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# Use of ablative fractional $CO_2$ laser in facial rejuvenation: a prospective observational cohort study

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## Abstract

**Introduction:** Over the years, techniques for treating facial aging have evolved, with oral, antioxidant, and nutritional treatments, topical cosmeceuticals, peelings, and technologies such as radiofrequency, infrared, intense pulsed light, and lasers. Currently, among the lasers used for rejuvenation, there are ablative and non-ablative ones. **Objective:** To show the effectiveness of ablative fractional CO2 laser in facial rejuvenation. **Methods:** The presented article is a study that shows the superiority in results when compared with other lasers and treatments, evaluating its side effects and recovery time. **Results:** the author presented the result through images that are in the work. **Conclusion:** The ablative fractional CO2 laser proved to be an important option for the treatment of facial rejuvenation, even with a technology that has more intense side effects and longer recovery periods compared to other fractional ablative lasers.

**Keywords:** $CO_2$ laser. Ablative fractional $CO_2$ laser. Facial resurfacing. Rejuvenation.

## Introduction

Currently, the concern with facial aging has motivated the advancement of technological resources in the development of increasingly effective techniques to promote Facial Rejuvenation. Over the years, techniques for treating facial aging have evolved, with oral, antioxidant, and nutritional treatments, topical cosmeceuticals, peelings, and technologies such as radiofrequency, infrared, intense pulsed light, and lasers. Currently, among the lasers used for rejuvenation, there are ablative and non-ablative [1-4].

In this context, the fractional ablative lasers: Erbium: YAG (Er: YAG) 2940nm; Yttrium Sapphire Garnet (YSSG) 2790nm, and $CO_2$ (carbon dioxide laser) 10,600nm. These lasers have been used efficiently and less aggressively in the postoperative period, requiring several sessions to try to achieve the same result as the more non-fractionated ablative lasers [1]. Nonablative lasers, which lead to lower morbidity and faster recovery, are lasers that operate in the infrared range (1000 to 1500nm) and have low absorption by water; their heat promotes collagen remodeling with improvement in rhytids and skin tone. At the end of 5 to 6 sessions, their results are much lower than those of ablative lasers, therefore, they are indicated for patients with a slight aging degree. Lately, the fractional Erbium Glass laser (FraxelTM) (1550 nm) is the equipment that comes closest in terms of results to fractional ablative lasers [2].

Facial resurfacing with ablative fractional $CO_2$ laser, after more than 20 years of use, has gone through an improvement phase with the discovery of new technologies to obtain an efficient and safe technique. This procedure called ablative fractional $CO_2$ laser proved to be effective in removing wrinkles and collagen contraction without the severe side effects of traditional ablative $CO_2$ laser [5].

In this regard, the $CO_2$ laser has two technologies: the traditional so-called pulsed $CO_2$ laser (10,600 nm), indicated for intense photoaging with excellent results in the treatment of cutaneous elastosis, rhytids, dyschromia, and scars. There is the destruction of the

epidermis, retraction, and remodeling of collagen fibers [5].

According to Patriota (2007) [6] the ablative fractional $CO_2$ laser technology is based on the principle of selective photothermolysis, developed by Anderson Parrish in 1980, and the principle of this technology is the selective and specific destruction of a target on the skin with minimal thermal damage to other adjacent tissue structures. Over the last few years, there has been the development of new lasers and new technologies, providing postoperative care with fewer side effects, shorter recovery time, and results close to traditional laser resurfacing, but with a greater number of procedures [7].

Therefore, the present study aimed to show the effectiveness of the ablative fractional $CO_2$ laser in facial rejuvenation through a prospective observational cohort study.

## Methods

### Study Design

The rules for a prospective observational cohort study were followed (The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies). Available in: https://www.equatornetwork.org/reporting-guidelines/strobe/. Accessed at 2023/04/10.

### Ethical Approval

This study followed the ethics committee's compliance and preserved the patient's anonymity, as well as preserving the rights and care of the patient and their information as recommended by the Declaration of Helsinki of 1964. The technique used in this study is already enshrined in the literature and the ablative fractional $CO_2$ laser is registered with the Health Surveillance Agency (ANVISA) under number: 80726740008, as well as registered with the Food and Drug Administration (FDA).

