

Nonablative Fractional Laser Resurfacing

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Abstract:

The desire to achieve cosmetic rejuvenation and reduce effects of aging and photodamage urged scientists to develop effectual techniques which have minimal side effects and impressive long-term efficacy. Traditional ablative resurfacing laser therapy has been used for several years; however, it has harmful side effects on the patient's skin such as dyspigmentation, persistent erythema, infections, acneiform eruptions and scarring. It also prolongs downtime, so it puts a significant burden on society. Nonablative resurfacing laser therapy declines side effects of traditional therapies, although it has lower effectiveness in comparison with ablative one. Nonablative fractional resurfacing laser therapy commenced a modern technique which diminished side effects, while maintains the efficacy of traditional methods. The aim of this current review is to sum up nonablative fractional laser therapies used for skin photorejuvenation at the past and present time and to evaluate the indications, advantages and classification of it and non-fractional resurfacing laser therapy.

Keywords: Lasers; photorejuvenation; nonablative fractional resurfacing; Rejuvenation, Skin; Skin Aging

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Introduction

There is a great demand in human history up to now to reverse cumulative effects of aging. Prevention medicine is growing to find and reduce the risk factors of skin health such as radiation, sun exposure, ultraviolet radiation, free radical substances, poor diet, genetics, and so on. But it can never eradicate all the known risk factors so scientists have devised useful methods of skin care to diminish signs and symptoms of photoaging. Laser therapy is one of the appropriate techniques and nowadays is frequently considered for facial skin rejuvenation.

Laser is one of the significant tools in the field of dermatology to improve medical conditions of the skin and it is an optical device which stimulates the atoms so that intensify electrical

impulses and emits an powerful focused beam of light that causes transference of energy to a target such as idea of using radiation for skin diseases was applied many years ago. In the 1980s carbon dioxide (CO₂) lasers were established as an initial photorejuvenation method(1). Although it was an effective step in skin resurfacing therapy, it has considerable adverse effects, including infection, long term erythema, dyspigmentation and excessive scarring. New devices and methods were established to minimize side effects of photo rejuvenation and patient downtime.

Generally, we classify skin resurfacing into traditional ablative, nonablative, ablative fractional and nonablative fractional categories. Ablative therapies are invasive procedures which demolish layers of skin. Ablative laser skin resurfacing is a process where the upper layers of aged or damaged

skin are evaporated by applying a controlled laser beam. Although they are highly effective, the risk of undesirable side effects is high. A large number of studies have been performed to assess the efficacy and safety of these techniques. Short-term and long-term side effects can happen following conventional CO₂ laser resurfacing. Expected reactions include impermanent skin fragility, peeling and redness are lasting from one to three months. Frequent short-term side effects contain milia and acneiform eruptions, seen in up to 84%(2,3). Usual delayed side effects are dyspigmentation (hyper and/or hypopigmentation). The incidence of hyperpigmentation subsequent to CO₂ laser resurfacing differs in skin type but ranges from 26% to 36% (2,4-7). Because of these various demolish adverse effects, newer rejuvenating laser devices have been introduced to remodel skin with little healing time and less patient discomfort. Although nonablative laser resurfacing procedures are much less invasive than ablative lasers, they may have unimpressive results. In nonablative methods, the thermal energy of laser beam produces injury specially in dermal layer of skin with minimal damage to the epidermis. This injury stimulates neocollagenesis and synthesis of skin protein. Remodeling of the treated area by laser makes the photoaging lesions to be disappeared. In nonablative methods the risk of infection is lower than ablative laser resurfacing because the epidermal layer remains approximately intact.

Nonablative laser resurfacing systems can be categorized into three main classifications: mid-infrared lasers that affect the dermis and are suitable for nonablative resurfacing; visible lasers, including the pulsed dye laser (PDL) and the pulsed 532-nm potassium titanyl phosphate laser (K.T.P), alone or combination with the 1064-nm neodymium:yttrium-aluminum-garnet (Nd:YAG) laser; and intense pulsed light sources (IPL)(8-10). Nonablative laser therapies have many cosmetic beneficial effects such as making the skin texture, discoloration, and preexisting scarring better and also reduce patient downtime(11,12). Immediately after the nonablative laser therapy, patient may complain about redness and edema, which remains for 1 to 3 days in contrast to ablative fractional treatments in which edema and erythema last longer and bleeding and/or oozing can be noticed, and downtime can

prolong up to 14 days(13,14).

Nonablative laser Resurfacing Systems

One of the initial studies assessed a nonablative therapy for dermal remodeling used a 1,064-nm Q-switched Nd:YAG laser with 5.5 J/cm² and a 3-mm spot size was suitable for improvement of rhytids(8,15,16). The 1,064-nm wavelength causes fairly deep penetration to the skin, which induces minimal laser-tissue interaction(8,15). It targets mainly pigments of the skin and is practicable to get rid of benign pigmented lesions seen in photodamaged and aged skin(8,17). We can use this laser with or without a carbon particle solution(16,18).

