

# Complications in laser dermatologic surgery. Part II: fractional and non-fractional ablative laser and fractional non-ablative laser

*Complicações com o uso de lasers. Parte II: laser ablativo fracionado e não fracionado e laser não ablativo fracionado*

## ABSTRACT

Conventional ablative lasers remove the epidermis and part of the dermis completely, and achieve excellent results in the treatment of photoaging. Non-ablative lasers have become more popular, since they inflict less thermal damage on the dermis and do not remove the epidermis, thus reducing the recovery time and the risk of side effects. Fractioning has recently been introduced in non-ablative lasers, with the goal of developing a system with the efficiency of the ablative and the safety of the non-ablative lasers. Fractional ablative lasers form total dermal-epidermic ablation columns, whereas fractional non-ablative lasers generate microscopic zones of dermal-epidermic thermal lesions, yet they preserve the stratum corneum.

**Keywords:** lasers; carbon dioxide; postoperative complications; rejuvenation; photoaging

## RESUMO

Os lasers ablativos convencionais removem completamente a epiderme e parte da derme e promovem excelentes resultados no fotoenvelhecimento. Apesar disso, os lasers não ablativos tornaram-se mais populares devido ao reduzido tempo de recuperação e menor risco de efeitos colaterais, pois causam dano térmico na derme e não removem a epiderme. Recentemente foi introduzido o fracionamento nesses lasers com o objetivo de se obter sistema tão eficiente quanto o dos ablativos e tão seguro quanto o dos não ablativos. Os lasers ablativos fracionados formam colunas de ablação total dermoepidérmica, e os não ablativos fracionados criam zonas microscópicas de lesão térmica dermoepidérmica deixando íntegro, entretanto, o extrato córneo.

**Palavras-chave:** lasers; dióxido de carbono; complicações pós-operatórias; rejuvenescimento; fotoenvelhecimento

## INTRODUCTION

Laser-assisted ablative resurfacing of the skin is a precise and effective way of removing the external layer of damaged skin and stimulating neocollagenesis and retraction of the skin.<sup>1,2,3</sup> Based on the principle of selective photothermolysis, early laser resurfacing technologies could only be applied to continuous waves systems, namely the 10,600 nm CO<sub>2</sub> and 2,940 nm Erbium:YAG laser systems.<sup>4-6</sup> They are indicated for skin rejuvenation and scar treatment, offering highly satisfactory results. However, they have a protracted postoperative period and unacceptably high side effects due to prolonged exposure to the energy produced by the laser.<sup>2,4,5,7,8</sup>

In an attempt to improve collagen stimulation with regard to short infrared non-ablative lasers (800–1450 nm diode lasers and long-pulsed 1064 nm Nd:YAG lasers) and mitigate the

## Continuing Medical Education



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Received on: 06/08/2010  
Approved on: 05/03/2011

This study was carried out at the authors' private practices in Porto Alegre, (RS) Brazil.

Conflict of interests: none  
Financial support: none

drawbacks of epidermal ablation, fractional non-ablative lasers were developed. Non-ablative laser technology stimulates collagen through dermo-epidermal coagulated microcolumns, without ablation of the epidermis.<sup>4,6</sup> Fractional, non-ablative lasers use wavelengths of 1,565 nm, 1,550 nm (Erbium glass laser), 1,540nm (Erbium glass rod laser), and 1,440nm, which are suitable for the treatment of acne, post-surgery or trauma scars, dyschromias, photoaging, melasma, striae, sagging, and deep rhytids.<sup>4,9</sup> Results are satisfactory, recovery occurs in 2 or 3 days, and side effects are minimum. Nevertheless, many sessions are required, making it a high-cost procedure.<sup>4,6</sup>

Further research was carried out to obtain skin resurfacing as effective as that provided by traditional ablative lasers, however, with a safety level similar to that offered by fractional, non-ablative lasers. Fractional CO<sub>2</sub> ablative and Erbium:YAG lasers – which remove only columns of the epidermis – were introduced in 2006,<sup>5</sup> providing greater depth control and more selective thermal damage, meaning a significant reduction in the occurrence of serious side effects, but without compromising treatment efficacy (Table 1).<sup>2,4,8,10</sup>

However, the majority of complications associated with laser resurfacing are not linked to laser type, but rather to the depth of cutaneous damage, which in turn is linked to the excessive number of passes, density (the number of microscopic thermal lesions per area), pulse duration, and fluence used.<sup>1,2,6</sup> Additionally, it is necessary that both papillary and superior reticular dermis are reached by the procedure to stimulate collagen synthesis and for cutaneous surface leveling to take place, respectively. Therefore, it is essential that the depth of cutaneous resurfacing is controlled to obtain good results with minimum side effects.<sup>2</sup>

Despite the known efficacy and safety of ablative lasers<sup>2,7,8</sup> and the reported low rates of serious complications, side effects can occur even with experienced professionals.<sup>6,11,12</sup> Complications are rare and must be distinguished from any expected side effects experienced by all patients undergoing ablative laser procedures (e.g. erythema, edema, moderate pruritus, sensation of localized heat, and exudative areas).<sup>1,3,6</sup>

Likewise, side effects must also be distinguished from operational errors.<sup>11</sup> Operational errors can result from insufficient training, inadequate selection of patients, incorrect indication and diagnosis, application of overlapping pulses, excessive use or misuse of parameters, and inappropriate postoperative management – factors likely to potentially increase the morbidity rate of any laser system.<sup>3,6,11,13</sup>

This study aims to review the side effects lasers can cause and suggest how these can be handled, since there is little literature about this subject. This is key to better patient care, thereby preventing morbidity and sequelae.

For pedagogical reasons, the subject has been subdivided into early and late side effects. This review is based on articles available on the PubMed database, selected according to the following parameters: keywords used – lasers, carbon dioxide, post-operative complications, rejuvenation, and photoaging; and publication timeframe: 1999–2010. All articles had to be related to

dermatology. Descriptions of how those side effects that did not present consensus were handled and those which were occasionally controversial, were also drawn from the literature. Early side effects were considered those occurring in the first 7 days of the postoperative period, while late side effects were those that became apparent around the second week (Table 2).<sup>14,15</sup>

In a retrospective study, Berwald et al.<sup>15</sup> described the complications encountered within their 8-year experience with CO<sub>2</sub> and Erbium:YAG lasers in 749 patients with phototypes I–V who underwent ablative resurfacing. All patients underwent systemic prophylaxis for the herpes virus that did not include antibiotics and antifungals. Erythema in the postoperative period was closely observed, receding before the sixth week. Post-inflammatory hyperpigmentation (PIH) occurred in 32% of cases, hypopigmentation in < 1%, and infection in 2% of patients. Irritative dermatitis was the most frequent early complication, occurring in 10.6% of patients.

