Laser skin resurfacing

More than a cosmetic procedure

DESHAN FRANK SEBARATNAM MB BS(Hons), MMed, FRCP(London)
PATRICIA LOWE MB BS(Hons), MMED, FACD
ADRIAN LIM MB BS, FACP, FACD

Ablative lasers are used for skin resurfacing to promote tissue remodelling and skin rejuvenation, with advancements in technology leading to safer devices, including fractional delivery systems. Common indications for treatment with ablative fractional lasers include photoageing, the appearance of lines and wrinkles, actinic dysplasia, acne and burn scars, and benign facial papules. Patients must be informed of the potential adverse effects of laser skin resurfacing, as well as the postprocedure recovery process.

Ablative lasers vaporise layers of skin to induce tissue remodelling and subsequent skin rejuvenation. Over the years, technological improvements have led to safer devices, such as those yielding fractional delivery with both cosmetic and medical indications. This article provides an overview of the types of lasers used for skin resurfacing, as well as some indications and complications of this procedure.

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Conjoint Associate Professor Sebaratnam is a Staff Specialist at Liverpool Hospital, Sydney; and Cosmetic Dermatologist at uRepublic Cosmetic Dermatology & Veins, Sydney. Associate Professor Lowe is a Staff Specialist at Royal Prince Alfred Hospital, Sydney; and Cosmetic Dermatologist at uRepublic Cosmetic Dermatology & Veins, Sydney. Dr Lim is Dermatology Staff Specialist at Royal North Shore Hospital, Sydney; and Cosmetic Dermatologist and Phlebologist at uRepublic Cosmetic Dermatology & Veins, Sydney, NSW.

Evolution of laser devices used for skin resurfacing

The classic ablative lasers are the carbon dioxide (CO_2) and erbium:yttrium-aluminium-garnet (erbium:YAG) lasers. The CO_2 laser was the first ablative laser, introduced almost 60 years ago, and became a popular skin resurfacing tool for wrinkles and scars from the 1990s.[1] The erbium:YAG laser was introduced in the mid-1990s and was rapidly established as a versatile resurfacing laser because of its capability of vapourising tissue with less collateral damage than the CO_2 laser. Both the CO_2 and erbium:YAG lasers remain popular resurfacing lasers today.

CO_2 versus erbium:YAG ablative lasers

The CO_2 laser emits infrared radiation at a wavelength of 10,600 nm, mainly targeting water. The laser facilitates tissue ablation and underlying tissue coagulation. The erbium:YAG laser delivers a wavelength of 2940 nm with an at least 10-fold greater affinity for water compared with the CO_2 laser.[2] The erbium:YAG laser also produces more superficial ablation per pass with less thermal coagulation, resulting in shorter healing times and less post-treatment erythema and postinflammatory hyperpigmentation. Conversely, a reduction in thermal heating is correlated with reduced haemostasis and less impressive skin tightening with erbium:YAG laser resurfacing.[3]

In the early days, the energy delivery of the CO_2 laser was continuous, with crude control of the energy output resulting in frequent overheating and burns. The development of pulsed technology allows for enhanced control of the energy output and a reduction in complications, making CO_2 resurfacing of the full face safer. However, erbium:YAG lasers can be manipulated to incorporate subablative pulses to increase residual thermal heating and improve the skin-tightening effects. The advent of fractional laser technology in the mid-2000s reinvigorated skin resurfacing by further reducing the procedural downtime and potential complications of ablative lasers.[4]

