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# Acne and Dermatosurgical Treatment

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**Abstract**

**Background:** There are a number of dermatosurgery techniques available to achieve treatment of acne complications, such as punch grafting, microneedling laser ablations, chemical peels, platelet-rich plasma, subcision, cryotherapy, fractional microneedling radiofrequency and CROSS technique. Each method has advantages and disadvantages. As there are no specific data available from the prospective studies in this field it is uneasy to recommend which surgical approach to acne complications offers the best result. Accordingly, it is also mandatory to appropriately select acne patients in order to achieve a complete and permanent treatment.

## Introduction

Acne is a very common disease that has been estimated to affect 95–100% of 16- to 17-year-old boys and 83–85% of 16- to 17-year-old girls. Acne settles in the vast majority by 23–25 years of age, but 1% of males and 5% of females exhibit acne lesions at 40 years of age. Acne is highly aesthetically embarrassing for adolescents, an age with enough of its own intrinsic concerns of self-image. Severe cystic acne causes pain, recurrent bleeding, and purulent discharge. In 99% of cases acne affects the face and is associated with poor employment prospects and difficulties in interpersonal relationships. Postacne scarring is particularly devastating and may be an at-risk factor for suicide. Scarring occurs early in acne and may affect some 95% of patients with this disease, relating to both its severity and delay before treatment. All types of acne, from papulopustular through nodulocystic disease, can cause scarring and adequate treatment must be started early. Scars are visible to an observer if they are abnormally colored or shaped, have altered contour or texture, or are longer than about 1 cm in length. Poorly oriented, orificial distorting scars (ectlabium, ectropion), or those crossing cosmetic units are very noticeable. These are uncommonly a problem in the acne-scarred patient, but are more common in surgical or burn scarring. These are best dealt with by excisional surgery incorporating Z or W plasties or similar techniques. Color, texture, and length of scar are often best dealt with by resurfacing techniques and specific visible light laser therapy. Contour defects may be small or reasonably superficial, and respond to resurfacing procedures such as dermabrasion, $CO_2$ laser, or erbium laser resurfacing. The use of some of the new filling agents may supplement these. A variety of autologous filling agents are also available, such as punch grafting, autologous lipocollagen, autologous collagen, and cultured fibroblasts, for these

superficial defects. For deeper defects the addition of fat transfer has been invaluable [**1**].

### The Evolution of Inflammatory Lesion to Scar Formation

Acne scarring begins life with the evolution of the humble noninflammatory comedone into an inflammatory lesion that ruptures through the weakened infrainfundibular section of the follicle. The end result of follicular rupture is a perifollicular abscess. Small abscesses incorporating the horny core will discharge through the skin. This will be repaired without scarring in about 7–10 days. The epidermis is always attempting repair, and cells grow from the epidermis and appendageal structures to encapsulate the inflammatory reaction. If this is complete there is resolution of the lesion without incident. Sometimes, however, this encapsulation is incomplete and further rupture occurs. The result may be the appearance of multichanneled fistulous tra cts. This may appear as grouped open comedones with a number of interconnecting keratinized channels histologically. These fistulas may be so large that a bridge of normal tissue is clearly visible overlying a tunnel of scar tissue. Ice pick scars are also of this variety, with histology showing these to be reticulate tunnels lined by hyperplastic epithelium. Often there are remnants of infla mmation, even in old scars of this type. Other types of outcomes depend on the extent and the depth of the inflammation. If the dermal inflammation is severe, total necrosis of the follicle may ensue and sloughing will produce a focal scar. If the inflammation is severe, and especially if rupture occurs deeply in the follicle, the inflammation will extend well beyond the environment of the hair follicle into the subcutis, along vascular channels, and around sweat glands. This wreaks havoc in these deep tissues, inducing deep scarring and destruction of subcutaneous fat. If the inflammation is very deep, transepidermal discharge is often not available as a method of resolving the abscess. As healing occurs and attempts at encapsulation of this deep inflammation ensue, this may form into papules, nodules, or cysts. Cysts are in effect giant, closed comedones [**2**].

### Atrophic Acne Scarring

Scars that result in the loss of tissue are much more common than thickened scars. They most commonly involve dermal scarring, but may also involve the underlying fat. All healing scars will go through phases of healing including inflammation, granulation tissue formation with fibroplasia neovascularization, wound contracture, and tissue remodeling. Acne lesions are unusual in that the inflammation is initiated beneath the epidermis in the infrainfundibular region of the pilosebaceous structure. Thus the subsequent scarring often involves deeper structures rather than just the surface. As the scars mature and contract they draw in these surface layers, leading to the appearance of indention or atrophy. The enzymatic activity and inflammatory mediators also destroy the deeper structures and this loss of structure adds to the production of atrophic scarring [**3**].

### Types of Atrophic Scars

The depth and the extent of the inflammation will determine the amount, type, and depth of scarring [**4,5,6**].

Superficial Macular Scars: If only the epidermis and superficial dermis are involved, the scars may appear as discolored macules that may be either erythematous, if inflamed and comparatively early or young scars or with altered pigmentation. Pigmentation may be increased in patients with more olive skin, and represents mostly postinflammatory hyperpigmentation that will fade in 3–18 months if sun protected. Reparative treatment may not always be required. If treatment is sought, medical therapy may suffice, with topical reparative creams such as retinoic acid or a-hydroxy acids often used in conjunction with topical steroids. Alternatively or additionally, light skin peels with glycolic acids, Jessner's solution, or variants and vascular lasers may be utilized [**4**].

