

Facial Rhytides—Subsurfacing or Resurfacing? A Review

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Study Design/Background and Objectives: Currently, ablative laser therapy (with CO₂/Er:YAG lasers) is considered an effective and promising method of skin rejuvenation. The induction of collagen synthesis was observed after treatments with the CO₂ laser and with the long-pulsed Er:Yag laser. In past years, the undesirable side effects and risks of these methods have led to intensified research efforts in the fields of non-ablative facial rejuvenation as well as subsurfacing by means of non-ablative laser systems and intense pulsed light systems. The objective is to achieve selective, heat-induced denaturalization of dermal collagen that leads to subsequent reactive synthesis of neocollagen but does not damage the epidermis. This article reviews the use of different types of lasers and intense pulsed light sources for the non-ablative treatment of facial rhytides.

Results: The results of numerous clinical and histological investigations have recently indicated that these new technologies are successful. Some studies demonstrated remarkable effects with non-ablative systems; others, however, showed only limited cosmetic improvement or none at all.

Conclusions: After critical review and assessment of current literature on the treatment of rhytides, we have found that non-ablative methods do not appear to be a comparable alternative to ablative skin resurfacing in terms of their efficacy and side effects. *Lasers Surg. Med.* 32:405–412, 2003. © 2003 Wiley-Liss, Inc.

Key words: laser; non-ablative; rhytides; skin rejuvenation; subsurfacing; wrinkles

“Wrinkles should merely indicate where smiles have been.” Mark Twain 1897 (1)

INTRODUCTION

To date, ablative methods involving laser treatment with CO₂ and Er:YAG lasers have proven to be an effective and reproducible mean of treating perioral and periorbital wrinkles [2–5]. These procedures consist of removing the epidermis down to the middle papillary dermis. It has been shown that selective heating of dermal collagen by treatment with CO₂ and long-pulsed Er:YAG lasers leads to a reactive dermal neocollagen formation and tightening of facial skin [3,4,6–8]. The major disadvantage of ablative treatment methods is the erosion of large surfaces, which necessitate a recuperation period of 1 to 2 weeks. There are also potential risks (infections, scarring, hyper- and

hypo-pigmentation [4,9,10]), which is why new options in non-ablative skin rejuvenation have been the subject of research for the past several years. Non-ablative laser and intense pulsed-light (IPL) systems are currently being examined as alternatives, which would tighten the skin without harming the epidermis. Analogous to the ablative methods, the mechanism of action is based on selective thermal damage followed by new collagen formation. Below, the different laser and IPL systems are presented and critically discussed along with findings of the studies which have been published.

MATERIALS AND METHODS

Table 1 indicates the authors of the studies in this field, the laser or IPL systems used, number of patients, histology, skin types (according to Fitzpatrick), class of rhytides, treatment areas, number of treatments, laser parameters, follow-up period, results, and side effects. The assessment of the therapeutic outcome was performed by means of ultrastructural analysis, optic profilometric measurement, photographic documentation, and/or the clinical picture as well as the subjective impressions of the patients.

Clinical Findings

Diode laser (980/1450 nm). In 1998 Muccini et al. were the first to use a 980-nm diode laser in vitro on breast, eyelid, and eyebrow tissue. They treated solar elastosis and measured tissue shrinkage after treatment. The authors found a tissue shrinkage of up to 16% with 8 W. This is comparable to the results with the CO₂ laser after three passes (15%). Two patients were also treated as part of studies on wound healing. The results were investigated histologically [11]. In the first phase of a three-part study of non-ablative cutaneous remodeling with a 1450 nm mid-infrared diode laser, Hardaway et al. demonstrated that this laser type is capable of targeting dermal collagen and stimulating fibrosis at depths where solar elastosis resides [12]. In phase II, clinical changes and side effects in the treatment of single facial (periorbital, perioral) rhytides in nine patients were examined. The clinical improvement

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TABLE 1. Studies Concerning Non-Ablative Facial Rejuvenation

