaceous unit blocks its opening. Blackheads appear if the contents of the comedones oxidize, but whiteheads do not. This follicular compartment eventually bursts, releasing sebum into the dermis. In addition, skin bacteria like *Prorionobacterium acnes* use lipases to digest sebum and liberate free fatty acids [10, 11]. This causes the skin to become irritated, which then triggers the infiltration of leukocytes and the formation of a papule. Pseudocysts, which manifest topically as pustules, are the result of dermal and subcutaneous inflammation that has spread to the deeper layers of the skin [4]. Many internal and external factors, including inflammatory mediators, contribute to this intricate process as shown in (Fig. 2). When an abscess or follicle bursts, the wound might begin to heal. Some of the immune cells involved in the wound healing process include keratinocytes, fibroblasts, endothelial cells, nerve cells, lymphocytes, monocytes, and neutrophils [12].

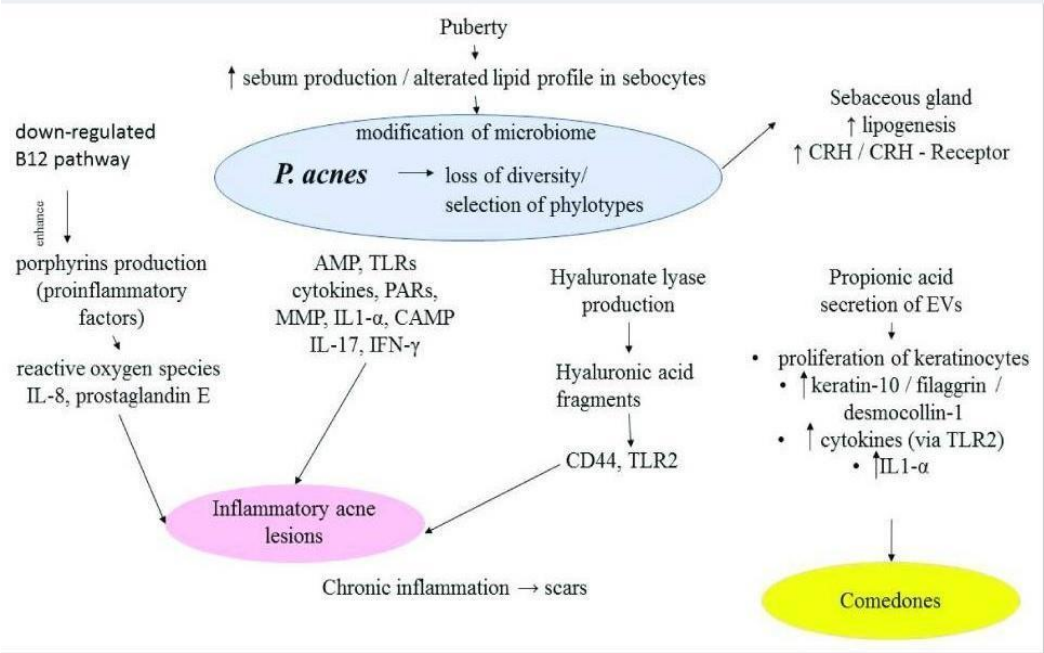

Figure 2. Loss of diversity in Propionibacterium acnes, the selection of phylotypes, and the many target actions of this bacterium in acne [11].

Causes of acne by bacteria Acne-causing P. acnes promotes inflammation through increasing production of inflammatory molecules as AMP, TLRs, cytokines, PARs, MMP, IL-1a, CAMP, hyaluronate lyase, and porphyrins. The maturation of keratinocytes is altered as a result of elevated amounts of keratin 10, filaggrin, and desmocollin 1. It does this via activating the CRH/CRH receptor pathway, which in turn increases the sebaceous glands and sebum generation. Corticotropin-releasing hormone (CRH), antimicrobial peptide (AMP), extracellular vesicle (EV), interferon (IFN) gamma, interleukin (IL), matrix metalloproteinase (MMP), protease-activated receptor (PAR), and Toll-like receptor are all examples of inflammatory mediators (TLR) [10].

Wound healing and scar formation

Wound healing is a multi-step process that begins with inflammation and continues with the formation of granulation tissue and matrix remodeling as a scar forms. Scar development is heavily influenced by inflammation. inflammatory can cause vasomotor responses in capillaries, the production of inflammatory mediators, and even melanogenesis. This is followed by the creation of granulation tissue, in which the vascular of the site is restored and growth factors are released, activating fibroblasts and culminating in collagen production. Finally, extracellular matrix metalloproteinases (MMPs) and tissue inhibitors undergo structural development and enzymatic remodeling, making up what is known as matrix remodeling. Scars may develop into hypertrophic or atrophic forms depending on how these factors react [12]. Many people notice post-inflammatory changes such as erythema (redness), hyperpigmentation (brown spots), or hypopigmentation (white spots) on their skin [9].

Acne management

Acne lesion management requires a thorough patient history, diagnostic testing, and physical examination. In order to properly screen young women for hirsutism, dysmenorrhea, and polycystic ovary

syndrome, a hormonal profile is usually necessary. This profile consists mostly of testosterone, LH, FSH, and DHEA [7]. To reduce excessive oil production, patients may be recommended to use a light cleanser three times each day. Moisturizing creams should be avoided. Sunscreen in the form of gels or sprays is recommended. Furthermore, the patient's diet might be adjusted in accordance with the medication recommended in order to boost efficacy and achieve encouraging outcomes. As a result, an appropriate guideline should be offered to a patient in order to get improved results [4]. Acne medical treatment options include both topical and systemic treatment.

The following are examples of topical management:

Tretinoin and adapalene are two examples of topical retinoids that may be used either alone or in combination with other antibiotics. Tetracyclines (clindamycin, nadifloxacin, and azithromycin), antibiotics (benzoyl peroxide), comedolytic agents (azelaic acid), and chemical peeling agents are all effective topical treatments for acne (beta hydroxy acids). Comedones and papules may be treated with topical dapsone [7].