In a retrospective review, Graber et al.<sup>16</sup> evaluated short- and long-term (1 year) side effects of 961 consecutive 1,550 nm fractional, non-ablative laser procedures in 422 patients. Side effects occurred in 73 (7.6%) procedures, with acneiform eruption (18 cases), herpetic infection (17 cases), and erosion (13 cases) being the most frequent. The least frequent side effects were PIH (7 cases), prolonged erythema (8 cases), prolonged edema (6 cases), and dermatitis (2 cases). Impetigo and purpura occurred only once. When phototypes and occurrence or absence of side effects were compared, it was possible to verify that patients with higher phototypes had more complications ( $p = 0.007$ ). The result was all the more evident when evaluating PIH incidence (0.26% in phototype II patients and 2.6%, 11.6%, and 33% in phototypes III, IV, and V, respectively). The authors wish to emphasize that the rates of fractional, non-ablative laser side effects are significantly lower than those described for ablative CO<sub>2</sub> and Erbium:YAG lasers.

With the aim of providing the widest possible perspective on the subject, the most common side effects in skin resurfacing using fractional and non-fractional ablative lasers and fractional, non-ablative lasers are reviewed here together with several rare complications.

## EARLY SIDE EFFECTS

### *Pain and edema*

Post-resurfacing pain is a common event and is treated with systemic analgesics. Occlusive bandages control pain, but they also increase the risk of infection.<sup>14</sup> Pain rarely occurs after the second day of the postoperative period and must be investigated if it occurs (dryness and infection are common causes).<sup>3</sup> Compresses or cold water sprays can be useful. Oral analgesics (codeine) combined with an anxiolytic (lorazepam 1–2 mg, twice or three times daily) are considerably effective in the control of pain.<sup>14</sup>

Edema usually varies from mild to moderate, with peaks on the second and the third day, and can last for up to 1 week.<sup>9,10</sup> Nevertheless, it can appear dramatic, even alarming, and become uncomfortable for the patient.<sup>3,10</sup> Its intensity can be relieved

Table 1: Currently available laser equipment\*

Manufacturer	System	Laser type	Wavelength (nm)
<b>Ablative</b>			
Alma	Harmony	Er:YAG	2,940
CO2 Pixel		CO2	10,600
CO2 Omnilift Pixel		CO2	10,600
Cutera	Cutera Fractional Pearl	Er:YSGG	2,790
Cynosure	CO2 Affirm	CO2	10,600
Eclipsemed DOT	DOT SmartXide	CO2	10,600
SmartXide CO2 10.600			
Ellipse Inc.	Juvia	CO2	10,600
Focus Medical	Er NaturaLase	Er:YAG	2,940
Fotona	Plus SP	Nd:YAG/Er:YAG	1,064/2,940
Dualis SP	Nd:YAG/Er:YAG	1,064/2,940	
Dualis XS	Er:YAG	2,940	
Fidelis XS	Er:YAG	2,940	
Lasering	SX Mixto	CO2	10,600
Lumenis	Active FX Ultrapulsed	CO2	10,600
Deep FX Ultrapulsed	CO2	10,600	
Lutronic	eCO2	CO2	10,600
Matrix	LS-25	CO2	10,600
Palomar	Lux 2.940	Er:YAG	2,940
Quantel	EXEL O2	CO2	10,600
FX4 e FX12	Er:YAG	2,940	
Sciton	Profractional	Er:YAG	2,940
Sellas	Cis F1	CO2	10,600
Solta Medical	Fraxel re:pair	CO2	10,600
<b>Non-ablative</b>			
Cynosure	Affirm	Nd:YAG	1,440 ± 1,320
Palomar	Lux 1.540	Er:Glass	1,540
Lux 1.540	Nd:YAG	1,440	
Lux DeepIR	Infrared	850 - 1,350	
Sellas	1.55	Erbium fiber	1,550
Solta Medical	Fraxel re:store	Erbium fiber	1,550
Syneron	Matrix RF	RF bi-polar/Diode	915

CO<sub>2</sub>, carbon dioxide; Erbium:YAG, erbium:yttrium-aluminum-garnet (laser); Erbium:YSGG, erbium:yttrium-scandium-gallium-garnet (laser); Nd:YAG, neodymium-doped: yttrium-aluminum-garnet (laser); RF, radiofrequency;

\*Adapted from: Metelitsa Al. et al.<sup>4</sup>

with the application of ice bags or cold water compresses during the immediate postoperative period.<sup>10</sup> The use of an oral or intramuscular corticosteroid (40–60 mg prednisone daily for a variable period of 3–5 days) can be useful in isolated cases.<sup>10</sup>

Two studies, using 1,550 nm and 1,540nm Erbium:YAG lasers respectively, concluded that patients had more pain and edema when higher fluences, higher densities, and a greater number of pulses were used.<sup>17,18</sup>

### Pruritus

Pruritus can affect more than 90% of cases<sup>3,10,14</sup> and last from 3 to 21 days.<sup>3,9</sup> Most patients are affected in the first

2 weeks, with pruritus usually being secondary to physiological healing.<sup>3,19</sup> A number of other factors can contribute to its occurrence: dryness, crust formation, irritation induced by emollients or topical medications, an infectious picture, and psychological discomfort.<sup>3,10,14,19</sup> Desquamation and post-fractional, non-ablative laser xerosis occur in 60% and 87% of cases, respectively.<sup>10</sup> Once infections and contact dermatitis are excluded, pruritus can be treated with cold compresses, oral antihistamines, such as difenhydramina 25–50 mg every 4 or 6 h or cetirizine 10 mg, and/or lorazepam 1–2 mg three times daily. Hydrocortisone ointment or cream also produces good responses, depending on the patient's dryness or skin type.<sup>3,14,19</sup> Patients

**Table 2: Early and late side effects**

Early side effects	Late side effects
Petechia	Milia
Contact dermatitis	Acne
Bacterial infection	Persistent erythema
Fungal infection	PIH
Viral infection	Hypopigmentation
Abscess	Scars
	Ectropion and synechia