Deeper Dermal Scarring: In an often unfortunate attempt at repair, sheaths of cells grow out from the epidermis and appendageal structures. This encapsulation of the inflamed contents may be completely or partially effective. If this encapsulation is only partially effective, recurrent rupture of the follicle may ensue and multichanneled tracts ocur. In such circumstances excision of the entire multichanneled apparatus may be required. If the deeper dermis is affected in a punctate fashion, sharp-walled or ice pick scars are produced. These are very distressing to the

patient and are probably the most resistant to corrective techniques. If there is more extensive dermal damage linear or broader troughed scars may result. It is also important to conceptualize where in the skin the scar is occurring from its appearance. A well-defined linear troughed scar is a dermal event and will benefit from dermal augmentation. A large ill-defined divot is not predominantly a dermal event, but is deeper and needs subcutaneous filling agents [**5,6**].

Perifollicular Scarring: Follicular or perifollicular acne inflammation produces hypopigmented papular scars from destruction and attenuation of collagen and elastin fibers in the tissues surrounding the hair follicles. This is most common on the trunk [**5**].

Fat Atrophy: Facial fat is destroyed by the inflammatory mediators at work in the deep cystic activity of acne lesions. The cystic lesions are also space occupying and their eventual resolution will leave a void that cannot be filled by the atrophied subcutaneous tissues. Instead the tissues are drawn in from surface layers, and this effect is worsened by the contracture of the scarring around these cysts. Lipoatrophy occurs in a general way as a result of the aging process. The sharpness of the convexities of the cheeks, chin, and frontal bossing diminish and the concavities of the preauricular, temples, inframalar, and perioral tissues become exaggerated [**5**].

Post acne scars are polymorphic and various types of scars usually coexist in the same individual as below. It is very important that each scar be assessed individually and treated accordingly. The method of the intervention depends on the types of the scars, overall appearance of the face and budgets of the patient. Ice pick scars are narrow, deep sharply marinated epithelial tracts that extend vertically to the deep dermis or subcutaneous tissue. The skin looks as if it has been pierced by an ice pick or sharp instrument. Ice picks scars seem to make a small, deep, “hole” in the skin. They are the most common acne scars that occur on the cheeks and have a “punctate” appearance. Ice pick scars develop after an infection from a cyst or other deep inflamed skin tissue and its way to the surface leaving a long column-like scar. Rolling scars are distensible, depressed scars with gentle sloping edges. Roling scar are shallow depressions that are best appreciated with a change in surface lighting. They can vary in size and often coalesce with neighboring rolling scars. Rolling scars are shallow, wide and have a subdermal fibrous tether. These scars are caused by damage under the surface of the skin. They give the skin a wave-like appearance. Boxcar scars are angular scars with sharp vertical edges, and resemble the scars left by chicken pox. They may be shallow or deep, punched out, wide at the surface and at the base are most often found on the cheeks and temples7. Hypertrophic scars are elevated, fibrotic scars, more common in males and frequently seen in the mandibular area of the face and back of the chest. Often the result of severe acne, they generally stay within the boundary of the original wound, and may decrease in size over time. Keloids are seen more often in acne lesions. They are seen more often in males, on the back and chest [**6**].

**Treatment of Postacne Scarring**

There are some central tenets in the treatment of acne scarring, the first being that there is no general cookbook available to treat every patient. Each scar and each patient must be treated individually and on their merits according to the patient characteristics and the scar characteristics. Scar topography is usually the most important and variable characteristic. A sharply punched out scar will not be treated in the same manner as a linear scar or a grossly atrophic zone. Patient characteristics such as skin type and amount of disease are also of importance. A patient with olive skin and 3 gently atrophic scars will not be treated in the same way as a patient with pale skin and 50 such scars. The second tenet is that scars are not removed except by excisional techniques; the contour is modified and normalized but the scar remains. This may be difficult to explain to the patient. The treatment may require revision or secondary procedures to optimize results. Contour correction requires a certain degree of judgment that may need fine tuning. Third, it is not useful to attempt the treatment of postacne scarring unless knowledge is obtained of many of the described techniques, because treating acne scars is difficult and unrewarding if not optimally addressed. We can use dermabrasion, needling, subcision, punch techniques, rhytidectomy, fat transp-

lantation, fillers, lasers, radiofrequency, chemical peeling, CROSS technique and PRP ve scar treatment according tos car characteristics (**Table 1**) [**7,8,9,10,11,12,13**].

## Treatment of Atrophic Acne Scarring

### Dermabrasion

Ffor the modern applications of dermabrasion through the work of Kromayer at the turn of the century. Kurtin and other dermatologists in the 1950s, and Yarborough and many others in the 1960s through the 1980s. More recently dermatologists have been active in the literature on abrasive treatment and on appropriate anesthesia for this procedure. Dermabrasion can be performed with a variety of devices. Sandpaper has been used, but has largely been replaced by machine-driven techniques. These machines are capable of high torque, delivering steady even dermabrasion with a serrated wheel, diamond embedded fraises, or wire brush end pieces. These end pieces are graded from fine—producing a light abrasive procedure—to coarse—producing a more substantial effect. The choice of handpiece is directed both by operator preference and by the particular patient profile. The procedure is performed on frozen or tumesced facial skin and taken into papillary dermis, or in areas of more severe scarring, into reticular dermis. Dermabrasion may be performed on top of $CO_2$ laser resurfacing and seems to speed healing in a similar fashion to the erbium laser. While this procedure certainly has been the mainstay of acne scar revision for many decades, it has been somewhat overtaken by the considerable hyperbole and some real advantages of laser resurfacing. While laser resurfacing is technically an easier procedure and is less bloody than dermabrasion, good comparative studies of these two resurfacing procedures are lacking. For many candidates with acne scarring, dermabrasion remains a good alternative to lasers. Dermasanding has recently been added utilizing drywall/ plaster sanding screen or moistened silicone carbide sandpaper to manually dermabrade the skin. All dermabrasion techniques, as with other resurfacing techniques, are at their best in the treatment of dishlike rather than ice pick scarring, and are best in fair skinned or very dark patients. Aggressive therapy is associated with a higher complication rate, and it is best to advise multiple dermabrasions or ancillary techniques such as punch grafting or excisional techniques. Microdermabrasion utilizing aluminum oxide crystals has been touted as being useful in the treatment of facial scarring. In this method, small crystals of aluminum oxide are expelled from a nozzle toward the skin, abrading it in a series of microlacerations, and then used crystals are aspirated back from the skin surface and discarded. Multiple treatments are required and its efficacy in the treatment of acne scarring remains somewhat unclear. It is most successful when used to soften scar edges in superficial atrophic scars of the rolling or boxcar subtypes [**14**].

