Australasian Journal of Dermatology

Australasian Journal of Dermatology (2015) **56**, 186–191 doi: 10.1111/ajd.12303

PROCEDURAL DERMATOLOGY

Laser skin resurfacing: A patient-centred classification based on downtime

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INTRODUCTION

Laser skin resurfacing is used to address cutaneous concerns including acne scarring, photoageing (particularly dyschromia and vascular changes), rhytides and skin laxity. In response to the increasing consumer demand for clear, concise and relevant information and in the interests of informed consent, we have devised a user-friendly patient-centred classification system for laser skin resurfacing. Existing skin resurfacing classifications do not adequately meet the above objectives. In this article, we categorise resurfacing lasers, review existing resurfacing classification systems and propose a patient-centred classification based on downtime (the period of time following resurfacing where patients may choose not to appear in public due to expected side-effects such as erythema, oedema and exudate).

ABLATIVE LASER RESURFACING

Ablative laser resurfacing uses energy to rapidly heat and vaporise the epidermis and superficial dermis. The subsequent healing and remodelling of damaged proteins leads to skin tightening. The primary lasers used for ablative resurfacing are the carbon dioxide (CO_2) laser, the erbium:yttrium-aluminium-garnet (Er:YAG) laser and the erbium:yttrium-scandium-gallium-garnet (Er:YSGG) laser.[1]

The CO_2 laser was developed in 1964. The emitted wavelength of 10 600 nm is absorbed by water, causing rapid heating and vaporisation of tissue and the subsequent tightening of lax tissue. However, excessive thermal injury in the dermis produces an unacceptable risk of adverse events, including persistent erythema, infection, post-inflammatory hyperpigmentation, persistent hypopigmentation, demarcation lines and hypertrophic scarring.[1,2] Patients typically experience significant downtime post-CO_2 laser treatment, in the order of days to weeks.[3]

In the 1990s the Er:YAG laser was introduced as an alternative to CO_2 laser. The Er:YAG laser emits light at a wavelength of 2940 nm, which approximates the absorption peak of water (3000 nm) much more closely than the CO_2 laser. This correlates to more superficial ablation, a shorter downtime and a lower incidence of side-effects. However, there is less dramatic clinical improvement than in using traditional CO_2 resurfacing. The Er:YSGG laser was then developed in 2008 with the aim of providing deeper dermal heating than the Er:YAG laser while minimising the healing time. Its wavelength of 2790 nm is lower than that of the Er:YAG and CO_2 lasers, and has tissue interaction characteristics somewhere between that of Er:YAG and CO_2 lasers.[1,2]

Ablative laser resurfacing remains the gold standard in textural skin rejuvenation due to consistent clinical enhancements. However, its use has been limited by the extended downtime post-treatment and morbidity, along with its potential complications.[4]

NON-ABLATIVE LASER RESURFACING

In an effort to overcome the morbidity associated with ablative lasers, non-ablative modalities were introduced in the late 1990s. The term non-ablative resurfacing encompasses a wide range of treatments including infrared lasers, visible light lasers and intense pulsed light. These induce selective injury of the dermis while keeping the epidermis largely intact. Infrared lasers target dermal water (using concomitant cooling to spare epidermal water) so as to improve skin texture, fine lines and acne scarring. Visible light lasers, such as the pulse dye laser (585–595 nm), target haemoglobin and melanin, thus ameliorating dyschromia and telangiectases. Intense pulsed light sources use high-intensity flash lamps to emit non-coherent light in a broad wavelength spectrum (420–1200 nm) which targets telangiectasias, dyschromia and, to a lesser degree, fine wrinkles.[1,2]

The non-ablative lasers are minimally invasive and offer significantly shorter downtimes compared to ablative

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Conflict of interest: none

Submitted 1 October 2014; accepted 28 November 2014.

Abbreviations:

Er:YAG	erbium:yttrium-aluminium-garnet
Er:YSGG	erbium:yttrium-scandium-gallium-garnet
MTZ	microthermal zone

Table 1 Fractional devices

Device	Wavelength (nm)	Medium	Ablative *vs* non-ablative
Fraxel re:fine, PaLoVia, Emerge	1410	Er:glass	Non-ablative
Affirm, Starlux	1440	Er:glass	Non-ablative
Fraxel re:store, Sellas	1550	Er:glass	Non-ablative
Fraxel dual, Lavieen	1927	Thulium	Non-ablative
Pearl fractional	2790	Er:YSGG	Ablative
Profractional, Pixel, LightPod Era	2940	Er:YAG	Ablative
Fraxel re:pair, AcuPulse, Mixto, Fraxis	10 600	CO_2	Ablative

AcuPulse, Lumenis, Yokneam, Israel; Affirm, Cynosure, Westford, MA, USA; Emerge, Palomar Medical Technologies, Burlington, MA, USA; Fraxel, Solta Medical. Hayward, CA, USA; Fraxis, Ilooda, Gwonseon, Gyeonggi-do, South Korea; Lavieen, WonTech, Yuseong-gu, Daejeon, South Korea; LightPod Era, Aerolase, Tarry Town, New York, USA; Mixto, LASERINGusa, San Ramon, CA, USA; PaLoVia,, Palomar Medical Technologies, Burlington, MA, USA; Pearl fractional, Cutera, Brisbane, CA, USA; Pixel, Alma Lasers, Buffalo Grove, IL, USA; Profractional,, Sciton, Palo Alto, CA, USA; Sellas, Sellas, Yuseong-gu, Daejeon, South Korea; Starlux,, Palomar Medical Technologies, MA, USA.

