



Evaluating resurfacing modalities in aesthetics



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Abstract Skin resurfacing for cutaneous rejuvenation has evolved with the development of a plethora of nonsurgical and minimally invasive modalities. We have highlighted the advances in laser therapy, chemical peels, radiofrequency, microneedling, and platelet-rich plasma therapy. We have also included studies providing head-to-head comparisons between procedures and discussed relevant debates in the field. We have examined additionally combination treatments and resurfacing in acne scars, melasma, and skin of color.

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Introduction

Nonsurgical resurfacing modalities include laser and light treatments, radiofrequency (RF), microneedling (MN), and chemical peels.^{1,2} Laser modalities have become popular owing to their purported ease of use, relatively low-risk profile, and predictable postoperative course.^{1,3,4} The traditional carbon dioxide (CO₂) laser, which is considered the gold standard of resurfacing, is associated with substantial morbidity and extended postoperative healing. This has led to the development of fractional lasers, which offer improved safety, but at the cost of lower efficacy and the need for additional treatment sessions. RF, especially radiofrequency microneedling (RFM), provides an excellent alternative to fractional lasers, and it has been found to have similar efficacy and safety.⁵ Medium- and deep-depth peels can also

be effective for skin resurfacing by inducing neocollagenesis and improving photoaging.⁶ MN and platelet-rich plasma (PRP) can be used on various skin types and may be useful in combination treatments.^{7–11} MN enhances skin tone and improves skin texture, whereas PRP promotes collagen and elastin regeneration. PRP is modestly beneficial for the treatment of aging skin and improving facial skin texture.⁹ Because PRP enhances healing, it is also a great adjuvant therapy for resurfacing modalities,¹² especially in combination protocols for acne scars.^{13,14} The addition of PRP has shown recent promise.^{15–20} We reviewed and evaluated various skin resurfacing modalities regarding their efficacy, ease of treatment, safety profile, and patient satisfaction.

Laser therapy

CO₂ lasers

Traditional, unfractionated, fully ablative CO₂ laser (10,600 nm) resurfacing has been used to treat wrinkles, scars, warts,

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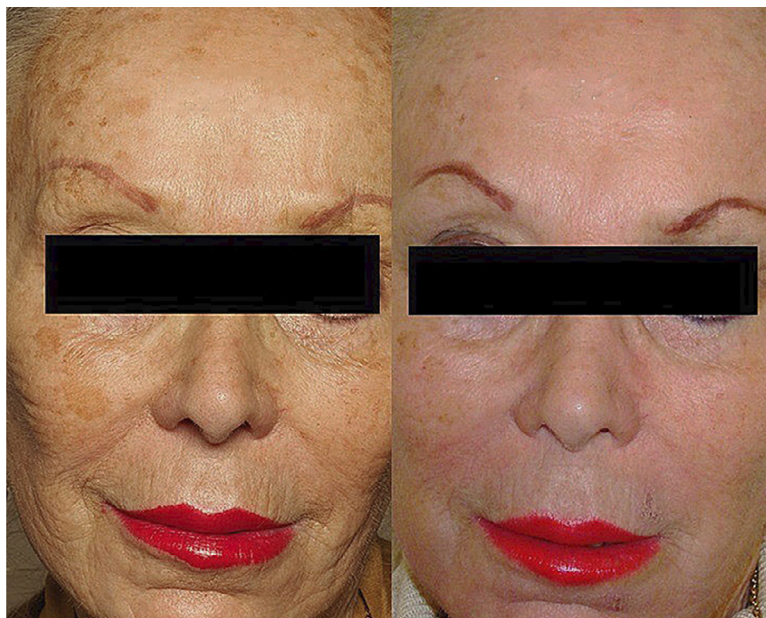


Fig. 1 Moderate-to-severe skin aging and photodamage is shown. Left, Before treatment. Right, After three sessions of FR- CO₂ laser (FIRE-XEL, Bison Medical, Seoul, Korea). CO₂, carbon dioxide. Reproduced with permission from Leslie Ortner, MD.

premalignant lesions, and benign neoplasms.^{21,22} Although the fully ablative CO₂ laser is highly effective for facial rejuvenation, it is associated with long recovery times and has considerable adverse effects, including increased risk for dyspigmentation and unpredictable healing responses that can result in keloid, hypertrophic scarring, ectropion, and eclabion.²³⁻²⁵ These risks increase patient anxiety and may decrease patient satisfaction.

