Erbium Laser for Skin Surgery

Subjects: Dermatology

Contributor: Luigi Bennardo

The Erbium laser is a very versatile laser system used in dermatology. Its ability to be almost selectively absorbed by water makes it a perfect device for managing various cutaneous skin conditions.

Keywords: Erbium laser ; Er-Yag laser ; seborrheic keratosis ; skin scars ; facial rejuvenation

1. Introduction

Er:YAG lasers have proven to be very effective in removing benign, premalignant, and malignant skin lesions, using these devices by performing multiple passes over the lesion up to its complete removal. Various conditions have been approached with this method, such as seborrheic keratoses, acrochordons, intradermal cysts, congenital melanocytic nevi in neonates, and acquired melanocytic nevi in adults. Hypopigmentation or hyperpigmentation may result in the treated area [1].

2. Insightful Discussion

Physical processes regulate the interaction between the electromagnetic radiation emitted by a laser source and biological tissues, the exchange of energy between the wave and the substrate, and the targeted tissue's biological response [2].

Water is the skin's main component (about 77% of its volume), so it plays a fundamental role in laser-tissue interaction. Surgical lasers emit in the infrared spectrum region where, compared to penetration, the absorption of radiation by the water molecules prevails [3][4]. The primary objective of a surgical laser is to reach a target with minimal thermal damage. This goal is usually achieved by vaporizing the tissue in less time than it takes for heat to diffuse (i.e., in a shorter thermal relaxation time (TRT). This consideration is crucial for the correct use of surgical lasers: pulses with high power and very short duration generate minor thermal damage [2].

The Erbium laser works emitting a 2940 nm wavelength and has a very high water absorption (16 times more than the 10,600 nm wavelength of a CO_2 laser) [5][6]. Therefore, the penetration depth of the Erbium laser is minimal, confined to the uppermost parts of the epidermis, associated with a minimal thermal injury in the adjacent tissues [7].

Acne scars and facial rejuvenation are two hot topics in dermatology; various lasers are currently used to manage these cosmetic issues, ranging from devices selectively targeting collagen [8][9] to intense pulsed lights and fractional lasers [10].

Fractional lasers produce thermal columns that induce heating and denaturation of collagen with subsequent neo-collagen genesis (biostimulation) in the treated areas [11]

These features make the Erbium laser suitable for many skin surface interventions, from resurfacing treatments to the vaporization of numerous benign dermatological lesions in sensitive areas [12][13].

The Erbium laser's reduced depth of ablation implies the need to carry out multiple laser passes. Therefore, the clinical end-point is no longer based on the feedback of the color indicators (as in CO_2) but on evaluating non-objective visual parameters related to operator experience [14].

These two lasers may also be used in a combined mode, with a decreased incidence of crusting and pruritus following treatment compared with treatment with CO_2 lasers alone [15].

In the literature, many studies have reported the effectiveness of the Erbium laser in resurfacing [16] and in vaporizing hyperkeratotic lesions, [17] stressing its differences from CO_2 laser surgery [18][19][20].

Khatri treated over 360 lesions in 27 patients using this device. Among the lesions treated, the following were also present: acrochordons, nevi, milia, xanthelasmas, seborrheic and actinic keratosis, solar lentigos, verrucae, syringomas, and sebaceous nevi. Moreover, a Bowen disease was treated, showing no sign of relapse. Only eight lesions (2.2%) relapsed, five sebaceous hyperplasias, and three solar lentigos. Laser removal of malignant or premalignant lesions should be performed with great care and limited to superficial basal cell carcinomas or in situ squamous cell carcinomas if the patient refuses surgical excision. The laser removal of nevi should also only be performed in cases where the lesion can be surely classified as benign [21].

One of the first proposed dermatological indications of Er:YAG laser was the management of actinic keratoses. The first study recruited five patients with multiple facial actinic keratoses treated using two to three passes of the laser. All patients showed a reduction in precancerous lesions ranging from 86% to 89%, with re-epithelialization occurring after 5–8 days and erythema lasting up to 6 weeks after the procedure. A histologically proved reduction in solar elastosis three months after treatment was also noted [22].

Ostertag et al. used Er:YAG laser to treat congenital melanocytic nevi in newborns. Ten infants affected by a congenital epidermal nevus were recruited immediately after birth. Six patients presented the lesions on the scalp, while the other two patients presented the lesions on the trunk and the remaining newborns on the extremities. Treatments were performed mainly in general anesthesia, in a single session when the nevi interested the extremities, and in multiple sessions (due to the significant extension of the lesions) when they involved the trunk. The researchers experienced good results, with no or minimal repigmentation, in eight of ten patients and with very few side effects such as postoperative pain, bleeding, and scarring. The removal of congenital melanocytic nevi with laser remains a controversial topic due to the potential risk of malignant transformation of this kind of lesion [23].

