Adjunctive HEALITE II 830 nm LED-LLLT Improves the Results Following Aesthetic Procedures

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Running head: HEALITE in adjunctive therapy

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ABSTRACT

There are certain sequelae which almost inevitably follow any invasive or even noninvasive medical procedure on a patient whether the procedure is surgical or nonsurgical in nature, such events as discomfort, erythema, edema and hematoma formation. These post-procedural events can be mild or severe, might negatively impact the patient's swift return to normal activities of daily living (ADL) and can represent a major problem to the aesthetic or cosmetic surgeon. Recently, light-emitting diode (LED) phototherapy (LED-LLLT) at 830 nm with Lutronic's HEALITE II™ system has attracted attention in wound healing indications for its anti-inflammatory effects and control of erythema, edema and bruising. These findings strongly suggest that the adjunctive indication of the HEALITE with 830 nm LED-LLLT would be ideal after any surgical or nonsurgical aesthetic intervention to speed up the resolution of sequelae, while at the same time accelerating wound healing and potentially improving the therapeutic effect of the procedure whether it involves conventional invasive surgery or something as mild as a mild epidermal peel, and anything in between. A growing body of clinical evidence is showing that applying HEALITE 830 nm LED-LLLT as soon as possible post-procedure successfully hastens the resolution of all sequelae associated with patient downtime, in addition to speeding up frank wound healing by more than one-half. This article presents that evidence, and attempts to show that 830 nm LED-LLLT with HEALITE delivers swift resolution of postoperative sequelae, minimizes downtime and enhances patient satisfaction.

BACKGROUND & RATIONALE

Patient downtime after any surgical or nonsurgical aesthetic or other procedure needs to be kept as short as possible to allow patients to return swiftly to their activities of daily living (ADL), and the shorter this downtime can be, the happier and more satisfied are the patients. Satisfied patients reflect positively on the success of the practitioner. In the case of an unhappy and dissatisfied patient, however, the reverse is certainly true. Even when the final results may be good, if the patient has suffered severe or prolonged postoperative sequelae, such as erythema, edema, bruising or a combination of all of these, together with a concomitantly prolonged downtime, she or he will definitely be unhappy at least in the shorter term.

Virtually every interventional approach in the aesthetic field, whether surgical or even nonsurgical with minimally invasive techniques, is associated with some postoperative after-effects as a result of the inevitable epidermal and dermal damage or irritation. The response to this is inflammation as the first, and necessary, phase of the wound healing process. The classic post-wound signs of inflammation are rubor (redness), calor (heat) and dolor (pain) with occasionally tumor (swelling) added to the mix. The redness (erythema) is the result of blood vessel hyperactivity as an early part of the inflammatory process. Increased leukocyte activity to fight any invading pathogens, taken together with the extra volume of blood in the dilated superficial vasculature, leads to the possible rise in temperature in the affected area, or even systemically in the case of a more severe and deeper wound. When sensory nerve endings are damaged, the result is the sensation the cerebral cortex recognizes as pain, and the influx of interstitial serum from damaged blood vessels to the dermal extracellular matrix in the damaged area can result in swelling, or edema. Sometimes this is a protective mechanism, as in a sprained or strained joint, to act as a natural splint immobilizing the affected joint. However, this same edema also causes pressure pain via the pressure-sensing members of the mechanoreceptors. If all of these persist for some time, then the patient is forced to alter or suspend their normal ADL, and that represents undesirable downtime.

830 nm as an ideal wavelength: The early LLLT literature in the late 80s and 90s pointed to the near-infrared wavelength of 830 nm from mostly gallium aluminum arsenide (GaAlAs) laser diode-based low level laser therapy (LLLT) systems as being extremely effective in pain attenuation and wound healing,[1-3] owing to the deep penetration capabilities of that wavelength into soft tissues, and even through bone.[4,5] The development of the new generation of so-called "NASA LEDs" in the late 1990s added light-emitting diodes as a valid phototherapeutic light source to the clinical armamentarium,[6] and near-infrared LEDs were quickly shown to be effective in wound healing, establishing the efficacy of LED-LLLT in the New Millennium.[7]