Authors	Laser/ IPL system	No. of patients	Histology	Skin type	Class of rhytides	Treatment area	No. of treatments	Follow up period	Results	Side effects
Hardaway et al. [12]	1450 nm diode laser (12 W, 150–500 milliseconds)	10	+	I–IV	nn	Postauricular	1–2	2 months	Only histological investigation (see above)	Transient erythema and edema, mild hyperpigmentation, 2 pat. atrophic pitted scars
Hardaway et al. [13]	1450 nm diode laser (12 W, 200–300 milliseconds)	9		I–III	nn	Periorbital, perioral	3	6 months	Mild improvement of rhytides	Transient erythema and edema, transient hyperpigmentation
Goldberg et al. [14]	1450 nm diode laser (14 W, 160–260 nm)	20		I–IV	I–II	Perioral, periorbital	2–4	6 months	Seven pat. no improvement, 10 pat. mild improvement, 3 pat. moderate improvement of rhytides	Transient erythema and edematous papules, transient hyperpigmentation
Zelickson et al. [15]	Pulsed dye laser (585 nm, 0.45 milliseconds, 3.0–6.5 J/cm ²)	20		nn	nn	Perioral/ periorbital	1	6–14 months	>50% improvement of rhytides	Transient purpura, edema 2 pat. w/postinflam. hyperpigmentation
Bjerring et al. [16]	Pulsed dye laser (585 nm, 0.35 milliseconds, 2.4 J/cm ²)	40		nn	I–III	Full face	1–2	6 months	Significant improvement of rhytides, significant increase of procollagen III in the fluid of suction blisters	No side effects
Hohenleutner et al. [17]	Pulsed dye laser (585 nm, 2.5 J/cm ²)	12		I–II	nn	Face	1	6 months	No adverse effects	One pat. w/“very” mild improvement, 11 pat. w/no improvement in wrinkles
Rostan et al. [18]	595 nm long pulsed dye laser (585 nm)	15	+	nn	nn	Cheeks	4	3 months	18.1% statistically significant improvement of photodamage	Minimal to no side effects
Zelickson et al. [44]	Pulsed dye laser vs. IPL	9	+	nn	nn	nn	nn	nn	Only histological investigation	
Ross et al. [20]	Er:Glass laser (1540 nm, 400–1200 mJ/cm ² , 1 millisecond)	9		nn	nn	Postauricular	1	2 months	No improvement of rhytides	Erythema, edema, scars
Fournier et al. [21]	Er:Glass laser (1540 nm, 8 J/cm ² /pulse, 3 milliseconds)	52	+	I–IV	nn	Perioral, periorbital	4	6 weeks	62% of pat. satisfied to very satisfied, 17% increase of epidermis thickness, 40.2% reduction of anisotropy	No side effects
Lupton et al. [22]	Er:Glass laser (1540 nm, 10 J/cm ² , 3.5 milliseconds)	24	+	I–II	nn	Perioral, periorbital	3	6 months	25–50% improvement of rhytides	Transient erythema and edema
Goldberg et al. [23]	Nd:YAG (1064 nm, 5.5 J/cm ²) vs. Silk Touch CO ₂ (18 W)/ultrapulsed CO ₂ (60 W, 300 mJ/cm ²)	11		I–II	I–II	Perioral/ periorbital	1	90 days	All pat. improvement with CO ₂ , 3 pat. w/improvement of the rhytides, no difference from CO ₂ , 6 pat. w/improvement of rhytides, not as effective as CO ₂ , 2 pat. w/no improvement of the rhytides	Pinpoint bleeding→ reepithelialization for 3–5 days, (6–11 days with CO ₂), transient erythema
Goldberg et al. [24]	Nd:YAG (1064 nm, 2.5 J/cm ²)	61		I–II	nn	Full face	1	32 weeks	Improvement of skin texture and elasticity, 97% improvement of rhytides in all patients	Transient erythema, 5 pat. w/purpura, 3 pat. w/pinpoint bleeding, 1 pat. w/postinflam. hyperpigmentation
Goldberg et al. [25]	Nd:YAG (1064 nm, 7 J/cm ²)	8		II–IV	I–III	Perioral/ periorbital	3	3 months	Six pat. w/min. mild improvement of rhytides, 2 pat. w/no improvement	75% petechiae, 33% pinpoint bleeding
Cisneros et al. [26]	Nd:YAG (1064/532 nm, 6–7/4–5 J/cm ²)	22		nn	nn	Perioral/ periorbital	2	nn	81% improvement of rhytides	nn
Goldberg et al. [43]	Nd:YAG (1064 nm, 7 J/cm ²)	6	+	II–IV	nn	Infraauricular	1	3 months	Only histological investigation	