Antibiotics like doxycycline, minocycline, and amoxicillin may be used to treat acne on a systemic level since they are effective as both antibiotics and anti-inflammatories. Isotretinoin and other oral retinoids may decrease acne by controlling sebum production. Low-dose estrogen and progestin are examples of oral contraceptives. Anti-androgen treatment can be achieved using oral diuretics such as spironolactone [7].

Lasers and other acne treatment options

Laser, radiofrequency, and light-based therapy methods have recently been employed to treat acne and acne scars. In the event of inflammatory acne, they are regarded to be beneficial. The effectiveness of topical agents can be increased. Recent research has shown the following options for treating acne: Studies have demonstrated that the photodynamic or photothermolysis properties of a Potassium Titanyl Phosphate (KTP) laser may reduce the severity of acne in as little as four to six sessions.

It has the same properties as a KTP laser and is a pulsed dye laser operating at 585 nm and 595 nm. Collagen production and dermal remodeling may be encouraged with the use of a pulsed colored laser. One research suggests that the production of transforming growth factors may also be stimulated by using a pulsed coloured laser. The result is decreased inflammation and enhanced neocollagenesis. When used with a diode laser, it reduces redness, swelling, and scarring.

1450-nm diode laser

This laser has been demonstrated to be effective in treating facial acne when used in conjunction with a dynamic cooling device. Acne is helped by the reduction in sebum production caused by thermal coagulation of the sebaceous lobule in the related pilosebaceous unit.

Erbium Glass Laser at a wavelength of 1540 nm is helpful in reducing excess oil production and acne scarring.

Intense pulsed light

Acne may be effectively treated with only one light source (in the 500-to-1200 nm spectrum) with topical porphyrins.

Radiofrequency has been proven to decrease inflammation, particularly around the sebaceous glands and perifollicular region, when combined with a pulsed light device.

Photodynamic therapy and low-intensity light treatment

The employment of different wavelengths of light can aid in the breakdown of *P. acnes* bacteria cell membranes [2].

Acne scarring management

Acne scarring is one of the most common acne complications. Various treatment strategies have been researched and investigated in recent years in order to find

the best potential therapy choice for acne sufferers [13]. To comprehend the many forms of scars, we must first learn about the scar creation and healing processes. Collagen at the location of the lesion may change as a result of the complicated process of wound healing. Atrophic or hypertrophic scars emerge as a result of such loss or increase of collage tissue. Atrophic scarring is more prevalent than hypertrophic or keloidal scarring [12].

Scars from atrophic acne

There are three distinct forms of atrophic acne scars: icepick, boxcar, and rolling. Scars are classified in this way according to their structure and appearance [3] as shown in (Fig. 3).

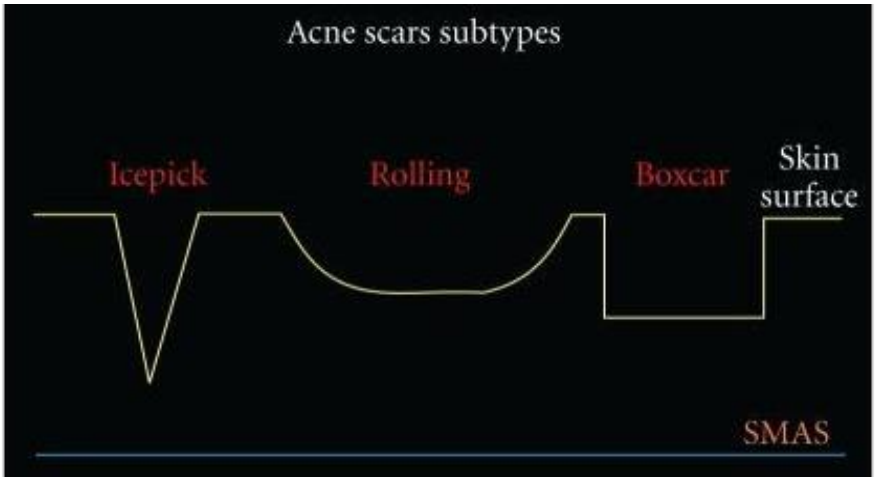

Figure 3. Acne scars subtypes [12]

Icepick scars

These are typically less than 2 millimeters in size and have a thin and profound appearance. clearly delineated and equipped with appropriate epithelial tracts that are capable of invaginating into the deep dermal or subcutaneous tissue. According to Fabbrocini, the width of the entrance of these scars is more than that of the infundibulum, which results in the formation of a "V" shape [12] as shown in (Fig. 4).

Figure 4. Icepick scars [12]

Rolling scars

These scars seem like they are part of the natural skin. According to a study of 2010, their breadth can range anywhere from 4 to 5 millimeters, and their "M"-shaped morphology is caused by the adherence of the dermis to the subcutis [12]. They have a shady appearance as a result of the adhesion of the skin to the dermis as it goes to the subcutaneous tissue as shown in (Fig. 5). According to another research from 2020, therapy is necessary at this level [3].

Figure 5. Rolling scars [9]

Boxcar scars

These scars range from round to oval in shape as shown in (Fig. 6). They take on the impression of having a "U" shape due to their vast surface area as well as their broad foundation. Box scars can be very shallow, measuring only 0.1 to 0.5 millimeters in depth, or they can be rather deep, measuring more than or equal to 0.5 millimeters. Fabbrocini mentioned in his paper that breadth can range from about 1.5 to 4.0 mm [12]. The look of these scars frequently resembles that of scars caused by *Varicella sp* [3].