Fractionated CO₂ lasers deliver energy in microthermal zones. Columns of untreated skin tissue remain between the microthermal zones, which start a rapid tissue repair process to enhance the speed of healing. Most patients are fully epithelialized and resume normal activities within 7 to 10 days of the procedure.^{26,27} This modality yields excellent outcomes for photodamage, rhytids, textural abnormalities, and scars with reduced adverse events and more predictable postoperative courses compared with traditional, fully ablative CO₂ laser resurfacing (Figure 1).^{28,29} Patient satisfaction is typically high.^{3,28,29} In comparison with fully ablative lasers, more treatment sessions are required to achieve the same outcomes, which can increase patient cost.²⁴

Erbium:Yttrium-aluminum-garnet lasers

Ablative, non-fractionated erbium:yttrium-aluminum-garnet (Er:YAG) lasers (2,940 nm) target water. The epidermal cells are vaporized in a meticulous skin peeling effect when heated water turns into gas. This leads to formation of collagen and skin tightening.⁴ The water absorption coefficient at 2,940 nm is 10 times that of a CO₂ laser, which limits its depth of tissue penetration and results in more precise ablation with minimal thermal damage of surrounding tissues; Er:YAG is

limited, however, by its lack of hemostasis. It can also cause serious adverse events, including scarring and complicated wound healing.^{30,31} When multiple-pass Er:YAG and single-pass CO₂ laser were observed in a manner such that there were similar quick postoperative histologic results, similar healing and cosmetic improvement occurred.³⁰ Other authors showed that the efficacy of a variable-pulse Er:YAG did not equal that from CO₂ laser resurfacing.³¹ Fractional Er:YAG laser is substantially safer than its non-fractionated counterpart; complications including discoloration, scarring, and skin infection, however, can still occur.^{32,33} This laser can cause mild skin tightening to improve laxity and rhytids.³⁴ It may also be used for atrophic acne scars, photodamage, hypopigmented scars, and dyspigmentation (Figure 2). Patients typically experience minimal postoperative downtime.^{32,34}

Non-ablative lasers

Non-ablative, non-fractionated lasers can be used for skin resurfacing. The outcomes are mild compared with those of ablative lasers; they are a good option, however, for patients who prefer safer treatments with minimal recovery time in exchange for gradual improvements. Picosecond (PS) lasers, such as the 755 nm alexandrite and dual 532/1064 nm neodymium:yttrium-aluminum-garnet (Nd:YAG), are useful for treating acne scars and photoaging.³⁵⁻³⁷ The risk of serious adverse events with non-ablative lasers is substantially lower compared with ablative lasers.^{38,39} Non-ablative fractionated lasers have been used to treat wrinkles, texture, and acne scars in addition to hyperpigmentation secondary to photodamage and aging.^{40,41} These lasers are moderately effective, safe, and require shorter downtime.



Fig. 2 Severe atrophic acne scarring, including inflamed rolling and boxcar scars, is shown. Left, Before treatment. Right, After three sessions of FR-Er:YAG laser (Pixel, Alma Lasers, Caesarea, Israel). Er:YAG, erbium:yttrium-aluminum-garnet.

