CLINICAL APPLICATIONS OF A NEW DEVICE FOR FRACTIONAL PHOTOTHERMOLYSIS

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Summary

Fractional photothermolysis, is a novel concept for treating the sequelae of cutaneous photoaging, skin pigmentation disorders, superficial vascular malformations, acne scars and stretch marks or striae. It creates a pattern of microscopic zones of tissue coagulation that heal over several weeks while the skin retains a normal appearance. Aim to achieve homogeneous thermal damage at a particular depth within the skin, fractional photothermolysis creates microscopic thermal wounds (microscopic treatment zones) and specifically spares tissue surrounding each wound. Fractional photothermolysis is a promising new modality that, based on this preliminary report, produces a consistent level of efficacy for the tested treatments with significantly reduced side effects.

Riassunto

La fototermodissoluzione è una nuova tecnica per trattare le sequele dell’invecchiamento cutaneo, le alterazioni della pigmentazione cutanea, le malformazioni vascolari superficiali, le cicatrici esito di acne e le smagliature. Questa nuova tecnica laser permette di creare una griglia di microscopiche aree di coagulazione cutanea che si rigenerano in alcune settimane lasciando alla cute un aspetto normale in ogni fase. Invece di creare un danno termico omogeneo, la fototermodissoluzione frazionale crea piccolissime aree di danno risparmiando il tessuto intorno ad ognuna di esse, in modo da avere dei serbatoi cellulari da cui far partire la rigenerazione.

Basandosi sui risultati di questo e di altri studi preliminari la nuova metodica sembra produrre miglioramenti consistenti per tutti gli inestetismi trattati con una frequenza molto bassa di effetti collaterali.
INTRODUCTION

Fractional photothermolysis, is a novel concept for treating the sequelae of cutaneous photoaging, skin pigmentation disorders, superficial vascular malformations, acne scars and stretch marks or striae. It creates a pattern of microscopic zones of tissue coagulation that heal over several weeks while the skin retains a normal appearance. Rather than creating a global tissue effect at the surface of the target tissue, or in the dermis alone, this treatment creates injury in a tiny fraction of the skin treated, coagulating multiple columns of tissue of about 100 µm in diameter, spaced 500 µm and extending through the epidermis and deeply into the dermis for about 500-700 µm. The number of microscopic thermal wounds can vary from 400 to 750 every spot. The laser tested in this study is an ER:Glass (erbium glass) laser whose wavelength of 1540nm is absorbed by the water of the skin cells and by means of its special lens array, it can stimulate the deep, the superficial dermis and epidermis at different temperature grades. It produces an evenly low level of thermal neocollagen and elastin stimulation on all the treatment areas and, in addition, a high level thermal heating and coagulation within the fractional areas.

In contrast to ablative skin resurfacing and non ablative dermal remodeling techniques which aim to achieve homogeneous thermal damage at a particular depth within the skin, fractional photothermolysis creates microscopic thermal wounds (microscopic treatment zones) and specifically spares tissue surrounding each wound. This laser treats about 20% of the skin with each session.

MATERIALS AND METHODS

Fifty five healthy subjects of Fitzpatrick skin type II–V received treatments with the Matisse® laser (Quanta System S.p.a., Italy). Matisse® laser (Quanta System S.p.a., Italy), uses fractional photothermolysis to achieve its clinical effect. 30 patients (25 females, 5 males aged 40-70 years, mean age 55 years) for treating the sequelae of cutaneous photoaging and pigmentation disorders, 10 patients (8 females, 2 males aged 20-35 years, mean age 26 years) for superficial low flow capillary vascular malformations or generalized telangiectasia syndrome, 5 patients (3 females, 2 males aged 25-50 years, mean age 34 years) for acne scars, 10 patients (7 females, 3 males aged 20-30 years, mean age 24 years) for stretch marks/striae.
Exclusion criteria were history of keloid formation, history of isotretinoin use within the last 6 months, current systemic infections, pregnancy and severe systemic or dermatologic diseases. No anesthesia was used to perform the exposures and for pain control was used the cooling device on the machine handpiece. Patients were photographed and evaluated preoperatively and at 1, 2, 4, 8, and 12 weeks after the last session. At each visit patients were asked to evaluate any difference noted. 3 months after the last session evaluation of results were made on a scale of 1-9, with 1 representing no results and 9 representing excellent results by a blinded physician and by patients themselves. Silicone negative imprints of the right cheek were made to the patients treated for sequelae of cutaneous photoaging.