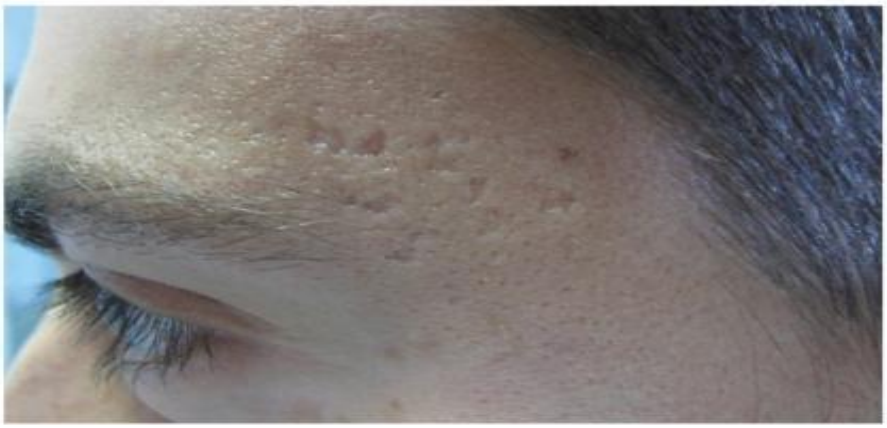

Figure 6. Box scars [12]

Grading acne scars

It is not uncommon to see many types of scars on the same patient, which might make it difficult to properly evaluate and treat the patient. Consequently, in response to the suggestion made by Goodman and Baron, a

quantitative scale was implemented. This method is applied all over the world to determine the severity of the scarring [14]. It comprises the kind of the scars as well as the quantity of them. The following is how their system works:

Scars that are macular or slightly atrophic receive one point each; scars that are moderately atrophic receive two points; scars that are linear and toughed out or punched out receive three points; and hyperplastic papular scars receive four points.

The number of lesions is then multiplied by a point value that varies according to the range: 1 to 10 times 1, 11 to 20 times 2, and 20 and above times 3.

Later, Dreno and his colleagues created the Echelle d'Evaluation Clinique des Cicatrices d'Acné (ECCA) scale to evaluate acne severity. This approach classifies different types of scars as well as the number of scars based on their diameter. As described below; Scars less than 2 millimeters in diameter get 15, those between 2 and 4 millimeters in the form of a U receive 20, and those larger than 4 millimeters in the shape of a M receive 25. Elastolysis on the surface of the skin is given a score of 30, hypertrophic scars that have been present for less than two years receive a score of 40, and hypertrophic scars that have been present for more than two years receive a score of 50.

This is then ultimately given a rating of 0 for having no scars, 1 for having 5 to 20 scars, and 3 for having more than 20 scars.

The total score has a possible range of 0 to 540 points. Accuracy and prior training are prerequisites for this. This approach is an efficient method of subcategorizing scars, but it does have some restrictions owing to the fact that it can only be applied to the face, it takes a long time, and it can't account for all possible clinical circumstances [12].

Other kinds of scars include

There are further conditions such as sinus tracts, hypertrophic scars, and keloids that can cause scarring.

Hypertrophic scars and keloids

These types of scars are generated when there is an enhanced accumulation of collagen and a decreased activity of the enzyme collagenase [3]. Hypertrophic scars have the appearance of elevated, solid, pink, and dense fibrous connective tissue [12]. Keloids are often characterized by an overgrowth of fibrous connective tissue, which can cause the lesions they cause to be elevated and a reddish-purple color. According to researches of 2010 and 2020, in the event of keloid development, the process of healing a wound persists even after the lesion has been completely healed and individuals with darker skin tones are more likely to develop keloids and hypertrophic scars, which typically appear on the trunk [3, 12] as shown in (Fig. 7).

Figure 7. Hypertrophic Acne Scars [9]

Treatments for scars left behind by acne

In order to treat acne scars, it is necessary to evaluate the size, kind, and degree of scarring first. The individual's skin type is another significant factor to consider. First, a patient has to undergo a thorough evaluation that includes an accurate history as well as an examination, and after that, a treatment strategy should be developed. Additionally, it is necessary to provide your patient with mental aid because this may and will be a psychological trip for the majority of them [1]. Due to the fact that the duration of therapy and the ultimate results differ from patient to patient. The maintenance of acne scars can be approached in a number of different ways as shown in (Fig. 8), but an algorithmic approach may be helpful to us in this procedure. This method was proposed by Connolly and co. requires first treating the erythema and then considering using a combined therapy strategy for more successful outcomes [15].

