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ORIGINAL ARTICLE

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A pilot study on the use of a plasma skin regeneration device (Portrait® PSR^3) in full facial rejuvenation procedures

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Abstract A new modality, the Portrait plasma skin regeneration (PSR^3) system, allows precise and rapid treatment of photo-damaged skin, with controlled thermal injury and modification. Radio frequency (RF) energy converts nitrogen gas into plasma within the handpiece. Rapid heating of the skin occurs as the plasma rapidly gives up energy to the skin. This energy transfer is not chromophore dependent. The gold standard, carbon dioxide (CO_2) laser resurfacing, has decreased in popularity due to high morbidity and downtime. There is demand for a technology that can provide the degree of improvement obtained with resurfacing without the complications associated with its use. This study evaluated the PSR^3 technology in full facial procedures. A two-site prospective study evaluated safety and efficacy for a single pass treatment of the full face using the Portrait PSR^3 system. Improvement in skin texture, tone, fine lines, dyschromia, and rhytides were assessed. Two-millimeter punch biopsy specimens were taken pre- and 90 days post-treatment. Follow-up was performed at days 2, 5, 7, 30, and 90 post-treatment to monitor recovery, improvement, and any subsequent sequelae. Patients developed erythema and edema shortly after treatment, with no immediate epidermal loss or charring. Epidermal loss occurred in the subsequent 24–48 h followed by epidermal recovery in ~7 days. Histological investigation showed regenerative epidermal and dermal architecture. The Rhytec Portrait PSR^3 system provides an attractive alternative to standard lasers that is well tolerated by patients, stimulates collagen remodeling, and provides excellent clinical outcomes.

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Background

The use of high energy, pulsed, and scanned lasers in performing cutaneous resurfacing of the face is well-established [1]. The gold standard treatment of facial rhytides, carbon dioxide (CO_2) laser resurfacing, has decreased in popularity due to the high morbidity and downtime associated with its use [2, 3]. There is still a demand, however, for a technology that can provide the degree of improvement obtained with resurfacing without the complications associated with its use. A new energy modality has recently been added to the aesthetic physician's armamentarium, which achieves results similar to these resurfacing lasers. The Rhytec Portrait® PSR^3 System allows precise and rapid treatment of tissue with minimal thermal injury to surrounding tissues. Ultra high frequency RF (radio frequency) energy from the generator excites a tuned resonator within the handpiece that converts nitrogen gas into plasma within the handpiece. Nitrogen gas was chosen to produce the plasma because of its unique properties as an inert diatomic molecule, which locks up energy in a predictable manner when excited. The plasma emerges from the nozzle at the distal end of the handpiece and is directed onto the skin to be treated, with no RF energy being transferred to the patient. Rapid heating of the skin occurs as the excited gas forming the plasma gives up energy to the skin. Unlike lasers, this energy transfer is not chromophore dependent.

Through essentially instantaneous generation of plasma, individual plasma pulses of 6 mm diameter are produced, which will give predictable tissue effects. A 5-mm gap between the distal end of the nozzle and the target tissue provides consistent energy delivery to the skin in line with displayed values. Reducing the distance below 3 mm results in an increase in energy delivery compared to displayed values, whereas extending the distance beyond 8 mm reduces the energy delivery compared to displayed values. This latter technique can

be of value when working along the mandibular line to produce a "feathering" effect.

The plasma is characterized by a yellowish color, known as the Lewis–Rayleigh afterglow, with energy locked up in metastable states of nitrogen molecules. Adjustment of the RF power and RF pulse width by the generator enables control of tissue effects by altering the amount of energy contained in the plasma pulse. The energy per pulse is adjustable by the user from 1 to 4 J, in 0.1-J increments, with a pulse width of approximately 15 ms at the 4-J setting.

A spectrum of effect is therefore possible, achieved by efficiently transferring energy to the skin via thermal conduction, with the amount of energy varied according to the energy setting employed. Energy delivery is essentially Gaussian in distribution, with nominal overlap of pulses desirable. The depth of effect is dependent upon the amount of energy delivered per pulse. As PSR is not dependent upon a chromophore in the skin to mediate energy absorption, a unique thermal profile is observed histologically, as a result of evenly delivering energy to the target tissue.

