Avoiding complications in laser dermatology

Laser procedures have become increasingly popular in the aesthetic and dermatology sector. In the majority of cases the treatments are associated with mild transient side-effects, and fortunately long-term complications are uncommon. In addition to accurate patient selection, a thorough understanding of laser physics and light-tissue interaction is essential in minimizing the risk of complications. This article explains the possible complications that may arise from laser treatments in the aesthetic practice involving the skin only (ocular hazards are not discussed). Measures to avoid such complications as well as some tips as to their management will be discussed.

BY FIRAS AL-NIAIMI

Firas Al-Niami

Common side-effects

Depending on the type of laser and procedure performed, temporary and transient side-effects are extremely common and in some procedures are an expected desired clinical endpoint. These will be discussed here briefly but strictly speaking do not fall under the category of complications.

Erythema for example is almost always present as a result of heat scattering following any laser procedure. It tends to fade within 24 hours and is often accompanied by oedema, which similarly fades within 24 hours, except when it involves the peri-orbital areas where it tends to last a bit longer. In symptomatic cases the use of ice packs and a short course of oral corticosteroids can help.

Bruising with the use of pulsed dye laser (PDL) is common, particularly with the use of shorter pulse widths less than 6 milliseconds, and generally tends to fade within 7–10 days. Care should be taken if this occurs in individuals with lighter skin types as well as in the lower legs due to the possible risk of post-inflammatory hyperpigmentation (PIH) once the bruising settles. This can be avoided by using longer pulse widths, lower fluences, and adequate cooling (1).

Peri-follicular erythema is a desired endpoint in laser hair removal (LHR) and generally tends to fade within a few hours. Pain can be minimized by the use of local anaesthetics where appropriate, cooling methods, and the use of longer pulse widths where appropriate to the clinical setting.

Complications

Complications that may arise from laser treatments are best defined as undesired events that occur as a result of laser treatments without intention. These can be divided in minor, intermediate, and major complications.

Minor complications

Acne/milia

These minor complications are generally easy to treat and are most likely to be due to disruption of pilosebaceous units by photothermolysis resulting in inflammation and follicular occlusion. Individuals with a past history of acne are particularly prone to this. Milia often result due to occlusion of eccrine ducts and follicles secondary to the use of occlusive ointments in the aftercare period of resurfacing procedures. In general, switching to light cream-based emollients and the lapse of time is all that is required.

The development of acne has been reported to occur following LHR on the face. Although the exact mechanism for this is unknown, it is likely that follicular occlusion and thermal effects play a role (2). Treatment includes topical and systemic antibiotics.

Occlusion folliculitis can occur in LHR particularly on the lower legs in women and the backs in men. It tends to occur during the first few treatments when the hair shaft is thicker. Treatment with topical (and in some cases oral) antibiotics is often sufficient.

Purpura

Purpura is a common expected outcome in many cases with the use of PDL and in some conditions, such as port-wine stains, is an expected clinical endpoint. A rare complication of LHR is, however, the development of purpura, often in the lower legs, which represents the rupture of small cutaneous vessels as a result of gravity and higher hydrostatic pressures (3). Termination of LHR is not required in most cases, and leg elevation and the use of compression stockings will suffice.

Contact dermatitis
This is a complication that tends to occur as a result of either «irritancy» to the products used following a laser procedure (irritant contact dermatitis) or are due to «sensitization» and the development of allergy to the topical agents (allergic contact dermatitis). This complication is more common following ablative resurfacing procedures as a result of the loss of epidermal barrier leading to increased penetration of the topical products together with the «heightened» local cutaneous immunological response as a result of the epidermal barrier disruption (4). Management includes short course of topical corticosteroids and the use of less irritating topical products (gentle cleanser and light emollients) and the cessation of any culprits in the event of a suspected or confirmed allergic contact dermatitis.

Line of demarcation
This complication represents a colour step-off between treated and non-treated areas and typically occurs in ablative, and to a lesser degree non-ablative rejuvenation procedures. This may not necessarily be due to high fluences and tends to occur more often in lighter skin types and individuals with actinic bronzing. Measures to minimise this include confining treatments to cosmetic subunits and «feathering» the edges of the treated areas by using lower fluences and densities, and in skilled hands the use of high repetition mode in a «painting» fashion.