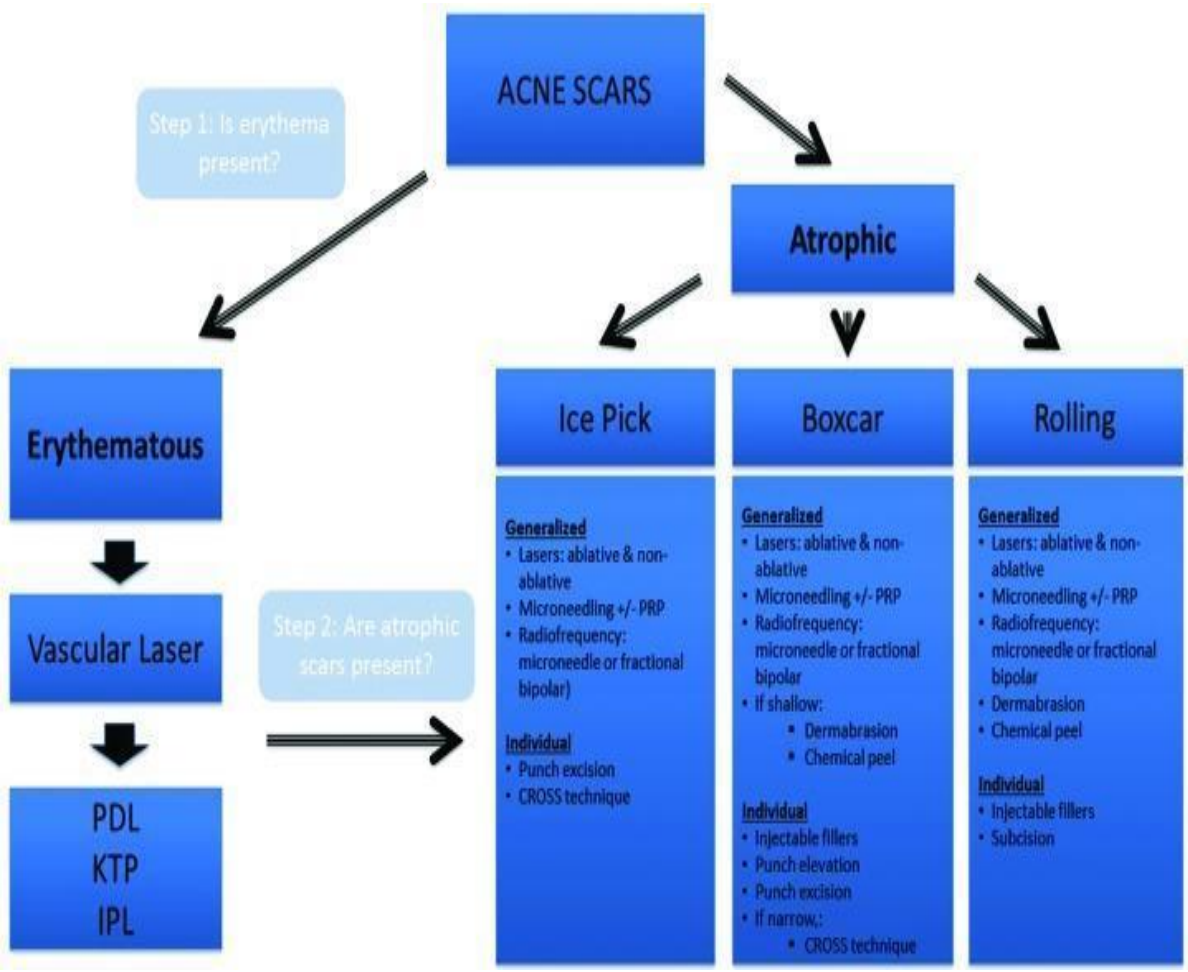

Figure 8. Guidelines for the management of acne scars [15]

Scarring from acne can look different on different people. Patients who suffer from nodulocystic acne are likely to have this condition. At first, changes in pigmentation appear, followed by scarring; this condition frequently calls for oral isotretinoin treatment. On the other hand, minor acne can be treated with oral antibiotics to stop future

outbreaks of the condition. It is imperative that we have an understanding of the significance of the medical history of such individuals before beginning any therapies for acne scarring. Because the therapy for acne with isotretinoin and oral antibiotics typically lasts for a longer period of time, patients' compliance levels tend to vary from one another [2].

The following (Table 1) provides an overview of the primary categories of treatment techniques that physicians take into consideration while treating acne scars [1].

Table 1. The following provides an overview of the primary categories of treatment techniques that physicians take into consideration while treating acne scars

Description	Therapy	Considerations	Comment
Spherical Atrophic Scars			
Scarring atrophy that rolls	Filler and/or ablative resurfacing	Ablative resurfacing (lasers) with added dermal filler as a support.	There is an encouraging response to the therapy at first, but it gradually fades.
Boxcar Scars			
Boxcar scar	CO_2 laser or erbium-YAG laser Edges of scars are removed then non-ablative treatment is followed	Treat individual boxcar scars, first on the edges to create a circular shape then remove the edges to reduce the shadowing.	In case of darker tone individuals, do perform a patch test to rule out hyper pigmentary changes. Often a filler is needed to aid the scar treatment.
Icepick Scars			
Ice Pick acne scar – vertically running scars	Surgical or punch excision	First inject an anesthesia then excise and suture it with two stitches of 5-0 or 6-0 absorbable suture.	Give 8 to 10 days for the stitches to heal and if any scar after surgery remains, it may be ablated.
Ice Pick acne scar - fanning out scars		Locate the pore's route and trace it.	

Oral medication for acne scars

Isotretinoin (0.5 mg/kg/day) is an oral medicine that has been suggested for acne scarring [1].

Peels using chemicals

Scars may be treated cosmetically using this method. The degree of a chemical peel's penetration and its subsequent consequences categorize it. They might be shallow, affecting just the top layer of skin (epidermis-papillary dermis), intermediate (affecting papillary and upper reticular dermis), or deep (affecting mid-reticular dermis) [3]. In order to facilitate and speed up the healing process, we apply several chemicals to the patient's skin during a chemical peel to remove the outer skin layers [12]. Chemical peels can successfully repair scars that are less in size and depth. Although deep peels such as phenols provide great results with thick collagen synthesis, they are not generally utilized because of cardiotoxicity [15].

Acids including glycolic, lactic, salicylic, resorcinol, and tretinoin are often employed in superficial peels. Baker-Gordon or Litton phenol is used for deep peels, whereas TCA (35–50%) or Jessner Solution (resorcinol,

lactic acid, and salicylic acid in ethanol) is used for medium peels [3].

Chemical peels frequently need a mix of treatments. According to research, icepick and rolling scars are frequently treated with topical retinoids and alpha hydroxy acids. Peels have different effects depending on the patient's skin and scars. Studies demonstrate that TCA 50%-90% peels are effective on box scars, but only somewhat effective on ice pick scars in those with hyperkeratotic skin types [12].

TCA (high concentrations) peels have been shown to improve ice pick scars and increase patient satisfaction [1]. Safe and efficient, glycolic acid induces epidermolysis and thins the stratum corneum in a superficial peel. It can be used in most patients with great compliance, with the exception of pregnant women and patients with contact dermatitis. Five sessions every two weeks yield the best results. Temporary hyperpigmentation is possible. Pyruvic acid, which has both peeling and antibacterial properties, has been used to cure mild acne scars. However, due to potential side effects including crusting, burning, irritation, and effects on the upper respiratory system, careful patient monitoring throughout administration is essential. One of the best peels for acne scars is salicylic acid, and it may improve the appearance of scars by over 30% with many sessions performed three to five times every three to five weeks. When used over a larger area of the body, though, it's important to keep an eye out for symptoms like rapid breathing and ringing in the ears [12].

Icepick and boxcar scars (narrow) were previously treated with high doses of TCA using the CROSS approach - the chemical rebuilding of skin scars. It was discovered that there was a positive improvement after three to six sessions. However, Connolly believe that a fractional 1550 nm erbium laser is preferable to rolling scars [15].