### Insisting on Technique – Optimization

Even though the ablative fractional $CO_2$ laser is registered in the world scientific literature and registered with ANVISA and the FDA, the present study presents the optimization of this technique for facial aesthetics, to corroborate its effectiveness and participant satisfaction.

### Participants

- **Case 1**
  - ✓ Participant: EAOL; 63 years old; Complaints: melanoses, static and gravitational wrinkles;
  - ✓ Fitzpatrick phototype: 3
  - ✓ Glogau aging grade: 4

- **Case 2**
  - ✓ Participant: MDCP; 79 years old; Complaint: deep wrinkles and sagging;
  - ✓ Fitzpatrick phototype:2
  - ✓ Degree of aging of Glogau: 4

- **Case 3**
  - ✓ Participant: GADG; 66 years old; Complaint: wrinkles and sagging;
  - ✓ Fitzpatrick phototype: 4
  - ✓ Degree of aging of Glogau: 4

- **Case 4**
  - ✓ Participant: VMM; 47 years; Complaint: Deep static wrinkles and sagging;
  - ✓ Fitzpatrick phototype: 3
  - ✓ Degree of aging of Glogau: 3

- **Case 5**
  - ✓ Participant: CARP; 50 years; Complaint: static wrinkles and sagging;
  - ✓ Fitzpatrick phototype: 2
  - ✓ Degree of aging of Glogau: 3

### Technique - Ablative Fractional $CO_2$ Laser

The article presented is a study that highlights the important results of the ablative fractional $CO_2$ laser when compared to other lasers and treatments, evaluating its side effects and recovery time, and then presenting the reference used for the development of its work.

According to Verma, Yumeen, Raggio (2023) [1], the $CO_2$ laser application techniques are directly related to its basic parameters of wavelength, energy, pulse duration, spot size (Spot Size), and skin cooling. The wavelength, measured in a manometer (nm) is 10,600nm and is related to the depth of penetration into the skin, therefore, the longer the wavelength, the deeper the laser penetration, always concerning its chromophore. Energy is measured in joules, its amount emitted in a unit of area is called fluence, measured in J/cm2. The rate of energy emitted is called power and is measured in watts(w). A watt is one joule per second (w=1/sec).

The power per unit area is called irradiance, it is measured in w/cm2, therefore, the greater the fluence (energy) the greater the destructive capacity of the laser. In Smartxide equipment (Deka Laser) the power adjustment can be used up to 30w. Pulse duration or exposure time, is the time that the fired light ray acts on

the target, and is directly related to the degree of thermal injury, that is, the greater the pulse, the greater the width of the thermal microzones (MTZs). The pulse in the Smartxide equipment (Deka Laser) is from 0.2 to 2ms [1].

The spot size is the size of the spot caused by the laser light beam. The larger the spot size, the greater the penetration and the better the energy distribution in the target tissue. In the Smartxide equipment (Deka Laser) the spot size is 120µm. Frequency measures the number of shot emissions in a given time interval, measured in Hz (Hertz), in Smartxide equipment (Deka Laser) the frequency is from 5 to 100Hz. The point density is the number of MTZs (points) contained in an area, that is, the greater the number of points, the greater the percentage of skin treated and, therefore, the greater the amount of energy and destructive force of the laser.

The stack is the emission of a shot exactly on top of the previous shot, increasing the depth of the ablation with greater security, since there is a cooling of the skin between the shots, in the Smartxide equipment (Deka Laser) the number of stacks goes from 1 to 5 shots. There are several types of scanners, there are devices with consumable tips, and others not. The scanner can be normal, interlaced, and randomized, in addition to having different formats: rectangles, squares, hexagonal, triangles, linear, and variable sizes, according to the needs of the treated region [1].

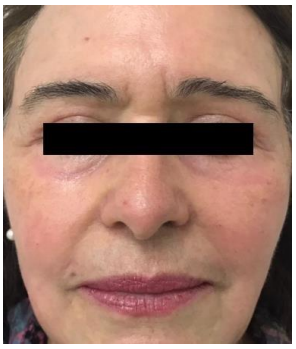
## Results

The mean age of the five participants was 61±12.9 years. To promote comfort and alleviate pain, oral midazolam was administered to participants, in addition to anesthetic blocks. In the postoperative period, patients evolve with little edema, which lasts for an average of 3 days, and crusts for an average of 6 days. Hyperemia occurs the more intense the procedure is, being more noticeable for about 30 days. Hyperchromies can happen mainly due to too much sun exposure and or incorrect use of sunscreen, in the post-laser period, its treatment is done with topical medication, with acids and lighteners, on average for 30 to 40 days.