Urticaria
Short term wheals typical of urticaria can occur occasionally following laser procedures and represent mostly a form of physical urticaria called symptomatic dermographism. A rare variant of cold-induced urticaria can occur as a result of the cooling used during the procedure. Treatment is generally symptomatic and with a short course of anti-histamines.

Intermediate complications

Hyperpigmentation
Postinflammatory hyperpigmentation (PIH) is a relatively common complication of laser therapy and is often observed in individuals with lighter skin types although idiosyncratic cases can occur in any skin type. Common causes for this complication include the use of high fluences, inadequate cooling, and treatment in tanned individuals (often associated with a degree of crusting in the latter group due to increased epidermal absorption of the laser radiation). The mechanism involves primarily an increase in melanin dispersion from active epidermal and follicular melanocytes as a result of the inflammation and in some cases as a result of the damage to the basement membrane leading to uptake of the melanin by melanophages (sometimes referred to as dermal type of PIH) (5, 6).
PIH generally tends to improve over time, and its management involves the use of vigorous sun protection and in some cases the use of lightening creams of which hydroquinone is the most effective. In some cases of intense purpura, a short course of topical corticosteroids after laser therapy can reduce the risk of PIH.

Hypopigmentation
Hypopigmentation as a result of laser therapy is far less common than PIH. Though this complication may be transient, in some cases it can be permanent and notoriously difficult to treat. The mechanism involves either complete destruction of both epidermal and follicular melanocytes as a result of excessive thermal damage, or the suppression of melanogenesis by melanocytes as a result of the inflammatory process triggered by the laser injury (7). Immunohistochemical studies have shown a normal number of melanocytes, and it is possible that a reduced tyrosinase activity, an enzyme which is heat-sensitive, is responsible for this phenomenon (8). Temporary hypopigmentation is relatively common following the use of Q-switched lasers, possibly due to targeting the melanosomes in the melanocytes as described above.
In some cases the use of narrow band UVB phototherapy or excimer laser may help through the stimulation of melanocytes (9). Recently there have been some published reports on the use of fractional laser technology, with good results (10). Delayed hypopigmentation typically seen in some cases after full ablative resurfacing is fortunately less common nowadays thanks to the increasing use of the fractional methods.

Crusting/blistering
Crusting and blistering both imply epidermal injury. In crusting often suprabasal necrosis of the epidermis occurs with subsequent sloughing off of the necrotic tissue. Although the mechanisms involved are similar to blistering, the latter can also occur as a result of cleavage at the dermo-epidermal junction as a result of thermal injury and often involves full epidermal separation from the dermis due to damage of the basement membrane. In the majority of cases these complications occur as a result of inadequate high fluences, cooling failure, pulse stacking, treatment in tanned individuals, or inadequate removal of make-up. In some cases debris accumulated at the hand piece can lead to focal areas of overheating of the epidermis leading to crusting.
Blistering can also occur in laser tattoo treatments and in particular in the case of high ink density, pulse stacking, pulse overlap and the use of excessive

fluences (11). Large unilocular blisters tend to occur at distal extremities such as the wrist and ankle. Blisters occurring in the setting of non-ablative fractional lasers are often the result of «bulk heating», and subsequent treatments should be performed with lower densities. Intact blisters should either be left alone and a non-adherent dressing applied, or drained carefully with the use of a sterile needle with good antiseptic cover afterwards.

The management of crusting involves the regular use of a petrolatum-based ointment with the area kept clean (occasionally with the use of antiseptic agents). It is vital that the formed scabs are not picked or removed, as this can result in hypopigmentation or scarring.

Signs of acute epidermal injury with impeding crusting or blistering include whitening or greying of the treated area which should be promptly treated with vigorous cooling and the regular use of lubricating ointments. It is worth mentioning that some cutaneous infections can present with vesicles or blisters, and this should be prevented.

Paradoxical hypertrichosis

This complication is a relatively common phenomenon in LHR and tends to be a particular problem in individuals with skin types III-V and in particular in the face. Although the physical consequences of this are minor, it generally tends to cause a lot of distress among its sufferers. The exact mechanism for this «stimulated hair» is unknown though hormonal influences could play a role and exclusion of an underlying endocrine disorder in females is recommended. The condition is defined as an increase in the colour, density, and coarseness of hair following LHR.