Dermabrasion

The epidermis and top dermis are removed using Sandpaper with hydrogen peroxide, or electrical instruments with a spinning wheel connected. This contributes to Healing wounds and producing new collagen [3]. Chemical peels, dermabrasion, and lasers can all be utilized to resurface the skin however, dermabrasion is more successful for rolling and superficial boxcar scars [1]. Dermabrasion's main goal is to encourage re-epithelialization. Dermabrasion is used to remove the epidermis, papillary dermis, and reticular dermis. Microdermabrasion, on the other hand, merely removes the outer skin. These operations should be conducted under local or general anesthesia, with the patient not being on isotretinoin medication. Pigmentary alterations can occur in patients with dark skin tones [12]. Histologically, new collagen production can be detected in the dermis. Post-procedural discomfort, scarring, increased sun sensitivity, milia development, and pigmentary alterations may occur in certain individuals [15].

Microneedling

Micron-sized needles of a micropen puncture the skin, stimulating the production of new collagen and elastin. Acne scars aren't the only thing this method may help with; wrinkles, fine lines, cuts, and even pores can all benefit from it [3]. Micro-clefts deep in the dermis, made by the tiny needles, trigger the release of growth factors that hasten wound healing and boost collagen and elastin production. This reduces the look of wrinkles and scars, especially acne scars that have a tendency to roll. Although it takes longer to see results, it is far safer than peels and lasers since the epidermis is not removed and the healing process is quick. According to research, plasma rich proteins PRP concentrates can help get better results [15].

Subcision

A simple and successful way of treating atrophic scars. The adhesions between the

superficial skin and the fibrotic connective tissue are removed during this operation. A specific needle known as a needlepoint has been utilized to aid in the manual treatment of scars [3]. Typically, the needle is 18 gauge with a tip that functions as a tiny scalpel [1]. Results have been encouraging; however, it is less helpful for icepick and boxcar scars than it is for rolling acne scars. Subcisions may be made with hypodermic needles of 18 or 20 gauge with triangular tips, or Nokor needles of 18 gauge with triangular points. It's painful and could make you swell, bruise, bleed, or get an infection [15].

Mesotherapy

Hormones, plant extracts, and vitamins are injected under the skin to promote skin regeneration and firming [3].

Microsubcision (MSUBxTM, Suneva Medical, Inc., San Diego, California)

In this cutting-edge technique, a hypodermic needle is used to create a hollow beneath the scar, which is then filled with fibrin clot or injectable dermal fillers [1].

Excision

Surgical excisions can be done in severe cases of acne scars. This can comprise punch excision or grafting, as well as elliptical excision and stitching. Punch grafting necessitates greater expertise, a donor location, and extra care [1]. Punch excision is commonly used to treat ice pick and boxcar scars. A carefully selected punch needle is utilized, and the wound is sutured, followed in certain circumstances by laser resurfacing. Punch elevation is recommended for larger scars, particularly boxcar scars [15].

Cosmetic fillers

According to recent research, injectable fillers can be used to repair scars. This not only heals scar depressions but also promotes collagen formation. Fillers have been shown to be useful as a single or combined treatment [3]. A needle is put in the middle of the scar and then gently retracted as filler is injected and finally molded to create good outcomes using a linear threading approach. Fillers are frequently injected in several directions using the fanning technique. Fillers are useful in treating deep and rolling acne scars and improving skin texture, but a patient should be fully informed about the surgery and any risks involved [1]. Bellafill TM and Artefill TM are now widely utilized for a variety of purposes. They aid in the addition of volume, collagen formation, and the reduction of scar shadowing [1]. Soft fillers can successfully cure atrophic rolling or boxcar scars. Punctures, linear threading, fanning, cross-hatching, and other injection methods may be used to place these fillers. Temporary, permanent, and semi permanent fillers are all available. The temporary measure will be in effect for a limited time and will need an additional meeting. Hyaluronic acid fillers (HAF) are one kind of injectable filler. Collagen production is boosted by HAF, making skin more supple [15].

Semi-permanent fillers (Sculptra and New Fill) encourage the creation of fibrous tissues to enhance the look of scars, particularly rolling scars, and can last up to two years. However, synthetics are also available under the brand name Radiesse and are used to treat boxcar scars following subcisions [15]. Permanent fillers endure for years and may be molded to the underlying connective tissue, but if they aren't placed correctly, they may need to be surgically removed. Polymethylmethacrylate (PMMA) is a synthetic filler that is frequently utilized in permanent fillers [15].

Silicone-based treatments

Hypertrophic scars have responded well to silicone-based scar therapies. By promoting blood vessel growth and hydration, it helps heal wounds [1].

Corticosteroids

- Hypertrophic scars and keloids are treatable with intraregional steroid injections. According to research, Triamcinolone can help remove scars by increasing fibroblast

proliferation, collagen production, and inhibiting collagen degradation [3].

5 FU (Florouracil)

Combining 5 FU with intralesional corticosteroids and PDL has shown promising results in a number of clinical studies for acne scars [3].

Carboxy therapy

In this procedure, carbon dioxide gas is administered to the skin or adipose tissue to encourage the healing of oxygen-depleted skin [3].

Fat transplantation

Autologous fat transplantation can restore severely depressed scars and facial features [1].

Hyaluronic Acid (HA)

HA can be injected as dermal fillers into the mid-to-superficial dermis. NASHA (non-animal stabilized hyaluronic acid) is commonly utilized. The Tyndall or Rayleigh effect, which causes blue skin discoloration in fair-skinned persons, is common. According to studies, it can only produce short improvements, hence alternative therapy should be sought [1].

Radiofrequency

The dermis is warmed by radiofrequency, leading to the regeneration of collagen and a reduced chance of scarring and infection. Its original use was in skin regeneration, but recent research has shown it to be effective in the treatment of scars as well [3]. Improvements in RF devices have made the process less painful and more targeted, since the energy can now be directed to the target area without damaging the epidermis. Bipolar RF and fractional RF are currently being employed, with improved outcomes for icepick and boxcar scars. Although RF can produce discomfort, erythema, and scabbing, good outcomes can be obtained in three to four sessions [15].