Comparison

Comparing the above lasers, fully ablative CO₂ is the most efficient for deep wrinkles with an efficacy superior to that of fully ablative Er:YAG.⁴² Fractional Er:YAG was as effective as fractional CO₂ in recent studies; discomfort, however, was greater with the latter.⁴³ Full-field ablative Er:YAG was superior to fractional CO₂ in periocular and periorbital areas because fractional CO₂ targets elastin less effectively.⁴⁴ Preliminary results indicate that PS lasers may be as effective as fractional CO₂. Multiple sessions of fractional lasers are required to yield similar outcomes to a fully ablative laser treatment. The tightening effect of fractional lasers has not been consistent and may be inferior to that of a fully ablative laser.⁴⁵

Radiofrequency

RF technology uses heat to cause controlled damage to collagen and subsequently induce neocollagenesis. Unlike lasers, electrothermal RF energy does not target certain chromophores; however, the conductive properties of the tissue (eg, skin hydration, adiposity, and collagen content) affect the radius of thermal penetration.⁴⁶ RFM combines RF with MN by introducing thermal energy at various depths in the skin through the needles. RFM can be accomplished with bipolar or monopolar delivery and insulated or non-insulated needles.⁴⁷

A split-face study of Korean patients comparing three treatments with fractional RF at 2-week intervals for periorbital wrinkles found a 20% improvement in the wrinkle area compared with the untreated side.⁴⁸ Another study reported the safety and efficacy of RFM with insulated tips for skin rejuvenation in patients with skin type VI, which resulted in improved wrinkles, acne scars, and overall skin appearance.⁴⁹ A recent systematic analysis found fractional RF with microneedles or electrode pins to be effective for skin aging when performed on the face, neck, and décolletage.⁵⁰ A study of 333 patients compared fractional RF to fractional Er:YAG laser and found that wrinkle improve-

ment was dependent on the modality and cosmetic subunit of the face.⁵¹ The treatment-blinded physicians, who assessed wrinkle change, scored significantly greater improvements with RF around the jawline and with Er:YAG in the periorbital area. Different areas of the face could benefit from different devices.

In a 2016 multicenter clinical trial of 49 patients who received three monthly non-insulated RFM treatments, all patients showed improvement on the Fitzpatrick wrinkle scale on the mid and lower face, with 65% showing significant improvements.⁵² Two RFM studies on facial photoaging showed significant improvement and high patient satisfaction, and positive outcomes were maintained at the 3-month and 6-month followup periods.^{53,54} Another study of RFM on periorbital wrinkles reported significant improvement according to the Fitzpatrick wrinkle scale with three treatments at 3-week intervals.⁵⁵ A similar RFM study for periorbital wrinkles on 20 Korean patients showed significant improvement at a 6-month followup with high patient satisfaction.⁵⁶ Single treatment with non-insulated RFM with 12-month followup found durable effects, especially in perioral and perinasal tightening as measured with three-dimensional volumetric assessments in a 15-patient study.⁵⁷

There are advantages and disadvantages to resurfacing with RFM. Compared with fully ablative modalities, RFM is safer for darker skin types. With proper technique, there is a reduced risk of hyperpigmentation owing to minimization of epidermal injury with more predictable healing.⁴⁷ There is also reduced recovery downtime and a lower overall complication rate.⁴⁶ RFM requires a detailed understanding of the various devices available and biothermal properties of the area being treated to achieve desirable results.⁵⁸ Adjustments in needle depth and energy are needed for different locations of the face. To achieve improvement in rhytids, more treatments with RFM are typically required compared with lasers and chemical peels, and the outcomes can be less consistent between patients.⁵⁸ It is our opinion that RFM has a disadvantage on the eyelids compared with fractional or fully ablative Er:YAG laser because the sliding of the needles is not smooth. The cost of RFM can vary

substantially depending on the equipment used and the number of treatments; it is generally less expensive, however, than laser ablation. Overall, RFM can be an excellent resurfacing option for patients who desire minimal downtime and are at risk for postinflammatory hyperpigmentation (PIH).