The author distinguishes two patterns of paradoxical or stimulated hair growth. Namely one involving the treated area and another involving the surrounding adjacent areas. In the former this is often due to insufficient fluences leading to photobiostimulation of the hair follicles instead of stem cell damage. In such cases the use of higher fluences or double passes (with adequate care and cooling) may be required. It is also noteworthy that in finer hairs the target for laser (follicular melanin) is reduced, and therefore ideally shorter wavelengths and pulse widths are required. This is often performed by experienced laser practitioners with thorough knowledge of this treatment and its potential side-effects.

In the second scenario in which stimulated hairs appear in the adjacent areas of the treated sites the mechanism here involves diffusion of heat to the surrounding areas at low levels that lead to stimulation in the mitochondria leading to biostimulation of hair follicles (12). In such cases adequate pre- and post-treatment cooling of the adjacent surrounding areas is required.

Prolonged post-laser resurfacing erythema

The exact timing for the erythema to be defined as «prolonged» is unclear; however, this term defines the presence of prolonged erythema following a laser procedure (most commonly ablative and non-ablative rejuvenation) beyond the expected duration for such an intervention. Some laser experts define this as seven days for non-ablative fractional ablation and six weeks after ablative procedures. There is, however, no general consensus on this. In some cases this prolonged erythema may progress to scarring or PIH. The risk of prolonged erythema is present in particular among patients with «plethoric» skin or rosacea. Treatment includes vigorous sun protection as well as the use of some topical treatments such as vitamin C serum. In some cases, particularly when pruritus is present, a short course of topical corticosteroids can be used. In many cases treatment with PDL or IPL in non-bruising settings can further help ameliorate this complication.

Major complications

Scarring

Scarring is the most serious and feared laser complication by both practitioners and patients. It results from irreversible injury to the collagen and adnexal structures leading to the inability of the stem cells to repopulate the damaged cells. In some patients, there is an inherent susceptibility for scar formation. Risks include the use of excessive fluences, inadequate cooling (in particular due to «bulk heating» with the use of deeper penetrating wavelengths such as 1064 nm Nd:YAG), post-treatment infection, pulse stacking, particularly at purpuric settings, or crusting/blistering if not managed promptly. Scarring can also occur due to irreversible collateral thermal damage when using long-pulsed millisecond lasers in the treatment of tattoos where the chromophore (exogenous ink) is very small. Therefore, procedures such as LHR should avoid treating hairs overlying tattoos.

Treatment of established hypertrophic scars includes corticosteroid injections, silicone gel sheets, and PDL. Early treatment with PDL in the event of an incipient scar formation (for example prolonged erythema) can in some cases avert such a complication (13).

Atrophic scarring is more challenging to treat although both ablative and non-ablative fractional treatments can be used with some success (14).

Indentations

Indentations that occur following epidermal damage (crusting, blistering, erosions, etc.) are often the result of associated marked collagen damage and shrinkage often as a result of high fluence or inadequate cooling of the skin. Whilst isolated collagen

damage and shrinkage can certainly occur with the inadequate use of deep penetrating lasers that generate «bulk heating» such as 1064 nm Nd:YAG, subcutaneous indentation may occur as a result of isolated subcutaneous fat injury with fat necrosis or a panniculitis-like inflammation. Such complications were often observed with the use of cryolipolysis or radiofrequency devices (15). The use of devices with «vacuum suction» may also result in such injuries.
In some cases shallow indentations may spontaneously recover over time, however, deeper indentations tend to be permanent and though difficult to treat, filler injections or autologus fat transfer can in some cases offer a remarkable cosmetic improvement.

Infections
Cutaneous infections as a result of laser treatment can pose a particular problem due to the risk of scarring that may ensue. The risk of infection increases with any disruption of the epidermal barrier such as crusting and blistering. The risk is the highest among ablative laser procedures. Infections can be divided into bacterial, viral, and yeast infections.
Bacterial infections are commonly caused by Staphylococcus aureus and are a particular risk with ablative procedures due to the degree of oozing, crusting and epidermal barrier disruption. Pain is a particularly useful diagnostic sign, together with evidence of superficial crusting or focal areas of patchy erythema with erosions. The risk appears to be higher after 48 hours after ablative procedures and should be treated promptly with oral antibiotics and appropriate topical antiseptic agents. In high risk cases such as immunocompromised patients pre-treatment with oral antibiotics might reduce this risk (11). The use of topical antibiotics after laser resurfacing can lead to an increased risk of contact dermatitis, and the clinician should be aware of this.
Viral infections are almost always due to reactivation of herpes simplex infections (HSV) and are a risk in both ablative and non-ablative procedures, particularly with procedures performed around the mouth (16). The appearance of painful crusting or vesicles following such procedures should alert the practitioner to the possibility of this diagnosis. Empirical anti-viral treatment should start promptly as disseminated HSV infections are likely to delay re-epithelialization and lead to scar formation. It is generally agreed now that prophylactic treatment is given to almost all ablative procedures, and in high-risk cases of non-ablative treatments.
Yeast infections, most commonly with Candida species, are rare and present often with erythema and pruritus, particularly following ablative procedures (17). Treatment includes systemic anti-yeast agents.