Vascular lasers including Pulsed dye 585-nm, PDL 595-nm, Pulsed KTP 532-nm were used but have absolute minimum efficacy therefore it has been mostly superseded by longer wavelength infrared lasers such as Nd:YAG 1064-nm, Diode 1450 and Erbium glass 1540, which have a better effect on the mid dermis, causing cosmetic improving in rhytides.

Intense pulsed light devices for example Quantum SR 515-1200 nm have been used in the treatment of photodamaged skin(19). They combine targeting of dyspigmentation and vascularity with longer wavelengths, thereby resulting in global improvement in photodamaged skin(1,20). Their effect on wrinkle improvement has been evaluated with evidence of histologic neocollagenesis six months post-treatment(1,20). Although IPL device can lead to photorejuvenation but there is some risk of epidermal damage especially in dark skin patients. It is improbable to destroy the top layers (epidermis) of the skin because it uses several wavelengths of increased energy to heal the skin. Several sessions are normally required to have the desired outcome. Three to six sessions are often needed for successful results for skin rejuvenation. In spite of all the beneficial features of IPL therapy, this is a considerable disadvantage of this method which prolongs procedure to have ideal results. As mentioned above this type of procedure may not be suitable for all skin types, especially tanned or dark skinned patients, because skin discoloration can occur.

Nonablative skin rejuvenation with radiofrequency based systems produces skin tightening through

controlled dermal collagen contraction and neocollagenesis without epidermal injury. Radiofrequency technologies constantly progress towards the purpose of skin rejuvenation. Radiofrequency technology divided into monopolar or bipolar(21) and both of them are appropriate for treatment of cutaneous disorders(8,22). One of the prominent advantage of radiofrequency devices is ability to transfer thermal energy to greater depths of the dermis and subcutaneous layer without causing superficial layer of skin to be burned severely(23). Bipolar RF devices as well as combined approaches using light and Radiofrequency represent yet a novel and modern approach to entire-body rejuvenation(8,22,24-26). The combination of bipolar radiofrequency (RF) with either infrared laser at 900 nm or IPL (500-1200 nm) at lower fluences has been evaluated for the systematic reduction of all aspects of photodamage and rhytids(1,27-29). The combination of Radiofrequency technology with diode laser or IPL has been shown to induce tissue contraction and has considerable effects on laxity, rhytides and other aspects of photodamage(1,29).

The Science of Fractional Resurfacing

In 2003 nonablative fractional lasers were introduced for photorejuvenation to reduce side effects of ablative laser therapy through minimal dose of laser to patient skin. In fractional methods a maximum of 95% of the skin remains intact and The intact surrounding tissue enables for future usage as a viable tissue(13). Fractional resurfacing have the safety of nonablative technologies and the efficacy of traditional ablative resurfacing techniques(30). This technique uses a device which targets energy more precisely than other devices. Fractional laser produces microscopic columns of thermal damage rather than removing the whole superficial layer of the skin. The surrounding skin cells are left intact(31). The body's physiological healing procedure produces new, healthy tissue to substitute the columns of impressed tissue so improve the skin being treated(31).

Fractional photoresurfacing can be accomplished by nonablative fractional resurfacing (NFSR) and ablative fractional resurfacing (AFR). Nonablative fractional photothermolysis is currently certified by the US Food and Drug Administration (FDA)

for the treatment of pigmented lesions, periorbital rhytides, skin resurfacing, melasma and soft tissue coagulation, acne and surgical scars, and actinic keratoses(13).

There are two main classifications of fractional technologies based on the wavelength's affinity for water. First category is ablative devices with wavelengths that are highly absorbed by water. This include both erbium yttrium aluminium garnet (Er:YAG; 2,940 nm) or yttrium yttrium gallium garnet (YSGG; 2,790 nm) and carbon dioxide (CO₂; 10,600 nm) lasers. Second category with wavelengths only fairly absorbed by water are nonablative (1410 nm, 1440 nm, 1540 nm, 1550 nm)(13). Nonablative fractional resurfacing(NFSR) is immediately achieving tremendous popularity in clinics and is known as the gold standard for laser resurfacing for several indications such as the treatment of photodamage, rhytids, melasma and acne scars (30,32-35). Fractional nonablative laser resurfacing has been available for patient since 2004. True nonablative fractional skin resurfacing (NFSR) requires three criteria: (1) nonablative mode of tissue coagulation, with the stratum corneum remaining intact and tissue not being vaporized, (2) creation of multiple microthermal zones surrounded by islands of viable tissue and (3) resurfacing with extrusion and replacement of damaged tissue, with re-epithelialization within 24 hours(30).

True NFSR is a device with an appropriate wavelengths to penetrates deeply to accomplish collagen remodeling and creation of microthermal zones with rapid re-epithelialization. The target for fractional photothermolysis is tissue water and the main targets here are epidermal keratinocytes, dermal collagen and dermal vascular structures(36,37).

There are different systems which working with NFSR technology. The most widely applied NFSR device is the 1550-nm erbium-doped mid-infrared fiber laser, which does not have an impact on the stratum corneum but act on deeper tissue and the target is the high water substance in both epidermal and dermal structure. It is not selective for the other chromophores in the skin, such as melanin or hemoglobin(13,38).