PIH, post-inflammatory hyperpigmentation

must be advised not to scratch the affected area as excoriation can cause permanent scarring.<sup>14</sup>

### **Purpura**

Although it has little consequence in the long term, purpura can persist for several weeks after complete re-epithelialization has taken place, though it can resolve without treatment.<sup>3</sup> A case of delayed purpura, beyond the third postoperative day, was reported with a fractional, non-ablative laser.<sup>4,16</sup> It can also occur when striae are treated.<sup>9</sup> The use of non-steroidal, anti-inflammatory substances and aspirin should be avoided, as well as skin fractionation, due to the fragility of the skin during the recovery period.<sup>4</sup>

### **Contact dermatitis**

Generally, contact dermatitis is irritative and rarely a true type IV delayed hypersensitivity reaction. Use of the patch test fails to demonstrate allergic dermatitis.<sup>2,6</sup> The estimated incidence ranges from 5 to 10%,<sup>3</sup> although such incidence rates may have decreased due to little use of topical medications up to the point where the skin is completely re-epithelialized.<sup>2,3,10,14</sup>

Contact dermatitis is characterized by erythema, a burning sensation, and pruritus during the first 4 weeks after laser treatment.<sup>2</sup> The cutaneous surface, deprived of its epidermal barrier, or the thin re-epithelialized skin become susceptible to topical irritants, such as perfumes, propylene glycol, lanolin, cleansing products, emollients, and ointments.<sup>2,3</sup>

It is important to verify whether patients are self-medicating, especially with phytotherapy, and to remind them to avoid using make-up in the first 2 postoperative weeks.<sup>2,3,6,10,14</sup> The condition is treated with the suspension of probable irritant agents and the implementation of cold compresses combined with the administration of medium-potency non-fluorinated, topical corticosteroids, and oral antihistamines for the relief of pruritus and cutaneous eruptions.<sup>2,6</sup> In more serious cases, supervised use of ultra-high potency topical corticosteroids is indicated to avoid any delay in cutaneous healing.<sup>2,6</sup>

### **Bacterial infections**

The risk of post-resurfacing infection is mentioned in the literature as it can potentially lead to scar formation.<sup>19,20</sup> Infection rates are higher when procedures are carried out on

the full face when compared to localized treatments.<sup>3</sup> Rates of bacterial infection in traditional resurfacing tend to be low (0.5–4.5% of cases), and even rare when fractional, non-ablative lasers are used, occurring in only 0.1% of cases.<sup>4,21</sup>

A study showed that more than 50% of infections were polymicrobial infections, involving the following microorganisms: *Pseudomonas aeruginosa* (41%), *Staphylococcus aureus* (35%), *Staphylococcus epidermidis* (29%), and different species of *Candida* (24%).<sup>14</sup> *S. aureus* has been reported in other studies as the most common infectious agent in open wounds,<sup>2</sup> whereas gram-negative bacteria, including *P. aeruginosa*, were the most common bacteria in wounds dressed with occlusive bandages when applied for more than 48 h or in patients who made use of prophylactic oral antibiotics.<sup>1,2</sup>

The signs of bacterial infection develop between the second and 10<sup>th</sup> day of the postoperative period,<sup>2,10,14,20</sup> manifesting as sudden or persistent pain (50% of cases), pruritus (29% of cases), areas of accentuated erythema, yellowish and strong smelling secretion, pustules, and erosions with crusts (Figure 1).<sup>2,3,4,10,14,19</sup>

The most serious clinical consequence of coagulase-positive infection by *S. aureus* is toxic shock syndrome, which can occur in patients who ignore the severity of the infection,<sup>3</sup> or as secondary to impetiginization resulting from superficial infection by gram-positive *Streptococcus pyogenes* or, less frequently, *S.*



**Figure 1:** Perioral bacterial infection after CO<sub>2</sub> laser treatment.



*aureus*,<sup>1,14</sup> which is characterized by meliceric discharge and the absence of pain.<sup>14</sup>

Christian et al.<sup>20</sup> described late infections following full face CO<sub>2</sub> laser resurfacing that appeared 3–5 weeks after the end of the oral antibiotic period, suggesting that late infections can be related to exogenous infection sources, such as contaminated emollients. Christian and colleagues recommended that the face be thoroughly cleaned with chlorhexidine before the procedure and that intranasal mupirocin cream and gentamicin in otological solution be used before the procedure and in the postoperative period to minimize the risk of infection.

Studies suggest that most infections occur with the use of occlusive bandages after facial resurfacing, at rates which range from 0 to 20%.<sup>14,20</sup> However, further and extensive studies are needed to determine those rates more precisely.<sup>20</sup> Occlusive bandages in the postoperative period reduce patients' discomfort and accelerate healing. Open bandages nevertheless need the continuous and frequent use of emollients to prevent the wound from becoming overly dry. This shows the controversy that exists regarding possible lines of action in the postoperative period.<sup>20</sup>

When infection is suspected, secretions must be cultured and an antibiogram test must be carried out.<sup>2,4,22</sup> Wood's lamp can be used to diagnose infection by *P. aeruginosa*, which can be visualized in the wound as it fluoresces green under the lamp.<sup>14</sup> Wound care must be meticulous, with frequent bandage changes and the application of acetic acid compresses for 10–15 min every 2 h, aimed at reducing bacterial colonization. The acetic acid solution for the compresses can be obtained by dissolving a teaspoon of white vinegar in a glass of cold water.<sup>2,3,6</sup> Patients must be advised to always wash their hands with antibacterial soap before changing the bandage. Towels used for washing the face must not be reused during the recovery process.<sup>6</sup>

In the present study, bacterial infection incidence was of 7.6% when antibiotic prophylaxis was absent, falling to 4.3% in patients who received prophylactic ciprofloxacin systemically. The use of topical intranasal mupirocin was not effective in reducing the risk of bacterial infection.<sup>3</sup> Although recommended for patients with an increased risk of infection (immunosuppressed patients and patients with cardiac valvulopathy), the routine use of prophylactic antibiotics is controversial.<sup>2,4</sup>

When bacterial infection is suspected, a wide-spectrum systemic antibiotic (penicillin, first-generation cephalosporin or ciprofloxacin) is administered while waiting for the results from the bacterial culture and antibiogram.<sup>2,14</sup>