A large and continuously growing body of evidence now exists pointing to the safety and efficacy of LED-LLLT as a stand-alone modality for a variety of indications, including treatment of inflammatory acne[8,9] in light-only skin rejuvenation[10,11] and wound healing in a variety of recalcitrant wounds.[12] In the paper on skin rejuvenation by Lee and colleagues referenced above, [11] the histological, ultrastructural and immunohistochemical assessments clearly demonstrated the existence of photoenhanced mechanisms associated with the wound healing process which underpinned the successful rejuvenation results. In her paper, Lee compared the effects among LED treatment with 633 nm and 830 nm on their own and the combination of 830 nm and 633 nm with a control group. Although all LED-treated groups showed statistically significant results compared with the controls, the 830 nm group proved superior to the other LED groups in all aspects including collagenesis, skin elasticity, expression of tissue inhibitors of matrix metalloproteinase (TIMP) 1 and subjective patient satisfaction. The power of the remodelling process to show a steady increase in the good results out beyond 12 weeks after the final treatment session was also clearly demonstrated. Based on these and other corroborating data it was thus suggested by Kim and Calderhead that LED-LLLT, especially at 830 nm, was not only effective on its own but would have an even more interesting role as an adjuvant regime to any existing aesthetic intervention.[13]

Basic Mechanism of Phototherapy: Briefly, phototherapy is based on the direct transfer of incident photon energy between the incoming photons and the cellular energy pool resulting in a viable clinical reaction, but without heat or damage. As Karu has stated, the basic mechanism for phototherapy involves absorption of the incident photon energy (photoreception), transduction and amplification of the signal within the target followed by a photoresponse.[14] The main therapeutic target for the visible light wavelengths, 633 nm in particular, is the cytochrome c oxidase enzyme in the mitochondrial respiratory chain in the target cells, resulting in a photochemically-induced cascade leading to the production of adenosine triphosphate (ATP) and eventual cellular photoactivation.[15] Photoactivated cells can repair themselves or be repaired if damaged or compromised; if they have a function to perform, they will do it faster and better; and if there are not enough of them more will be recruited in or they will proliferate. In the case of near-infrared energy such as 830 nm the mechanism is photophysical rather than photochemical and the target is different, the latter being elements within the cellular membrane rather than direct activation of cellular organelles. However the end result is the same, namely photoactivated cells. The mechanism for near-IR energy is schematically summarized in Figure 1, together with a summary of the main skin cells targeted by 830 nm and how they react when photoactivated.[13]

Post-Procedure Application of HEALITE: In the paper referenced above, Kim and Calderhead stated in their conclusion that; "the combination of appropriate LED phototherapy as an adjunct to many other surgical or nonsurgical approaches where the architecture of the patient's skin has been altered will almost certainly provide the clinician with even better results with less patient downtime, in a shorter healing period, and with excellent prophylaxis against obtrusive scar formation."[13] This statement is based on the two main areas of action of 830 nm LED-LLLT which have been well-demonstrated in the literature: all aspects of wound healing, and pain attenuation. Under the wound healing aspect, 830 nm LED-LLLT can help to control the erythematous and edematous aspects of the all-important inflammatory stage in addition to accelerating regression of any hematoma formation, and post-procedural pain and discomfort are rapidly attenuated.