Chemical peels

To meaningfully treat deep, static wrinkles, a chemical peel must reach the mid-reticular dermis. For chemical peels and skin resurfacing, the phenol-croton oil peel is considered the standard for treatment of deep rhytids⁵⁹; more superficial peels, however, can offer benefits when used in combination with laser resurfacing or microdermabrasion.⁶⁰ Studies with modified formulations and concentrations of croton oil allowed for a more precise application and control of peel depth.⁶¹ Croton oil is derived from a shrub native to India, *Croton tiglium*, whereas phenol is an aromatic hydrocarbon that is thought to act as a vehicle to transfer the croton oil into the reticular dermis.^{6,62} A study of 20 patients comparing CO₂ laser to phenol-croton oil peel for upper lip wrinkles showed significantly greater improvement with the peel at the 6-month followup.⁶³ A four-patient split-face study comparing CO₂ laser and phenol-croton oil peel found both treatments to be effective in diminishing rhytids; the laser side showed greater improvement on the nasolabial folds and chin, but with greater patient discomfort.⁶⁴ More comparison studies are needed to further characterize outcomes and determine the ideal patient qualities and application techniques.

Compared with other resurfacing modalities, deep chemical peels can offer some of the most dramatic and durable results.⁶⁵ Unlike lasers, there is no equivalent to “fractionated” technology for chemical peels to reduce adverse effects. Phenol-croton oil peels require an experienced provider and very careful patient selection. Treatment is not recommended for skin types IV to VI. Patients must be able to tolerate the pain and downtime, and they must also strictly adhere to aftercare instructions to avoid adverse outcomes. There is a long and comparatively painful recovery period, which typically lasts 2 to 4 weeks until patients can return to normal activities. Risks include cardiac arrhythmias during treatment, prolonged erythema (3–6 months), infection, hypertrophic scarring, and pigmentary changes.⁵⁹ The cost of phenol-croton oil peels is often lower than that of fully ablative laser treatments. Owing to the toxicity of phenol, suitable facilities for cardiac monitoring (not required when only two cosmetic units are treated), intravenous hydration, and protective equipment and proper training for staff are needed if full-face phenol-croton oil peels are performed.⁶⁶

Microneedling

MN, also known as percutaneous collagen induction therapy, involves repetitive puncturing of the skin using sterilized microneedles delivered by a dermaroller or dermapen. The pro-

cedure creates tiny perforations at the papillary dermis level with minimal disruption of the epidermis, which limits adverse effects and minimizes downtime.⁶⁷ It is used extensively for atrophic acne scars, skin rejuvenation, melasma, and stretch marks.⁶⁸ MN enhances the production of collagen types I, III, and VII, while also increasing tropoelastin.⁶⁷ Multiple treatments can offer noticeable clinical improvement of photoaged skin with corresponding histologic enhancement.

A number of studies have shown an improvement of acne scars with only occasional transient side effects, including mild erythema and edema lasting for a few hours.^{69–72} A study found that rolling scars benefitted the most from MN.⁷³ A recent study with 12-month followup reported improvements in facial and non-facial atrophic scars in various skin types with minimal risk of adverse events.⁷⁴ MN can be synergistically combined with other modalities in the treatment of acne scars and melasma as discussed in the sections below.

MN has also been explored to treat striae distensae^{75,76}; however, there is controversy on whether MN is more effective than fractional CO₂ laser. Some studies indicate that it is more effective,⁷⁷ whereas others support the use of fractional CO₂ laser.⁷⁸ For striae, MN has also been shown to be as efficacious as non-ablative lasers, particularly in skin types III or IV.⁷⁹ Compared with laser treatment, MN can be more affordable and safer.