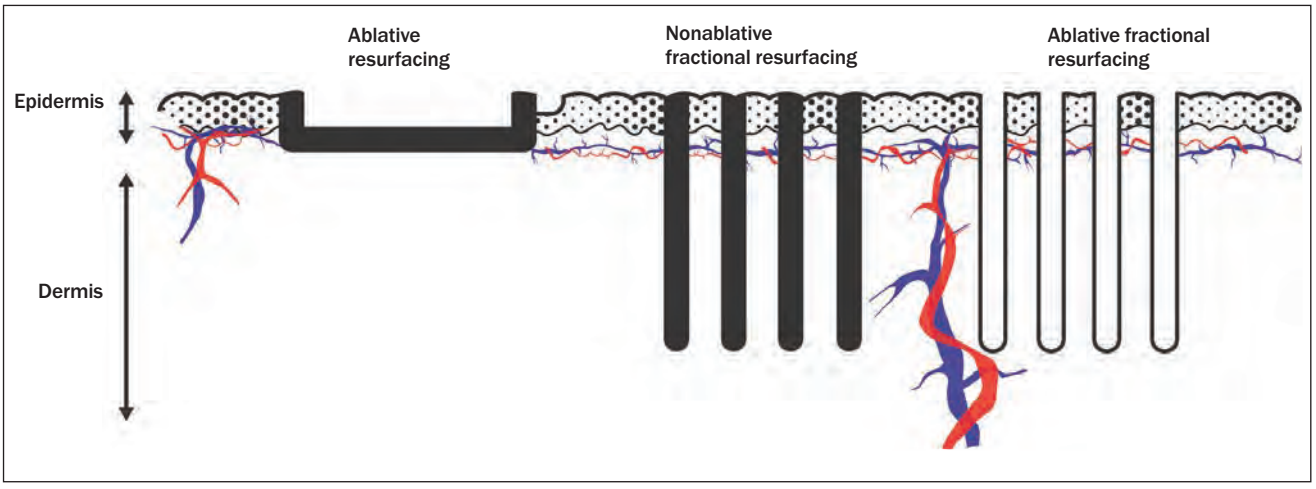

Figure 1. Comparison of laser–tissue interactions in ablative resurfacing, nonablative fractional resurfacing and ablative fractional resurfacing.[1]

Fractional lasers

Fractional laser devices deliver microchannels of energy to the skin with intervening areas of untreated tissue. The microchannels are known as microthermal zones and can penetrate depths of up to 1.5 mm and a width of 100 to 400 mcm, with up to 6400 microchannels per cm^2 (Figure 1).[1,4] Typically, only 5 to 20% of the surface area is targeted. The normal intervening skin acts as a reservoir for tissue regeneration by providing nutritional support and an intact microstructure for keratinocyte and fibroblast migration.

The 1550 nm nonablative laser was the first fractional device to appear on the market in the mid-2000s and is still widely used today. Other popular nonablative fractional lasers include the 1927 nm wavelength laser and lasers with wavelengths between 1320 and 1550 nm.[1,4] The inherent advantages of nonablative fractional lasers include short recovery times; improved patient tolerability; and their suitability as an ideal adjunct to other procedures, such as intense-pulsed-light and vascular lasers. In the late 2000s, the classic ablative lasers – CO_2 and erbium:YAG – were reconfigured as fractional laser devices, giving the ablative lasers a new lease of life for skin rejuvenation treatments.

Ablative fractional lasers are more effective than their nonablative fractional counterparts, with greater improvements in collagen remodelling and skin tightening, but with longer recovery times and more potential adverse effects, such as persistent erythema and postinflammatory hyperpigmentation, although these adverse effects are significantly reduced when compared with traditional nonfractional ablative lasers.[5] Nonablative fractional lasers typically lead to erythema and oedema lasting two to three days post-procedure, followed by micro-exfoliation without bleeding or oozing (Figure 2). By comparison, ablative fractional lasers produce pinpoint bleeding for one to two days and moderate to marked erythema lasting one to three weeks. Nevertheless, ablative fractional lasers have a much more favourable side effect profile compared with their nonfractional counterparts.

Figure 2. Nonablative fractional laser resurfacing on day 1 (a, left) and day 3 (b, right) post-procedure. Patchy exfoliation is observed on day 3 with complete surface recovery by day 5 to 7.

Images courtesy of the authors. Images are published with patient consent.

Indications of laser skin resurfacing

Given their favourable efficacy and adverse effect profile, ablative fractional lasers are now considered the gold standard for skin resurfacing.[1,4,6] Common indications for treatment with ablative fractional lasers include photoageing, the appearance of lines and wrinkles (rhytides), actinic dysplasia, acne and burn scars and benign facial papules.[6-8]

Skin rejuvenation

Since the 1990s, fully ablative laser resurfacing with the CO_2 laser initially, followed by the erbium:YAG laser, has been

Figure 3. Actinic cheilitis with whitish plaques and erosions (a, left). Healthy pink vermillion two months after full ablative laser resurfacing (b, right).

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the mainstay of therapy. With the advent of fractional lasers in the mid-2000s, the popularity of skin resurfacing has risen. In our experience, the erbium:YAG laser is best suited for fine to medium rhytides and darker skin tones on account of its superior safety profile. By comparison, the CO_2 laser is better suited for deeper rhytides, with the aim of skin tightening. Fractional ablative lasers (CO_2 and erbium:YAG) have an established role in the management of photoageing and rhytides and can complement other rejuvenative procedures, such as the use of injectables (e.g. botulinum toxin and fillers) and other energy devices (e.g. intense-pulsed-light and vascular lasers).[9]

Acne scarring is a key indication for fractional laser resurfacing ...