## FUNGAL INFECTIONS

*Candida albicans* is the most frequent agent in fungal infections occurring after skin resurfacing.<sup>1,2,14,19</sup> The incidence of cutaneous candidiasis is reported to range between 1 and 3%.<sup>3,19</sup>

The infection starts between the seventh and the 14<sup>th</sup> day of the postoperative period.<sup>2,4,14</sup> Patients present with pruritus, pain, and whitish erosions on a highly erythematous base,<sup>2,10,14,19</sup> as well as satellite lesions outside the treated area.<sup>14</sup> A direct mycological examination must be carried out if infection is suspected.<sup>2</sup>

Treatment is carried out by changing the bandage frequently, cleaning the area with diluted acetic acid, and by applying topical antifungals, such as silver sulfadiazine<sup>2</sup> or nystatin cream<sup>14</sup> and/or 200–400 mg fluconazole administered orally once daily.<sup>2,14,22</sup> In a study where ketoconazole or prophylactic oral fluconazole were administered, no fungal infection was observed.<sup>14</sup> While antifungal prophylaxis is rarely administered to patients who undergo laser resurfacing, it is, however, necessary in those who present increased risk due to a history of angular cheilitis, diabetes, immunosuppression, or oral, nail, or vaginal candidiasis.<sup>19</sup> Rokhsar et al.<sup>3</sup> recommend the use of 100 mg fluconazole four times daily, for 5 days, independently of a previous history of candidiasis.

## Viral infections

Herpetic infections occur in fractional ablative laser and in non-ablative laser-based resurfacing in 0.3–2% of cases.<sup>4</sup> Nonetheless, infection rates increase when traditional ablative lasers are used, with 2–7% of cases presenting reactivation of the herpes simplex virus (HSV).<sup>4,14</sup> HSV reactivation in the postoperative period can be highly detrimental,<sup>2</sup> and it is very important to diagnose and treat the infection early to prevent scar formation.<sup>2,10</sup> Infection generally occurs in the first week after laser resurfacing<sup>14</sup> and is characterized by delayed healing, pruritus, superficial dysesthesias, and erosions rather than by classic vesicopustules, due to the absence of the epidermis.<sup>2,4,6,14</sup>

Given that most patients present subclinical levels of HSV, prophylactic use of oral antivirals such as aciclovir, famciclovir, or valaciclovir is recommended preventively in perioral or full face ablative resurfacing.<sup>2,4,6,13</sup> Nevertheless, prophylaxis is only administered when fractional, non-ablative laser resurfacing is used, when there is previous history of the infection.<sup>4</sup> Prophylaxis must start 1 or 2 days before the laser procedure and continue for 5–7 days or until the skin is completely healed.<sup>2</sup> Several authors prefer famciclovir,<sup>14</sup> administered in a 500-mg dose twice to three times daily (due to increased bioavailability), as well as a 500-mg valaciclovir dose, administered twice daily in patients without a history of HSV, and administered three times daily in patients with a previous history of HSV.<sup>3</sup> Prophylaxis notwithstanding, herpetic infection sometimes does occur.<sup>2,6</sup> In such cases, doses of oral antivirals equivalent to those used in treating the herpes zoster virus must be used.<sup>2</sup> Although not yet described in fractional lasers, if a situation of disseminated herpes should occur, intravenous therapy with hospitalization would be justified.<sup>2,4,6</sup>

## Other infections

A study described a rare case of viral warts spreading on the face after CO<sub>2</sub> continuous wave laser skin resurfacing, with spontaneous resolution after 5 days. The authors believe that even though the patient was healthy, the triggering factor was immunosuppression combined with the subclinical presence of papillomavirus in the area of resurfacing.<sup>23</sup>

Rao et al.<sup>2</sup> described a case of post-resurfacing facial infection by *Mycobacterium fortuitum*, with the patient presenting

painless, erythematous nodules that improved after multiple incisions and drainage combined with the administration of oral ciprofloxacin for 4 weeks. Infection by mycobacteria usually starts between the fourth and sixth week of the postoperative period. In spite of this being a rare condition, it should be considered in the differential diagnosis when the patient presents delayed infection and does not respond to the conventional treatment for ulcerations and to the use of antibiotics, antifungals, or antivirals.

Rendon-Pellerano et al.<sup>13</sup> described a case of *S. aureus* infection in the mandibular line and ipsilateral auricular pavilion which started 10 days after CO<sub>2</sub> laser resurfacing, subsequently developing into a parapharyngeal abscess due to a delay in antibiotic administration.

## LATE SIDE EFFECTS

### *Milia cysts*

Milia cysts were observed in 11–14% of patients who underwent traditional ablative resurfacing<sup>4,10,14</sup> and in up to 19% of patients who underwent fractional, non-ablative laser resurfacing.<sup>4</sup> They usually develop between 3 and 8 weeks after the laser procedure and are secondary to the depth of cutaneous damage and the use of occlusive bandages, oils, or creams during the healing process.<sup>2,4,10</sup> Most cases resolve spontaneously, simply with regular cutaneous cleansing in the postoperative period.<sup>2,14</sup> Other measures that aid resolution include the topical application of either tretinoin or glycolic acid, and manual extraction using a sterilized needle.<sup>2,10,14</sup>

### *Acne*

Common in traditional post-ablative resurfacing, acne can occur in up to 80% of patients.<sup>2,4</sup> With the use of fractional lasers, acneiform eruption rates are lower (between 2 and 10% of cases).<sup>4</sup> Aberrant follicular epithelialization during healing can contribute to the exacerbation of acne 1 or 2 weeks after laser resurfacing.<sup>6,9</sup> Patients who presented acne before the procedure are more prone to develop that clinical picture.<sup>2,9,14,16</sup> The use of vaseline-based ointments, occlusive bandages and medium- and high-potency topical corticosteroids also seems to be involved in the intensification of this clinical picture in patients with dark skin or previous history.<sup>14</sup> Niwa et al.<sup>24</sup> described a case of acneiform eruption in the sixth day of the postoperative period, attributed to excessive use of vaseline, in a sample of 12 patient who underwent 2,940 nm fractional laser resurfacing.

Kim et al.<sup>7</sup> described a case of transient acneiform eruption after the treatment of acne scars with fractional, non-ablative laser (1,550 nm). The clinical picture probably occurred due to fissures visible on the tip of the laser handpiece. The cutaneous lesions were treated with minocycline and low doses of oral prednisolone for 4 days.