A device is known as a fractional one, if it produces microscopic spots less than 400 microns in diameter. The effectiveness of fractional treatment

depends on two factors: percentage of surface inclusion and considering area of tissue treated. Professional dermatologist usually recommend four to six therapy sessions. They urge their patients to receive treatments with a seven to ten days interval between each session. A meticulous consultation is carried out to debate the suitable pre- and postoperative care for patient during the period of the treatment. We can advise patient to start topical tretinoin at least four to six weeks prior to Fraxel laser treatment(30). Patients are advised to interrupt all topical tretinoin five to seven days before treatment(130). Topical tretinoin is begun again five days as post-treatment(30). For NFSR and AFR the patient's medical history include of herpes simplex infection is an important priority because fractional photothermolysis can cause relapse of herpes simplex infection(13). A study looked into the short-term adverse effects follow fractional photothermolysis. They demonstrated that 100% of patients had temporary erythema, 82% had edema, 86.6% felt dry skin, 60% experienced flaking and 26.6% bronzing(13,39). There is a retrospective study by Graber et al. which shows only 7.6% of treatments caused complications, acneiform eruptions are the most frequent of them (1.87%) herpes simplex reactivations are the next complication (1.77%) (13,40). No disparity in side effects was observed between various types of human skin and body locations, except for post-inflammatory hyperpigmentation, which occurred more often in darker skin types(13,39). We need only topical anesthesia to control pain during nonablative fractional resurfacing procedures.

Clinical Indications for NFSR

Nonablative fractional laser skin resurfacing (NFSR) has been used to treat numerous numbers of skin conditions. There are several clinical indications for NFSR for patients such as facial and extra-facial wrinkles, photodamage, acne scars, surgical / traumatic scars and melasma(30). In one study the most accepted indication for NFSR in male patients was treatment of acne scars (44% of all indications in male patients) although it was facial photoaging / wrinkles in female patients (48% of all indications in female patients)(30). The author found that male patients have shorter recovery from erythema and edema of NFSR than

females and this may be in part due to greater epidermal and dermal thickness and also larger sebaceous glands in males compares with female skin(30).

Complications

Complications with NFSR are extremely unusual. In the study performed by VIC A. NARURKAR the side effects included isolated cases of blister formation, transient post-inflammatory hyper pigmentation and impermanent petechiae among over 600 Fraxel laser treatments. Permanent scarring or pigmentary changes have not been detected in this study(30).

Different Kinds of Nonablative Fractional lasers for Resurfacing

There are different systems working with NFSR technology. The 1550 nm Fraxel Restore Laser(Reliant Technologies, Mountain View, CA) is the most comprehensive studied and utilized true NFSR device which develops random patterns of microthermal zones(30). Histological studies using Fraxel device show that full epidermal healing takes place during the first 24 hours post-treatment(13,41). This method decrease complications including infections, prolonged redness, edema and other disorders associated with former kind of resurfacing procedures. Nowadays different kind of laser system which are based on the fractional photothermolysis are available to cure photodamage situations.

Another nonablative fractional laser that has recently been introduced to rejuvenate the skin is the Starlux-1540 fractional laser which produces stamped pattern of microthermal zones(13). Fractionated light consists of hundreds of micro beams instead of a solid beam of light that is emitted by most previous lasers.

The Starlux-1540 laser (Starlux, Palomar Medical Technologies, Burlington, MA) which is the second commercially introduced nonablative fractional device put micro beams of laser light into the skin. After each session, the skin is exposed to tens-of-thousands of beams of laser light. During subsequent treatments, the laser treats the intervening zones that were not previously treated. After a series of sessions, the entire surface will

have been exposed to the laser.

Another system is Quasi nonablative fractional devices include a 1440-nm laser (Affirm, Cynosure) (30). Affirm is the initial microthermal rejuvenation device with the registered Combined Apex Pulse (CAP) 1440 nm laser technology. The Affirm laser is a great breakthrough in nonablative cosmetic lasers for microthermal skin rejuvenation, wrinkle reduction and acne scars. The results with this type of laser are not immediate and no one accomplishes a 100% response. The responses are very variable among individuals. Most individuals require at least four to six treatments to attain a visible response(30). Risks of bulk heating are theoretically greater in Affirm laser than Fraxel and Starlux as a result of the mode of delivery and more superficial treatments(30).

Conclusion

The science of laser skin resurfacing has changed significantly during the past two decades up to now. Although many procedures for skin rejuvenation are experienced, there is an appreciable variability in recovery time, side effects and also efficacy. The investigation into resurfacing laser therapy transform procedure from ablative lasers into nonablative lasers, including PDL, Nd:YAG, IPL, Radiofrequency and the latest one which is fractional laser resurfacing. Nonablative fractional laser resurfacing is developing very rapidly to become the gold standard for laser resurfacing therapy for various indications including photorejuvenation therapy, at least in men(30). Nonablative fractional laser resurfacing technologies is now capable of producing suitable and sufficient efficacy while reducing side effects and downtime, so they are more acceptable to most of the patients. Scientists keep on developing methods for skin photorejuvenation. Current treatment modality requires extensive research to achieve novel technologies in near future.

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