**Chemical Peeling:** While light chemical peeling has been utilized for many years by dermatologists for active acne, chemical peeling is not useful for anything more severe than

**Table 1.** Acne Scarring Treatment Algorithm

| Erythematous scars | Ice Pick Scars | Boxcar scars | Rolling scars |
|---|---|---|---|
| Vascular lasers: PDL, KTP and IPL | Generalized: Ablative and nonablative lasers, microneedling and PRP, radiofrequency; microneedle or fractional bipolar | Generalized: Ablative and nonablative lasers, microneedling and PRP, radiofrequency; microneedle or fractional bipolar | Generalized: Ablative and nonablative lasers, microneedling and PRP, radiofrequency; microneedle or fractional bipolar Dermabrasion and chemical peeling |
| | Individual: Punch excision, CROSS technique | If shallow: Dermabrasion and chemical peeling | Individual: Injectable fillers, subcision7 |
| | | Individual: Injectable fillers, punch elevation, punch excision | |
| | | If narrow: CROSS technique | |

the mildest acne scarring. Repeated light peels with variations of resorcinol salicylic acid, lactic acid, TCA or stronger glycolic acid peels do help mild scarring, and probably is the treatment of choice for this early superficial scarring. Home regimens incorporating the daily use of fruit acids and retinoic acid are also useful. More severe scarring will temporarily improve with the edema engendered by stronger peels, but as this abates so does most of the improvement. There have been great advances in peeling techniques with standardization of peel concentrations, augmentation of peeling agents, and the introduction of peeling pastes, and some long-term improvement can occur, but it is the least likely of the resurfacing techniques to improve the acne-scarred patient (**Table 2**) [**15**].

**Laser Resurfacing:** It is an effective treatment and is easier to use than other modalities. Different types of lasers are very useful in treating scars, except for deep ice pick scars. Pulsed and scanned $CO_2$ lasers have caused an increase in resurfacing procedures. The technique, largely introduced by dermatologists, has spread to many other disciplines. However, despite some limitations, lasers seem to be the major resurfacing tools for acne scarring carrying us into the new millennium. It has to be said that the public, the press, laser companies, and the medical profession have all shown rather excessive enthusiasm for the relatively new technique of laser resurfacing. The extent of complications such as late hypopigmentation and scarring is now being reported for $CO_2$ laser, problems shared with other resurfacing procedures. Another inherent problem of the $CO_2$ laser system is delayed healing, specifically the inflammatory or "lag" phase. There are two methods of dispersing the heat created by the interaction of the laser beam with tissue. The first is by instantaneous ablation, where the energy is converted to a superheated plume. The second method involves transmission of the heat by a mixture of scattering and direct transmission of unabsorbed energy. This second method of heat dissipation leads to necrotic thermally damaged tissues at the base of the wound that must be removed before epidermal regrowth can ensue. This translates into prolonged healing and erythema. The search for a laser able to minimize this transmitted energy began with shorter pulsed $CO_2$ lasers then microsecond domain $CO_2$ lasers, but recently the emphasis has turned to the less thermally active erbium laser. Erbium laser is 10 times more avidly taken up by water than $CO_2$ laser, leading to more complete ablation of tissue and producing only a very fine layer of thermal damage. Estimates vary, but most investigators suggest that 4–5mm of tissue are removed per joule of fluence. With an epidermis between 60 and 100mm in thickness, somewhere between 15 and 25 J of energy is required for complete epidermal ablation and access to the papillary dermis. This may be accomplished by stacking a number of passes with a low-power laser or overlapping the pulses to achieve this stacking, either freehand or with a computerized scanning device. As useful as these techniques have been for their ablative effect

**Table 2.** Acne Scarring Treatment Algorithm with Chemical Peeling

| Scarring Types | Chemical Peeling Agents |
|---|---|
| Very superficial: Destrucion of the stratum corneum without creating a wound below the stratum granulosum | Glycolic acid 30-50% applied briefly for 1-2 minutes, Jessner solution applied 1-3 coats, and TCA 10%. |
| Superficial: Destruction of part or all of the epidermis, anywhere from the stratum granulosum to the basal cell layer | Glycolic acid 50-70% applied for a variable time (2-20 minutes), Jessner solution applied in 4-10 coats, and TCA 10-30%. |
| Medium Depth: Destruction of the epidermis and part or all of the papillary dermis | Glycolic acid 70% applied for a variable time (3-30 minutes), TCA 35-50%, augmented TCA (CO2 plus TCA 35%; Jessner solution plus TCA 35%; glycolic acid 70% plus TCA 35%). |
| Deep: Used for destruction of the epidermis and papillary dermis, extending into the reticular dermis: | Phenol15 |