Oral antibiotics such as tetracycline, doxycycline and minocycline are used early and in short courses to avoid scarring.<sup>2,4,6,14</sup> In addition, topical occlusives and exceptionally thick or oily sunscreens are stopped.<sup>14,22</sup> Usually, the condition is self-limiting and the use of non-comedogenic emollients is recom-

mended.<sup>4</sup> More resistant cases can be treated with a night-time combination of erythromycin, benzoyl peroxide, and tretinoin gel, once the lesion has healed. Topical isotretinoin is contraindicated because of the possible development of hypertrophic scars in the damaged skin.<sup>14</sup>

### *Erythema*

Transient, post-resurfacing cutaneous erythema is expected to occur in 100% of patients and has a more prolonged duration when ablative procedures are used. However, persistent erythema can be a challenging complication.<sup>2,4</sup> It can last from 1 to 8 months (average: 3.5 months) when the ablative CO<sub>2</sub> laser procedure is used.<sup>1,4,6</sup> In non-ablative resurfacing, erythema can be considered as persistent if it lasts for more than 4 days. Persistent erythema is reported in less than 1% of cases when non-ablative procedures are used, reaching more than 12.5% when an ablative laser is used.<sup>4</sup>

Even though fractional Erbium:YAG procedures are slightly more aggressive than traditional lasers, the erythema caused by fractional Erbium:YAG procedures improves faster than the erythema caused by CO<sub>2</sub> laser.<sup>3,12,14</sup> The short-pulse CO<sub>2</sub> laser seems to cause less residual thermal damage, which can be translated into a lower degree of erythema.<sup>3</sup> When induced by short-pulse Erbium:YAG laser, erythema is usually less severe and of shorter duration, persisting, on average, for several weeks.<sup>6</sup> In the older Erbium:YAG laser system, erythema lasted less than 4 weeks, while in the fractional laser system – depending on the parameters used – erythema can persist for 12 weeks or longer. This is due to the greater depth of penetration of the laser beams used in fractional techniques and the consequent improvement in clinical results.<sup>10</sup>

The mechanism of erythema development is uncertain. However, it may be associated with the increased blood flow of the inflammatory response, the immaturity of the epidermis, the reduced absorption of light by melanin, and the decreased optical dispersion of light in the dermis.<sup>2,14</sup> The upper eyelids are particularly prone to erythema, possibly due to the reduced thickness of the tissue. The greater the number of laser passes, the deeper the resurfacing and more notable the improvement. However, such advantages are accompanied by more protracted healing and persistent erythema in the postoperative period.<sup>3</sup>

Erythema is proportional to the depth of skin resurfacing and prevails in areas of delayed healing and where ablation has reached the reticular dermis.<sup>2,3,10</sup> Other factors associated with a greater risk of persistent erythema are: a large number of passes or overlaps of the laser radiation, aggressive intra-operative debridement of dry skin, contact dermatitis in the postoperative period, delayed healing owing to infection, trauma, or use of irritant substances.<sup>2,14</sup>

The use of topical ascorbic acid after re-epithelialization seems to reduce the duration and severity of erythema through its anti-inflammatory action.<sup>2,4,6,10,14</sup> The role of corticosteroids in reducing erythema in the postoperative period is controversial.<sup>2</sup> One percent hydrocortisone cream can be used two to four times daily after re-epithelialization.<sup>14</sup> Some studies have shown

that topical use of ascorbic acid on the de-epithelialized cutaneous surface can cause persistent erythema and the formation of telangiectasias.<sup>2,6</sup> Notwithstanding, erythematous areas whose rigidity and infiltration may suggest that the incipient formation of scars must be promptly and assertively treated with powerful corticosteroids or pulsed dye laser irradiation.<sup>6</sup> Following complete re-epithelialization (usually 10–14 days after resurfacing), most patients can camouflage the erythema using make-up while waiting for it to disappear gradually.<sup>3</sup>

In the treatment of persistent and recalcitrant erythema, Zhang et al.<sup>2</sup> suggest the use of pulsed dye laser or intense pulsed light (IPL). Sub-purpuric doses administered every 1 or 2 weeks can be used until the erythema disappears. Application of a red light-emitting diode (LED) can be beneficial in reducing the erythema's duration and intensity due to its anti-inflammatory and healing effect.<sup>4,5,10</sup>

### Hyperpigmentation

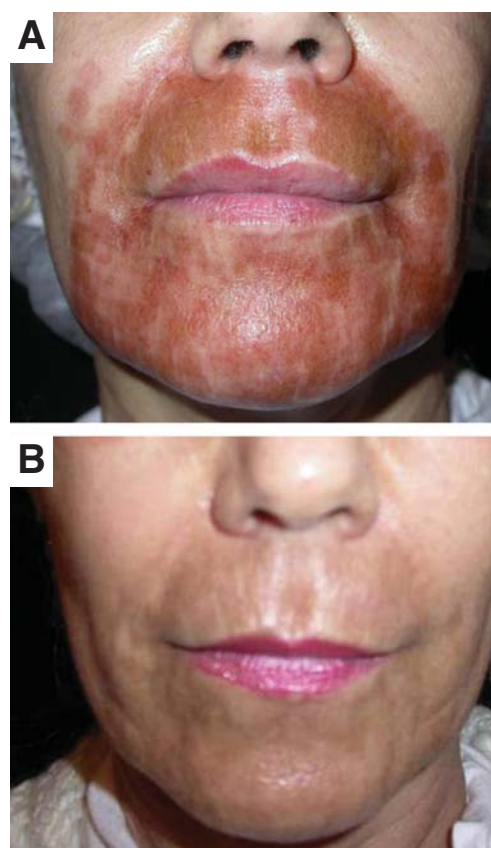
Post-resurfacing hyperpigmentation can be transient or long-lasting. Transient hyperpigmentation is one of the most common post-ablative resurfacing complications, occurring in one-third of patients, independently of phototype. It is, however, considerably less frequent when fractional lasers are used.<sup>2,4,6,13</sup> Notwithstanding, patients with higher phototypes (III–IV; who have freckles, melasma, or dyschromias) present an increased risk of PIH.<sup>1,2,7,12,14,22,25</sup>