The treated stratum corneum and epidermis are left intact after treatment. This has the benefit of providing a natural biological barrier while the wound healing mechanism is initiated. The continuous, intact epidermis supports faster healing and a microenvironment supporting skin regeneration. Due to the plasma pulse purging oxygen from the impact site, no oxidative carbonization or vaporization is seen. Therefore, the potential for unpredictable hotspots and charring, which can result in scarring, is minimized.

The effect of PSR plasma on the skin architecture is characterized by two zones of effect: a zone of thermal damage (ZTD), wherein the cells are rendered non-viable, and a zone of thermal modification (ZTM), wherein the cells are thermally modified, yet remain viable (Fig. 1). A pre-clinical study has demonstrated that applying two pulses of energy to the same location results in a nominal increase in the ZTD of approximately 10 μm at high energies. This is hypothesized as being due to vacuolation of cells at the limit of the ZTD, noted histologically, where the cell cytoplasm is turned to vapor, resulting in an insulative phenomenon occurring that limits the absorption of further energy.

The non-viable treated skin, denoted as the ZTD, sheds from the treated skin architecture 48–96 h post-treatment, by which time a new epidermal layer has formed. The ZTM provides an environment that supports intense physiologic activity that initiates and supports ongoing skin regeneration. At high energy settings, temperatures averaging 60°C are achieved in the dermis to a depth of approximately 500 μm. The subsequent modification of the treated dermal layer is sufficient to cause a degree of denaturation, yet the cells remain viable; this is evident as the thermally modified zone does not slough in the post-treatment phase. This zone becomes the site of intense fibroblast activity at around day 10 after treatment, resulting in the deposition of new collagen and elastin fibers. Unlike the remodeling seen post-CO_2 laser treatment, where new collagen is laid down in a planar fashion, the remodeling seen post-PSR treatment is characterized by the collagen and elastin fibers being oriented perpendicular to the dermo/epidermal (D/E) junction in a matrix formation.

Supporting clinical work

During the course of 2003, a number of clinical studies were performed in the US with the Portrait® PSR^3 system (the investigational device). The purpose of the initial study, conducted by Ronald Moy M.D. and Jean-Francois Tremblay M.D. at the University of California Los Angeles (UCLA) Medical Center in Los Angeles, was to characterize the performance of the system across its energy spectrum on human skin. Twelve patients underwent treatment on a 2×2 cm post-auricular skin site. Patients were treated with a single non-overlapping pass at energy settings of 1, 2, 3, or 4 J. Clinical evaluation and skin biopsies were performed on days 0, 10, and 30 after treatment. Skin biopsy specimens were examined blinded to the energy setting used.

Treatment resulted in immediate and energy-dependent erythema, edema, and de-epithelialization with minimal charring. Utilizing temporary tattoos as markers, measurable

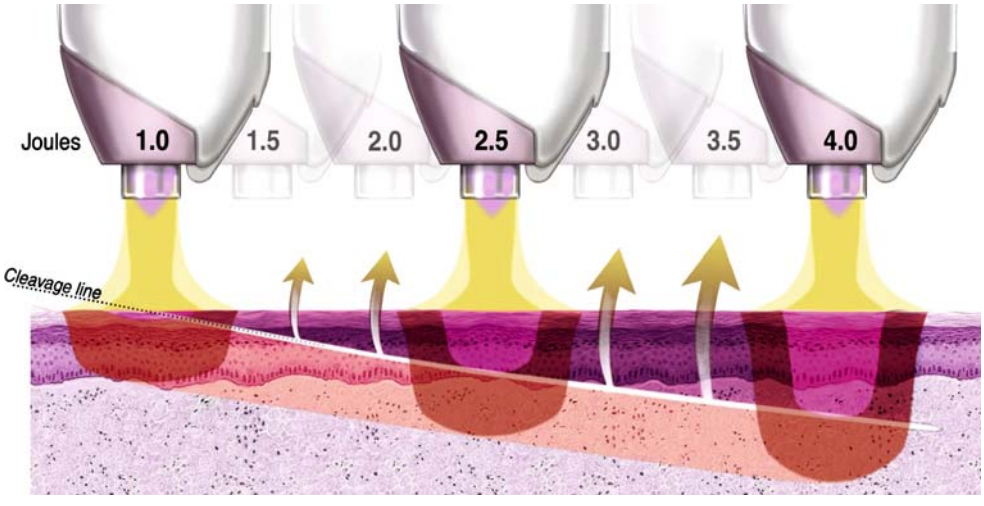

Fig. 1 The two zones of effect: the ZTD (*purple*) and the ZTM (*red*)