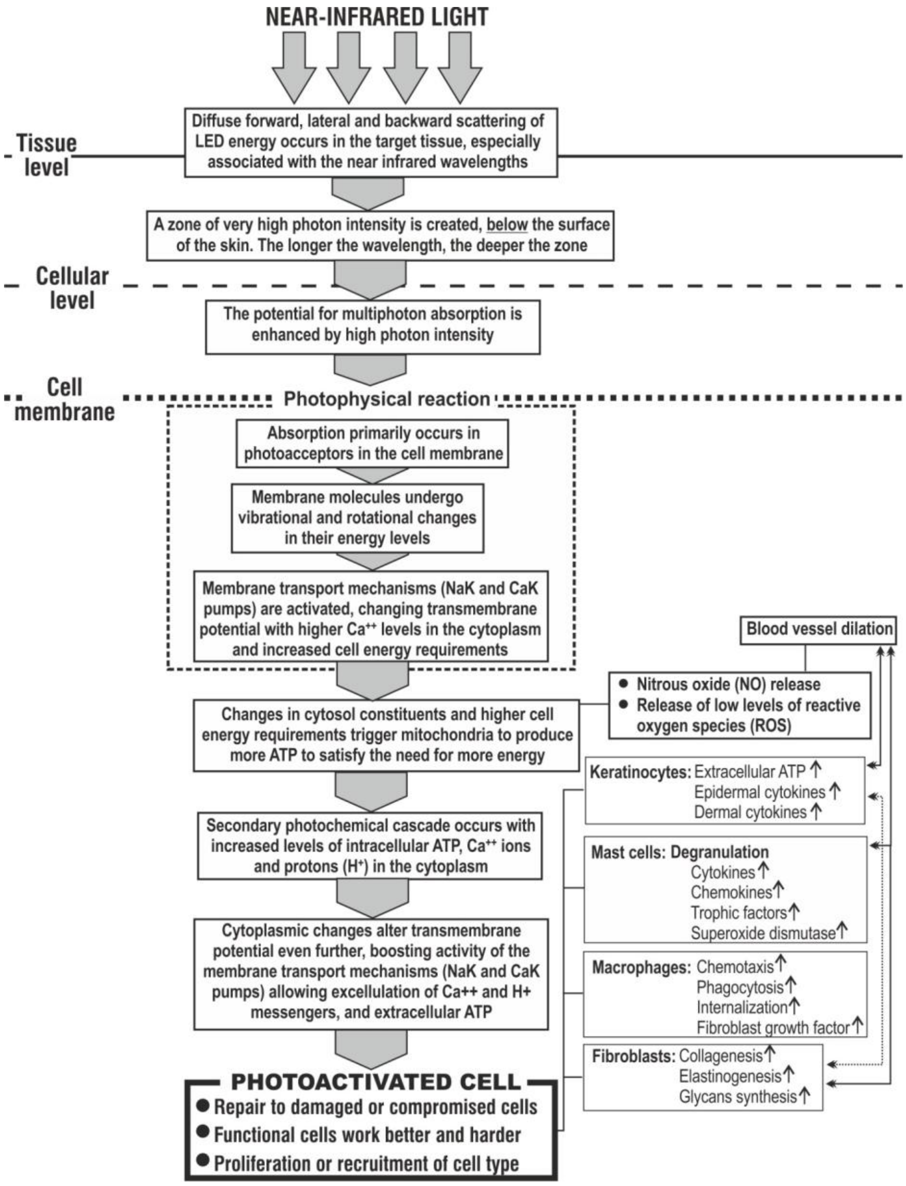

Figure 1: Schematic illustration of the processes involved in irradiation of skin with near-infrared light (left column) and a summation of the target cells and their specific photoreactions

Why is inflammation so important to the adjunctive application of HEALITE in all aesthetic procedures? Inflammation is often regarded as an enemy. However, it is only when inflammation is uncontrolled that it becomes a real enemy, otherwise it is a necessary evil because without the effects associated with the inflammatory phase cells, such as fibroblast growth factor synthesized by macrophages,[16] the proliferation phase may be delayed or incomplete. It is understood that the inflammatory stage cells must be allowed to complete their cycle, as mast cells, macrophages and neutrophils express growth factors in addition to performing their own functions, and both growth factor release and function performance are enhanced with near-infrared (near-IR) light energy.[17-19] In the case of macrophages irradiated with near-IR energy compared with unirradiated controls, phagocytic activity was significantly enhanced and the expression of fibroblast growth factor (FGF) was greater than 20-fold that of unirradiated controls.[18] A single treatment of normal skin with 830 nm LED-LLLT compared with unirradiated controls demonstrated photoenhanced degranulation of mast cells at 48 hr, accompanied by an ultrastructurally-demonstrated inflammatory response with the appearance of significantly greater numbers of mast cells, macrophages and neutrophils even though the skin was uninjured and appeared completely normal to the naked eye.[17] In other words, the 830 nm LED-LLLT had started off the wound healing process, but without any actual wounding of the target tissue. As for the proliferative phase, 830 nm LED-LLLT has also been shown to stimulate fibroblast proliferation and activity *in vivo* compared with unirradiated controls (as yet unpublished data, personal Communication, Prof. YM Park, Seoul National University, Seoul, South Korea:), and to rejuvenate photodamaged fibroblasts as clearly shown in a split-face ultrastructural assay comparing unirradiated skin with 830 nm LED-LLLT irradiated skin *in vivo*.[11] For the remodelling phase, near-IR LLLT supported the transformation from fibroblasts to myofibroblasts, resulting in much better remodeling of new tissues following experimental damage which was simulating a surgical procedure.[20] The tensile strength of the irradiated tissues was greater even though the bulk of the unirradiated tissues was larger.

