TRAUMATIC AND SURGICAL SCARS: SUCCESSFUL TREATMENT WITH A 1,565NM ERBIUM-GLASS NAFL COMBINED WITH IPL

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Scars are a very common condition of the general population and can have a profound impact on the psyche of the patient such as low self-esteem and feelings of psychosocial isolation. Various therapeutic approaches have been proposed for improving the clinical appearance of scars. Fractional mode of ablative and non-ablative lasers has become a novel strategy for the treatment of scars. A total of 43 patients (Fitzpatrick skin type II to IV), clinically diagnosed of surgical and post-traumatic scars from January 2015 to December 2016, were treated. Each treatment comprised of several passes over the scars with different devices, using a 1.565nm scanned erbium-doped fiber NAFL and an IPL. All patients noted subjective improvement in cosmesis and functionality after treatment, also with a decreased pain and an increased mobility on the underlying plans. Numerous therapeutic strategies for traumatic and surgical scars have been suggested to date, but no consistent treatment modality has been established yet. In our study, we have shown that there was a significant collagen remodelling with decrease of scar vascularity and significant improvement of pliability of scar after combined treatment with non-ablative fractional resurfacing and IPL resulting in a remarkable improvement in scar vascularity, pigmentation and height.

Scars are a very common condition that affect approximately 4.5-16% of the general population and depending on the degree of disfigurement, can have a profound impact on the psyche of the patient such as low self-esteem and feelings of psychosocial isolation (1). Clinically, scars can impede the patient's range of motion, and can cause pain, dysesthesia, and pruritus.

Various therapeutic approaches have been proposed for improving the clinical appearance of scars, including corticosteroids, hydrant creams, different chemical acid peels, surgical revision, microdermabrasion, silicone gel application, pressure therapy, radiation and skin needling, with different opinions on the results (2-10).

Technologies designed primarily for cosmetic applications, such as fractional laser resurfacing and laser hair reduction, have been adapted for consistent functional enhancement.

Fractional mode of ablative and non-ablative lasers has become a novel strategy for the treatment of scars, and some authors have suggested that treatment with fractional lasers for various scars, such as postoperative, atrophic and acne scars, has demonstrated to safely improve the appearance of the scars (6).

Fractional treatment is achieved through a pattern of microscopic thermal zones produced by the laser beams at specific depths in the dermis. Fractional photothermolysis stimulates the epidermal turnover and dermal collagen remodeling (11).

Recently, non-ablative fractional laser and

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ablative 10.600 nm carbon dioxide fractional laser have been suggested as successful approaches for improving the appearance of scars (12-16).

A 1.565nm near-infrared, erbium-doped fiber NAFL (Lumenis Ltd., Yokneam, Israel) that has been cleared by the FDA for skin resurfacing and coagulation of soft tissue was released in 2013. The device delivers laser energy non-sequentially using a sophisticated patent pending scanning algorithm. Variations in microbeam distribution and clustering of microthermal treatment zones due to multiple passes of laser energy delivery, as seen with rolling pattern handpieces, are thereby prevented (17). An integrated, thermokinetically cooled sapphire crystal treatment tip enhances epidermal protection and reduces intraoperative discomfort. The combination of non-sequential energy delivery and contact cooling also limit the degree of dermal bulk heating, minimizing the risk of post inflammatory hyperpigmentation, bullae formation, and scarring.

As well described in Literature, IPL works on the principles of laser and selective photothermolysis; the light energy is absorbed by particular target chromophore and then converted to heat energy, which causes damage to the specific target area (18).

In the current study, we showed the effectiveness of this novel 1.565nm scanned erbium-doped fiber NAFL combined with IPL, for the treatment of traumatic and surgical scars.

MATERIALS AND METHODS

Forty-three patients (Fitzpatrick skin type II to IV), clinically diagnosed with surgical and post-traumatic scars from January 2015 to December 2016, were treated. Informed consents were obtained from all patients before treatment.

This study included 17 males and 26 females aged between 27- and 63-years-old; 14 patients had Fitzpatrick skin type II, 25 had Fitzpatrick skin type III, 4 had Fitzpatrick skin type IV. Exclusion criteria were photosensitivity, use of photosensitizing drugs and history of keloid formation, active local or systemic infection, use of botulinumtoxin A, chemical peels, dermal fillers in areas to be treated within the previous 3 or 4 months and use of isotretinoin or ablative laser to target areas within the past 12 months.