immediate linear skin contraction averaging 11.6% (n=6) was observed using the high-energy settings of 3 and 4 J. All treated areas were completely re-epithelialized within 7 days. No scarring was observed. Thermal injury was limited to the epidermis and dermo-epidermal junction using 1 or 2 J. Thermal injury reached the papillary dermis averaging 8.2 and 11.8 μm in depth below the D/E junction using 3 and 4 J, respectively. At day 10, the epidermis appeared mildly thickened. The dermis showed a moderate inflammatory infiltrate with increased vascular density. Evidence of collagen remodeling was observed in the papillary dermis at day 10 and 30 at energy settings of 2 J and above. In the case of 2 J, the remodeling was patchy.

This study was followed by further studies designed to investigate the therapeutic benefits of treating peri-oral and peri-orbital rhytides with the investigational device. Drs. Moy and Tremblay performed a study on peri-orbital rhytides at the UCLA Medical Center. Twelve patients with skin types I–III and having peri-orbital rhytides were treated with one to two passes (1.5–3.5 J) of non-overlapping pulses using the investigational device. Follow-up visits were scheduled at 10 days, 1, and 3 months after treatment. Clinical assessment was performed at baseline and at each subsequent visit using standardized digital photography analysis, blinded observer assessment and patient questionnaires. The procedure was well tolerated by all patients. Side effects included erythema, edema, and epidermal de-epithelialization. No scarring or dyspigmentation was observed. Peri-orbital skin was completely re-epithelialized within 5 to 7 days with minimal residual erythema at day 10. All patients showed at least 30–50% improvement in skin texture and severity of peri-orbital rhytides at day 10 and 30. Additional improvement was observed at 3 months. Patients' self-assessment paralleled the clinical improvement measured. Patients satisfaction rate was found to be moderate (2 pts.) to high (8 pts).

Richard Fitzpatrick M.D. of La Jolla Cosmetic Surgery Center, La Jolla, CA and Roy Geronemus M.D. of the Laser and Skin Surgery Center of New York, NY performed a two-site study on peri-oral rhytides. A total of 24 patients at the two sites comprised this study. Patients had their upper lip treated with the investigational device. Patients were allocated into six groups treated at a specific energy setting, ranging from 1.5–4 J. Two patients from each group were treated with a single pass and two with two passes. Two-millimeter punch biopsies were taken for histopathology analysis immediately after treatment and at 30 days, subject to patient consent. Skin treated with the investigational device showed a range of tissue effects across the energy settings. These consisted of mild erythema and desquamation at the low-energy settings and more persistent erythema with desquamation at the high-energy settings. The epidermal layer remained in situ immediately post-treatment and was shed over the after 48–72 h. All treatment sites had fully regenerated epidermis at the day 10 follow-up, with energy dependent levels of collagen remodeling.

After the completion of these studies, an analysis of the data was performed. Based on this analysis, a new protocol was raised to evaluate the efficacy of the investigational device in treating photodamage on the full facial unit. The study consisted of an evaluation of high-energy settings (3–4 J) used in a single treatment, single pass protocol.

Single pass high energy investigation design

The design of the investigation was to evaluate the safety and efficacy of the Portrait® PSR^3 technology in the treatment of the full face in a two-site prospective study. Subject to patient consent, the treated skin was biopsied at the time of surgery and at 90 days post-procedure, with samples sent for histopathological investigation. For each area treated, healing time, quality of regenerated epidermis, post-operative discomfort, ZTD, and amount of erythema were recorded. Patients had samples from their day 90 biopsies sent for analysis of the ZTD, basal vacuolarization, epidermal vacuolarization, dermal inflammation, and overall epidermal quality.