**Photoaging and skin pigmentation disorders (Fractional Rejuvenation or Fractional Resurfacing).**

Photoaging refers to the clinically visible changes of skin chronically exposed to UV light. Mottled pigmentation in the form of both hyper and hypopigmentation, telangiectasia, coarsened texture, dull or sallow coloration, enlarged pilosebaceous units, wrinkles, and benign and malignant neoplasm are the clinical findings in photoaged skin. It has been well established that the wavelengths of UV radiation (UVA) are responsible for much of the visible changes of photoaging.

Until the middle of the 20th century, treatment options were limited to application of various natural and synthetic preparations to the skin, chemical peels or dermabrasion. The development of the pulsed CO2 laser/computerized pattern generator in the early 1990's, and the Erbium (Er:YAG) laser made it possible to obtain more consistent and predictable results than with the peels and dermabrasion, and led to the widespread acceptance of Ablative Laser Resurfacing by cosmetic surgeons and patients. Although highly effective for wrinkles, brown spots, and even sagging skin, the disadvantages of the Ablative Laser Resurfacing include discomfort, oozing wound as well as the long-term risk of scarring and changes in skin pigmentation.

During the late 1990's, Non-Ablative Laser Resurfacing became popular. Using a variety of laser wavelengths, or intense pulsed light sources some acting more towards the skin surface, some deeper in the collagen layers, Non-Ablative techniques are capable of improving skin texture, pigment abnormalities, and even some tightening occasionally, with no or minimal risk and without any downtime. However, multiple treatments are needed, and with a few unpredictable exceptions, the results are limited. During each treatment of fractional laser resurfacing millions of microscopic small volumes of thermal damage are distributed within the skin, the epidermal repair is fast, heals within 24 hours by keratinocyte migration into the defect. The barrier function of the epidermis is preserved during this process, no visible wound is created, so no wound care is needed and makeup can be applied immediately.
Patients should avoid taking oral retinoids for at least 3-6 months prior to treatment, and topical retinoids should be discontinued at least 2 weeks before treatment. The treatment is performed in the office. The treatment area is cleansed with a mild abrasive cleanser. The laser head is moved over the treatment area, using an overlapping technique, so that a total of 2-4 passes are made over each area. The skin is kept cool during the treatment. The actual treatment takes approximately 30 minutes. The energies and pulse durations were varied based on the grade of photoaging according to Glogau Wrinkle Scale and Fitzpatrick skin type.

<table>
<thead>
<tr>
<th>Glogau wrinkle scale</th>
<th>Findings</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td></td>
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<tr>
<td>1, no wrinkles</td>
<td>Early 20s or 30s</td>
</tr>
<tr>
<td>2, wrinkles in motion</td>
<td>30s to 40s</td>
</tr>
<tr>
<td>3, wrinkles at rest</td>
<td>50 plus</td>
</tr>
<tr>
<td>4, only wrinkles</td>
<td>60s or 70s</td>
</tr>
</tbody>
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<p>| Table II |
| Treatment Parameters |</p>
<table>
<thead>
<tr>
<th>Wrinkle scale</th>
<th>Age (years)</th>
<th>Laser Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, no wrinkles</td>
<td>Early 20s or 30s</td>
<td>No treatment needed.</td>
</tr>
<tr>
<td>2, wrinkles in motion</td>
<td>30s to 40s</td>
<td>Pulse duration 4-7 ms / 6-11 mJ spot 2/3 passages in overlapping.</td>
</tr>
<tr>
<td>3, wrinkles at rest</td>
<td>50 plus</td>
<td>Pulse duration 6-9 ms / 9-12 mJ spot 2 passages in overlapping.</td>
</tr>
<tr>
<td>4, only wrinkles</td>
<td>60s or 70s</td>
<td>Pulse duration 6-10 ms / 9-13 mJ spot 2 passages in overlapping.</td>
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</tbody>
</table>

In Fitzpatrick skin types V-VI, to avoid post-inflammatory hyperpigmentations it is better to use the treatment parameters of the Glogau wrinkle scale 2 in every case. Immediately after treatment a sensation of heat or "sunburn" is common, lasting about 30 minutes, and is easily relieved by cool compresses and only moisturizers and zinc sunscreens are used on the face. In the week after treatment, the skin may become somewhat dry and red. This "bronzed" appearance and dryness is from the surface of each laser "spot" separating and sloughing off. During this time potentially irritating skin products such as AHAs or retinoids should be avoided. In most cases, the redness and bronzing will gradually improve over a week. The intervals and numbers of sessions vary also with Glogau wrinkle scale.
Table III

<table>
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<tr>
<th>Wrinkle scale</th>
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<th>No treatment needed</th>
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<td>1, no wrinkles</td>
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<td>30s to 40s</td>
<td>4 sessions/ interval 2-3 weeks</td>
</tr>
<tr>
<td>3, wrinkles at rest</td>
<td>50 plus</td>
<td>5 sessions/ interval 2-3 weeks</td>
</tr>
<tr>
<td>4, only wrinkles</td>
<td>60s or 70s</td>
<td>6-7 sessions/ interval 2-3 weeks</td>
</tr>
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Skin superficial low-flow capillary vascular malformations and generalized telangiectasia syndrome.