The clinical evaluation was objectively based on clinical photography before treatment and one month after last laser treatment session by means of clinical improvement and patient satisfaction. Side effects and complications were also recorded at each session.

The cosmetic improvement of the scars was evaluated by the physician and the patients independently, using a quartile grading scale; grade 0: no improvement, grade 1: minimal improvement, grade 2: moderate improvement, grade 3: marked improvement, grade 4: near-total improvement. The patients were also asked to scale their subjective satisfaction with the treatment on a quartile grading scale; grade 0: no satisfaction, grade 1: little satisfied, grade 2: somewhat satisfied, grade 3: satisfied, grade 4: very satisfied.

Devices

The patients were treated with a non-ablative fractional resurfacing (NAFR) module (ResurFX) and Intense Pulsed Light (IPL) for the M22 multi-application platform (Lumenis Ltd., Yokneam, Israel).

The ResurFX system delivers pulsed near-infrared laser light with a nominal wavelength of 1.565 nm via a sapphire contact-cooled tip. At each impact, the laser generates an array of focused microspots with a density adjustable by the operator and varying from 50 to 500 μ beams/cm. The practitioner can choose any of the six different shapes (hexagon, circle, doughnut, square, rectangle, or line), and scan sizes ranging from 5 to 18 mm, with energy of up to 70 mJ/ μ spot.

The light spectrum, for IPL, ranges from 515 nm to 755 nm. The light is absorbed by the chromophores within the skin, principally the melanin in the pigmented lesions, and hemoglobin with its derivates (oxy- and deoxyhemoglobin) within the blood vessels. The chromophores absorb different light wavelengths, and the absorbed light is transformed into thermal energy, causing damage to the chromophores and the lesions where they are located.

Procedure

Half an hour before each treatment, a very thin layer of an anesthetic cream containing 7% lidocaine and 7% tetracaine was applied to the right hemi-face. After removal of the anesthetic cream, a careful disinfection of the area was performed. Each treatment comprised several passes over the scars, each with a different setting as follows.

At first, using the 1.565nm scanned erbium-doped fiber NAFL, each scar was first treated using a small spot size covering the whole extension of the scarring areas (settings: 300 microspots/cm² with 40mJ/cm²). Then, it runs a second pass on the entire area, including the healthy surrounding areas, using a large spot size (settings: 200 microspots/cm² and 50 mJ/cm²). These treatment settings were repeated at each of the first two/three treatment sessions, in order to remodel the collagen, and to guide the healing of the wounds. Subsequently, when the appearance of the scar is improved, further two therapeutic sessions will be performed to improve the redness resulting from residual inflammation.

In the second step, two passes of IPL (590 nm /560 nm – 560 nm/515nm) are performed covering the whole extension of the scarring areas, and then proceed with the 1.565nm scanned erbium-doped fiber NAFL, with the same modes as previous treatments.

Immediately after each treatment, a water-based emulsion containing triethanolamine was applied to the treated area, and the patients were requested to apply at home the cream two times a day for a week to maintain hydration of the skin and to apply a protective sunscreen 50+ three times a day throughout the treatment course. The patients received a total of four/five treatments, with a four weeks interval between each treatment. The start of the treatment was 1 week after suture was removed for patients with surgical scars, and as early as possible, after the healing of the wounds, for post-traumatic scars.

Case 1

A 29-year-old male with Fitzpatrick skin phototype III presented with extensive traumatic scars of the right half of his face after a car accident six months prior. He reported tarmac abrasions on his right cheek and forehead and a wound on the right eyelid, which was sutured at the emergency room. A hypertrophic scar remaine along with impaired eyelid functionality. Over the course of the months, he suffered from the aesthetics dissatisfaction and the limited mobility in his right eyelid (Fig. 1).