The two sites comprised Suzanne Kilmer M.D. of the Laser and Skin Surgery Center of Northern California, Sacramento, CA and Richard Fitzpatrick M.D. of La Jolla Cosmetic Surgery Center, La Jolla, CA as the principal investigators. A total of 24 patients were enrolled across the two sites. All treatments were carried out using a topical anesthesia regime, supplemented with oral medication (comprising Valium 10 mg and Vicodin×2) at the Sacramento site. During the course of the study, the use of oral medication as an adjunct to the topical anesthesia regime was adopted at the second site. The patient cohort was divided into three groups, with each group treated at a specific energy level, rising in 0.5-J increments ranging from 3–4 J. The patients in each group were treated with a single pass with no wiping of the treated epidermal layer after the procedure. The purpose of the study was to assess the efficacy of PSR in improving skin texture, tone, fine lines, and dyschromia. Follow-up was performed at days 2, 5, 7, 30, and 90 post-treatment to monitor post-treatment recovery, improvement, and any subsequent sequelae to treatment.

The investigations were undertaken in compliance with the Code of Federal Regulations, as specified in 21 CFR 812, and according to the principles of clinical investigation of medical devices for human subjects specified in BS EN (ISO)14155.

IRB approval

The protocols were submitted for the Institutional Review Board (IRB) review and approval before commencement of the investigation. Patients entered into the investigation were required to sign a photographic release form, an informed patient consent form, and authorization form (permitting release of their information to the company in compliance with the Health Insurance Portability and Accountability Act) and were managed in accordance with routine practice.

Inclusion criteria

It was agreed with the principal investigators that enrollment would include any patient who consented to participate in the investigation who would otherwise have been receiving ablative therapy for photodamage, with no limitation with regard to skin types.

Exclusion criteria

The following exclusion criteria were employed:

1. Any patient not considered suitable for entry by the investigator,
2. Any patient who declined to participate in the investigation,
3. Any patient who was under the age of 18, and
4. Any patient who was pregnant.

Treatment protocol

The two sites performing the study, Dr. Fitzpatrick in San Diego and Dr. Kilmer in Sacramento, treated patients at discrete energy settings (range 3–4 J).

Patients were treated in the offices of the principal investigators using their existing treatment suites. The patients were treated as day cases. All treatments were carried out using a topical anesthesia regime (EMLA) applied to the face under occlusion for 2 h before treatment. Dr. Kilmer also provided her patients with oral medication comprising Valium 10 mg and Vicodin×2 pre-treatment. This is in line with her standard protocol for performing full face resurfacing using a CO_2 laser. Dr. Fitzpatrick adopted the use of oral medication as an adjunct to the topical anesthetic regime during the course of the study. In this case, oral medication comprised either 800 mg Ibuprofen, 1×Vicodin, or 1×Xanax pre-treatment.

Patients were allocated into one of three groups; each group were treated at a specific energy setting, ranging from 3.0–4.0 J, of non-overlapping pulses of energy. Each group was treated with a single pass, with no wiping of the treated area after the conclusion of the procedure.

Each patient was scored by the physician in terms of severity of wrinkles (wrinkle severity: no wrinkles=1, fully wrinkled=9) before treatment and at the 90 day follow-up. Physician scoring of textural irregularity was also performed at these time points using the following method:

1. Completely smooth without lines;
2. Mild papular or linear textural changes as seen in early photodamage;
3. Moderate papular or linear textural changes as seen in significant photodamage;
4. Widespread, easily seen papular or linear surface irregularity as in cutis rhomboidalis.

Subject to patient consent, 2-mm punch biopsies were taken for histopathological analysis pre-treatment and at the conclusion of the 90-day follow-up period. The biopsies were taken from the lateral canthus at the San Diego site and from the pre-auricular area at the Sacramento site. Petrolatum-based or topical antibiotic ointment was prescribed for the patient (depending on allergies) for post-treatment application. Simple dressings were provided for up to 10 days post treatment if required. The patient was free to return home after the treatment.

Follow-up visits were performed on days 2, 5, 7, 30, and 90. Clinical assessment was performed at baseline and at each subsequent visit. All patients were encouraged to report any discomfort or concern on the day of treatment and at subsequent follow-ups.

During the follow-up examination, the following were determined and recorded by the investigators in the 'Patient Follow-up Record' form:

1. Degree of epidermal removal,
2. Degree of re-epithelialization,
3. Degree of erythema,
4. Degree of hyper-pigmentation,
5. Degree of hypo-pigmentation,
6. Area of scar (if applicable), and
7. Raised height of scar (if applicable).

Scoring took the form given in Table 1.