Actinic dysplasia

Photodamage is often accompanied by actinic dysplasia, which can be improved with skin resurfacing, especially with the use of traditional ablative (nonfractional) lasers. Historically, ablative lasers, such as the CO_2 and erbium:YAG lasers, have been used to treat actinic keratoses; these compare favourably with field 5-fluorouracil and trichloroacetic acid (30%) peels.[10,11] Ablative lasers are generally not the first-line options for actinic dysplasia because of issues related to their access and cost. However, fully ablative (nonfractional) lasers remain a popular treatment option for actinic cheilitis (Figure 3). Laser-assisted drug delivery with fractional lasers is being implemented increasingly to create microchannels for faster and improved penetration of topical agents to increase their clinical response and efficacy (e.g. to enhance topical aminolaevulinic acid penetration in photodynamic therapy for actinic dysplasia and skin cancers).[12]

Scarring

Acne scars

Acne scars can be broadly classified as atrophic or fibrotic scars, with several subtypes according to their morphology (Figure 4). Fractional nonablative lasers (e.g. 1550 nm) and fractional ablative CO_2 and erbium:YAG lasers have been shown to improve the appearance of atrophic acne scars.[7,13] A systematic review concluded that ablative fractional lasers offer an improvement range of 26 to 83%, compared with 26 to 50% for nonablative fractional resurfacing.[13] Acne scarring is a key indication for fractional laser resurfacing and can be performed as a standalone procedure or in combination with traditional nonfractional resurfacing.

Burn scars

Hypertrophic burn scars can result from various thermal and caustic injuries, such as those caused by fire, scalding water,

Figure 4. Acne scars can be broadly classified as atrophic (indented) or fibrotic (raised) scars, with several morphological subtypes.

Image courtesy of the authors. Image is published with patient consent.

Figure 5. Severe fire burn injury resulting in hypertrophic scarring and contractures, with limitations to neck and mouth movements.

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chemicals and electricity. Burn scars can result in significant functional and psychological morbidity, especially as scar contractures limit movement and with scar dysaesthesia (Figure 5). Hypertrophic burn scars are managed with physical therapies, intralesional corticosteroids, surgical revisions and fractional ablative lasers. Fractional ablative lasers can improve scar appearance and symptoms through the delivery of ablative microchannels inducing scar remodelling. A typical regimen is three sessions of fractional CO_2 at one- to three-month intervals, resulting in improvements in scar pliability; texture; vascularity; pigmentation; and symptoms of itch, pain and dysaesthesia.[8] Additionally, topical triamcinolone is routinely applied to the treated scar for optimum penetration (via laser-assisted drug delivery) to facilitate corticosteroid-induced scar remodelling.[14]

... benign facial papules, ranging from seborrhoeic keratosis to syringomas, can be effectively treated with spot resurfacing ...

Focal ablative resurfacing

Focal or spot ablative resurfacing is commonly used for small skin lesions, typically on the face, where laser precision and control are advantageous. A constellation of benign facial papules, ranging from seborrhoeic keratosis to syringomas, can be effectively treated with spot resurfacing using ablative CO_2 and erbium:YAG lasers. Depending on the device, the laser spot size can vary from smaller than 1 to 4 mm or larger, to match the size of the target lesion. Box 1 presents some considerations before referring a patient for laser spot ablation.

Figure 6. Dermatosis papulose nigra, a variant of seborrhoeic keratosis at baseline (a, left) and three months after spot laser resurfacing directed to the individual lesions (b, right).

Images courtesy of the authors. Images are published with patient consent.

1. ARE THERE OTHER MORE SUITABLE ALTERNATIVES TO FOCAL 'SPOT' RESURFACING?

GPs should consider the following before referring a patient for laser spot ablation.