Platelet-rich plasma

PRP includes platelet-derived growth factors, angiogenesis factors, and fibrinogen, which, upon activation, lead to collagen induction and remodeling. PRP may be beneficial for the treatment of aging skin, but the evidence is currently more convincing for facial skin texture.⁹ Most studies on PRP have been performed for atrophic acne scars and indicate that PRP enhances the effects of MN, subcision, and lasers.^{13,14,80–83} PRP reduces complications and enhances the tolerability of MN and subcision while offering superior results.^{84,85} In addition to improvements in skin texture and tone, PRP is associated with greater patient satisfaction, decreased postprocedural downtime, and improved quality of life.^{86–89}

PRP in conjunction with fractional CO₂ or Er:YAG laser has generally shown superior results compared with laser monotherapy in the management of acne scars^{90–93}; however, although one study showed that laser-associated edema and erythema significantly improved, the scar quality did not,⁹⁴ and in another study, there were surprisingly more side effects and longer downtime associated with PRP.⁹⁵ As will be discussed below, PRP alone or in combination with MN can be beneficial for melasma.⁹⁶ For striae, PRP is an effective modality, either as monotherapy or in combination with MN and trichloroacetic acid (TCA).⁹⁷ PRP alone may also be more effective for striae than other less potent modalities, such as microdermabrasion and topical tretinoin.^{98,99}



Fig. 3 Moderate atrophic acne scarring is shown. Left, Before treatment. Right, After three sessions of RF microneedling (Secret RF, Cutera, Brisbane, CA). RF, radiofrequency.

Treatment approaches

Acne scars

Performing resurfacing of acne scars requires careful consideration of patient skin type, acne scar type, and severity of scars. Lasers and RF are the most effective monotherapies, and fractional RF (Figure 3) was as effective as fractional lasers in a Cochrane review.¹⁰⁰ A 755 nm PS laser has been effective in rolling scars.³⁵ Ice pick scars respond well to 100% TCA using the chemical reconstruction of skin scars technique.¹⁰¹ Rolling scars can also be corrected with a combination of simple procedures, such as subcision with fractional laser or fractional RF with filler.^{102,103} Boxcar scars can be managed with punch elevation and removal in combination with fractional RF.¹⁰⁴

Combination therapies are more effective than monotherapy because atrophic acne scars often require volume restoration, enhanced tightening, and tissue movement (eg, surgical modalities) with resurfacing.¹⁰⁵ Subcision can first be performed in patients with large numbers of boxcar and rolling scars. Performing subcision before CO₂ laser has yielded better outcomes for all scar types.¹⁰⁶ A systematic review showed that energy-based modalities, such as fractional lasers and fractional RF, and other minimally invasive modalities, such as needling and PRP, can be used in multimodal therapies with promising clinical outcomes.¹⁴ A combination of fractional CO₂ laser with RF intensifies the thermal effects, which can offer better results in fewer sessions without increasing significant side effects.^{49,107,108}

MN can yield global improvements in texture and tone, and it is also beneficial on oily skin. It has been combined synergistically with other modalities, such as polymethylmethacrylate filler, subcision, and chemical peels.¹⁰⁹⁻¹¹² PRP can be used to enhance neocollagenesis and postprocedural healing and to decrease postprocedural downtime. It can be combined with fractional CO₂ or Er:YAG laser, MN, or subcision;^{91,95,110,113} therefore, in resource limited settings, various minimally invasive modalities can be successfully combined to treat severe acne scars with excellent results.⁸⁴ Combination of newer energy-based technologies, such as lasers

or RF, with simple techniques, including TCA chemical reconstruction of skin scars technique, subcision, fillers, MN, PRP, and punch excision, can provide improved outcomes compared with monotherapy.^{103,114-116}

Melasma

Resurfacing modalities used for the treatment of melasma include chemical peels, lasers, microdermabrasion, and more recently, MN and PRP. Chemical peels have traditionally been used for the treatment of melasma, and effective peels for epidermal melasma have included Jessner solution, salicylic acid, and α -hydroxy acids.¹¹⁷ In comparison, dermal and mixed melasma have improved with TCA 25 to 35% with or without Jessner solution. MN decreases epidermal melanin density and can lead to improvement of various melasma types.^{118,119} In combination with sunscreen and topicals, MN can promote clinical and histologic improvement of refractory facial melasma.¹²⁰ MN has also been shown to enhance the transdermal drug absorption of topical skin lightening agents, such as vitamin C in skin types I to III.^{121,122} The deeper and more uniform delivery of tranexamic acid through microchannels created by MN has shown better clinical outcomes compared with microinjections of the drug.¹²³ PRP may be helpful in refractory melasma as intradermal microinjections or in combination with MN.^{96,124}