Table 1 Scoring form

Epidermal removal	No removal=0	20% removed=1	20–50% removed=2	50–70% removed=3	All removed=4
Re-epithelialization	No epidermis=0	20% of normal=1	20–50% of normal=2	50–70% of normal=3	Normal epidermis=4.
Erythema and pigmentation	Absent=0	Minimal=1	Mild=2	Moderate=3	Severe=4
Hyper- and hypopigmentation	Absent=0	Localized/spotty=1	Large patches=2	Moderately widespread=3	Very widespread=4

In addition, the patients were asked, before each examination, to complete a patient questionnaire, using visual analogue scales, regarding levels of pain, discomfort, acceptability of treatment, duration of healing, skin smoothness, degree of improvement of skin tone, and scarring. Scoring consisted of making a mark on a 10-cm line demarcated at 1-cm intervals. Each end of the line was awarded a score of 0 or 10 according to the extreme points of reference pertaining to an individual measure. In addition, patients were asked whether they would recommend the treatment to a friend and were required to provide a yes/no answer.

Patients were encouraged to report any discomfort or concern at the time of examination. Other observations or patient comments were also recorded at the discretion of the investigator.

Photographic records were made pre-treatment, immediately post-treatment, and at each subsequent follow-up visit. The photographs were subject to independent, blinded evaluation by a trained observer for assessment of improvement. After processing to slide, the biopsy samples were shipped to an independent Histology laboratory (Dak Dak Laboratories, Philadelphia, PA, USA) for blinded assessment of the ZTD, epidermal thickness, grenz zone measurement, and solar elastosis using H&E and VVG staining.

Collagen reformation and neocollagenesis A separate histology report was commissioned to look at collagen reformation, neocollagenesis, and elastogenesis in the biopsy samples taken from the study by the Department of Surgical Research, Northwick Park and St Mark's Hospital, Harrow, UK. A specific stain, Picrosirius Red 34B, which accentuates the birefringent properties of viable collagen, was employed to identify collagen reformation and neocollagenesis, whereas Hart's modification of Millers stain for elastin was employed to identify elastotic material in the biopsies.

Results

The scores of the three treatment groups (3.0, 3.5, and 4.0 J) have been aggregated to provide a mean score.

Twenty-four out of 24 patients enrolled into the study completed the study. The use of a topical anesthetic regime (EMLA) was tolerated by all patients, with a mean patient pain score of 4.3 on day 0 post-treatment (range, 1.5–7.5). The first five patients at the San Diego site recorded pain scores ranging from 1.5 to 4.5, which prompted the introduction of oral medication as part of the anesthetic regime. The following seven patients at this site recorded post-operative pain scores of 2.5 to 6.5, indicating an improvement in toleration to the treatment. The mean pain score registered at the Sacramento site post-treatment was 5 (range, 2.5–7.5). The mean duration of treatment was 14.3 min at a 4-Hz pulse repetition rate producing a mean number of pulses of less than 1,000.