- Are you worried about the lesion – can malignancy be excluded? If you are uncertain of the diagnosis, a biopsy or referral is recommended. A shave excision will offer treatment and diagnosis simultaneously
- Are there other more suitable treatment options? Consider treating the lesion with cryotherapy, curettage or cautery, or shave excision
- Is the lesion on the face (exposed) or torso (covered)? Lesions on the torso, such as multiple seborrhoeic keratoses, can be treated effectively with cryotherapy as the procedure is safe, quick and cost-effective and should be first line
- Is field treatment a better option than spot treatment? Actinic keratoses on a background of marked photodamage may be an indication for field treatment to the entire region (e.g. topical 5-fluorouracil)

Benign facial papules

One of the most common cosmetic presentations is dermatosis papulosa nigra, a subtype of seborrhoeic keratosis (Figure 6). Many cases are amenable to cryotherapy, gentle curettage and cautery, all of which are reasonable firstline therapies. However, for cosmetically sensitive locations, such as the eyelids, nose and lips, lasers offer superior control and finesse. These growths can be treated with ablative lasers using spot sizes of 1 to 2 mm in diameter.

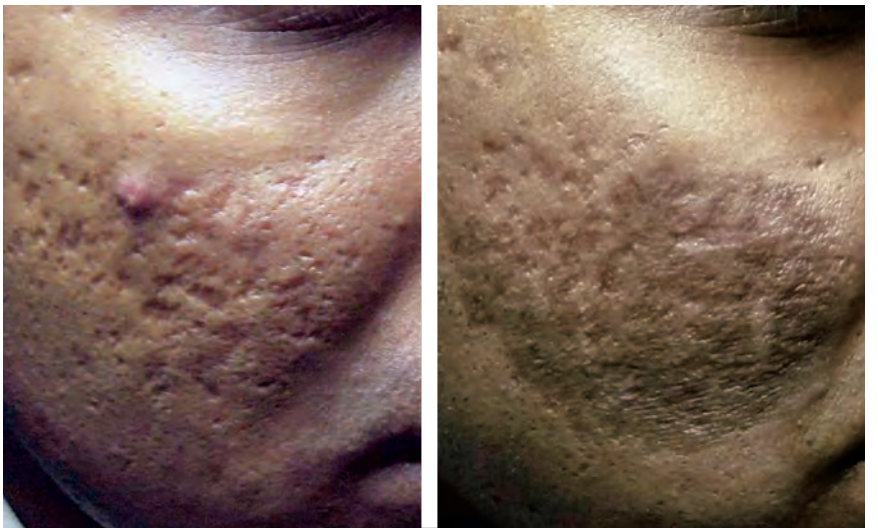

Figure 7. Atrophic acne scarring on Fitzpatrick type 5 skin at baseline (a, left) and six weeks after ablative fractional laser resurfacing, resulting in moderate postinflammatory hyperpigmentation (b, right). The pigmentation significantly resolved after five months of topical hydroquinone treatment.
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Other types of benign facial papules include dermal naevi, angiofibromas, sebaceous hyperplasias, syringomas (sweat duct tumours), neurofibromas and xanthelasma (cholesterol deposits), all of which are amenable to ablative laser removal. However, many of these tumours, particularly syringomas, will eventually recur, as it is not possible to completely remove the deeper portion of the lesion without the risk of scarring.

Rhinophymas

Ablative lasers can be used effectively to treat rhinophymas secondary to rosacea. A practitioner's preference and familiarity with a particular device will determine the resurfacing modality that is used. Studies comparing laser resurfacing with electrosurgery or scalpel excision have shown similar outcomes.[15] Severe rhinophyma can also be debulked efficiently using electrosurgery wire loops. Mild rhinophymas can be sculpted either using a fully ablative laser with a variable spot size (e.g. in the range of 3 to 6 mm) or high-density fractional ablative lasers, followed by a second 'touch-up' treatment, if required.

Complications of laser skin resurfacing

The safety of laser therapy is well established, although, as with any intervention, adverse effects are possible. Preoperative clinical review should include an evaluation of the Fitzpatrick skin phototype, recent or planned sun exposure, recent artificial tan application, immunological or inflammatory comorbidities, any history of herpes simplex virus infection, allergies, scarring, previous cosmetic or surgical procedures and the medication history for risk stratification purposes. Photograph-containing documentation before and after the procedure should be mandatory. Transient adverse effects of laser skin resurfacing include post-treatment discomfort, oozing, crusting, itching, bruising, swelling, skin sensitivity, redness and acne breakouts. Bacterial, viral and candidal infections can complicate resurfacing procedures, and prophylactic antimicrobials are often considered. Depending on the laser employed, potential longer-term sequelae include permanent hypopigmentation or prolonged hyperpigmentation (Figure 7) and, rarely, scarring. The patient's informed

Figure 8. High-intensity (level 7) resurfacing of severe acne scarring at baseline (a, left) and day 1 postresurfacing (b, centre) showing moderate laser wound exudate, and at day 7 (c, right) showing complete re-epithelialisation of the laser wound. The recovery images are patient selfies submitted for telemonitoring.