Lasers should be reserved for refractory cases of melasma.¹¹⁷ Low-fluence Q-switched (QS) Nd:YAG laser has been shown to be safe.¹²⁵ A series of five to 10 treatment sessions spaced 1 week apart are required. Treatment with the QS Nd:YAG laser after microdermabrasion has been effective in refractory mixed-type melasma.¹²⁶ Within the first few months of treatment with a QS laser, there remains a risk for rebound hyperpigmentation and a high recurrence rate of melasma. Additionally, the PS laser can be used to break up pigment through its photomechanical effects rather than thermal energy.¹²⁷ This allows for pigment to be removed without the thermal damage associated with QS lasers. Studies have shown that the PS laser is effective in treating melasma and is less likely to cause PIH.¹²⁷ The fractionated ablative lasers, such as CO₂ and Er:YAG, may

provide immediate improvement, but there is still a high risk of PIH 1 to 2 months following the procedure, which may be related to melanocyte stimulation at the periphery of pigmented patches.¹²⁸ Using lower fluences and shorter pulses may decrease the risk for PIH from thermal injury.¹²⁹ Fractional technology, however, results in incomplete removal of abnormal melanocytes, and is therefore associated with a high risk of rapid recurrence. For all resurfacing treatments, it may be necessary to use anti-pigmentation creams for at least 4 to 6 weeks before the procedure.

Skin of color

Resurfacing procedures that are relatively safe to be used for skin of color include MN, RFM, PRP, and non-ablative and ablative fractional lasers. MN and RFM offer a more advantageous safety profile, particularly in skin types IV to VI compared with conventional resurfacing techniques.¹³⁰ PRP is safe in dark skin types and enhances tone and texture when combined with MN.^{131,132} Non-ablative fractional lasers have been used frequently in Asian populations to treat fine lines and wrinkles and to improve skin texture. A greater number of treatments using lower density and wider treatment intervals can minimize risk of PIH without affecting clinical outcomes.³⁰ This can be combined with intense pulsed light to achieve improvement in skin tone without prolonging downtime.¹³³ More recently, the 755 nm PS laser with diffractive lens array was shown to be safe and efficacious for targeting textural irregularities and dyspigmentation in Chinese skin.¹³⁴

Fractional resurfacing is a relatively safe and efficacious modality in dark skin types; however, there is a paucity of high-quality studies involving skin types V and VI.¹³⁵ Ablative fractional laser is very effective for wrinkles, mottled dyspigmentation, pore size, and textural irregularities, but is limited by the occurrence of PIH, especially in Asians.³³ It can be combined with intense pulsed light for photoaging, especially in patients who already have some dyspigmentation and are willing to undergo a longer recovery.¹³⁶ There still remains some debate as to whether fractionated ablative lasers should be performed on skin of color.

Conclusions

With the advent of newer minimally invasive treatment options, there is a plethora of resurfacing modalities that can be used for global facial rejuvenation. During a cosmetic consultation, the aesthetic provider should discuss the available options and suggest a management plan that considers the patient's expectations, efficacy and safety of each modality, longevity of results, and lifestyle and budget limitations.

Although the fully ablative CO₂ laser remains the gold standard of resurfacing by which all other modalities are measured, it is mostly recommended for severe skin aging. For more mild-to-moderate skin aging, newer modalities,

such as RF and fractional lasers, are being increasingly used. These treatments offer an improved safety profile and decreased downtime at the cost of more treatments. Other minimally invasive options, such as MN and PRP, are now becoming more popular because they can easily be combined with other treatment modalities.

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