Two common capillary vascular malformations are the salmon patch (naevus simplex) and port wine stain (naevus flammeus). Salmon patch are very common and occur in about 40% of all newborns. They are usually small flat patches of pink or red skin with poorly defined borders. Most lesions will spontaneously disappear within the first year of life.

Port Wine Stain are much less common than salmon patches, occurring in about 0.3% of newborns. A port wine stain is usually a large flat patch of purple or dark red skin with well-defined borders. At birth the surface of the port-wine stain is flat, but in time it becomes bumpy and often more unsightly. The face is most commonly affected although they can occur anywhere on the body. Where present, they generally appear on one side of the body with a sharp mid-line cut-off.

Some port wine stains may fade over time but most remain unchanged or may even deepen in colour. They do not shrink by themselves or disappear spontaneously. If the port-wine stain affects the face and neck, it may have a severe impact on the social, psychological and economic development.

Generalized telangiectasia syndrome refers to telangiectases that develop in the absence of any preceding or coexisting cutaneous or systemic disease.

Different presentations of primary telangiectases have been arbitrarily classified as distinct syndromes, designated by terms that often are descriptive based on inheritance, age of onset, anatomic distribution, morphology, prognosis, or associated findings. No recognized nomenclature exists for these telangiectatic disorders. Generalized essential telangiectasia (GET) refers to one syndrome of acquired primary telangiectases that are so termed because of their widespread anatomic distribution. The physiologic factors causing blood vessel dilatation in GET are yet to be elaborated. Familiar cases have been reported with an autosomal dominant pattern of inheritance. Unlike other laser sources and intense pulsed light devices, which relies on selective absorption of broadband light by hemoglobin, the 1540nm wavelength has a direct thermal effect on the dilated vessels in the upper dermis with a random pattern of coagulation and a progressive discoloration of the vascular lesions. In this way we can avoid an extensive thermal damage to the skin due to the excess of haemoglobin present in these lesions.

The treatment is performed in the office. The treatment area is cleansed with a mild abrasive cleanser. The laser head is moved over the treatment area, using an overlapping technique, so that a total of 3-4 passes are made over each
area. The skin is kept cool during the treatment. The energies and pulse durations varies. 10-13 mJ/spot with a pulse duration of 7-10 ms. The end point after each session is a remarkable discoloration of the vascular lesion followed by a mild redness. The interval between sessions is about 2 weeks and the number of sessions vary from 4 to 7 according to the lesion severity and extension. After the treatment cool compresses must be applied and only moisturizers and zinc sunscreens used.

**Acne scars**

Acne is one of most common skin conditions in the world. Nearly 80 percent of people aged 11 to 30 years have acne, most often on the face, chest and back. However, acne is not restricted to any age group; adults in their 20s, 30s and even into their 40s can get acne. Most cases of acne responds to treatment and clears up without leaving scars. Healed acne does leave scars in some people, however, and it is not easy to predict who will have scars after acne and who will not. Severe, inflamed, cystic acne always leaves scars after healing, but in some people even superficially inflamed acne can result in scarring.

Whether acne scarring is deep or superficial, extensive or scattered, the esthetic result can be less than desirable and even disturbing. Acne scars can give the skin an "old" look. Scars may also contribute to an appearance of age as the skin loses its elasticity over the years.

A number of treatments are available to remove or improve acne scars. Acne scars result from two types of tissue response to the inflammation of acne: (1) increased tissue formation, and (2) loss of tissue. Increased tissue formation are scars caused by increased tissue formation by a build up of collagen in the skin. These are called hypertrophic and keloid scars.

Scars resulting from loss of tissue are more common than scars resulting from increased tissue formation. The last type of scars will benefit of fractional photothermolysis.