Stem cell treatment

In vitro, stem cells are multiplied and differentiated into various types of cells required for growth, and they can be injected into patients' autologous tissues or activated locally for tissue regeneration. While the exact mechanism of action remains a mystery, contemporary dermatology is only one of several medical fields where stem cell therapy is being studied for its potential to promote renewal, regeneration, and repair [16].

Acne scar laser therapy

Acne scars may be effectively treated using lasers and other light-based therapies instead of the more conventional methods. Among their many effects is a reduction in inflammation, a dampening of sebaceous gland activity, and the killing of P. acnes bacteria. Therefore, while lasers used in acne treatment operate to reduce acne lesions, they may also aid in reducing the likelihood of permanent scarring. However, comedonal acne does not respond to them [2]. The following (Table 2) provides Both ablative and non-ablative lasers may be used to treat skin conditions, with the latter kind being preferable because of its ability to stimulate collagen production and skin regeneration by penetrating deeper into the skin [3].

Scar-related erythema is what has to be addressed first when attempting to reduce the appearance of acne scars (SAE). This may be cured by a variety of lasers and light systems, including pulse dye lasers.

Pulsed Dye Laser (PDL)

The pulse dye laser (PDL) is an excellent treatment for erythema. It works by selectively eliminating arteries in the dermis via thermolysis and improving the appearance of erythema. PDL act on oxyhemoglobin in the yellow and green range of cutaneous blood vessels, that peak at 418, 542, and 577 nm, respectively. Heating vessels safely with long wavelengths, such as 595-600 nm, helps prevent purpura [15].

It has been shown to enhance scar texture, elasticity, and hypertrophic scar healing by increasing matrix metalloproteinase-13

(collagenase-3) and lowering collagen III deposition [12]. Multiple clinical research has shown that pulsed dye lasers (PDLs) with 585 nm flash pumps are effective in reducing the appearance of hypertrophic acne scars on the face after only a few treatments [15]. PDLs may be used for a variety of purposes, one of which is collagen remodeling by a heating procedure similar to that used to generate transforming growth factor beta (TGF-), which activates fibroblasts and improves the texture of atrophic scars [15].

Studies have shown that 585 nm PDL is the most effective PDL for icepick scars, whereas Nd:YAG is the most effective for boxcar scars. Because of the risk of pigmentary changes, purpura, and blistering, those of darker skin tones should use PDL with care [15]. PDL works better on Fitzpatrick I-III skin tones since they have less melanin. PDLs have been demonstrated to alleviate pruritus-related discomfort [12].

Table 2. Acne scar laser treatments [15]

Laser category	Traditional	Fractionated
	10,6000 nm CO_2	Fractional 10,6000 nm CO_2
Ablative	2,940nm ER:YAG	Fractional 2940 nm ER:YAG
		Fractional 2,790nm YSGG
	1,064nm Nd:YAG	
	1,320nm Nd:YAG	
	1,450nm diode	Fractional 1,550nm Er-doped
Non-ablative	755 nm laser with a picosecond pulse	Fractional 1,540nm Er:glass
	585 nm PDL	
	595 nm PDL	
	532 nm KTP	

PDL: pulsed dye laser; KTP: potassium titanyl phosphate

Potassium Titanyl Phosphate (KTP)

The KTP laser (also known as frequency-doubled Nd:YAG) reduces the erythema of surgical scars by focusing on the oxyhemoglobin that is often overlooked. As measured by the Vancouver Scar Scale, KTP improves the vascularity of a scar. KTP is very successful in PIE because it targets just the papillary dermis. Results from SAE using 20–30 ms pulses at 6–9 J/cm2, spot size 4-5mm, have been very promising [15]. In order to treat rosacea and telangiectasia, the KTP green light laser has been authorized for use [17].

Conventional Ablative lasers

The most effective method of treating scars is using an ablative laser. Carbon dioxide (CO_2) lasers operate at 10,600 nm, whereas Er:YAG lasers operate at 2,940 nm and are pulsed. The tightness of skin and contraction of collagen are the mechanisms through which they work. Since these lasers are so potent, less treatment time is required for the same results. These lasers penetrate the skin less deeply because they concentrate on the water there. However, they have the potential to prolong the healing process and increase the risk of pain, irritation, post-procedure pigmentation, scarring, and infections [15].

Conventional 10,600 nm CO_2 laser

CO_2 laser has been shown in several studies to enhance the appearance of the skin by normalizing its texture and tone. Pigmentation and erythema after surgery, however, are not uncommon [15]. Acne flare-ups are possible with fractional lasers, but they may be controlled using a CO_2 laser, which is less invasive than a non-fractional

ablative laser and employs photothermolysis [1].

Conventional Er:YAG laser at 2,940nm

This laser is less harsh but more accurate and focused than ordinary carbon dioxide lasers. As a result, the dermis absorbs more energy and causes less harm to the surrounding tissues. This laser has less discomfort and a faster recovery period due to its high power and better precision. Because it lacks hemostatic qualities, it may result in bleeding [15]. According to certain research, carbon dioxide lasers can give better outcomes with fewer side effects. Laser resurfacing can enhance boxcar scars (raised and shallow), but it is less successful for icepick scars and requires more treatments. Aside from acne scars, ablative lasers have been shown to be beneficial in Scars from accidents and operations [18].

Ablative fractional lasers

Advanced lasers like the fractional variety are available. In comparison to ablative lasers, they provide the same or better outcomes after a single treatment with fewer adverse events. However, you may need a number of sessions before seeing results. Erythema, postinflammatory pigmentary changes, and discomfort are all mitigated by these lasers. A fractional 10,600 nm CO_2 laser, a 2,940 nm Er:YAG laser, and a 2,790 nm Yttrium scandium gallium garnet (Er:YSGG) laser are all examples of such devices.