Results can be seen in the first week, evolve over many months, last for many years, and are very similar to Backer's phenol peeling, treating skin photoaging, blemishes, superficial, medium, and deep wrinkles, and sagging. The five clinical cases that were prospectively collated are presented below.

**CASE 1 – 63 years**

***(Fitzpatrick phototype: 3; Glogau Aging Grade: 4)***

| Before | After (30 days) |
|---|---|
|  |  |

Participant with thin skin on the face and eyelids showed a result of great improvement in skin tone and the treatment of wrinkles with a significant decrease in sagging of the face and eyelids.

**CASE 2 – 79 years**

***(Fitzpatrick phototype: 2; Glogau Aging Grade: 4)***

| Before | After (30 days) |
|---|---|
|  |  |

Participant with medium-thickness skin and deep wrinkles showed a significant improvement in the treatment of wrinkles and skin sagging on the eyelids and the entire face.

**CASE 3 – 66 years**

***(Fitzpatrick phototype: 4; Glogau Aging Grade: 4)***

| Before | After (30 days) |
|---|---|
|  |  |

Participant with thin skin thickness and medium and deep static wrinkles presented important results in the treatment of sagging eyelids, faces, and medium and deep wrinkles.

**CASE 4 – 47 years**

***(Fitzpatrick phototype: 3; Glogau Aging Grade: 3)***

| Before | After (30 days) |
|---|---|
|  |  |

Participant with medium-thickness skin on the face and thin skin on the eyelids, with a high degree of sagging and deep wrinkles, with significant improvement in the results in the treatment of wrinkles and facial and eyelid sagging.

**CASE 5 – 50 years**

***(Fitzpatrick phototype: 2; Glogau Aging Grade: 3)***

| Before | After (30 days) |
|---|---|
|  |  |

Participant with medium-thickness skin, with a degree of flaccidity and wrinkles for age, showed a great improvement in the condition of flaccid eyelids and medium wrinkles.

## Discussion

The present study reported the same advantages mentioned by Coelho concerning the traditional surgical techniques available, which presents the ablative fractional $CO_2$ laser with several advantages, which are reduced healing time, low-risk anesthetic procedures, less bleeding, less inflammation, and minimal undesirable side effects [8]. There are also other results such as those by Talarico and Pecora (2012) [9] who cite the associations between $CO_2$ laser and other surgical procedures bringing better results and personal satisfaction of patients compared to the use of laser alone.

According to Nascimento (2004) [10], facial aging is the physiological process where there are degenerative changes such as skin flaccidity, reduction of fat pads, muscle hyperkinesis, and osteocartilaginous wear, producing unfavorable aspects to facial aesthetics. Aging can be classified into Intrinsic (biological, genetic, chronological) and Extrinsic (environmental, photoaging). Intrinsic aging is caused by clinical, histological, and physiological changes in the skin not exposed to the sun, while extrinsic aging is caused by sun exposure, known as photoaging, and is responsible for most cosmetic skin changes [11].

The assessment of the degree of solar damage looks for pigmentary alterations, the number of solar keratoses and epitheliomas or even other types of cancer, the degree of suninduced rhytids, and the presence or absence of poikiloderma. Rhytids associated with exposure must be distinguished from dynamics associated with movement and expression, such as folds, gravitational grooves, and sleep lines. Glogau has developed a classification for photoaging that is useful in assessing actinic damage. Each cosmetic unit on the face must be evaluated separately [12].

Table 1. Glogau classification. Aging groups.

| | |
|---|---|
| ***Grade I: Soft (Usually between 20-35 years old)*** | ✓ No keratoses<br>✓ Few wrinkles<br>✓ No scars<br>✓ Little or no usual makeup |
| ***Grade II: Moderate (Usually between 35 years old)*** | ✓ Early actinic keratoses – slight yellowish discoloration of the skin<br>✓ Initial wrinkles – lines parallel to the smile<br>✓ Few scars<br>✓ Little makeup |
| ***Group III: Advanced (Usually between 60-75 years old)*** | ✓ Actinic keratoses – obvious yellowish discoloration with telangiectasias<br>✓ Wrinkles – present at rest<br>✓ Moderate acne scars<br>✓ Always wear makeup |
| ***Group IV: Severe (Usually between 60-75 years)*** | ✓ Actinic keratoses and skin cancer have occurred<br>✓ Wrinkles – a lot of flaccidity and wrinkles of actinic, gravitational, and dynamic origin<br>✓ Severe acne scars<br>✓ Always wears make-up, which does not cover, but "plasters". |

Source: Kede, Sabatovich (2004) [12].