in other diseases, their effect on acne scarring needs to be critically examined. First, just how well resurfacing works for acne scars seems to vary widely in the literature. Some experienced practitioners claim excellent results, others less so. Although resurfacing procedures still are central to our current treatment of postacne scarring, we lack some understanding of exactly how they exert their beneficial effects. Resurfacing procedures may be thought of as having both horizontal and vertical treatment vectors on tissue. Whether resurfacing works by vertical ablation of shoulders of scars and rhytides or whether these techniques work by a horizontal "tightening" of tissues by the laying down of an organized layer of collagen parallel to the skin surface has been the topic of substantial debate. Possibly both opinions are correct in part, and possibly of different importance with different resurfacing tools—$CO_2$ lasers and chemical peeling being more horizontal, while dermabrasion and erbium laser perhaps being more vertical. However, no amount of stretching out or ablating deep dermal and subcutaneous structural loss with resurfacing tools will deal with severe atrophic scarring, and the likely outcome of overly aggressive therapy is an increased complication rate, especially scarring and hypopigmentation. True long-term hypopigmentation is likely with any deep-wounding agent that requires healing of the reticular dermis. Although good comparative statistics are lacking, complications postresurfacing in patients with acne scarring appear more common, possibly emanating from attempts often made to deeply treat these patients. This hypopigmentation is a late event and probably represents late and deep dermal fibrosis. "Pseudo-hypopigmentation" appears to be very common and represents nothing more than removal of sun-damaged blotchy coloring by the laser and a line of demarcation existing between treated and untreated skin. With earlier $CO_2$ lasers it was difficult to forge reproducibility between operators and even consecutive patients with the same operator. Collimation helped considerably allowing the distance from the skin to cease to be a variable. The scanners and automated handpieces also have been of great use in removing horizontal hand speed as a variable and we have reached a point where we are able to compare treatment parameters with reasonable accuracy. The understanding that total fluence delivered to a region as a measure is vital for comparison purposes rather than passes, power per pulse, and computer scanner settings has been a major advance. The erbium laser has allowed a precision of ablation that we have not seen before with other modalities. However, considerable inaccuracies and difficulties of comparison exist with this laser system, revolving around the difficulty of defining end points and the requirement for multiple passes. Erbium lasers are typically able to produce 1–3 J/pulse. This energy is translated into fluence levels dependent on the spot size. When using spot sizes sufficiently large to treat broad facial areas, fluence generated in a single pulse is often inadequate to penetrate through the epidermis and impact the papillary dermis. Thus reliance is made on multiple passes to reach the required depth. However, the end points are so difficult to define with erbium laser that one battles to know where a first pass differs from a third pass or a fifth pass. Scanners have been of little help with this problem. An alternative method to pulse stacking is to rely on the overlapping of pulses. Erbium lasers have a top hattype profile to the pulse, so where pulses are overlapped this section has the added contributions of the two pulses, that is the pulse is effectively doubled in the overlapped area. If this region is overlapped by the following pulse and is overlapped by the row of pulses above and below the current row of pulses then a contribution of three or more pulses on an individual spot will triple or quadruple the fluence to that area. Thus in a single overlapping pass by hand or scanner, an effective fluence is delivered to exert treatment to epidermis and dermis. The use of both $CO_2$ and erbium lasers in a combined fashion has recently become fashionable and has some merit in the treatment of postacne scarring. This may be delivered concomitantly by using the $CO_2$ laser during the erbium pulsing or more commonly sequentially, with erbium laser used as the final pass or passes to remove the thermally denatured tissue left from previous $CO_2$ laser passes. This limits the thermal damage left in tissue, as most of this tissue is vaporized. This in turn allows faster healing with less temporary sequela as compared to $CO_2$ laser alone. A novel approach to the problem of a healing epidermal wound is to be found in the recent advent of

nonablative resurfacing. Both Q-switched 1064 nm Nd: YAG and 1320 nm Nd: YAG lasers have been used for this technique. Although there are no studies on its effects on scarring, this technology is theoretically attractive for patients with postacne scarring of certain types where the dermis is mostly affected and the epidermis spared. If this technology can eventually be shown to be safe and effective it may hold promise for these patients. Another change in approach is the use of radiofrequency devices to ablate the skin. These devices may allow a similar effect to laser resurfacing but are cheaper devices that appear reasonably safe to use with a relatively short recovery time, although only early studies are available. $CO_2$ and Er: YAG lasers are the most commonly used ablative lasers for the treatment of acne scars. Er: YAG laser reduces damage to surrounding structures, with the laser energy being confined to a more superficial depth. The most commonly used nonablative lasers are the 1320/1064-nm Nd: YAG and the 1.450-nm diode lasers. Clinical outcomes for scars range between 20% and 30% mean improvement. Recovery and side effects are favorable compared with ablative lasers [**16,17**].

**Fractional photothermolysis:** The treatment delivers a series of microscopic laser spots. In nonablative fractional photothermolysis, the epidermis is coagulated, but the stratum corneum remains structurally intact. One of the most important lasers to use this technology is the 1550-nm erbium fiber glass [**18**].

**Radiofrequency:** A revolutionary method of scar therapy is microneedling RF. This process is gentle, resulting in the disappearance of 25-75% of scars. Temporary erythema may occur [**19**].

**CROSS technique (Chemical reconstruction of skin scars):** It is the most successful treatment for deep scars. Cross involves the application of TCA in high concentrations like 90% onto focal areas of acne scarring. Excellent results can be seen in almost all patients after 5-6 treatment sessions. It is well tolerated, recovery is quicker than that with laser. It may be combined with other treatments like laser [**20**].

**Rhytidectomy:** Patients often will show how they would like their skin improved by stretching it flat, dragging it upwards and laterally in the direction of their ears, and physician and patient alike may feel that the patient would benefit from a rhytidectomy. However, this is not often successful, as scars tend to return within a few months. If true tissue laxity exists along with acne scarring, then these patients may benefit, but this is an uncommon finding. Moreover, if patients are gaunt as a sequela from their acne scarring, rhytidectomy will often make them more so [**21**].