Conclusion

The use of laser and light devices has increased greatly over the years, resulting in a rise in complications from the use of these devices. Fortunately, most devices available to us are generally safe, and serious complications are rare among trained and experienced professionals. Indeed, a recently published study showed that the majority of laser complications occurs as a result of practitioners' mistakes. Lack of thorough knowledge of laser physics and poor training coupled with improper patient selection are unfortunately all too common nowadays. Therefore, in the author's opinion a sound knowledge of laser physics coupled with a thorough knowledge of laser complications and how to avoid them should hopefully lead to an overall decline in such incidents. ▲

Correspondence address:
Dr. Firas Al-Niaimi
skin Head Office
Harborne Road 34
Edgbaston, Birmingham B15 3AA – UK
E-mail: firas55@hotmail.com

References:
1. Goldberg D: Laser treatment of vascular lesions. Clin Plast Surg 2000; 27: 173–180.
2. Carter JJ, Lanigan SW: Incidence of acneform reactions after laser hair removal. Lasers Med Sci. 2006; 21(2): 82–85.
3. Goldberg DJ: Complications in laser treatment of unwanted hair. In: Goldberg DJ (ed): Complications in cutaneous laser surgery. Taylor & Francis, London 2004.
4. Nanni CA, Alster TS: Complications of carbon dioxide laser resurfacing. An evaluation of 500 patients. Dermatol Surg 1998; 24: 315–320.
5. Chan NP et al.: The use of non-ablative fractional resurfacing in Asian acne scar patients. Lasers Surg Med 2010: 42(10): 710–715.
6. Lanigan SW: Incidence of side effects after laser hair removal. J Am Acad Dermatol 2003; 49: 882–886.
7. Goldberg D: Laser treatment of benign pigmented lesions. eMedicine. Available from: URL:http://www.emedicine.com/derm/topic517.htm. Accessed November 14, 2005.
8. Laws RA et al.: Alabaster skin after carbon dioxide laser resurfacing with histologic correlation. Dermatol Surg 1998; 24(6): 633–636.
9. Alexiades-Armenakas MR et al.: The safety and efficacy of the 308-nm excimer laser for pigment correction of hypopigmented scars and striae alba. Arch Dermatol 2004; 140: 955–960.
10. Tierney EP, Hanke CW: Treatment of CO2 laser induced hypopigmentation with ablative fractionated laser resurfacing: case report and review of the literature. J Drugs Dermatol 2010; 9: 1420–1426.
11. Berg D, Nanni CA: Complications of dermatologic laser surgery. eMedicine. Available from: URL: http://www.emedicine.com/derm/topic525.htm. Accessed November 14, 2005.
12. Deasai S et al.: Paradoxical hypertrichosis after laser therapy: a review. Dermatol Surg 2010; 36(3): 291–298.
13. Jin AR et al.: Laser therapy for prevention and treatment of pathologic excessive scars. Plast Reconstr Surg 2013; 132(6): 1747–1758.
14. Hedelund L et al.: Fractional nonablative 1,540-nm laser resurfacing of atrophic acne scars. A randomized controlled trial with blinded response evaluation. Lasers Med Sci 2010; 25(5): 749–754.
15. Bogle MA, Dover JS: Tissue tightening technologies. Dermatol Clin 2009; 27(4): 491–499.
16. Graber EM et al.: Side effects and complications of fractional laser photothermolysis: experience with 961 treatments. Dermatol Surg 2009; 34: 301–305.
17. Alam M et al.: A prospective trial of fungal colonization after laser resurfacing of the face: correlation between culture positivity and symptoms of pruritus. Dermatol Surg 2003; 29(3): 255–260.