Suntanned patients – whose melanocytes have been stimulated – present greater risk of PIH, which can endure for months.<sup>2</sup> Transient PIH and melasma recurrence can occur with fractional, non-ablative laser use.<sup>9</sup> Fractional, non-ablative lasers can be used in all phototypes, but greater caution should be taken when treating phototypes at the upper end of the scale (Figures 2 and 3).<sup>9,16</sup>

Post-resurfacing PIH usually appears 32 days after the procedure and lasts an average of 112 days.<sup>14</sup> It occurs in 35–40% of patients with Fitzpatrick skin types I–III.<sup>10,12,14,22,25</sup> In one study, it occurred in 68% ( $n = 22$ ) of phototype IV patients.<sup>3</sup> PIH severity and duration are correlated to the cutaneous depth of the



**Figure 2:** Post-inflammatory hyperpigmentation in the malar region after CO<sub>2</sub> laser treatment.



**Figure 3:** (A) Postoperative image of the perioral region after 2,940 nm Erbium:YAG laser and (B) transient PIH.

resurfacing procedure<sup>2</sup> and intense and prolonged erythema.<sup>7</sup> Another study described two cases of transient PIH in a sample of 12 patients who underwent 2,940 nm fractional laser resurfacing, with clinical resolution in 2 months following the use of corticosteroids and topical whitening substances.<sup>24</sup>

PIH risk in patients with a higher phototype is decreased when using the Erbium:YAG laser, when compared to the CO<sub>2</sub> laser.<sup>10</sup> Even though PIH after resurfacing with variable-pulse Erbium:YAG laser lasts longer than PIH observed after treatment with short-pulse Erbium:YAG laser, the former does not lead to a PIH that is as persistent as the one observed after multiple passes of CO<sub>2</sub> laser (average of 10.4 weeks using a variable-pulse Erbium:YAG laser and of 16 weeks using a CO<sub>2</sub> laser).<sup>6,7,10</sup> In addition, the use of an Erbium:YAG laser with scanner in dual mode can induce alterations in pigmentation more frequently than when using the handpiece alone.<sup>7</sup>

It may be necessary to carry out pre-laser tests on small areas to adjust the parameters to be used in each patient. Higher fluences, lower densities, and prolonged pulse intervals are generally used when resurfacing darker skins with a fractional laser.<sup>4</sup> Moreover, examining the patient's existing scars can help to determine their tendency to develop hyperpigmentation.<sup>14</sup>

PIH must be treated early. However, aggressive treatments before re-epithelialization is complete must be avoided, as they can worsen the condition.<sup>2,14,22</sup> The regular use of wide-spectrum sunscreen and avoiding exposure to the sun for at least 6

or 8 weeks before and after the procedure are important if one is to avoid PIH.<sup>2,10,14,16</sup> In addition to sunscreen, whitening agents such as hydroquinone, tretinoin and kojic, azelaic, ascorbic, and glycolic acids are also first-line treatments.<sup>2,4,7,10,12,14</sup> In persistent cases, superficial peelings of 30–40% glycolic acid and 30% salicylic acid, or microdermabrasion (either fortnightly or every 3 or 4 weeks) can accelerate the resolution of dyschromia.<sup>2,10,14</sup>

Patients who present increased PIH risk must have their skin prepared during the 3 months prior to the procedure, rather than the standard 6-week period.<sup>2</sup> The preparation can be carried out with a combination of hydroquinone and glycolic acid or tretinoin, or hydroquinone cream used alone that, according to some studies, reduce the risk of PIH due to the inhibition of melanin production.<sup>14</sup> As the result of two recent studies (involving 22 and 100 phototypes I–III patients, respectively) on the use of depigmenters before the laser procedure, and where no difference was found in the incidence of PIH post-resurfacing, pre-treatments aimed at reducing hyperpigmentation have become controverted.<sup>3,6</sup> The lack of variability in results could be due to the fact that topical agents exert their effect primarily on the superficial epidermis and therefore do not reach the deeper melanocytes (found between the hair follicles or adnexal structures), which strengthen hyperpigmentation.<sup>6</sup>

Kontoes et al.<sup>26</sup> described IPL effectiveness in three patients with persistent erythema and hyperpigmentation secondary to CO<sub>2</sub> laser resurfacing. IPL was applied in those patients 1 week after complete re-epithelialization, when the erythema was still in the initial stage. IPL was carried out with 515–590 nm filters, 25.0–31.5 J/cm<sup>2</sup> fluences, variable pulses, and two or three sessions at 4-week intervals.

### **Hypopigmentation**

Hypopigmentation is an uncommon, late, and permanent complication that does not depend on the patient's phototype – although some authors relate it more frequently to phototypes I–III.<sup>1–3,14,22,25</sup> Its incidence is estimated in 6–20% of patients, becoming visible between 3 and 10 months after ablative laser resurfacing.<sup>2,10,12,14,27</sup> There are no reports of hypopigmentation when fractional, non-ablative lasers are used.<sup>9</sup> True hypopigmentation reflects the reduced number of melanocytes and is correlated to the presence of persistent erythema, to resurfacing depth, and to the degree of thermal damage.<sup>2,3,7,10,15</sup>

In most average-depth procedures, which are usually carried out on highly photodamaged skin, true hypopigmentation is rare and must be distinguished from pseudo-hypopigmentation or relative hypopigmentation.<sup>2,6</sup> Pseudo-hypopigmentation occurs when the new skin is fairer than that in adjacent areas, due to its healthy condition when compared to photodamaged skin.<sup>2,7,28</sup> This can also occur transiently in patients of darker skin due the greater contrast in skin color, however, the pigmentation process is quicker.<sup>2,7,13</sup>

Hypopigmentation is an extremely rare side effect in fractional laser-assisted resurfacing. A case was described in which transient hypopigmentation was observed on the 15<sup>th</sup> day of the postoperative period. This was attributed to the prophylactic use

of tretinoin and hydroquinone, with resolution occurring after suspension of the latter. Post-laser persistent hypopigmentation lasting for several months was observed in two patients who had hypertrophic scarring in the cervical region.<sup>4</sup>

There is no evident difference in hypopigmentation rates when short-pulse (90 ms) CO<sub>2</sub> laser is compared to longer-pulse (950 ms) lasers or to Erbium:YAG lasers.<sup>3</sup> Hypopigmentation seems to be less common (4% of cases) and occurring later when Erbium:YAG lasers are used than when CO<sub>2</sub> lasers are used.<sup>10</sup>