**Undermining of Scars (Subcision):** This technique involves undermining of acne scars, breaking up the scar, detaching it, and releasing the surface from deeper attachments. This procedure produces a pooling of blood under the defect. The blood acts as a spacer, keeping the scar base from immediately reattaching to the surface layers. The subsequent organization of this blood clot induces longer term correction by the formation of connective tissue. Correction of the defect after one treatment is partial. Successive treatments appear to produce further improvement. Undermining scars is not new and for many years has been used as an adjunct to Fibrin foam or Fibrel implantation, dermal grafting, and microlipoinjection. As a standalone corrective technique it has only recently been described as subcision or dermal scarification. Many types of contour defects are cited as valid indications for these undermining techniques, including depressed distensible and bound down scars, depressed skin grafts and surgical wounds, wrinkles, depressed contours such as malar grooves, and cellulite dimples. However, it is invaluable, and probably at its best in the correction of acne scars, with most atrophic varieties improving with one to three treatments. This technique may be readily combined with resurfacing. It allows the practitioner to help all levels of scarring, but especially allows patients with mild to moderate scarring to escape with less resurfacing than would appear at first glance to be necessary. A probe, either a sharp hypodermic needle or a blunt cannula, is inserted under the skin immediately subdermal adjacent to the scar and aimed at that level until it abuts resistance at the scar. The inserted instrument is designed to match the size of the scar, usually no. [**19,20,21**] in size. An initial backward and forward motion much like the tunneling of a liposuction procedure

is used, but after resistance to tunneling starts to decline and the scar is almost freed from the surface the direction is changed. The instrument is now passed sideways in a sweeping action to complete the freeing up of the skin from its base. The depression should be seen to visibly lift at the completion of the procedure. There should be some minor bleeding under the scar, and this is felt to be important in the degree of improvement gained. Contraindications are few, but include active acne cystic disease under the scar, bleeding diathesis, and active infection. There are some predictable sequelae such as bruising and swelling present for 1–2 weeks. Complications include acneiform cystic lesions that may follow disruption of acne sinus tracts and may require low dose intralesional steroid injection with or without antibiotics. A range of responses ranging from partial to excessive is seen. Partial response is usual, while excessive response is seen in 5–10% and may require topical or dilute intralesional steroids. A strange type of excess response is a doughnut shape that may occur if a sharply punched out scar is too widely undermined. It has a reported success rate of 50-60% in the treatment of rolling scars. Short-term outcomes are superior to dermal fillers. A probe such as sharp hypodermic needle, blunt cannula or Nokor needle is inserted under the skin immediately subdermal adjacent to the scar. It may be readily combined with resurfacing procedures like lasers [**21,22**].

**Subcision-suction method:** Among therapeutic modalities of acne scars, subcision is a simple, safe procedure with a different and basic mechanism for correcting atrophic and depressed scars. Subcision releases scar surfaces from underlying attachments and induces connective tissue formation beneath the scar directly, without injury to the skin surface. Therefore, subcision is a valuable method, but due to high recurrence rate, its efficacy is mild to moderate. To increase the efficacy of subcision, a new complementary treatment of repeated suction sessions was added at the recurrence period of subcised scars. In this before and after trail, 58 patients with mild to severe acne scars of various types such as rolling, superficial and deep boxcar, pitted scars were treated by superficial dermal undermining, with mainly 23-guage needles. The protocol for suctioning was: start of suction on third day after subcision for flat and depressing subcised scars and its continuation at least every other day for 2 weeks. Forty-six patients followed the protocol completely, had 60–90% improvement in depth and size of scars (significant improvement) with mean: 71.73%. 28.2% of them had '80% improvement or more' (excellent improvement). Twelve patients started suction late and/or had long interval suction-sessions, had 30–60% improvement (moderate improvement) with mean: 43.75%. Freq uent suctioning at the recurrence period of subcision increases subcision efficacy remarkably and causes significant and persistent improvement in short time, without considerable complication, in depressed scars of the face. Therefore, subcision-suction method is introduced as a new effective treatment[**23**].

**Deep Autologous Filler Agents for Atrophic Acne Scars:** When deeper defects are the concern then dermal grafts and autologous fat transfer techniques should be employed. With deep atrophic scarring, just treating the surface will give a temporary and incomplete result as the initial swelling and euphoria subsides, revealing continuing tissue deficiency. Furthermore, dermal and fat transfer techniques may also be employed at the same time as resurfacing techniques. By the use of such a combined approach to scarring of deep and superficial types, excessive surface treatment is avoided and the consequent risk of complications is diminished. Initially fat transfer was not considered a useful technique in the treatment of scarring, but refinements in understanding and technique have occurred and its place has assumed importance. It is true that superficial scarring is not an indication for a deep filling agent, as the dermis is a busy place with many tightly packed structures. A scarred dermis is also not a nourishing spot for a fat transplant. The role of fat is as a deep volume augmentation, a foundation for the tissue to sit on. This allows the operator to concentrate on the more superficial assault on the dermal component of the scar by resurfacing or by more superficial dermal augmentation techniques [**24**].

**Punch Techniques:** There are many scars that are not amenable to pure resurfacing procedures such as dermabrasion, erbium laser, or $CO_2$ laser. These include scars with a very white atrophic base, as well as sharply punched out ice pick scars and some chic-

kenpox or postherpetic scars. These are amenable to punch removal techniques such as punch excision, punch elevation, and punch replacement. One needs a wide variety of different-size punches if one is to use punch methods of scar correction-from 1 mm in size, in increments of 0.25 mm, up to 3 mm. It is then possible to remove only the scar with a very small margin of normal tissue. They should be sharp, straight-walled, and seamless. Punch excision removes a pitted scar with a straightwalled disposable or hair transplant punch that is slightly larger than the scar being addressed. The site may then be allowed to heal by second intention or sutures may be placed to oppose the wound. More than 40 years ago it was noted that biopsies performed at the time of dermabrasion were extremely hard to detect once the dermabrasion had healed. Caver described that dermabrasion after excision