CO_2 fractional laser at 10,600 nm

When applied with a strong pulse, fractional lasers show improvement across a broader region with less erythema. It may be used on the neck, back, chest, and periorbital area, although with less intensity and density than on the face and periorbital area because of the greater likelihood of muscle penetration and contact [15].

Fractional Er:YAG at 2,940nm and Yttrium Scandium Gallium garnet (Er:YSGG) at 2,790nm Laser

Scars that have atrophy with time, these lasers tend to produce excellent outcomes with little side effects, although repeated sessions are required to achieve the best results. Mild erythema may be observed in certain circumstances following the surgery [15].

Conventional Non-ablative lasers

Short-pulse and long-pulse Nd-YAG lasers, as well as Q-switched Nd-YAG lasers, are among these devices. These lasers are effective because they target water and stimulate collagen remodeling without ablation of the epidermis, although the results may be subtle and may need many treatments [15].

By stimulating the production of heat-shock protein 70 and type I procollagen and increasing the thickness of collagen in the papillary and reticular dermis, the 1064 nm Nd:YAG laser induces collagen remodeling. However, cooling systems are required for operation with this thermal laser. Such lasers come in a few different flavors: long-pulsed, short-pulsed, and Q-Switch [15]. Short-pulsed 1064 nm lasers have been shown to be effective for atrophic scars despite the potential for erythema, pain, and edema; long-pulsed 1064 nm Nd:YAG lasers have shown similar efficacy for atrophic scars while being less beneficial for deep scarring.

1064nm Q-switch Nd

The targeted and speedy treatment that the YAG laser delivers may be used on melanin, tattoo ink, and other pigments.

Non-ablative fractional lasers

Collagen remodeling may be prompted by a new type of lasers that specifically target water, hemoglobin, and melanin. Recovery time is reduced since the epidermis is not removed, but more treatments are required to get the same results [15].

Er:glass fractional 1,540nm laser

The Er:glass laser has been shown to be effective in treating acne scars, with no permanent discoloration or scarring occurring as a result of the procedure and little skin redness. The structure of the skin was shown to be identical to normal skin in experiments conducted on people of different ethnic backgrounds, including Italians and Asians. Scars like boxcars, rollers, and icepicks may all benefit from this treatment [15].

Although numerous sessions of EDL are necessary to get the desired outcomes in treating acne scars with minimal unwanted effects like bleeding, erythema, infection, and so on. According to studies, atrophic scars improved significantly with EDL laser treatment in both trunk and face locations, with minor erythema. For those with darker skin tones, EDL is likely safe [15].

755nm picosecond alexandrite laser

A picosecond laser delivers gentler energy over a shorter length of time. Because of its distinct character, the negative consequences are minimal. This laser, known as Picosure, has demonstrated improvement in instances of atrophic rolling scars. The laser stimulates the production of collagen, elastin, and mucus, all of which contribute to the healing of skin wounds. The discomfort is bearable. Combining 532nm and 1064nm Alexandrite picosecond lasers, known as PicoWay, is being studied for its potential to reduce acne scars [15].

The following (Table 3) provides an overview of the adverse effects of cutaneous lasers.

Table 3. Adverse effects of cutaneous lasers [15]

Lasers	Adverse Effects
Pulsed Dyed Laser (PDL)	It may induce purpura, bleeding, and pigmentary changes in those with dark skin.
Frequency-doubled Nd:YAG (also known as Potassium Titanyl Phosphate, or KTP)	Hypopigmentation and hyperpigmentation in people with dark skin after inflammation.
Traditional 10,600 nm CO_2 laser	Changes in pigmentation, discomfort, an outbreak of acne, and cutaneous infections
Traditional 2,940nm Er:YAG laser	Increased bleeding risk, cutaneous infections
Fractional 10,600 nm CO_2 laser	Erythema, Infections caused by bacteria on the face, neck, or ectropion, Because the lasers reach deeper, they have the potential to constrict the muscles under the skin
2.940 nm fractional Lasers made of Er:YAG and Er:YSGG (2,790 of each)	Mild erythema
1,064nm Nd:YAG laser	Induces redness and fever. The solution is to use brief pulses
Diode lasers operating at 1,450 nm wavelength	Post inflammatory hyperpigmentation
Fractional 1,540nm Er:glass laser	Transient erythema and edema
Fractional 1,550nm Erbium-doped laser (EDL)	Transient erythema, edema, and skin dryness
Picosecond 755nm Alexandrite laser	Transient erythema, edema, and mild pain

Combination therapy for acne scars

Numerous studies have demonstrated that combined therapy is more effective than a single approach. A combined approach of procedures with ablation or non-ablative lasers has proven successful for the medical care of boxcar wounds, for instance. Filler substances accompanied by lasers should be administered to individuals with atrophic lesions, whereas individuals without significant atrophy can be administered lasers first. If temporal scarring is present, filler injections should be considered at first [1].

The following (Table 4) provides diverse kinds of scars may be treated in different ways.

Table 4. Different kinds of scars may be treated in different ways: [3]:

Types of scars	Treatment modalities
Icepick scar	Fractional erbium laser, fractional CO_2 laser, radiofrequency, microneedling, trichloroacetic acid (TCA) peel, 70% TCA peel, excision. Platelet-rich plasma, dermaroller, and combined subcision.
Rolling acne scars	Subcision, microneedling, fractional non-ablative erbium laser, trichloride acid peel, intralesional hyaluronic acid gel injection, and irradiation with intense pulsed light (IPL) or the PicoSure laser. Microneedling with platelet-rich plasma (PRP) may be used in conjunction with the dermaroller and Er:YAG laser, 1450-nm mid infrared laser, and 30% trichloroacetic acid peels.
Boxcar scars	Procedures include as excision, NAFL or AFL laser, TCA peel, AFL LP Erbium, and fractional 1,540-nm laser Subcision, 1320 nm Nd:YAG nonablative laser, 30% trichloroacetic acid peels, 70% TCA, combined subcision and dermaroller, microneedling mixed with platelet-rich plasma, and fractional bipolar radiofrequency
Hypertrophic and Keloidal scar	Silicone gel sheets, fluorouracil, onion extract, and triamcinolone acetonide injections are some of the treatments available. Subcision and dermaroller in conjunction with a fractional CO_2 laser, 70 percent trichloroacetic acid, Cryosurgery, Therapy with intralesional triamcinolone and verapamil was combined with oral isotretinoin, focused radiofrequency, and observation. Using IPL with pressure garment treatment (IPL), Combining low, medium, or high doses of isotretinoin with a fractional carbon dioxide laser, micro needling, and platelet-rich plasma

The following (Table 5) methods have been ranked by their potential efficacy in treating scars based on their inclusion in many research [16].