It is important that any previous ablative treatment history (for example, dermabrasion or chemical peelings) is verified, as it increases the risk of hypopigmentation.<sup>25,27</sup>

In order to avoid hypopigmentation, the depth of resurfacing must be controlled, photodamage severity must be evaluated, and the procedure must be carried out within cosmetic units.<sup>2</sup> It is also important to highlight that the mandibular line is very susceptible to hypopigmentation and scars, so it must always be treated with a single laser pass only.<sup>3</sup>

In the management of hypopigmentation, topical psoralen and ultraviolet A can be used to stimulate melanin synthesis.<sup>2,10,28</sup> Exciplex laser<sup>10,28</sup> and the application of chemical peelings can also be used to soften demarcation lines.<sup>2</sup> Further options used to minimize color contrast in the skin include: repeating CO<sub>2</sub> resurfacing, using vascular or pigment lasers (for example, the Q-switched Alexandrite laser) or 1,550 nm lasers.<sup>3,27</sup>

Temporary hyperpigmentation and hypopigmentation are frequent complications in Erbium:YAG laser resurfacing. The patient's phototype and the intensity of the thermal damage caused during treatment with long-pulsed (modulated) Erbium:YAG lasers are important factors regarding the incidence and duration of these complications.<sup>7</sup>

### **Scars**

Scars are serious and devastating post-resurfacing complications.<sup>1,2,29</sup> Most patients who undergo fractional Erbium:YAG laser resurfacing re-epithelialize in 5–7 days (from 7 to 21 days in non-fractional lasers). Areas with deeper vaporization take relatively longer to heal. Minimal scars have been seen in a small number of patients when the procedure – both in ablative and in non-ablative fractional lasers – has been more aggressive or when a less careful technique was used.<sup>9,14</sup>

Although less than 1% become permanent,<sup>10,14</sup> transient scars can occur in up to 2.8% of cases.<sup>14</sup> Scars can be atrophic, hypertrophic, or keloidian, and are difficult to treat.<sup>2</sup> Sixty-four percent of physicians who use CO<sub>2</sub> lasers had at least one case of hypertrophic scarring.<sup>14</sup> Those scars usually develop in areas with pruritus, prolonged erythema, and delayed healing that have become hardened or red.<sup>2,10,29</sup> Delayed healing (14–21 days after laser application) increases the probability of scars (Figure 4).<sup>14</sup>

They frequently occur in areas that present post-resurfacing contact dermatitis or infection, or where ablation reached the reticular dermis.<sup>2,28</sup> In addition, certain anatomical areas such as the cervical, perioral, and periorbital regions, or those with osseous projections such as the mentum, mandible, and malar



region, are prone to the formation of scars (Figure 5).<sup>2,4,10,12,14,29</sup> Patients of higher phototype also present a greater predisposition for keloid scar formation. This is due to higher levels of melanin and the increase needed in the absorption of laser light (at least 40% greater in phototypes III–VI when compared to I and II). Therefore, extra care is recommended when choosing laser parameters for patients with phototype III or higher.<sup>25</sup>

In patients with keloid scars,<sup>2,14</sup> a history of radiotherapy,<sup>2</sup> rithydo-plasty, blepharoplasty, peeling, or dermabrasion,<sup>1</sup> or the use of oral isotretinoin 6 months before or 3 months after the procedure<sup>2</sup> present an increased risk of hypertrophic scarring.<sup>1,2,14</sup> The patients selected for resurfacing must not be using oral isotretinoin – preferably for 1 year, or ideally for 2 or more years.<sup>14</sup>

The diagnosis and early treatment of scars are important for the control of the condition.<sup>2</sup> In order to stimulate healing, areas with slow healing must be treated with pulsed dye laser at



**Figure 4:** Delayed healing in the glabella after 1,540 nm Erbium:YAG laser due to excessive overlapping of pulses.



**Figure 5:** Hypertrophic cervical scars after continuous CO<sub>2</sub> laser treatment.

low fluences and with weekly frequency.<sup>2,14</sup> Hardened or highly erythematous areas must be treated with a 1064 nm Nd:YAG laser and a 585 nm pulsed dye laser, in addition to topical application of an ultrapotent or intralesional corticosteroid<sup>2,4,6,10,27</sup> and silicone gel sheets.<sup>2,14,27</sup> Minor scars can be treated with 0.05% clobetasol gel, once daily for 5 days, being repeated once. Also, 1–10 mg/ml intralesional triamcinolone can be used. Triamcinolone can be combined with 5-fluorouracil (5-FU) and injected one to three times a week (0.1 ml of 10 mg/ml triamcinolone added to 0.9 ml of 50 mg/ml 5-FU, 1:9 dilution).<sup>14,28</sup> An occlusive fluorinated corticosteroid is recommended by some authors.<sup>14</sup> Manual massage of hardened areas can be beneficial when applied for 10–15 min, three or four times daily.<sup>3</sup>

### Ectropion

Although a rare condition, ectropion can occur mainly in the lower eyelids after aggressive laser procedures – even when fractional lasers are used.<sup>4,14,29</sup> Other factors that increase the risk of ectropion are flaccid eyelids and previous blepharoplasty.<sup>4,10,13,14,28,29</sup> A small number of patients can present light and transient palpebral retraction in the immediate postoperative period, though this is solved spontaneously.<sup>10,14</sup>

Low energy densities and few passes are recommended for infraorbital treatment to reduce risks. In addition, excessive collagen contraction during the procedure must be closely monitored, as it can lead to exaggerated eversion of the eyelid.<sup>4,5,29</sup> Appropriate handling includes massaging the affected eyelid using an upward motion and using topical corticosteroids, such as clobetasol, or intralesional triamcinolone, in combined fashion. Surgical correction may be needed if the problem persists.<sup>10,14,29</sup>

### Synechia

Synechia is the improper adhesion of the re-epithelialized surfaces, which results in the formation of an abnormal membrane during the healing process. It usually occurs in the lower eyelids on the first days of the postoperative period. Intervention must be carried out early on, with a local injection of lidocaine followed by gentle rupture of the membranous surface with a 30G needle. A corrective bandage is then applied for 3 or 4 days.<sup>3,28</sup>