but before closure improved the subsequent scar appearance. Gravelink and White have recently advocated simultaneous resurfacing with a $CO_2$ laser and punch excision. Alternatively the scar may be excised and followed by resurfacing 4–8 weeks later. Resurfacing has been shown to blur scars and may even totally eradicate them if performed in this window of opportunity of 4 and 8 weeks posto peratively. In a study by Harmon et al. findings showed that α and β4 integrin subunits show linear staining along the basement membrane zone before dermabrasion, while after dermabrasion intercellular staining throughout the spinous layers of the epidermis is seen. In the dermis, collagen fibers are seen to be sparse and disorganized before dermabrasion, but become unidirectional and parallel to the epidermal surface after dermabrasion. This increased fibroblast activity may be related to an upregulation of tenascin expression. Tenascin is an extracellular matrix glycoprotein, which among other actions interferes with integrin and mediated fibroblast attachment to fibronectin and is expressed before keratinocyte and fibroblast migra tion in fetal wounds. When biopsy specimens are taken early after primary wounding, there is diffuse staining of tenascin throughout the papillary and reticular dermis as there is soon after a dermabraded scar. However, if the biopsy is performed 6–8 weeks later, tenascin expression is localized along the primary incision line, while diffuse staining is still seen throughout the papillary and reticular dermis. Thus it appears that dermabrasion (and by inference other resurfacing procedures such as lasers) alters cell-to-cell and cell-to-matrix interaction within the epidermis and the dermis, and between these layers, inducing a decreased potential for scar formation. Thus resurfacing at the time of punch techniques or 4–8 weeks after the procedure is likely to truly blur or remove evidence of scarring. One caution is that inactivity of the acne is paramount if one is to successfully excise scars. If the acne is active, excising the scar, leaving cystic remnants, may incite postoperative cyst formation with untoward cosmetic outcomes of pointing or wound dehis cence, with consequent scar widening. Punch elevation is a variation of other punch techniques except that the scar that is punched out is not discarded. The tissue cylinder is incised down to the level of the subcutaneous fat. The scar is allowed to float up until it as the same level as the surrounding skin. If it does not rise easily it may be transected free at the level of the fat. The cylinder of tissue will fix in place by the patient's serum and sit as a graft, held in position by a little surgical tape. Resurfacing can be performed 4–8 weeks later if required. However, this is quite a limited technique, relying on adequate texture and color of the floor of the scar, which is rare. Punch replacement grafting is probably the best of these techniques for sharp-walled or deep ice pick scars. This technique has been used for several decades in dermatology. This technique is quite painstaking, as often 20 or more replacement grafts are required in a single session, but is usually worthwhile, as it often yields the best results for difficult sharply defined scars. The scar is punch excised as with the punch excision technique. The scar is discarded and is replaced with a slightly larger full-thickness skin graft, usually from the postauricular area. Unless the graft is traumatized it will usually survive well. Some of the grafts will heal level with the skin surface and some will be elevated. Resurfacing may be performed 4–8 weeks later in order to flatten the grafts and to further blur the margins. Eventually after some months the grafts become very difficult to locate. Occasionally several sessions of punch replacement grafts are performed several weeks apart. Selected patients with relevant scarring will respond better to punch replace-

ment grafting and resurfacing than they would with resurfacing alone. Punch replacement grafting allows the deeper scars to be treated by grafting so that less aggressive resurfacing may be practiced. It is useful for deeper and ice pick scars. A punch excision, approximately equal to the scar size, is first performed. We can do punch excision and closure, if our scar size more than 3.5 mm; secondly we can prefer punch incision and elevation, if depressed scar has normal surface texture; thirdly we can do punch excision and grafting, if our scar size more than 4 mm [**25**].

**Dermal Grafting:** A dermal graft is a strip or a section of dermis removed from one skin region and transplanted to replace lost dermis in another region. This permanent autologous collagen may be used to correct a linear or other deep dermal scar. The donor site is often the retroauricular fold, but may be wherever an unobtrusive scar may be left. Under local anesthetic, resurfacing via an infrared laser or dermabrasion removes the epidermis and superficial dermis. A laser or scalpel is used to excise a dermal strip and the area is sutured. A pocket the shape and size of the graft is prepared under the recipient site, usually using a 14- or 16-gauge sharp trocar. The cannula enters at one end of the trough, and after creating the pocket by undermining it exits at the opposite end of the linear defect. The cannula is withdrawn but the plastic sleeve is left behind so that it is extruding from both ends of the area to be corrected. The dermal graft is then attached to a suture on a straight needle. The needle is then fed through the plastic sleeve until it exits the other end. The trailing graft abuts the proximal end of the plastic sleeve and then the sleeve and the graft are pulled as a unit so that the graft lies in the formed dermal pocket and the sleeve has exited the wound. The distal or trailing end of the graft should be held with jeweler's forceps until one is happy with the graft position. The procedure may be performed with or without a simultaneous resurfacing procedure. Smaller grafts may be brought into position without an obturator. The technique most often offers a precise long-term correction. The only common complication is cyst formation if all epidermal and appendageal remnants have not been removed. All efforts should be made to strip the epidermis and to remove fat below the dermal graft if there are any hair bulbs present. Graft resorption may also occur in time with some grafts [**26**].