APPLICATION OF THE HEALITE II

The system as shown in Figure 2 is a free-standing, mobile lockable castered unit which can be easily moved from room to room and will operate on standard mains voltage. The articulated arm is fitted with "place and stay" type hinges to allow easy height adjustment of the treatment head. The treatment head is easy to change, if required, as there are 3 wavelengths available in a variety of wavelength configurations (830 nm and 633 nm monotherapy, and 830 nm/633 nm, 830 nm/415 nm and 633 nm/415 nm duo heads). The head can be swung horizontally through 180°, and displaced vertically by 90° to allow treatment in a sitting or lying position. The head comprises 5 LED planar panels with place and stay hinges to allow adjustment of the panels to follow any body contour from an almost flat arrangement for treatment of the back to being tightly wrapped around an arm or a leg. The treatment head is set up from 3 cm to 17 cm from the target tissue, and the system is operated in a hands-free mode, making it easy to use and clinician or therapist non-intensive.

Figure 2: The HEALITE LED-LLLT system. Note the adjustable panels comprising the treatment head, allowing contour matching of any area of the body to ensure even and homogeneous delivery of light energy over the target area. The hinges on the articulated arm are of the "place and stay" type, requiring no loosening or tightening of clamps, as is the case for the hinges on the planar LED panels.

Settings for the system are easily controlled from an interactive LCD display touch screen, and the system will automatically recognize the treatment head being used and display that on the screen. A range of intensities from 1 to 4 in ascending power density is available, and a range of fluences. The fluence and intensity settings are interlinked and microprocessor-controlled: changing the intensity for any given fluence automatically changes the irradiation time to ensure constant dosage. Fluences can also be manually set. LED emission will automatically shut off when the desired exposure time has been reached.

CLINICAL EXPERIENCE

Post-surgery: Upper eyelid blepharoplasty, with or without CO_2 laser assistance, results in edema and erythema caused by the inflammatory process, and hematoma formation. In a split-face study, Trelles and colleagues demonstrated that the application of LED-LLLT significantly accelerated resolution of these postoperative sequelae in the early stages after the operation, although the long-term result was not significantly better (Figure 3).[21] Although red LED-LLLT at 633 nm was applied in this study because at this time the 830 nm head had not been developed, from more recent results the 830 nm wavelength is even better.[11,13]

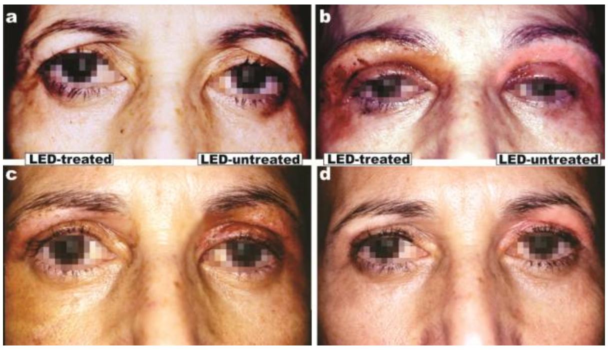

Figure 3: Upper and lower blepharoplasty and periocular resurfacing in a 48-year-old female. a: Baseline findings. Surgery and laser treatment (combined Er:YAG/CO_2 laser) will be performed bilaterally, but only the right side will be treated postoperatively with LED-LLLT. b: 72 hr post-operative findings (2 LED sessions). The LED-treated side at first glance appears worse than the untreated side, but if the position of the eyelids is noted, the left eye is more swollen than the right: this is LED-LLLT speeding up and then peaking inflammation on the irradiated side. c: Two weeks postop, the right side is looking much better than the left, more or less normal. d: At 6 weeks after treatment, there is not much difference between the two sides, although slight erythema still exists on the left eyelid. (The LED-LLLT system used was not HEALITE, but wavelength and dosimetry were identical. Photography and data courtesy of Mario A Trelles MD PhD, Cambrils, Spain)