Multidisciplinary approach towards acne scarring

Because acne scars have a detrimental influence on an individual's standard of life, it should be noted that not just medical treatment, but also mental health services must also be accessible for patients who require emotional guidance [19]. As a result, our primary objective should be to raise patients' self-esteem and improve their outward appearance [1]. Scar development can be reduced with early acne treatment. However, those suffering should be informed that scarring is a frequent consequence of acne, but it is treatable, so the person should stay cheerful and upbeat while still being practical about the possible consequences (Layton et al, 2001). To clear out potential risks for all treatments, an extensive medical and physical assessment should be

undertaken. A suitable time frame with a price range, a comprehensive counseling strategy, and reasonable final outcomes should be planned and conveyed to patients. This, consequently, serves to keep the patient calm and the process of treatment running well [1].

Table 5. Scar removal methods to choose from based on lesion kind [16]

Methods of treatment	Ice pick scars	Rolling scars	Boxcar scars
Subcutaneous peels			
TCA	++	-	++
The CROSS Method	++	-	++
Dermabrasion/microdermabrasion	+	-	+
Laser			
Laser surgery, ablative and nonablative	-	++	++
Photothermolysis, Fractional	++	++	++
Boxing methods			
A punch to the gut	++	-	+
Lifting the punch	-	-	++
Grafting to replace a missing punch	++	-	-
Enhancing agents for tissue	+	++	+
Needling	-	++	++
Subcision	+	++	+

++ = Effective, + = less effective, - = not effective

Discussion

Today, treating acne and acne scarring is difficult since not all patients can have 100% success in treating their acne scars. Although we had previously employed certain effective tools and improvements had been seen, the most effective results were not frequently attained. Following that, a variety of additional cutting-edge methods were put to use with better results, and we should inform patients about what is cutting-edge and best based on what we have seen work in both new and traditional therapies [20]. Resurfacing has been used for many years to treat acne scars, but it was ineffective when used alone; therefore, it improves results when combined with other procedures such as chemical peels, lasers, and other abrasive techniques for skin [14].

The way you look is more important in this age of online presence and concern for onscreen personalities, and scarring can be disfiguring. Which can lead to depression, nervousness, and isolation from society are common in patients. As a result, investigations and analyses on acne scarring can aid in the identification of appropriate treatment modalities [7]. Our main goal while managing acne sufferers is to lessen flare-ups, outbreaks, and potential scarring. According to studies, this can be accomplished by altering one's personal hygiene routine, nutrition, lifestyle, and surroundings [4]. Years of research have shown that several medical management methods for acne, including treating underlying diseases like PCOs, are successful. Recently, a mix of topical treatment, chemical peels, topical dapsone, and common oral medications including retinoids, antibiotics, etc. are utilized to achieve better outcomes. According to Sutaria her colleagues, it also depends on the type of acne that is present and the severity of the lesions. In order to cure acne,

radiofrequency, light-based therapy, and lasers are now often used [2, 7].

Scarring and wound repair involves granular tissue production, inflammatory conditions, and matrix modification. The ultimate state of scars is determined by the variety of changes that take place during those phases, which may vary from pigmentary alterations to the development of hypertrophic or atrophic scars [12]. Studies have shown that various grading scales can be applied to assess scarring. The results will vary as much as the treatment strategy. Patients with erythematous scars should start by treating the erythema. Oral antibiotics and isotretinoin can be used to treat initial scarring and pigmentary alterations [2].

Some research has been done on using TCA and CO_2 lasers to treat ice-pick scars. In 2013, Mohammad had positive results from using a CO_2 laser to treat ice-pick wounds, where dermal injury promotes delayed neocollagenesis. In addition, Lee and his associates declared in 2002 that 65% TCA was significantly more effective in treating icepick scars with a quick healing time and fewer problems [11].

This review article offers a variety of treatment methods that can be used depending on the kind and severity of scarring to help manage acne and acne scars. because we have looked into using several types of treatments. Therefore, care may be made to determine the right course of action after determining the kind of acne and acne scarring.

Conclusion

Numerous variables contribute to the development of various forms of acne scarring. According to the studies, various methods of treatment are presently used for managing both acne and acne scarring. Also included are additives made from chemicals, radiofrequency, light-based treatment, and lasers, as well as mixed therapies. Recent innovations include fat grafting and regenerative medicine. Every study determined that it is still too early to determine the efficacy of lasers isolated. Therefore, additional research should be conducted on each type of lasers separately to determine their effectiveness on each form of scar. Furthermore, studies comparing lasers and other approaches are still required. Although the information that was accessible assisted us determine how effective they are, using lasers alone is still an exhausting endeavor, and some people will not elect for it due to laser apprehension, severe processes, or an extended period for achieving outcomes. Prior to now, monotherapy has been used to treat acne scarring, but study demonstrates that merging various treatments will require less time and increase patient contentment. Consequently, in healthcare settings, an integrated strategy will be more efficient and will produce improved outcomes with a high rate of patient conformance and gratification.

Authors' contributions

Conceived and designed the experiments: M Naeem & S Lakhani, Performed the experiments: M Naeem & A Shahid, Analyzed the data: A Shahid, F Usman, S Yousaf & H Butt, Contributed materials/ analysis/ tools: ZE Maryam, Z Hassan & A Arshad, Wrote the paper: A Shahid & M Naeem.

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