**Fat Transplantation:** Fat is close to the ideal augmentation material in that it is cheap, readily available, and incapable of being rejected or causing allergic or other adverse tissue reactions. It is easy to work with and is without risk of communicable disease. However, the issue of permanence is unresolved. Is fat a temporary technique as was first thought or is it able to produce accurate, long-standing, autologous correction as others have come to believe? The technique consists of two phases: procurement of the graft and placement of the graft. Both phases are critical for the survival of the grafted tissue and have been through substantial modification. High-pressure removal of the fat by machine aspiration has been replaced by gentle hand aspiration. Tumescent anesthesia is performed for operative and postoperative patient comfort and to limit blood contamination. There has also been a tendency toward less open and interventionist handling of the extracted fat before reinjection. In the past, fat was treated with additives after removal or strained, whisked, washed, or filtered producing significant trauma to the fat. In 1921 Lexer stated, "it is necessary that the fat tissue is not damaged at the moment of its removal nor at the moment of its implantation." To this he may have added that it should probably not be damaged in between. The injection phase with small parcels of fat implanted in multiple tunnels allows the fat graft maximal access to its available blood supply. With the like-lihood of increased graft survival, overcorrection is not required. If further fat transfer is needed, additional fat may be taken at the time of original suction and stored frozen for further postoperative refinements as may be required. Fat is injected through a small nick made with a vented Nokor needle (BD), no. 11 blade, or similar instrument. When injecting into acne-scarred skin, undermining or subcision may be used to break up the scar tissue and release it from its attachments to deeper tissues. When subcision is employed with fat transfer it may add to the precision of correction. The fat injected will "normalize" the contour except where residual scar attachments impede this. These are then furt-

her undermined and released until this normal contour is achieved. The lipoinjection may be performed via a small no.18 cannula, as long as a 1 ml syringe is used. Fat is best injected deeply as a three-dimensional lattice of 0.1–0.2 ml aliquots and built up to support the more superficial skin layers. The 1 ml tuberculin-type syringe allows the finest control of the injection volume. This procedure may be used as an isolated procedure or with other procedures such as laser resurfacing. Antibiotics are usually used perioperatively. Some fat will not survive the transfer process. Some fat is disrupted during the suction, during the injection, or just fails to develop a blood supply. This percentage seems technique, region, and practitioner sensitive. Appropriately performed, more than 50% of transplanted fat would be expected to survive. However, most acne-scarred patients benefit from further top-up procedures, probably best timed for 3 months after the procedure. Overcorrection should be kept to no more than 10%. The residual fat may be frozen and this frozen fat may be used for at least 6 months after the procedure and probably 12 months. Blindness has been reported with fat transfer and one should use blunt cannulas, low-pressure injections, and small aliquots of fat and inject only on withdrawal of the cannula. Aging adds to the problems of the acne-scarred face in a number of ways. Deep acne scarring may produce severe facial fat atrophy. As facial structure (including fat) is lost with age, the acne-scarred areas fare worst. The combination of fat loss selectively with acne scarring and generally with aging often influences the patient to seek corrective surgery for long-standing acne scarring in their third, fourth, or even fifth decade. As facial skin starts to sag with aging it starts to be irregularly suspended on old fibrotic acne scars. This denies the skin its ability to descend evenly, producing an irregular cascading appearance. Fat transfer is able cosmetically to reproduce the youthful appearance of a fuller face in acne-scarred patients. It also has reconstructive ability as a deep foundation for deep acne scarring. Balancing the cosmesis of the facial structures becomes necessary if large amounts of facial fat are utilized. Implantation of fat in malar, chin, forehead, and other convexities may be necessary if concavity augmentation of cheeks, preauricular areas, and temples are to be kept in balance. Old patient photos should be scrutinized to improve and rejuvenate the patient's appearance rather than change the patient's countenance to something alien or foreign to them that they may find uncomfortable (**Table 3**) [**27**].

**Other Tissue Augmenting Agents:** There are a raft of new and older autologous, nonautologous biologic, and nonbiologic tissue augmentation agents that may be used for atrophic scar contour correction. This is perhaps the most exciting future direction for acne-scarred patients. The prospect of a safe

**Table 3.** Tissue Augmentation Agents for Scars

| Properties | Agents |
|---|---|
| Autologous | Autologous collagen (Autologen)<br>Isolagen<br>Lipocytic dermal augmentation<br>Dermal grafting<br>Microlipoinjection |
| Biologic nonautologous | Human<br>Dermalogen<br>Alloderm<br>Nonhuman<br>Hyaluronic acid<br>Bovine collagen<br>Polymethylmethacrolate microspher with collagen (Artecoll)<br>Fibrel |
| Nonbiologic | Silicon<br>Bioplastic<br>Artecoll<br>e-PTFE (Gore-tex, Softform)7 |

long-term or permanent correction with a tissue augmentation agent is palpable. It would allow the easiest and most exact form of correction for those with appropriate scarring. The search for the ideal augmentation agent continues [**24**].

**Collagen-Based Products**

**Autologen:** Autologous collagen processed from the patient's own tissues, known as Autologen (Collagenesis, Beverley, MA), was conceptualized to allay concerns of allergenicity and transspecies disease transmission, and to produce longer lasting results. The majör problem in using this agent is the recurrent requirement for a substantial volume of donor tissues. The future possibility of growing autologous collagen from small punch biopsy specimens may alleviate this supply problem. The longevity of correction, arguably more important in scar correction than other indications, has been reasonable to good, with correction maintained for 1–2 years with one to four injection sessions. This may relate to the absence of inflammation in biopsy sites as compared to that of bovine collagen sites[**24**].

**Dermalogen:** Human donor tissue from tissue banks is processed in much the same way as Autologen to achieve a homologous collagen. This should be potentially less allergenic than bovine collagen, but stringent requirements for control of potential comm unicable disease are necessary. This may also have promise in the future correction of scars as a readily available source rather than requiring the patient to submit to a number of procedures [**24**].

**Bovine collagen:** This very successful material has been used to treat more than 1 million patients since 1981. Although acne scarring is not a common indication for this product, it has been a legitimate use since its inception. Mostly the material used has been Zyderm collagen (Collagen Corp., Palo Alto, CA), but Koken Atelocollagen and Resoplast have also been used. Bovine collagen is mildly immunogenic because of its bovine origin, and patient double skin testing is required. Usually acne scars retain bovine collagen comparatively well, with Zyderm 11 being utilized for smaller distensible acne atrophic scars and Zyplast used for deeper acne scars. Two or three treatment sessions are usually useful to achieve optimum correction and then 1–2 years of correction may be attainable. It is not appropriate for scars that are not readily distensible, such as bound down or sharply marginated ones [**28**].