The $CO_2$ laser has two basic technologies, the most traditional is called ablative $CO_2$ laser, which acts on the entire skin of a treated area, and the most recent is called ablative fractional $CO_2$ laser, this technology is based on the principle of fractional photothermolysis, developed and used initially in 2004 by Manstein et al, which deals only with fractions of the skin with thermal damage in small areas called MTZs (Micro Thermal Zones), where the tissue surrounding

the MTZs is not injured, allowing rapid recovery from the epidermis. The target chromophore of the $CO_2$ laser is water, therefore, it affects several structures causing thermal damage such as collagen, blood vessels, and epidermal keratinocytes, reaching the epidermis and dermis, leading to epidermal turnover and collagen induction [13].

Furthermore, the $CO_2$ laser has its best indication in facial skin rejuvenation, providing the treatment of wrinkles, sagging skin, pigmented lesions, and acne scars, among the most important in facial rejuvenation. Unfractionated ablative $CO_2$ laser vaporizes the epidermis and superficial dermis and is used for laser dermabrasion or also called resurfacing, or rather laserabrasion. The chromophore is the intracellular water of the epidermis and extracellular water of the dermis, acting at a deeper cutaneous level, as the thermal injury induces collagen retraction and remodeling and the neoformation of collagen and elastic fibers. They are used in laser abrasion of facial skin photoaging, acne, and rhinophyma scars [14].

In addition, the fractional ablative $CO_2$ laser is equipped with a system called fractional because it treats only fractions of the skin in areas called Micro Thermal Zones (MTZs), which facilitates re-epithelialization. The physician can adjust the devices by determining the depth of the laser beam according to the power, the duration of the pulse, the distance between the points, and the diameter of the points. Anesthesia can be local. The recovery time is shorter than that of non-fractionated and it is used in skin rejuvenation, in the treatment of acne scars and hyperchromia [1,14].

The author's Costa et al. (2011) [15] described the following side effects: pain, edema, pruritus, micro crusts, purpura, contact dermatitis, and infections. The pain usually occurs on the 1st postoperative day and is treated with systemic analgesics and cold compresses. Oral analgesics (codeine) can be associated with anxiolytics (lorazepam 1-2 mg, 2 or 3 times a day). Edema, which is variable and can last up to 7 days, can be treated with ice packs, oral corticosteroids (prednisone 40-60mg per day for 5 days), or intramuscularly, when necessary [16].

Also, pruritus can occur in 90% of patients, remaining from 3 to 21 days and its treatment is done with cold compresses, oral antihistamines, or topical hydrocortisone. The microcrusts last from 5 to 7 days, or up to 2 weeks in more intense applications. Purpura may occur after the 3rd day of the procedure, and the use of acetylsalicylic acid, anticoagulants, and nonhormonal anti-inflammatory drugs should be avoided [1,2,16].

Added to this, contact dermatitis, usually caused by the use of medications, especially antibiotics, if it occurs, should be treated with medium-potency topical corticosteroids and oral antihistamines [2,3,16]. Bacterial infections occur in about 0.5-4.5% of cases with traditional resurfacing and 0.1% with fractional ablative lasers. The conduct is to collect material for culture and antibiogram; Wood's light can be used to diagnose *Pseudomonas aeruginosa*, which presents with greenish fluorescence, to initiate antibiotic therapy with broad-spectrum systemic drugs (penicillins, 1st generation cephalosporins or ciprofloxacin) until the result of culture and antibiogram [2].

Fungal infections can occur mainly due to *Candida albicans*, which is the most frequent agent, with an incidence of 1 to 3%, starting between the 7th and 14th postoperative day, with symptoms of pain, whitish erosions on an erythematous base and the presence of satellite lesions. The material should be collected for direct mycological examination. Treatment is with nystatin cream or silver sulfadiazine and oral fluconazole 200-400mg daily [16].