Goldberg [28]	Nd:YAG (1320 nm, 28–38 J/cm ²)	10	+	I–II	I–III	Full face	4	6 months	Two pat. w/substantial improvement, 6 pat. w/some improvement, 2 pat. w/no improvement of rhytides	Erythema
Goldberg [29]	Nd:YAG (1320 nm, 30–40 J/cm ²)	10	+	I–II	I–II	Full face	5	6 months	Two pat. w/substantial improvement, 4 pat. w/some improvement of rhytides	Erythema
Menaker et al. [30]	Nd:YAG (1320 nm, 32 J/cm ²)	10	+	nn	nn	Perioral/full face	3	3 months	Four pat. w/improvement, 6 pat. w/no improvement of rhytides	Erythema, blistering, postinflamm. hyperpigmentation, 3 pat. w/scars
Kelly et al. [31]	Nd:YAG (1320 nm, 28–36 J/cm ²)	37		I–II	nn	Periorbital	3	24 weeks	Significant improvement of mild to moderate rhytides, improvement of mild rhytides	Blistering, postinflamm. hyperpigmentation, 2 pat. w/scars
Levy et al. [32]	Nd:YAG (1320 nm, 36–39 J/cm ²)	13	+	I–III	nn	Periocular, periorbital	2	2 months	Pat. failed to see any improvement	Transient erythema, swelling, crusts, blistering
Trelles et al. [33]	Nd:YAG (1320 nm, 30–35 J/cm ²)	10	+	I–IV	nn	Full face, periocular, periorbital	8	6 weeks	Two of 10 pat. satisfied with results	Transient erythema and blisters
Goldberg et al. [34]	IPL (654 nm filter, 40–50 J/cm ² , triple pulse, 7 milliseconds, 50 milliseconds delay)	30		I–II	I–II	Forehead, perioral, periorbital	1–4	6 months	Nine pat. w/substantial improvement, 16 pat. w/some improvement, 5 pat. w/no improvement of rhytides	Erythema, blistering
Goldberg et al. [35]	IPL (590/755 nm filter, 40–70 J/cm ² , triple pulse, 3–7 milliseconds, 20–60 milliseconds delay) vs. Nd:YAG (1064 nm, triple pulse, 3–8 milliseconds, 100–130 milliseconds delay)	15		II–III	nn	Perioral	3–5	24 weeks	Mild to moderate improvement of rhytides in all patients, no difference between different cut-off filters or between IPL and Nd:YAG	Erythema, blistering
Goldberg [36]	IPL (645 nm filter, 40–50 J/cm ² , triple pulse, 7 milliseconds, 50 milliseconds delay)	5	+	I–II	I–II	Full face	4	6 months	Only histological investigation	
Bitter et al. [37]	IPL (550/570 nm filter, 30–50 J/cm ² , double/triple pulse, 2.4–4.7 milliseconds, 10–60 milliseconds delay)	49	+	I–III	nn	Full face	4–6	3–4 weeks	18% of pat. \geq 75%, 46% of pat. \geq 50%, 64% of pat. \geq 25% improvement of rhytides	Erythema, blistering
Negishi et al. [38]	IPL (550/570 nm filter, 28–32 J/cm ² , double pulse, 2.5–5 milliseconds, 20/40 milliseconds delay)	97	+	IV–V	nn	Full face	3–6	nn	“good/excellent” improvement in \geq 90% for pigmentation, in \geq 83% for telangiectasias and in \geq 65% for skin texture, some pat. w/reduction of rhytides	Erythema, blistering
Negishi et al. [39]	IPL (560 nm filter, 23–32 J/cm ² , double pulse, 2.8–6.0 milliseconds, 20–40 milliseconds delay)	73	+	IV–V	nn	Full face	5	1 month	79–100% improvement in 80.9% of pat. w/pigmentation 81.2% of pat. w/telangiectasias 55.9% of pat. w/wrinkles 87.9% of pat. concerning skin texture and smoothness	Transient erythema
Hernández-Pérez et al. [40]	IPL (570/645 nm filter, 25–45 J/cm ² , double pulse, 2.4–7.0 milliseconds, 20 milliseconds delay)	5	+	nn	nn	Full face	5	3 months	Improvement between moderate and very good in terms of wrinkles, dilated pores, thick skin, oily skin, general appearance of the skin	Transient erythema and fine desquamation of the skin