**Isolagen:** Isolagen is an injectable in vitro culture of autologous fibroblasts in an extracellular matrix. A punch biopsy specimen is taken, the fibroblasts fostered, and the suspension reimplanted. Expansion of the implant may be seen for many months after augmentation, presumably by new collagen production from the fibroblasts. It has been used for quite dramatic acne scars and may be used in conjunction with resurfacing techniques [**29**].

**Alloderm:** This is acellular human allograft dermis that may be used in multiple sheets to augment deeper defects of structure and possibly in single sheets for smaller acne scars. The same caveats as for Dermalogen in terms of stringent controls over cross-infection are required. Rejection is minimized by removing all cellular material, and longevity and nonresorption are among its best characteristics [**24**].

**Noncollagen Augmentation Agents**

**Hyaluronic acid:** Hyaluronic acid (HA) has the same chemical composition in all sources of this material. A fairly ubiquitous agent, it is present in large concentrations in human dermis, synovial fluid, vitreous body, umbilical cord, rooster combs, and in certain streptococcal species. The last two sources are those that provide this dermal augmentation agent commercially. The material has low allerginicity, is viscoelastic, transparent, nontoxic, and stabilizable to allow longer term correction. There are different agents available such as Hylaform (Collagen Corp.,Palo Alto, CA) and Restylane (Q Med, Uppsala, Sweden). Hylaform is derived from rooster combs and has a concentration of 6 mg/ml and Restylane is derived from the coating of fermented Streptococci with a concentration of 20 mg/ml. Both agents may be used for acne scars, with one to three treatments allowing longterm but temporary correction. Microinjection of HA directly under the individual scar offers valuable and immediate diminution of discrete depressed scars. Other volumizing fillers, such as poly-L-lactic acid and calcium hydroxylapatite, can be used where laxity of the skin or deep tissue atrophy ac-

centuates the appearance of the acne scars [**30**].

**Fibrel:** Fibrin foam or Fibrel implantation has shown promise in the treatment of scars for many years. Fibrel uses the mechanisms of wound healing to produce collagen under areas of scarring. A mixture of a porcine gelatin matrix, providing the scaffold for the clot to form, plasma for the necessary ingredients for collagen synthesis, and E-aminocaproic acid to inhibit fibrinolysis allows an excess collagen reaction to form under the scar. Lidocaine may substitute for the patient's plasma. Excellent persistence is attainable, although the awkwardness, the requirement for allergy testing, tissue infarction if injected inadvertently into deeper subcutaneous vessels, and prolonged inflammation in a few patients has limited its use [**31**].

**Artecoll:** Artecoll is a suspension of polymethylmethacrylate microspheres in a 3.5% collagen solution with 0.3% lignocaine. It is a permanent augmentation agent implanted at the dermosubcutaneous junction. It has only limited use for acne scars due to this placement requirement[ **29**].

**Silicon:** This product with an unfortunate and undeservedly maligned history was an excellent augmentation material for postacne scars. When correctly used in the so-called microdroplet injection method utilizing appropriate medical grade 360 centistokes silicon rather than industrial varieties and building up gradually over a number of injection sessions, this preparation was without peers for isolated scars. It would be very useful if this material surfaced again if the medicolegal hysteria engendered over its dubious problems in other areas is ever resolved [**32**].

**Intralesional drainage injection of triamcinolone acetonide for cyst:** This method helps reduce inflammation. One needle is attached to a syringe and used for injecting the steroid (triamcinolone acetonide 10 mg/mL), and the other needle is not attached to a syringe. This ensures an adequate delivery of drug, preventing the rupture of the cyst [**33**].

**Extraction of comedones:** After puncturing the macrocomedones in the center using the sharp-tipped cautery point, we can grasp the base of the comedone using standard dissecting forceps and squeezed and pulled out the contents. Twelve patients were treated with this technique, all of whom tolerated the procedure well and judged the cosmetics results as very good. We recommend this procedure for patients who have closed macrocomedones larger than 3mm in size, although it is an effective treatment for macrocomedones of any size [**34**].

**Other and New Treatments:** 755-nm pocisecond lasers, non-insulated fractional microneedle radiofrequency, variable-pulsed Er-Yag laser, long-pulsed Alexandrite laser, %70 glycolic acid peel plus microneedling, microneedling plus PRP combinations have been developed for acne scar treatment as new modality. (**Table 4**)

**Table 4.** Effective Treatment Modalities According to Scar Types

| Treatment Modalitiy | Icepick scars | Rolling scars | Shallow Boxcar scars | Deep Boxcar scars |
|---|---|---|---|---|
| 1st Choice | CROSS, punch excision | Needling, ablatvie laser, subcision, filler, fractional/nonablative lasers, fractional radiofrequency | CROSS, needling, ablative laser | Ablative laser, punch elevation, punch excision |
| 2nd Choice | Microdermabrasion, dermabrasion, peels, ablative laser, subcision, fractional/nonablative lasers, fractional radiofrequency, punch excision | PRP | Microdermabrasion, dermabrasion, peels, subcision, filler, PRP, punck excision | Dermabrasion, needling, subcision, filler, PRP, fractional/nonablative laser, fractional radiofrequency |

## Conclusion

Atrophic postacne scarring presents a difficult challenge to patients and doctors alike. It has not been a well-treated condition, but recent additions to our stock of techniques have helped improve this somewhat. Practitioners must look upon not only each patient's scarring as requiring individualized treatment, but the topography of each scar requires its own treatment. Only limited basic research activity has been performed on the natural history and evolution of acne scarring as well as objective long-term evaluation of its response to treatment. This is a problematic, distressing, and almost epidemic disease that would greatly benefit from such work.

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