The patient received 5 treatments, the first 3 sessions of only 1.565nm scanned erbium-doped fiber NAFL, followed by a further 2 sessions of 1.565nm scanned erbium-doped

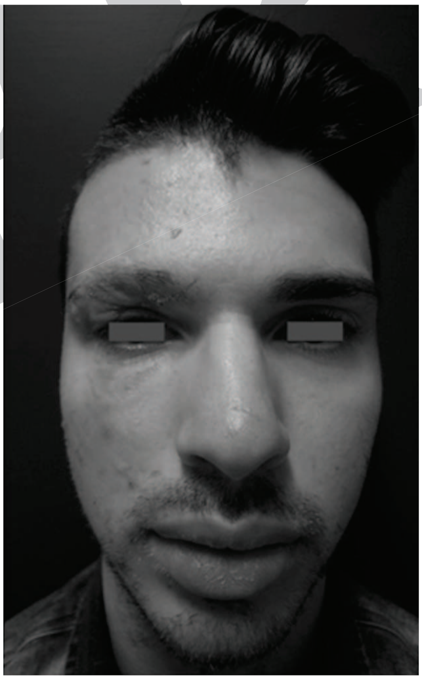

Fig 1. *Traumatic scar of the face. A 29-years-old male with Fitzpatrick skin phototype III six months after car accident.*

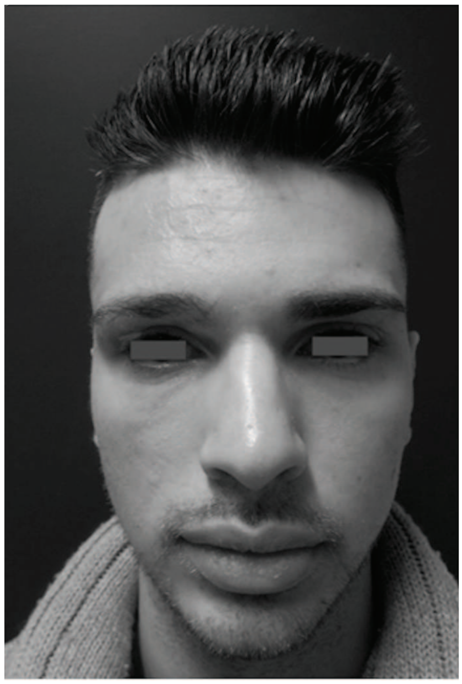

Fig. 2. *Patient after 5 treatments. The patient was completely satisfied with significant improvement in both texture and pigmentation.*

fiber NAFL combined with IPL (590nm - 560nm and 560nm – 515nm).

The treatments were well tolerated with mild, transient erythema and edema lasting 5/7 days after each treatment. The patient noted subjective improvement in cosmesis and functionality after each treatment. He also reported decreased pain and an increased mobility in his right eyelid throughout the treatment.

After the first treatment, the patient was able to resume working and a normal social life with minimal discomfort. From an aesthetic point of view, the patient noted significant subjective improvement in both texture and pigmentation with each treatment. After two treatments, the patient noted a 50% improvement in cosmesis and was very pleased with his results. After the last treatment, the patient was completely satisfied and agreed to perform two maintenance sessions of resurfacing every year in order to improve the appearance of his face further (Fig. 2).

Case 2

A 46-year-old female with Fitzpatrick skin phototype II presented with scars of the upper arms bilaterally after surgical brachioplasty one month prior. The patient began laser scar treatment, to improve the aesthetic appearance, after approximately 1 week from the removal of the suture (Fig. 3).

Fig. 3. *Surgical scars. A 46-years-old female with Fitzpatrick skin phototype II one month after brachioplasty and one week after the removal of the sutures.*

The patient received 4 treatments, the first 2 sessions of only 1.565nm scanned erbium-doped fiber NAFL, followed by a further 2 sessions of 1.565nm scanned erbium-doped fiber NAFL combined with IPL (590nm - 560nm and 560nm – 515nm).

The treatments were well tolerated with mild, transient erythema and edema lasting 5/7 days after each treatment. The patient noted subjective improvement in cosmesis after each treatment; in fact, the patient noted significant subjective improvement in both texture and pigmentation with each treatment. After two treatments, the patient noted a 60% improvement in cosmesis and was very pleased with her results. After the last treatment, the patient was completely satisfied and agreed to perform two maintenance sessions of resurfacing ever year in order to improve the appearance of her arms further (Fig. 4).

RESULTS

This study included 43 patients having surgical and post-traumatic scars with a broad range of atrophic and hypertrophic scars. The age of patients varied from 27-63 years with a mean of 46.7 years. The study included 17 males (39.5%) and 26 females (60.5%).