Er:YAG, erbium:yttrium-aluminium-garnet; Er:YSGG, erbium:yttrium-scandium-gallium-garnet

lasers. However the effects of non-ablative modalities are less dramatic clinically and patients require multiple treatments to achieve only a subtle improvement in skin texture.[1]

FRACTIONAL LASERS

The fractionation of laser light delivery was first introduced in 2004.[5] Multiple narrow microscopic columns of laser energy are emitted, absorbed by the relevant chromophore, leading to the development of microthermal zones (MTZs). Reservoirs of viable cells adjacent to the MTZs allow for more rapid re-epithelialisation, a shorter downtime and fewer complications than traditional full-field (non-fractional) systems.[6]

There are numerous fractional devices on the market, which are characterised as ablative or non-ablative, depending on the presence of an intact stratum corneum following treatment (Table 1).

LASER CLASSIFICATION SYSTEMS

As outlined above, lasers in dermatology can be classed according to whether they are ablative or non-ablative, and further, fractional or non-fractional. These groups can be further subdivided according to laser type, for example ablative lasers can be subdivided into CO_2, Er:YAG or Er:YSGG.

Lasers may also be classified according to depth of skin damage. Gold[7] suggests grouping fractional lasers into two groups: micro-ablative fractional laser systems, which produce epidermal and dermal damage to a depth less than 750 microns, and deep dermal ablative fractional laser systems, which produce damage beyond 750 microns.

Patient response to treatment is another classification system relevant to laser resurfacing. Fitzpatrick skin type has been universally employed to help identify patients at increased risk for developing adverse events after skin rejuvenation procedures. However Fanous[8] suggests that racial categories (Nordics, Europeans, Mediterraneans, Indo-Pakistanis, Africans and Asians) more accurately predict response to treatment (Table 2).

A NOVEL PATIENT-CENTRED CLASSIFICATION SYSTEM

For patients and allied health workers, terms such as ablative, non-ablative, fractional and non-fractional contribute little to their understanding of clinical reaction and expected down time. Whether a laser is based on CO_2 or infrared, or whether it can reach a depth of 750 microns is of little interest to a patient. In this setting, the ideal classification system would be unambiguous, free of jargon, logical and intuitively understood by patients and clinic staff. The classification method would also give an indication of treatment intensity, clinical efficacy and the expected downtime of the proposed resurfacing procedure.

Management of patient expectations in the cosmetic dermatology field is paramount to satisfactory outcomes. Patients are most interested in the recovery period (downtime) and clinical end-points. Thus, we have developed a novel patient-centred grading system which allows patients to factor in downtime along with the expected clinical outcome and cost when deciding upon the type of treatment they want. In our resurfacing classification, the gentlest true resurfacing starts at level 1 and progressively increases in intensity up to a maximum of level 7 (Figs 1–7). For completeness, non-ablative procedures using intense pulsed light, vascular lasers (e.g. 532 nm, 595 nm) or 1064 nm long-pulsed/Q-switched ‘laser toning’ devices are categorised as level 0 resurfacing. The level number approximates the downtime with respect to number of days required to recover (Table 3).

In our practice, implementation of the new patient-centred laser classification has empowered patients to make fully informed decisions on their treatment. Patients find the classification system simple to understand and are now able to select their preferred treatment regime based on both the desired clinical outcome and downtime. The grading system emphasises to patients that while ‘more invasive’ treatment modalities may offer greater clinical improvement, they will be typically associated with a more prolonged downtime. Conversely, therapies requiring little downtime may not offer such dramatic clinical results per

Table 2 Racial categories used to predict response to laser resurfacing[9]

Race	Original geographical habitat	Characteristics of skin and features	Complications	Candidate for laser resurfacing
Nordic, e.g., Swedish, Irish	Northern Europe	Light to very light colour Very fine skin and features	Erythema +++ Telangiectasia Scarring	Very good
European, e.g., French, English	Mid-Europe Southern Europe	Average colour Average coarseness of skin and features	Low incidence	Excellent
Mediterranean, e.g., Spanish, Greek	North Africa West Asia	Darker and coarser than the Europeans	Hyperpigmentation +/++ Erythema +	Very good
Indo-Pakistanis, e.g., Pakistanis, Thais	Upper middle Asia	Coarser and darker than the Mediterranean group	Hyperpigmentation +++	Poor
	Lower west Asia	Thick, oily skin and hair	Hypopigmentation +	
Africans, e.g., African Americans, Sudanese	Middle and lower Africa	Colour is black to deep black Features and skin are coarse to very coarse	Hypopigmentation +++ Hyperpigmentation ++	Very poor
Asians, e.g., Japanese, Koreans	East Asia	Colour varies from light to medium dark Skin and features are coarse to very coarse	Hyperpigmentation +++ Erythema +++	Good

Figure 1 Level 1 resurfacing with low intensity fractional 1550 nm laser. Suitable for Fitzpatrick skin types 1–6.