Post-ablative resurfacing: Trelles subsequently trialed 830 nm LED-LLLT in a split-face pilot study on LED phototherapy adjunctive to full-face ablative laser resurfacing with the combined Er:YAG and CO2 lasers (Unpublished data, personal communication from MA Trelles MD PhD). Figure 4 shows a patient at 72 hr post-procedure with one side of her face treated with 830 nm LED-LLLT and the other covered. The LED-treated side shows reepithelization had already started compared with the total covering of crusting and oozing on the non-LED treated side (Figure 4a): at that stage she had received 2 LED-LLLT sessions (830 nm, 60 J/cm², immediately and 24 hr post-treatment) and was preparing for her 3rd session. At 6 weeks after the procedure, 3 weeks after the final and 7th LED session, the LED untreated side was still erythematous and small areas of crusting had persisted, whereas the LED-treated side was more or less normal (Figure 4b). Based on the good results from the pilot study, Trelles and colleagues designed a controlled study in 60 patients on the use of 830 nm LED-LLLT adjunctive to full-face ablative laser resurfacing.[22] Thirty patients received a course of LED-LLLT immediately after, 24 hr and 72 hr after treatment, and then twice weekly for another 2 weeks with the remaining 30 patients as unirradiated controls.

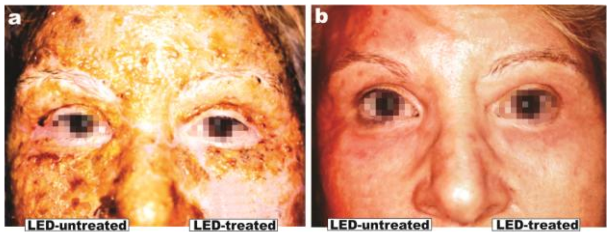

Figure 4: Full face ablative resurfacing in a 68-year-old female with a split-face comparison of LED-treated and untreated sides. Following full face laser ablation, the left side of the face was treated with 830 nm LED-LLLT (60 J/cm²) and the right side was covered as an unirradiated control. a: 72 hours after treatment, crusting and oozing are seen on both sides, but on the left side a clear area of reepithelization can be seen on the check with some islands on the forehead (2 LED sessions delivered). None is seen on the LED-unirradiated side. b: At 6 weeks postirradiation and 3 weeks after the 7th and final LED session, the right side is still erythematous and some crusting is still seen on the forehead, whereas the LED-irradiated side is fully healed with normal skin texture. (The LED-LLLT system used was not HEALITE, but wavelength and dosimetry [830 nm, 60 J/cm²] were identical. Photography and data courtesy of Mario A Trelles MD PhD, Cambrils, Spain)

Groups were compared for healing time and postoperative sequelae including erythema, pain, bruising and edema. In all aspects the LED-treated group was significantly superior to the controls group (Figure 5), and at 6 months after treatment, although a significant improvement compared with baseline was seen in both groups, an independent panel of assessors judged that the overall skin condition in the LED group was better than the control group based on the clinical photography. Figure 6 illustrates the speedy recovery from full-face Er:YAG/CO_2 aggressive ablative resurfacing assisted by 7 sessions of adjunctive LED-LLLT in a case of very severe photoaging brought on by long-term exposure to the sun while skiing (Figure 6a). Full healing with no erythema and an excellent result were seen only 6 weeks post-procedure, showing the potential for LED-LLLT to accelerate resolution of the postoperative sequelae, speed up the healing and to enhance the final result (Figure 6b).

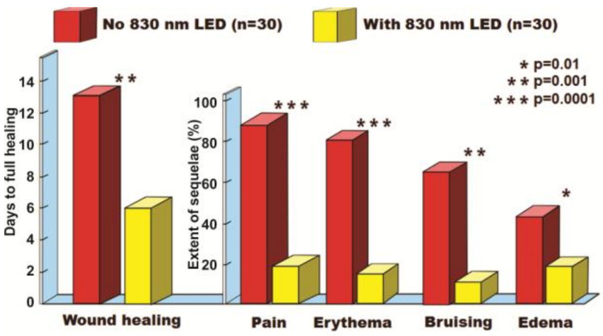

Figure 5: Graphical comparison of speed of wound healing and extent of the post-ablative sequelae at 72 hr postirradiation compared between the LED-irradiated and unirradiated groups, 30 patients per group. The LED group was significantly better in all aspects. The LED-LLLT system used was not HEALITE, but wavelength and dosimetry [830 nm, 60 J/cm²] were identical. (Based on data from Reference 22)