### OTHER SIDE EFFECTS

Delayed healing of wounds, excessive skin sensitivity to creams and traumas, and blisters are described in the literature. Blisters can occur mainly with the use of fractional lasers at high fluences and densities. It is recommended that the use of topical retinoid be discontinued several days before the fractional, non-ablative laser procedure, following reports of blister formation in patients who were using such substances during treatment.<sup>9</sup>

Small linear excoriations ranging from 2 to 16 mm can occur after fractional laser treatment. The most sensitive places are the upper lip, lower eyelid, and the forehead – probably due to the difficulty of keeping the laser handpiece in complete contact with the skin in those areas.<sup>4</sup> There are reports of bruises to the skin, particularly in regions other than the face, which are

dependent on the handpiece configuration of the fractional laser used (microthermal zones), especially in 1,440 nm and 1,540 nm lasers. Spontaneous resolution takes place in 2 or 3 weeks.<sup>9</sup>

A heat-induced 'recall' phenomenon has been observed after resurfacing when using 1,320 nm and 1,440 nm fractional lasers. Following resolution of post-laser transient erythema, some patients present a reappearance of erythematous macules after hot baths or prolonged direct exposure to sunlight. Although the precise mechanism for this is still unknown, it seems that participation of neurogenic or histamine cells, or of mastocytes, may be involved. The phenomenon usually resolves in 48 h without leaving sequels.<sup>4</sup>

A recently described complication in two cases relates to eruptive, post-fractional resurfacing keratoacanthomas. The two patients presented actinic keratoses in the treated region and, after an interval of 4–6 weeks into the postoperative period, developed the condition. The authors believe that the fractional laser used caused follicular trauma and thereby favoured the development of low-risk tumors.<sup>4,14</sup> Rendon-Pellerano et al.<sup>13</sup> described a case of granulomatous reaction in the vermilion border, starting on the third day after CO<sub>2</sub> laser resurfacing, which was treated with topical and systemic corticosteroids and improved in 4 months without scar formation. The incidence of such complications is very low.<sup>14</sup>

## FINAL CONSIDERATIONS

In general, carefully searching for signs of infection or slow re-epithelialization in the first 10 days is of paramount impor-

tance. Areas that did not re-epithelialize, present excessive erythema or become painful – uncommon findings in the postoperative period – must undergo culture. Persistent erythema is noticed in those who undergo vaporization at significant depths, and can persist for about 3 months or longer. PIH can start to manifest in 4–6 weeks and is almost certain to occur in patients with a higher phototype. It must be treated aggressively with a depigmenting agent, followed by ensuring full protection against the sun by means of blocking agents. A rarer side effect is the formation of incipient scars which can take place between the sixth and 12<sup>th</sup> week. It is important to pay attention to signs of this as indicated by the excessive stiffening of the skin and persistent erythema. If those signs are evident, the use of a topical fluorinated corticosteroid must be implemented. If areas of slow healing begin to develop strings, fibroses, or stiffening with elevation of the skin, intralesional injection with triamcinolone (alone or combined with 5-FU) must be carried out.

CO<sub>2</sub> and Erbium:YAG laser resurfacing are relatively safe and effective methods for cutaneous rejuvenation and scar correction. The technological developments that allowed the fractionation of laser rays reduced the risk of significant thermal lesions; however, well-designed studies that ratify this decrease in the occurrence of side effects are lacking. In spite of technological improvements, side effects can occur even with experienced professionals. Additionally, there is no consensus in the literature about the handling of side effects resulting from the use of lasers. Preventive measures, combined with prompt recognition of side effects and their appropriate treatment, reduce their occurrence and sequels in the long term. ●

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## QUESTIONS FOR CONTINUING MEDICAL EDUCATION (CME)

1. What is the wavelength of a CO2 laser?

- a) 810 nm
- b) 2,940 nm
- c) 1,540 nm
- d) 1,550 nm
- e) 10,600 nm

2. Which laser's wavelength is in the short infrared spectrum?

- a) 800 nm diode laser
- b) 1,450 nm diode laser
- c) 1,064 nm Nd:YAG laser
- d) All of the above
- e) None of the above

3. What are fractional, non-ablative lasers indicated for?

- a) Acne scars
- b) Postsurgical or trauma scars
- c) Melasma
- d) All of the above
- e) None of the above

4. What is an advantage of fractional, non-ablative lasers compared to fractional, ablative lasers?

- a) Greater efficacy
- b) Fewer sessions needed
- c) Fewer side effects
- d) All of the above
- e) None of the above

5. All of the answers below are the early side effects of laser-assisted post-resurfacing, except for:

- a) Petechiae
- b) Hypopigmentation
- c) Contact dermatitis
- d) Fungal infection
- e) Abscess

6. Milia cysts are late side effects observed in patients who undergo ablative resurfacing. After the laser procedure, when do they specifically occur?

- a) In the second week
- b) Between the third and eighth week
- c) After the 10th week
- d) They are not a late side effect
- e) They are not a post-ablative resurfacing side effect

7. What is the post-resurfacing side effect expected in 100% of patients?

- a) Transient cutaneous erythema
- b) Acne
- c) Transient hyperchromia
- d) Persistent erythema
- e) Milia cysts

8. Non-fractional post-ablative resurfacing hyperpigmentation:

- a) Is one of the most common complications
- b) Rarely occurs
- c) Never occurs
- d) Usually appears 1 month after the procedure
- e) Options a) and d) are correct

9. After ablative resurfacing it is important to monitor for signs of incipient scar formation, indicated by excessive stiffening of the skin and persistent erythema. When do these signs appear?

- a) Between the third and fourth week
- b) Between the sixth and 12th week
- c) After the fourth postoperative month
- d) They do not constitute a late side effect
- e) They do not constitute a side effect of ablative resurfacing

10. True hypopigmentation is a(n) \_\_\_\_\_ side effect:

- a) Uncommon
- b) Late
- c) Permanent
- d) All of the above
- e) None of the above

### Key

Palazzo Carpena El Ammar AB, Batista Costa F, Petersen Vitello Kalil CL and Campos VB. Complications in laser dermatologic surgery Part I: Non-fractional non-ablative lasers. Surg Cosmet Dermatol 2011; 3: 47-53.

1-c, 2-e, 3-a, 4-b, 5-b, 6-b, 7-b, 8-c, 9-b, 10-b

Answers must be sent using the website

[www.surgicalcosmetic.org.br](http://www.surgicalcosmetic.org.br).

The deadline for submitting answers will be provided by email with a direct link for accessing the journal.