nn, not named; pat., patients; postinflam., postinflammatory.

of the wrinkles was mild and did not correlate well with the histological findings in phase I. The side effects were transient erythema and edema as well as transient hyperpigmentation [13]. Phase III of the study is being currently completed.

Goldberg et al. also treated perioral and periorbital rhytides with a 1450 nm diode laser in a total of 20 patients; they observed moderate improvement among three patients and only mild one in 10 patients. Seven patients showed no clinical improvement. The profilometric findings were consistent with the clinical improvement. The most common side effects were edematous papules (lasting 1–7 days) and transient hyperpigmentation [14].

Dye laser (pulsed, 585/595 nm). The pulsed dye laser was first used by Zelickson et al. to treat sun-damaged skin. They succeeded in achieving 50% or more improvement in 9 out of 10 patients with mild to moderate wrinkling; 3 of 10 showed 75% or greater improvement. However, the patients with severe wrinkles did not have as much clinical improvement. The side effects they observed were postoperative purpura, swelling (1–2 weeks duration), and postinflammatory hyperpigmentation [15].

Bjerring et al. report a statistically significant reduction in facial rhytides. Unlike the findings of Zelickson et al., there were no side effects, which is most likely due to the much lower fluence they used. In addition, one group of 10 volunteers was selected for biochemical analyses. The same treatment protocol was used for their upper arms and forearms. After 72 hours of treatment a significant increase in type III procollagen could be found in the fluid of suction blisters over the treated area [16].

By contrast, Hohenleutner et al. were unable to find any improvement in the wrinkle lines of 11 of 12 patients 6 months after a single treatment with the 585 nm dye laser [17].

Rostan et al. first used the long-pulsed 595 nm dye laser in non-ablative treatment of moderate to severe photoaging and succeeded in attaining a significant improvement (18.1%) in the clinical grading of photodamage with minimal to no side effects [18].

Er:Glass laser (1540 nm). The 1540 nm Er:Glass laser has been described in human and animal studies [19].

Ross et al. did not identify any major clinical changes in their first human study after treating the retroauricular region. The side effects consisted of postoperative swelling and erythema for not more than 2 weeks; in some cases there was scarring, although more precise information was not provided about the numbers of patients affected [20].

Fournier et al. included a total of 60 patients with periorbital and perioral rhytides in their trial. Then they assessed the clinical findings of 52 patients and the histological results of three patients. Furthermore, they performed ultrasound imaging on four patients and silicone imprints of the depth of wrinkles on 16 patients to determine the anisotropy of the skin. A total of 62% of the patients stated that they were satisfied to very satisfied 6 weeks after the final session. Ultrasound imaging and profilometric evaluation demonstrated an increase of the dermis thickness up to 17% and a reduction of anisotropy of

40.2%, but none of the patients had full clearance of the wrinkles. No side effects were reported [21].