Images courtesy of the authors. Images are published with patient consent.

consent should include detailed information of the recovery process, recovery time and after-care procedures (e.g. sun avoidance), along with a discussion of potential complications. For resurfacing procedures, patients are routinely invited to submit a series of postprocedure smartphone 'selfies' (Figure 8) to allow for remote monitoring for any potential

TABLE. A PATIENT-CENTRED CLASSIFICATION SYSTEM FOR LASER SKIN RESURFACING.[16]

Resurfacing intensity level*	Downtime (days)	Main after-effects	Fitzpatrick skin phototype	Improvement in skin colour	Improvement in skin texture	Examples of types of devices used
1	0 to 2	• Erythema • Microflaking	1 to 6	+	+	1550 nm erbium-glass fractional laser
2	0 to 2	• Flaking • Swelling	1 to 4	++	+	Intense pulsed light with 1550 nm or 1927 nm fractional lasers
3	2 to 5	• Spot bleeding • Spot crusting	1 to 4	++	++	Intense pulsed light with 2940 nm erbium:YAG fractional laser
4	5	• Light exudate • Light crusting	1 to 4	++	++	Intense pulsed light with 2940 nm erbium:YAG superficial ablative laser and 2940 nm erbium:YAG fractional laser
5	5	• Moderate crusting	1 to 4	++	++	Intense pulsed light with superficial fractional CO_2
6	5 to 7	• Moderate exudate • Moderate crusting	1 to 4	++	++	Superficial and deep fractional CO_2
7	7 to 10	• Heavy exudate • Heavy crusting	1 to 3	+++	+++	Full resurfacing with erbium or CO_2

* The resurfacing intensity level is correlated with the expected downtime.
+ small; ++ moderate; +++ great.

2. RESURFACING RECOVERY TIME AND SMARTPHONE-BASED AFTERCARE MONITORING

With cosmetic procedures, the management of patient expectations is key to satisfactory outcomes. Patients are mostly interested in the recovery period (downtime) and clinical outcomes. An understanding of the postprocedure appearance and recovery process is necessary to plan their social and work activities around the resurfacing procedure.

We have proposed a patient-centred grading system for resurfacing procedures to inform patients of the associated downtime, expected clinical outcome and costs of the various resurfacing options (Table).[16] In our resurfacing classification, the least intensive resurfacing starts at level 1 and progressively increases in intensity to level 7 (Figure 8). The level number approximates the downtime with respect to the number of days required to recover (Table).[16] Multimodal therapy (e.g. fractional lasers combined with intense-pulsed-light or vascular lasers) can be undertaken to optimise the end results and minimise the recovery time.

We have also proposed a smartphone-based monitoring process using serial 'selfies' submitted by patients (Figure 8), which has been shown to be particularly useful in the aftercare monitoring of patients who have undergone more intensive resurfacing.[17]

complications. Box 2 presents practice tips related to informing patients about the postprocedure recovery process and aftercare monitoring process.[16,17]

Conclusion

Ablative lasers for skin resurfacing remain a valuable dermatological tool for both cosmetic and medical indications. The CO_2 and erbium:YAG lasers remain popular resurfacing devices and have been reimplemented in a fractional delivery mode for an improved safety profile. Nevertheless, complications, such as infections and dyspigmentation, can occur, which need to be fully discussed with patients, along with the expected recovery time for the proposed procedure. Box 3 presents some practice points for GPs. MT

3. PRACTICE POINTS

- The carbon dioxide (CO_2) and erbium:Yttrium-Aluminium-Garnet (erbium:YAG) lasers are classic ablative lasers used for skin resurfacing.
- The CO_2 laser has greater skin-tightening potential than the erbium:YAG laser but also a greater potential for thermal injury and complications.
- The erbium:YAG laser is associated with less thermal coagulation than CO_2 lasers and a greater potential for bleeding at greater treatment depths.
- Both the CO_2 and erbium:YAG lasers have fractional delivery modes for an improved safety profile, but this comes at the expense of efficacy.
- Field resurfacing is indicated for photodamage, ageing skin and acne scarring.
- Spot resurfacing is indicated for rhinophymas, actinic cheilitis and various benign facial papules.
- Resurfacing complications include herpes simplex virus reactivation, infection, dyspigmentation, prolonged erythema and scarring.
- Appropriate patient selection and informed consent are key factors for favourable patient outcomes.

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