Ablative skin lasers are usually used with caution in patients with higher Fitzpatrick skin phototypes (five and six) due to increased risk of changes in pigmentations. Er:YAG laser seems to be more effective in reducing this risk. Davis reported the treatment of milia in black skin using a short-pulsed Er.Yag laser with no changes in pigmentation, suggesting this kind of device as a viable alternative for patients with darker skin. This result was probably due to reducing the inflammatory phase compared to CO_2 and long-pulsed Er:Yag lasers [24].

An Iranian study compared using cryotherapy, electrodesiccation, CO_2 laser, and Er:YAG laser in the management of seborrheic keratoses. Thirty patients affected by facial seborrheic keratoses were randomly allocated in one of four groups treating the lesions with different methods, with therapeutic results evaluated eight weeks after surgery through clinical and dermatoscopic exams. The improvement rate was significantly higher in the CO_2, Er:YAG lasers and electrodesiccation group compared to the cryotherapy at the dermatological follow-up. However, no significant difference emerged among these three groups. The patients reported statistically significant lower satisfaction rates in the cryotherapy group compared to all other treatments. The authors also observed no difference in post-inflammatory pigmentation changes among groups and reported an unexpected longer duration of erythema in the Er:YAG group [25].

An Austrian study compared the use of electrodesiccation, CO_2 laser, and Er:YAG to remove multiple cutaneous neurofibromas in von Recklinghausen's disease. In this perspective paper, 15,580 neurofibromas were removed via electrosurgery, CO_2-, or Er:YAG laser ablation in 21 patients. In adjacent test areas, the researchers compared thermal necrosis, postoperative pain, re-epithelialization, length of postoperative erythema, and the cosmetic outcome of the treatments. Re-epithelization was shorter for Er:YAG laser (9.8 days) compared to CO_2 laser (20.8 days) and diathermy (27 days). Post-treatment erythema was shorter after Er:YAG laser treatment (8.2 weeks) compared to CO_2 laser (11.9 weeks) and diathermy (17 weeks), with the latter method constantly producing hypopigmented scars, while Er:YAG laser seemed the best way to prevent any kind of scars and guaranteed an optimal aesthetic outcome. The recurrence rate of the lesions was low with all methods, and patients were altogether satisfied with the results, with only one patient lamenting poor results after surgery [26].

Various American research groups used fractional Er:YAG laser to manage hypertrophic burn scars and post-traumatic scars. The results of this laser treatment seem promising, with a reduction in erythema and re-epithelization rate. A significant improvement was noted in all measured parameters, including dyschromia, atrophy hypertrophy, vascularity, and texture [27][28].

Fractional Er:YAG laser was also proposed to manage acne scars, with 25 patients receiving four treatment sessions at a one-month interval. Result assessment was performed using the Goodman and Baron grading. Ninety-six percent of patients showed good to an optimal outcome, with patient satisfaction higher than physician's photographic evaluation [29].

A split-face prospective trial compared the effectiveness of fractional CO_2 laser and Er:YAG laser to treat acne scars. Twenty-four subjects with acne scars were treated with a fractional Er:YAG laser on one side and a fractional CO(2) laser on the other side of the face. Two treatments with a 2-month interval were performed for every patient. The results assessment was performed one, three, and six months after the last procedure. Scars' improvement progressed significantly from 1- to 6-month follow-up. At the six-month follow-up, 55% of Er:YAG treated patients and 65% of CO_2 treated patients reported a 50% or higher improvement in scar presentation, although this difference was not statistically significant. Greater discomfort, however, was experienced by the patients treated with the 10,600 nm wavelength device [30].

The Er:YAG laser was proposed as a treatment for actinic cheilitis. An Israeli group treated twelve patients affected by this condition using Er:YAG laser, experiencing the resolution of the condition in all patients, with no recurrence of the disease in a mean 24 months follow-up, no postoperative complications, and a mean healing time of 22 days [31]. Another group treated an even bigger cohort of patients (99) and, using telephone interviews, followed them up to assess the recurrence rate over time. The mean follow-up time of patients was 66 months, and in this period, 85% of them remained disease free. 92.2% of the respondents believed there had been an improvement in the cosmetic appearance of their lips, and 93.5% were satisfied with the results of laser treatment. Scarring following laser therapy appeared in 5% of patients, showing how it may be challenging to treat this condition in the perioral area [32].

Compared to the CO_2 laser, which generates more significant thermal damage, Erbium laser intervention is less painful and complications such as delayed re-epithelialization, persistent erythema, dyschromic, and scarring outcomes are less frequent [26]. The advantage of the occasional use of anesthetics makes this laser a great alternative in patients with several lesions and patients who cannot undergo local anesthesia [33]. The major limitation to using the Erbium laser is its minimal coagulation capacity, which often brings difficulties over large areas or easily bleeding neoformations [18][19][26].

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