Lupton et al. also treated perioral and/or periorbital wrinkles in a total of 24 patients, all of whom showed a 25–50% improvement in their wrinkle score 6 months after the last session of laser treatment [22].

Nd:YAG laser (Q-switched, long-pulsed, 1064/532 nm). The Q-switched Nd:YAG laser was the first laser used as a non-ablative tool for skin rejuvenation. In their study, Goldberg and Witworth compared the Q-switched Nd:YAG laser with the Silk Touch CO₂ and the UltraPulse CO₂ laser. The CO₂ lasers demonstrated improvement in all patients. In 3 of 11 patients the Q-switched Nd:YAG laser produced results that were indistinguishable from that of the pulsed CO₂ lasers. In six patients clinical improvement was noted with the Q-switched Nd:YAG laser, but this was not as marked as with the pulsed CO₂ lasers. In two patients, no improvement with the Q-switched Nd:YAG laser was noted. The adverse effects from the use of the Nd:YAG laser were pinpoint bleeding and transient erythemas. The reepithelialization lasted an average of 3–5 days. The three patients with the clinical improvements comparable to the result achieved with the CO₂ laser, however, had erythema at the Nd:YAG sites even after 1 month, whereas the poor responders did not [23].

An improvement in the grade of wrinkles or the skin texture and elasticity by use of the Q-switched Nd:YAG laser was also cited in two additional studies by Goldberg et al. and one by Cisneros et al. In their first study Goldberg et al. reported about 97% improvement of wrinkles that was classified at least as “slight;” the investigators in the second study stated that there was clinical improvement in rhytides in six of eight patients which qualified at least as “fair.” Cisneros et al. achieved good results in all 22 patients with facial rhytides. The most common side effects were pinpoint bleeding and petechiae, transient erythema, and postinflammatory hyperpigmentation [24–26].

A pilot investigation to determine the treatment effect of a long-pulsed (2 milliseconds) frequency-doubled KTP Nd:YAG laser for mild-to-deep lip wrinkles and mild to moderate acne scarring was published by Bernstein et al. in 2001. Subjective assessment by the patients revealed an average improvement of 51.4% in upper lip wrinkles and 53.6% in acne scarring. Side effects were limited to transient erythema that resolved within maximum 2 hours [27].

Nd:YAG laser (long-pulsed, 1320 nm). The 1320-nm Nd:YAG laser was the first commercially available system designed exclusively for non-ablative facial rejuvenation. Two studies by Goldberg about treating facial wrinkles caused by UV exposure yielded similar findings: in both cases, 10 patients were involved in the study, and in each study two patients showed substantial improvement; six and four patients, respectively, showed some improvement; and two and four patients, respectively, experienced no clinical improvement of the rhytides. The adverse effects mainly consisted of postoperative transitive edema and erythema [28,29].

Menaker et al. demonstrated a 1-point (on a 0–5 point scale) improvement of wrinkle score in 4 of 10 patients, 3 months posttreatment; Kelly et al. achieved a small but statistically significant improvement in mild to moderate and severe rhytides 12 weeks after the final treatment. A final assessment 24 weeks after the final laser treatment showed a statistically significant improvement only in the severe rhytides group. The adverse effects in both studies were erythemas, blisters, and postinflammatory hyperpigmentations. There was scarring in three and two cases, respectively [30,31].

Levy et al. treated 13 patients in the periorcular region with the 1320-nm Nd:YAG laser. Furthermore, all patients were treated in the periauricular region for skin biopsies. Surprisingly, almost all failed to see any improvement, although the histological findings were promising and the profilometric measurements showed a marked reduction in the average roughness of wrinkles in four patients and a fair reduction in seven subjects [32].

Similar results were demonstrated by a subsequent study of 10 patients performed by Trelles et al. [33].