There was remarkable improvement in scar vascularity, pigmentation and height. All patients noted subjective improvement in cosmesis and functionality after treatment, also with a decreased pain and an increased mobility on the underlying plans. Clinical improvement assessment showed a mean grade of 3.6 for physician evaluation and a mean grade of 3.4 for patient evaluation. Patient's subjective satisfaction score was 3.3. No major complications were reported.

DISCUSSION

Numerous therapeutic strategies for traumatic and surgical scars have been suggested to date, but no consistent treatment modality has been established yet. From the numerous modalities used to improve scars, more effective laser treatments continue to emerge, becoming a popular therapeutic alternative.

Lasers such as the vasculature-targeting 595-nm pulsed dye laser and the full-field ablative 10 600-nm CO2 laser continue to be effectively integrated into the treatment of various scar types. These modalities are, however, somewhat limited in large traumatic scars because of modest efficacy and excessive thermal damage, respectively (19-22).

Treatment with pulsed dye laser is based on selective photothermolysis, with hemoglobin serving as the target chromophore. Moderate damage to local blood vessels results in a remodeling response that can help reduce scar erythema, pain, itch, and prominence (23-28).

Although not technically a laser, IPL works on the principles of laser, that is, selective photothermolysis, light energy is absorbed by particular target chromophore and then converted to heat energy, which causes damage to the specific target area (18).

Though the exact mechanism is unknown, (29) such laser-induced remodelling may be associated with evidence of new dermal collagen formation.

Fig. 4. *Surgical scars after 4 treatments. It highlighted a significant improvement in both texture and pigmentation with the resolution of the inflammatory state. The early treatment with non-ablative fractional laser allowed the collagen remodeling during the healing phase of the scars.*

A study by Goldberg showed histologic evidence of new upper papillary dermal collagen formation, associated to clinical improvement (30). Also Feng et al., found increased activity of fibroblasts; increased type-I and type-III collagens; and decreased elastin content, though the elastin fibres gets neatly rearranged, thus, there was a morphological evidence of clinical improvement(31).

The IPL today is also the most employed in treatment of variety vascular lesion (29). Here the IPL targeted on the chromophoreoxyhaemoglobin, which is abundant in the blood vessels. When activated, by IPL it causes photocoagulation of vascular endothelium, leading to fibrosis and obliteration of the blood vessels (32), thus ensuring improvement of the clinical condition.

Some of the most exciting recent advances in scar treatment are associated with the emergence of fractional photothermolysis in 2004 (7). Fractional photothermolysis is a recently developed laser technology that creates thousands of microscopic columns of thermal damage in the epidermis and dermis surrounded by islands of normal tissue, limiting the amount of injury and resulting in rapid epidermal repair. This involves the generation of a pixelated pattern of narrow columns of thermal injury (vaporization or coagulation of tissue) in the treatment area, based on the heating of tissue water. An early inflammatory response is followed by cell proliferation, matrix metalloproteinases guided turnover of extracellular proteins, and long-term neocollagenesis and dermal remodeling (33-35). As noted, fractional laser therapy is associated with a relatively low rate of complications, especially compared with full-field ablative devices.

In a study comparing the effect of ablative CO2 fractional laser with that of non-ablative 1.550 nm Erbium (ER), both modalities showed similar improvements of scar; however, treatment with the ablative CO2 fractional laser was considered more painful than the treatment with the non-ablative fractional laser, and resulted in more post-inflammatory hyperpigmentation and longer post-treatment erythema (36, 37).

Non-ablative fractional photothermolysis at wavelengths of 1.565 nm has been found to be effective for the treatment of scars, but fractional ablative laser has gained popularity in the last years due to its potentially greater efficacy in the treatment of both the dermal and epidermal components of scar tissue.

In our study, we have shown that there was a significant collagen remodelling with decrease of scar vascularity and significant improvement of pliability of scar after combiner treatment with non-ablative fractional resurfacing and IPL. These were because NAFL has its most effect in dermal remodeling while the IPL reduces residual inflammation coagulating the blood vessel and, furthermore, it may hasten the collagen metabolism as described above.

CONCLUSION

This work demonstrates the efficacy of treating traumatic and surgical scars using two different laser technologies. The low invasiveness of the two individual treatments allows us to associate them, benefiting from their specific targets. The NAFL's main target is water; its application will result in collagen remodeling. The IPL, with the wavelengths used, has the primary target for melanin and hemoglobin, its application will mainly result in the reduction of inflammation and, secondly, in collagen stimulation.