The treatment is performed in the office. The treatment area is cleansed with a mild abrasive cleanser and 8% glycolic acid lotion. The laser head is moved over the treatment area, using an overlapping technique, so that a total of 4 passes are made over each area. The skin is kept cool during the treatment. The energies and pulse durations varies. 8-12 mJ/spot with a pulse duration of 6-10 ms. The interval between sessions is about 2 weeks and the number of sessions vary from 4 to 5 according to the lesions severity and extension. After the treatment cool compresses must be applied and only moisturizers and zinc sunscreens used.

**Stretch marks or striae**

Stretch marks or striae are a form of scarring on the skin with a silvery-white hue. Stretch marks are generally associated with pregnancy, obesity, bodybuilding, puberty, and intense physical activity. They result from overstretching of the skin, which disrupts the normal production of collagen, causing a scar. They first appear as reddish or purple lines, but tend to gradually fade to a lighter color. The affected areas appear empty and soft to the touch.

This common condition will benefit of fractional photothermolysis.

The treatment is performed in the office. The laser head is moved over the treatment area, using an overlapping technique, so that a total of 3 passes are made over each area. The skin is kept cool during the treatment. The energies and pulse durations varies. 8-12 mJ/spot with a pulse duration of 6-9 ms. The interval between sessions is about 3 weeks and the number of sessions vary from 3 to 4. After the treatment cool compresses must be applied and elasticizing...
ointment was applied daily with a massage.

RESULTS

No major complications were seen. Complications of fractional laser are rare. Mild blistering, especially on the chin and temples may occur at higher powers and densities, and these have healed nicely. Scarring from the procedure is virtually unknown. Hyperpigmentation may occur in darker skinned patients, or patients prone to discoloration. The debris from the epidermal wound forms a "button" of Microepidermal Necrotic Debris (MEND), which sometimes give the treated area a bronzed appearance, until they are shed a few days to a week later. In the group of 30 patients (25 females, 5 males aged 40-70 years, mean age 55 years) treated for photoaging and pigmentation disorders the average results are 8.0 (1 no result, 9 excellent results) in patient self evaluation and 7.5 in physician's evaluation, with remarkable confirmation of skin texture improvement documented with silicone negative imprints. In the group of 10 patients (8 females, 2 males aged 20-35 years, mean age 26 years) treated for superficial low flow capillary vascular malformations or generalized telangiectasia syndrome the average results are 7.5 (1 no result, 9 excellent results) in patient self evaluation and 8.0 in physician's evaluation. In the group of 5 patients (3 females, 2 males aged 25-50 years, mean age 34 years) for acne scars, the average results are 7.5 (1 no result, 9 excellent results) in patient self evaluation and 7.5 in physician’s evaluation. In the group of 10 patients (7 females, 3 males aged 20-30 years, mean age 24 years) treated for stretch marks or striae the average results are 7.0 (1 no result, 9 excellent results) in patient self evaluation and 6.0 in physician's evaluation.

DISCUSSION

The 1540-nm is a mid-infrared wavelength of light, largely absorbed by intracellular and extracellular water in the skin, similar to the way that the light from resurfacing lasers is absorbed. This is not a wavelength at which there is high absorption of hemoglobin or melanin (the other main chromophores targeted in other light-based skin therapies). The penetration of light into the skin is much deeper than with carbon dioxide or Erbium:YAG (Er:YAG) laser wavelengths. Each pulse of laser light fired into the skin creates a column of coagulated tissue, extending from the surface of the epidermis into the dermis. Fractional photothermolysis treats a small fraction of the skin, leaving intact, undamaged skin around each treated area to act as a barrier and a reservoir for rapid healing. Interestingly, healing of the dermal layers seems to lack an "inflammatory" phase, especially at low microscopic treatment zones densities, although there is histological evidence of collagen remodeling and clinical evidence of skin tightening. Preservation of barrier function following treatment may explain the lack of clinically evident oozing and crusting and the absence of skin infections noted. Even more interestingly, although near- and mid-infrared laser wavelengths are poorly absorbed by melanin, there appears to be a controlled melanin release with melanin concentration in the microepidermal necrotic debris that act as "melanin shuttle", which are subsequently shed. The very good results showed by the use of this laser in the different clinical conditions described above are very good and demonstrate the versatility of this device with almost no risk for major complications. The device is very easy to use. The learning curve is also very shallow. There is almost no downtime whatsoever and almost no patient discomfort during treatment. It's use in superficial capillary vascular malfor-
Clinical applications of a new device for fractional photothermolysis

mations is a new application for fractional photothermolysis.

CONCLUSION

Fractional photothermolysis is a promising new modality that, based on this preliminary report, produces a consistent level of efficacy for treatment of photo aged skin, acne scars, capillary vascular malformations, stretch marks with significantly reduced side effects.
References


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