Figure 6: Full-face ablative laser resurfacing in a 58-year old female plus post-procedural LED-LLLT. a: Baseline findings showing severe photoageing with dyschromia, and deep lines and wrinkles due to excessive solar exposure during skiing. b: Result only 6 weeks after Er:YAG/CO_2 laser ablation followed by 7 sessions of LED-LLLT. No erythema or edema can be seen with an excellent overall result. (The LED-LLLT system used was not HEALITE, but wavelength and dosimetry [830 nm, 60 J/cm²] were identical. Photography and data courtesy of Mario A Trelles MD PhD, Cambrils, Spain)

Hematoma control: Unsightly hematoma formation, or bruising, frequently occurs after any procedure where tissues are incised and manipulated, and purpura is another form of bruising associated with pulsed dye laser treatment of blood vessels. LED-LLLT has been demonstrated to resolve bruising rapidly. Figure 7a shows a severe and extensive hematoma on the right leg of a 58-year-old male persisting at 2 weeks following full hip replacement surgery. Three treatment sessions with LED-LLLT were given and Figure 7b shows the very good result one week after Figure 7a. One of the putative mechanisms behind the efficacy of 830 nm LLLT in the resolution of hematoma is the upregulation of prostaglandin (PG)-I2, or prostacyclin, a very powerful platelet anti-aggregant. A study in the Keio Journal of Medicine used an immunoassay to detect levels of PG-I2 in 830 nm irradiated endothelial cells, which showed significantly high levels compared with unirradiated controls.[28] In another study on human hematoma *in vivo*, significantly higher levels of PG-I2 were detected following LLLT with 830 nm.[29] It has also been shown that 830 nm LLLT had a direct action on the fibrin mesh associated with hematoma formation and retention, coupled with increased blood flow and enhanced macrophage activity.[30]

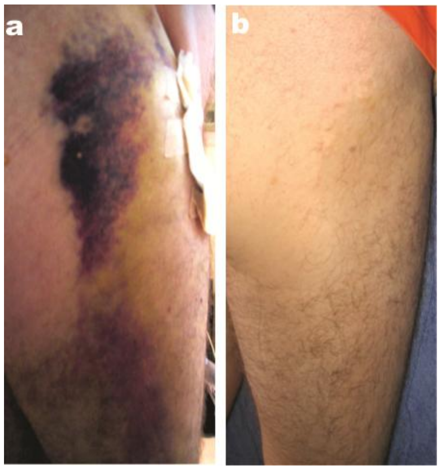

Figure 7: Large hematoma 2 weeks post-hip replacement before (a) and 1 week with 3 830 nm LED-LLLT sessions (b). (The LED-LLLT system used was not HEALITE, but wavelength and dosimetry [830 nm, 60 J/cm²] were identical. Clinical photography courtesy of the author)

Dermatitis treatment: When adverse side effects occur after any aesthetic procedure, the use of 830 nm LED-LLLT becomes even more important to control the adverse events and ensure the best possible result. Figure 8 shows the course of irritant contact dermatitis on the face of a 26-year-old female, following application of an alpha-hydroxy acid peel. She had been treated with corticosteroids for 2 weeks but no effect was seen. Her quality of life was very poor with pruritis and pain, and she would not go to work. She received 3 HEALITE sessions, 3 days apart, and the inflammation and irritation resolved.[13]

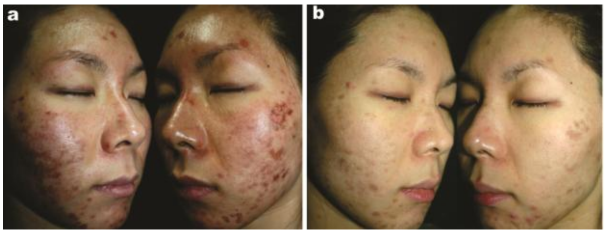

Figure 8 a: Treatment-resistant irritant contact dermatitis in a 26-year-old female following an alpha hydroxy acid peel for inflammatory acne. She was in pain with a very poor quality of life and did not want to go to work. b: She was treated 3 times with 830 nm HEALITE, 3 days apart, and this is the result 10 days after baseline. (From Reference 13, used with permission of the publishers. Courtesy of WS Kim MD PhD)