Viral infections in fractional ablative resurfacing occur with an incidence of 0.3% to 2%, while traditional ablative lasers are 2 to 7%. The infection occurs in the first week, and has slow healing, pruritus, dysesthesia, and superficial erosions and not the classic vesico-pustules, due to the absence of the epidermis [1]. Prophylaxis should be done 1 to 2 days before the procedure and up to 5 to 7 days after or until complete healing. The drugs used are famciclovir 500mg – 2 to 3x a day, valaciclovir 500mg – 2x a day, and 3x a day in patients with a previous history of herpes [16].

As for late complications, several are cited by Costa et al (2011) [15] such as milia cysts, which have an incidence of 11 to 14% of cases after traditional ablative resurfacing. Treatment can be done with tretinoin or topical glycolic acid or removal with needles, acne has a percentage of up to 80% in cases of traditional ablative resurfacing, in fractional lasers they are low, between 2 and 10%. It can be treated with tetracycline, doxycycline, and minocycline. In cases of persistence of the condition, erythromycin, benzoyl peroxide, and tretinoin gel can be associated, erythema in the non-fractionated ablative $CO_2$ laser occurs in 100% of the cases, and can last from 1 to 8 months, an average of 3.5 months. Erythema may be linked to increased blood flow, epidermal immaturity, decreased absorption of light by melanin, and decreased optical disposition of light in the dermis. The erythema is directly proportional to the depth of the laser, it is predominant in the region that reached the reticular dermis. Topical ascorbic acid reduces the duration and severity of erythema. Another treatment

is intense pulsed light for its anti-inflammatory and healing effects.

Hyperpigmentation occurs more frequently in non-fractionated ablative resurfacing, in approximately one-third of cases, and is less frequent in fractional ablative resurfacing. Using sunscreen for 6 to 8 weeks before and after the procedure decreases the risk of hyperpigmentation. Hydroquinone, tretinoin, kojic, azelaic, ascorbic, and glycolic acid are used in treatments. Hypopigmentation in unfractionated ablative $CO_2$ resurfacing occurs in 6 to 20% of cases, appearing 3 to 10 months after the procedure. In the fractional ablative $CO_2$ laser, this is a rare effect, but it is important to evaluate the history of previous procedures such as dermabrasion and chemical peelings, as these may increase the risk of hypopigmentation [1].

Also, scars usually occur in areas of itching, prolonged erythema, delayed healing, and hardened or reddened. Light scars can be treated with clobetasol 0.05% in a gel 1x a day for 5 days or more, in cases of scarring hypertrophy, intralesional triamcinolone, and 5-Fluoracil are indicated. Ectropion, although rare, can occur in the fractional $CO_2$ laser, and the factors that increase the occurrence of this complication are flaccid eyelids and previous blepharoplasty. Treatment can be with topical clobetasol or intralesional triamcinolone [1,2]. Synechia is an incorrect healing of the re-epithelialized surfaces, it occurs in the lower eyelids already in the first days after the procedure. The treatment is done with a 30G needle, gently in the first days of the complication [1].

## Conclusion

Laser facial rejuvenation treatments have evolved with their new technologies, from more aggressive lasers to ablative fractional resurfacing. Initially, the ablative $CO_2$ laser offered great results, however, with important side effects. With technological evolution, non-ablative lasers emerged, which in turn have a mild postoperative period, but with minimal results. Subsequently, fractional ablative lasers appeared, which presented lower results than the nonfractionated ablative $CO_2$ laser, with a single application, but which can be improved and approximate these results if the number of procedures is repeated. In the current article, the author presents an ablative fractional $CO_2$ laser as an excellent option for the treatment of facial rejuvenation. There is a need for further studies, to clarify the parameters to be used, so that the physician has safety and effectiveness in the results, providing well-being to his patient.

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## Ethical Approval

This study followed the ethics committee's compliance and preserved the patient's anonymity, as well as preserving the rights and care of the patient and their information as recommended by the Declaration of Helsinki of 1964. The technique used in this study is already enshrined in the literature and the laser ablative fractional $CO_2$ is registered with the Health Surveillance Agency (ANVISA) under number: 80726740008, as well as registered with the Food and Drug Administration (FDA).

## Informed consent

Not applicable.

## Data sharing statement

No additional data are available.

## Conflict of interest

The authors declare no conflict of interest.

## Similarity check

It was applied by Ithenticate®.



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