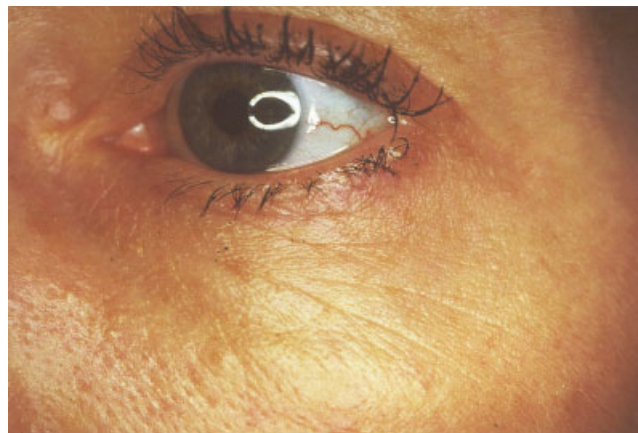
Drosner et al. only succeeded in achieving a transient improvement of a few weeks duration in the periauricular rhytides of 1 of their 10 patients (unpublished data, Fig. 1a–c).

IPL technology (500–1200 nm). Goldberg et al. demonstrated a substantial improvement in wrinkle severity 6 months after the final treatment with IPL technology in 9 of 30 patients. A total of 16 subjects showed some apparent clinical improvements and five subjects showed none. Three patients had transient blistering after at least one session [34].

A comparative study of high-energy flashlamp and Q-switched Nd:YAG lasers led to an analogous mild to moderate improvement in skin structure with no statistically significant difference in the subjective degree of improvement between the treatment groups. No subject showed marked or total improvement [35]. In a third publication there was only an analysis of histological findings [36].

Bitter et al. observed an improvement of 10–90% in terms of wrinkles and skin texture, irregular pigmentation, pore size, and telangiectasias; the greatest successes were visible in wrinkles, dilated pores, and telangiectasias. The main side effects observed in all patients were blisters and transient erythema [37].

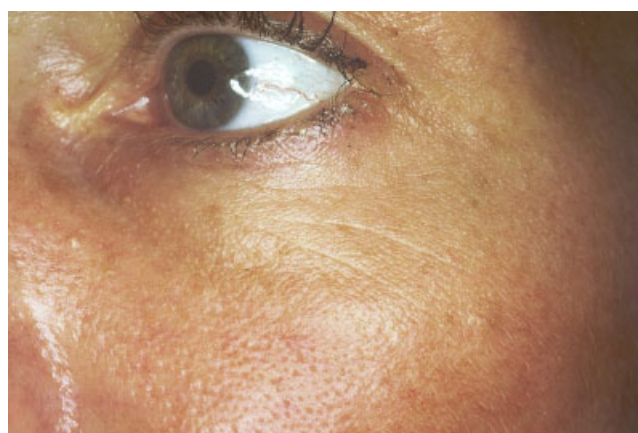
Negishi et al. first performed the technique of non-ablative skin rejuvenation with an IPL system in patients with skin types IV–V. A combined rating of both patients and physicians revealed a “good” or “excellent” improvement in 90% of the patients for pigmentation, in more than 83% of the patients for telangiectasias and in more than 65% of the cases for skin texture. A reduction of facial wrinkles was only present in a few cases. Transient erythema and blistering were the most commonly reported adverse effects [38]. An additional study of a total of 73 patients showed a 79–100% improvement of skin condition in 80.9% of patients with irregular pigmentation as well as 81.2% patients with telangiectasias. A total of 55.9%



a



b



c

Fig. 1. **a:** A 47-year-old female patient with periorbital wrinkles (2/00). **b:** Status 6 weeks after two subsurfacing treatments with a 1320 nm Nd:YAG laser at intervals of 6 weeks: discrete improvement of the wrinkles (4/00). **c:** Results 3 months after last treatment: regression of wrinkles (7/00) (reprinted with the kind permission of M. Drosner, MD, in Munich).

showed an improvement of 79–100% in fine wrinkles and 87.9% experienced 79–100% improvement of skin texture or smoothness. Mild transient erythema was reported as a side effect [39].