The combination of the two treatments in the same session is well tolerated. Procedure pain was reported as mild to moderate in most subjects and adverse events were generally limited to immediate post-treatment trace-to-moderate erythema and edema. The results achieved were remarkable improvement in scar vascularity, pigmentation and height.

REFERENCES

1. Lupton JR, Alster TS. Laser scar revision. Dermatol Clin 2002; 20(1):55-65.
2. Aust MC, Fernandes D, Kolokythas P, Kaplan HM, Vogt PM. Percutaneous collagen induction therapy: an alternative treatment for scars, wrinkles, and skin laxity. Plast Reconstr Surg 2008; 121(4):1421-9.
3. Conologue TD, Norwood C. Treatment of surgical scars with the cryogen-cooled 595 nm pulsed dye laser starting on the day of suture removal. Dermatol Surg 2006; 32(1):13-20.
4. Kim SG, Kim EY, Kim YJ, Lee SI. The Efficacy and Safety of Ablative Fractional Resurfacing Using a 2,940-Nm Er:YAG Laser for Traumatic Scars in the Early Posttraumatic Period. Arch Plast Surg 2012; 39(3):232-7.
5. Park GH, Rhee DY, Bak H, Chang SE, Lee MW, Choi JH, Moon KC, Bang JS, Kim BJ, Kim MN, Lee SY. Treatment of atrophic scars with fractional photothermolysis: short-term follow-up. J Dermatolog Treat 2011; 22(1):43-8.
6. Jung JY, Jeong JJ, Roh HJ, Cho SH, Chung KY, Lee WJ, Nam KH, Chung WY, Lee JH. Early postoperative treatment of thyroidectomy scars using a fractional carbon dioxide laser. Dermatol Surg 2011; 37(2):217-23.
7. Manstein D, Herron GS, Sink RK, Tanner H, Anderson RR. Fractional photothermolysis: a new concept for cutaneous remodeling using microscopic patterns of thermal injury. Lasers Surg Med 2004; 34(5):426-38.
8. Kim S. Clinical trial of a pinpoint irradiation technique with the CO2 laser for the treatment of atrophic acne scars. J Cosmet Laser Ther 2008; 10(3):177-80.
9. Nouri K, Elsaie ML, Vejjabhinanta V, Stevens M, Patel SS, Caperton C, Elgart G. Comparison of the effects of short- and long-pulse durations when using a 585-nm pulsed dye laser in the treatment of new surgical scars. Lasers Med Sci 2010; 25(1):121-6.
10. Nouri K, Rivas MP, Stevens M, Ballard CJ, Singer L, Ma F, Vejjabhinanta V, Elsaie ML, Elgart GW. Comparison of the effectiveness of the pulsed dye laser 585 nm versus 595 nm in the treatment of new surgical scars. Lasers Med Sci 2009; 24(5):801-10.
11. Bak H, Kim BJ, Lee WJ, Bang JS, Lee SY, Choi JH, Chang SE. Treatment of striae distensae with fractional photothermolysis. Dermatol Surg 2009; 35(8):1215-20.
12. Alexiades-Armenakas M, Sarnoff D, Gotkin R, Sadick N. Multi-center clinical study and review of fractional ablative CO2 laser resurfacing for the treatment of rhytides, photoaging, scars and striae. J Drugs Dermatol 2011; 10(4):352-62.
13. Degitz K. [Nonablative fractional lasers: Acne scars and other indications]. Hautarzt 2015; 66(10):753-6.
14. Shumaker PR. Laser tratment of traumatic scars: a