Ischemic ulcer post-filler: The use of fillers to model atrophic scars or areas of the face has become very popular, but is not without some potential adverse side effects, such as tissue ischemia caused by excessive or poorly-placed filler product. A post-filler ischemic ulcer with severe inflammation, pain and infection is seen in Figure 9a on the forehead of a 53-year-old male. He was treated with 12 sessions of HEALITE LED-LLLT over 5 weeks, and figure 9b sows the excellent result 1 week after the final treatment session. The pain was attenuated completely after the third session, and after the complete treatment protocol, all signs of necrotic ulceration, infection and inflammation had resolved with excellent reepithelialization.[12]

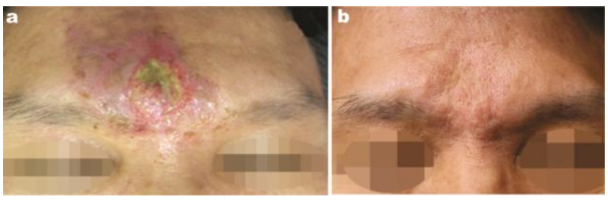

Figure 9 a: Ischemic ulcerative necrosis following filler placement in a 52-year-old male with infection, pain and severe inflammation. He was treated with 12 sessions of HEALITE 830 nm LLLT over 5 weeks, and the figure shows the result at 1 week after the final treatment session. There is still a depression, but reepithelialization is excellent with good texture. (From Reference 12, used with permission of the publishers. Courtesy of PK Min MD)

Severe sequelae post-lip tattoo: Lip tattoos have become very popular, but there can be major problems when they are performed in an illegal tattoo parlor, as was the case in the 54-year-old lady seen in Figure 10a. She ended up with severe pain, bacterial and viral infection with herpes simplex, severe inflammation and edema so that her lower face was badly swollen, and she had developed a mild case of Bell's palsy. Eleven HEALITE treatments were given over 3 weeks, and the excellent result is seen in Figure 10b, showing that HEALITE 830 nm LED-LLLT can not only control inflammation, edema and bacterial infection, but can also inactivate the viral component in herpes simplex and help redress the effects of mild Bell's palsy. in this patient's case, no recurrence of either the herpes simplex or the neurogenic condition was seen in an 8-month follow-up.

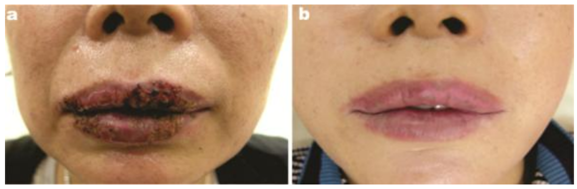

Figure 10 a: Baseline findings in a 54-year-old lady who attended an illegal lip tattoo parlor. She has bacterial infection, severe edema affecting almost the entire lower third of the face, pain, herpes simplex infection and slight Bell's palsy on the right side of her face. b: The excellent result after 11 HEALITE sessions over 3 weeks. All problems have been completely resolved, including the edema so that the lower third of the face has returned to its normal size. (From reference 12, used with permission of the publishers. Courtesy of PK Min MD)

Conclusions

Even in cases of severe adverse events following an aesthetic procedure, swift application of the HEALITE system at 830 nm, 60 J/cm² per session, can rescue the situation and produce excellent results, very quickly. In the case of normal levels of sequelae, the results are even faster. The aesthetic and cosmetic surgeon should therefore consider adding HEALITE II to his or her office armamentarium, and using the system routinely after any procedure which has altered the epidermal or dermal architecture in any way, from mild noninvasive procedures through IPL and ablative fractional laser rejuvenation, to frankly invasive surgical interventions. Erythema and edema as the result of inflammation are swiftly controlled, postoperative pain and discomfort are eliminated, infection both bacterial and viral is controlled and bruising is swiftly resolved. Patients will see better results, sooner, with extremely high satisfaction levels. HEALITE II is a comparatively inexpensive but wellengineered and very attractively-designed system which will offer many thousands of hours of problem free phototherapy, and a strong return on investment to the practitioner.

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