Hernández-Pérez et al. demonstrated a clinical improvement of moderate to very good in terms of the clinical features of photodamaged skin in Hispanic women (wrinkles, dilated pores, thick skin, oily skin). The side effects were transient erythema and fine desquamation of the skin [40].

Non-ablative radiofrequency. A radiofrequency (RF) device has also been tested for non-ablative facial rejuvenation by selective dermal heating. Unlike laser application, in which laser light is converted into heat, in the RF device electric current generates heat through resistance in the dermis. Preliminary studies suggest that RF power is able to achieve selective thermal heating at superficial levels in the papillary dermis as well as at deep levels (such as the subcutaneous fat) without losing energy to other absorbent structures (e.g., hemoglobin, melanin) and without epidermal damage. Clinical trials are underway to examine the efficiency of RF for superficial and deep skin tightening [41,42].

Histological Results

In some of the trials discussed above, biopsies of the skin were taken before treatment began as well as after a follow-up period of 1–6 months. The biopsy sites were usually parallel to the facial regions being treated and were taken from less visible areas (e.g., preauricular region, postauricular region). In comparison to the initial findings, in every case the histological assessments showed a marked increase in the fibroblasts in the dermis. At the same time, new collagen formation was observed, as was an increase in homogeneity in the papillary dermis and that of the reticular dermis below [11,15,19,28–30,36,37,43]. In his comparative histological study, Zelickson reports increased formation of collagen I and III, elastin, procollagen, and hyaluronate receptors after treatment with an intense pulsed light source (in 100% of specimens) and less after treatment with the pulsed dye laser (85.7% of specimens). The formation of collagenase, on the other hand, was induced primarily by the treatment with the pulsed dye laser (85% of specimens with pulsed dye laser versus 50% of specimens with IPL) [44]. Hardaway et al. clearly observed dermal fibrosis 2 months after treatment with the 1450 nm mid-infrared diode laser; however, the mild clinical improvement of the skin did not correlate to the degree of histological changes [12,13]. Similar discrepancies between histological and clinical findings were observed by Trelles et al. and Levy et al. [32,33].

DISCUSSION

“Once a technique or instrument is brought to the public’s attention by newspapers, television, radio, woman’s magazines or other forms of advertising, the scientific evaluation is over, and the race is on. . . The quickest way to force acceptance of a medical technique or instrument is to convince the public, who in turn convince physicians, who

demand approval and use. Again, the rational is that ‘If I don’t do it, someone else will.’ This is the new scientific method in medicine.” (Rox Anderson 1985) [45].

The research on non-ablative facial rejuvenation is the focus of controversial discussion, since none of the scientific analyses published to date could prove any clearly reproducible successes or therapeutic strategies [46,47].

The basic problem with all of the studies on subsurfacing is an issue of methodology. There are no standard and objective means of assessing the elasticity, irregular pigmentation, depth of wrinkles, and telangiectasias. The clinical findings are ultimately dependent on the subjective evaluation of physicians and/or patients. Photodocumentation has also shown to be an inadequate way of depicting the quality and persuasiveness of subsurfacing. In several studies, the different lighting conditions of pre- and post-operative photos, and the varying angles at which the photos are taken make it challenging to conclusively determine an improvement in the severity of rhytides [14,21,28,30,33,35,37,40]. The relatively new method of optical profilometry accompanied by silicone imprints was implemented by four authors. Goldberg et al. and Fournier et al. were the only ones for whom the profilometric findings corresponded to the clinical improvement of the wrinkle depth [14,21]. Trelles et al. and Levy et al., on the other hand, showed results from profilometric measurements that indicated much greater successes in terms of wrinkle depth than the clinical findings expressed [32,33]. For reasons such as these, the true reliability and persuasiveness of this method of analysis is debatable.

IPL technology and a total of six different laser systems were used in these studies, although none led to clinical guidelines as far as suitable wavelengths, fluences, or pulse duration were concerned. The lack of proof of a specific absorbent target structure for subsurfacing certainly makes it more difficult to make a decision about the ideal equipment or treatment parameters.