military perspective. Semin Cutan Med Surg 2015; 34(1):17-23.
15. Ozog DM, Moy RL. Discussing Fractional Carbon Dioxide Laser and Other Physical Treatments for Scar Prevention With Patients. JAMA Dermatol 2015; 151(8):815-6.
16. Heppt MV, Breuninger H, Reinholz M, Feller-Heppt G, Ruzicka T, Gauglitz GG. Current Strategies in the Treatment of Scars and Keloids. Facial Plast Surg 2015; 31(4):386-95.
17. Manstein D, Zurakowski D, Thongsima S, Laubach H, Chan HH. The effects of multiple passes on the epidermal thermal damage pattern in nonablative fractional resurfacing. Lasers Surg Med 2009; 41(2):149-53.
18. Hultman CS, Edkins RE, Lee CN, Calvert CT, Cairns BA. Shine on: Review of Laser- and Light-Based Therapies for the Treatment of Burn Scars. Dermatol Res Pract 2012; 2012(243651.
19. Jacob CI, Dover JS, Kaminer MS. Acne scarring: a classification system and review of treatment options. J Am Acad Dermatol 2001; 45(1):109-17.
20. Alster TS. Improvement of erythematous and hypertrophic scars by the 585-nm flashlamp-pumped pulsed dye laser. Ann Plast Surg 1994; 32(2):186-90.
21. Mustoe TA, Cooter RD, Gold MH, et al. International clinical recommendations on scar management. Plast Reconstr Surg 2002; 110(2):560-71.
22. Nast A, Eming S, Fluhr J, et al. German S2k guidelines for the therapy of pathological scars (hypertrophic scars and keloids). J Dtsch Dermatol Ges 2012; 10(10):747-62.
23. Brewin MP, Lister TS. Prevention or treatment of hypertrophic burn scarring: a review of when and how to treat with the pulsed dye laser. Burns 2014; 40(5):797-804.
24. Manuskiatti W, Wanitphakdeedecha R, Fitzpatrick RE. Effect of pulse width of a 595-nm flashlamp-pumped pulsed dye laser on the treatment response of keloidal and hypertrophic sternotomy scars. Dermatol Surg 2007; 33(2):152-61.
25. Garden JM, Tan OT, Kerschmann R, Boll J, Furumoto H, Anderson RR, Parrish JA. Effect of dye laser pulse duration on selective cutaneous vascular injury. J Invest Dermatol 1986; 87(5):653-7.
26. Anderson RR, Donelan MB, Hivnor C, et al. Laser treatment of traumatic scars with an emphasis on ablative fractional laser resurfacing: consensus report. JAMA Dermatol 2014; 150(2):187-93.
27. Parrett BM, Donelan MB. Pulsed dye laser in burn scars: current concepts and future directions. Burns 2010; 36(4):443-9.
28. Vrijman C, van Drooge AM, Limpens J, Bos JD, van der Veen JP, Spuls PI, Wolkerstorfer A. Laser and intense pulsed light therapy for the treatment of hypertrophic scars: a systematic review. Br J Dermatol 2011; 165(5):934-42.
29. Babilas P, Schreml S, Eames T, Hohenleutner U, Szeimies RM, Landthaler M. Split-face comparison of intense pulsed light with short- and long-pulsed dye lasers for the treatment of port-wine stains. Lasers Surg Med 2010; 42(8):720-7.
30. Goldberg DJ. New collagen formation after dermal remodeling with an intense pulsed light source. J Cutan Laser Ther 2000; 2(2):59-61.
31. Feng Y, Zhao J, Gold MH. Skin rejuvenation in Asian skin: the analysis of clinical effects and basic mechanisms of intense pulsed light. J Drugs Dermatol 2008; 7(3):273-9.
32. Sanchez Carpintero I, Mihm MC, Waner M. [Laser and intense pulsed light in the treatment of infantile haemangiomas and vascular malformations]. An Sist Sanit Navar 2004; 27 Suppl 1(103-15.
33. Orringer JS, Rittie L, Baker D, Voorhees JJ, Fisher G. Molecular mechanisms of nonablative fractionated laser resurfacing. Br J Dermatol 2010; 163(4):757-68.
34. Helbig D, Bodendorf MO, Grunewald S, Kendler M, Simon JC, Paasch U. Immunohistochemical investigation of wound healing in response to fractional photothermolysis. J Biomed Opt 2009; 14(6):064044.
35. Xu XG, Luo YJ, Wu Y, et al. Immunohistological evaluation of skin responses after treatment using a fractional ultrapulse carbon dioxide laser on back skin. Dermatol Surg 2011; 37(8):1141-9.
36. Yang YJ, Lee GY. Treatment of Striae Distensae with Nonablative Fractional Laser versus Ablative CO(2) Fractional Laser: A Randomized Controlled Trial. Ann Dermatol 2011; 23(4):481-9.
37. Ozog DM, Liu A, Chaffins ML, et al. Evaluation of clinical results, histological architecture, and collagen expression following treatment of mature burn scars with a fractional carbon dioxide laser. JAMA Dermatol 2013; 149(1):50-7.