Figure 2 Level 2 resurfacing with intense pulsed light and 1927 nm fractional laser.

treatment session and multiple treatment sessions may be required for better results.

In practice, the consulting dermatologist explains in plain English the varying levels of laser resurfacing. The patient is then shown photographs of the likely clinical reactions and anticipated improvement at each level. They are provided with a printed copy of the classification system, which also details the recovery period. Comprehensive patient education is essential as it enhances the patient's knowledge, intra-operative comfort levels, compliance, outcomes and satisfaction.[9]

The benefits of this classification system are not limited to patients. We have found it to be of enormous value to our nursing and clerical staff, facilitating consistent information delivery by all staff, resulting in a more cohesive practice and better informed patients.

Importantly this classification need not be device-dependent and should be flexible enough to permit combi-

Figure 3 Level 3 resurfacing with intense pulsed light combined with spot erbium:yttrium-aluminium-garnet and fractional erbium:yttrium-aluminium-garnet resurfacing. Note reduction of lentigines and seborrhoeic keratosis.

Figure 4 Level 4 resurfacing with intense pulsed light combined with erbium:yttrium-aluminium-garnet superficial peel and fractional erbium:yttrium-aluminium-garnet resurfacing.

Figure 5 Level 5 resurfacing with intense pulsed light combined with superficial fractional CO_2.

nation laser therapies. This classification system is applicable to any laser practice regardless of the number and types of devices used and aims to convey meaningful information on procedural efficacy and downtime.

The development of this patient-centred classification stemmed from years of clinical experience and relied heavily on visual feedback obtained from patients post-procedure. Teledermatology, via smartphone review of post-treatment photographs ('selfies'), has been particularly useful. Patients email sequential post-procedure photos via their smartphones, allowing for accurate medical assessment of their responses to the various resurfacing procedures (see Fig. 6). The photos are stored securely in the patient's electronic file. We envisage that individual dermatology practices may implement a similar teledermatology process and develop their own patient-centred laser classification systems. Furthermore, practices can tailor the number of grading levels according to their operative devices and their patients' responses to therapy.

CONCLUSION

Laser skin resurfacing options continue to expand and gain popularity in the treatment of photoageing, scarring and other textural skin abnormalities. The classification of resurfacing lasers has traditionally been based on whether a device is ablative or non-ablative, fractional or non-fractional. Motivated by the desire to move towards a patient-centred care model, along with the increasing consumer demand for information, we developed a simple laser rejuvenation grading system based on

Figure 6 Typical spot-bleeding (upper lip), erythema, exudate and crusting after level 6 resurfacing. (a) 1, (b) 4 and (c) 5 days post-fractional CO_2 resurfacing. This patient used a smartphone to take and send photos for telemonitoring.

Figure 7 Level 7 resurfacing with combination full resurfacing with medium depth erbium:yttrium-aluminium-garnet and fractional CO_2 resurfacing. (a) baseline, (b) 1 week post-laser, (c) 3 weeks post-laser. Note significant erythema, crusting and peeling still present after 1 week.

Table 3 Our novel patient-centred classification system

Level	Downtime (days)	Main after effects	Fitzpatrick skin type	Improvement in skin colour	Improvement in skin texture	Examples of types of devices used
0	0–1	Erythema Pigment darkening	1–4	+/++	–/+	532 nm/595 nm vascular lasers, 1064 nm Q-switched Nd:YAG (neodymium-doped yttrium aluminium garnet), intense pulsed light
1	0–2	Erythema Microflaking	1–6	+	+	1550 nm Erbium-Glass fractional laser
2	0–2	Flaking Swelling	1–4	++	+	Intense pulsed light with 1550 nm or 1927 nm fractional lasers
3	2–5	Spot bleeding Spot crusting	1–4	++	++	Intense pulsed light with 2940 nm Er:YAG fractional laser
4	5	Light exudate Light crusting	1–4	++	++	Intense pulsed light with 2940 nm Er:YAG superficial ablative laser and 2940 nm Er:YAG fractional laser
5	5	Moderate crusting	1–4	++	++	Intense pulsed light with superficial fractional CO_2
6	5–7	Moderate exudate Moderate crusting	1–4	++	++	Superficial and deep fractional CO_2
7	7–10	Heavy exudate Heavy crusting	1–3	+++	+++	Full resurfacing with erbium or CO_2

Nd:YAG, neodymium-doped yttrium aluminium garnet; Er:YAG, erbium:yttrium-aluminium-garnet.

expected downtime. This grading system allows patients to make realistic treatment choices, enables clinicians to better manage patient expectations, and increases patients' satisfaction post-treatment. We recommend that dermatology practices consider implementing a similar patient-centred classification system based on downtime.

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