The issue of the mechanism of action is also largely unresolved. It is assumed that an unspecific heating and damage of dermal collagen occurs which leads to the subsequent formation of new collagen within the dermis. In some cases, the corresponding histological examinations have yielded noteworthy results such as marked dermal fibrosis or the formation of new collagen fibers. Unfortunately, in most studies these changes usually do not correspond to the extent of the clinical reduction of wrinkles, which is usually much lower [12,13,33].

An interesting discovery was made by Prieto et al. in the course of non-ablative skin-rejuvenation with IPL technology. They treated the faces of a total of five patients with mild solar damage using the IPL-technology. Before and after the first session, specimens of treated and untreated skin were taken. Histological examinations showed no difference in quantity, quality, or morphological changes of collagen, elastic, or reticular fibers. By contrast, however, coagulative necrosis stemming from the presence of demodex organisms and a concomitant remission of perifollicular inflammation were observed. This led the authors to the conclusion that the visible esthetic improve-

ment to sun-damaged skin after non-ablative IPL therapy could be due to the coagulative destruction of demodex organisms [48].

At this writing, the extent that histologically confirmed neocollagen synthesis is critical to the success of non-ablative treatment methods, nor is it known how long this process lasts when it is achieved. It is also yet to be determined what the role of histologically confirmed neocollagen synthesis is in the success of non-ablative treatment methods and how long it lasts if it does occur.

The primary goal expected of such non-ablative procedures is to accomplish a long-lasting, effective reduction of wrinkles without major side effects or long period of recuperation. Our own experiences and a critical assessment of the studies on this topic have shown that this, unfortunately, is not the case. The side effects range from minor transient erythemas and cosmetically undesirable purpura to pinpoint bleeding all the way to dyspigmentation and scarring. A healing period of 2 days to 2 weeks is reported. Goldberg et al. worked with the Q-switched Nd:YAG laser until pinpoint bleeding occurred, which means we can only speak of a partially non-ablative technique in this instance [26]. In the studies performed by Menaker et al. and Kelly et al., scarring was reported in three and two cases, respectively, after treatment with the 1320 nm Nd:YAG laser (CoolTouch[®]) [30,31]. The lowest rate of adverse effects was observed after treatment with IPL technology [34,35,37–40]. However, this method leads only to “mild” or “moderate”/“some” improvement in wrinkles. Bjerring et al. were the only ones to report a significant reduction in wrinkles and no side effects when pulsed dye laser was used [16].

In many publications, the side effects, some of which are quite severe, are the result of a treatment which results in only “some” improvement of minor wrinkles in 4 of 10 patients or “moderate improvement;” in one study, there was no improvement in facial wrinkles at all (see Table 1) [13,14,23,24,29,30,32,34,35]. It is thus questionable as to whether or not and to what extent a “moderate” improvement or “some improvement” in the wrinkle score can be distinguished from the initial findings, let alone seen as a therapeutic success.

In conclusion, it is our opinion that skin resurfacing by CO₂ and Er:YAG lasers is still the gold standard for treating mild rhytides that result from aging and UV exposure. Subsurfacing as a means of simple reduction of wrinkles does not provide any convincing advantages vis-à-vis ablative procedure. This is because of the much more limited prospects of success and the side effects described; all in all, subsurfacing cannot be recommended as an equally viable alternative. If, however, non-ablative treatment methods are regarded as part of an comprehensive anti-aging program and accompanied by treatment of discrete wrinkles, solar lentigines, facial telangiectasias, and poikiloderma of Civatte, then they are certainly justified and very worthwhile as part of a regime of non-ablative facial rejuvenation.

We are facing the beginning of a promising development when it comes to the intense research in the field of non-

ablative treatment methods. Basic research in the future may be able to determine suitable target structures and optimal wavelengths so that one day subsurfacing may become the method of preference in treating wrinkles.

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