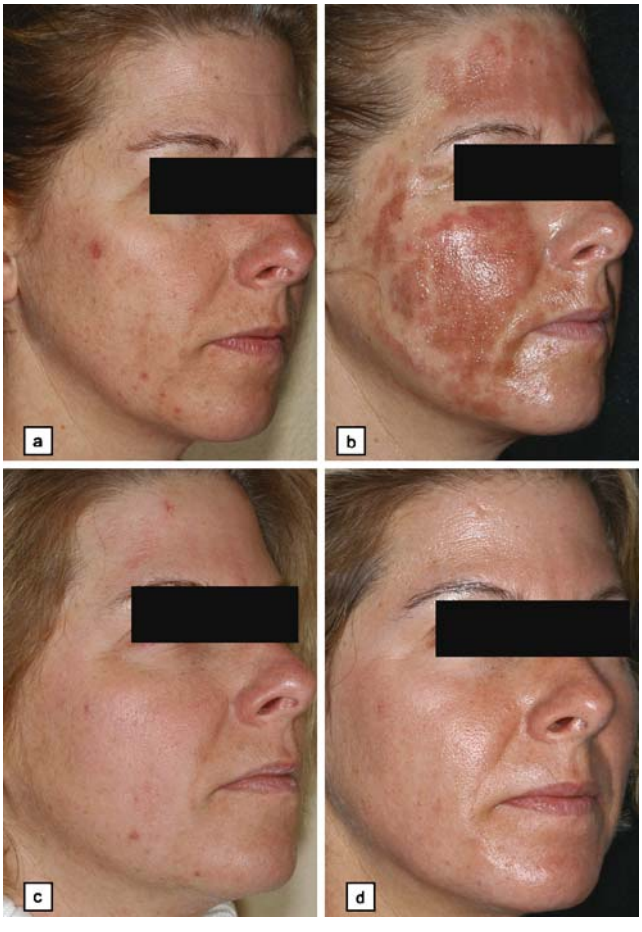

Fig. 2 Patient treated at 4 J, single pass at pre-treatment (**a**), 2 days post-treatment (**b**), 7 days post-treatment (**c**), and 90 days post-treatment (**d**). Note improvement in hyperpigmentation (courtesy of Suzanne Kilmer M.D.)

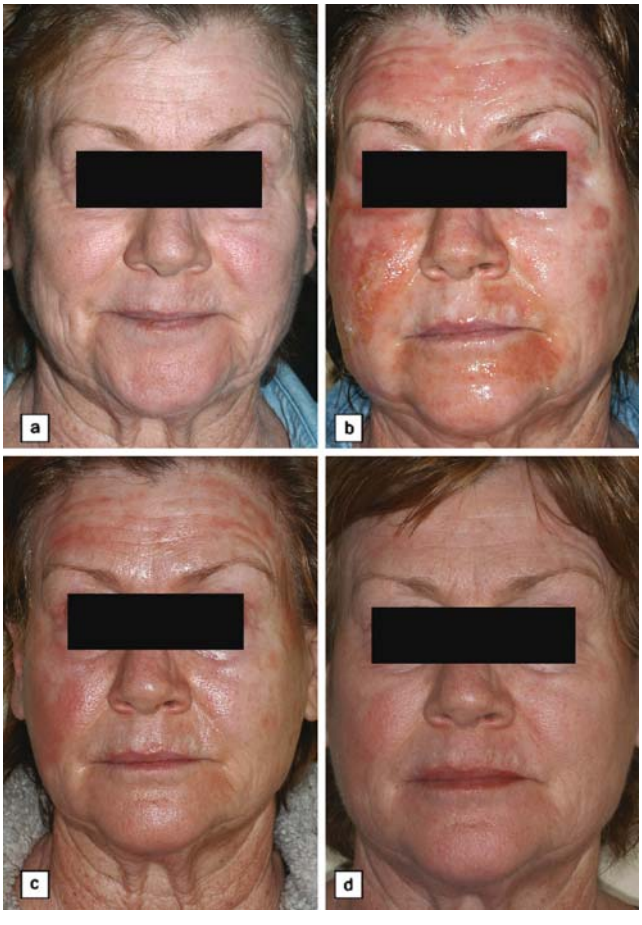

Fig. 3 Patient treated at 3 J, single pass at pre-treatment (**a**), 2 days post-treatment (**b**), 7 days post-treatment (**c**), and 30 days post-treatment (**d**). Note improvement in wrinkles (courtesy of Suzanne Kilmer M.D.)

Patients developed skin erythema and edema shortly after the treatment but with no immediate evidence of epidermal loss or charring (mean score for epidermal removal=0.5; range, 0–2). Treatment resulted in epidermal loss in the subsequent 24–48 h followed by epidermal recovery in ~7 days (healing time mean score=7.89 days). A mean re-epithelialization score of 3.7 was noted at the day 7 follow-up (3=70%, 4=100% re-epithelialized). The erythema in the immediate post-treatment phase was given a physician score of mild to moderate, reducing to minimal to mild at the day 7 follow-up at the Sacramento site but remaining at mild to moderate at the San Diego site. No significant erythema was noted clinically at the 30-day follow-up (mean value, 0.8). Transient, mild inflammatory hyperpigmentation was noted in the post-operative phase in some patients treated at the high energy level (4 J). This had resolved by the conclusion of the follow-up period (Fig. 2).

The physician-rated wrinkle scores ranged from 3–8 pre-treatment (mean, 5.5), indicating that enrollment included patients with mild to moderate photodamage. A mean wrinkle score of 4.2 for all energies was noted at the day 90 follow-up, note reduction in wrinkles in Fig. 3. Physician-rated textural irregularity ranged from 3–3.25 pre-treatment (mean, 3), with a range of 1.75–2.25 (mean, 1.9) noted at the day 90 follow-up (Fig. 3).

Individual patient scores for degree of improvement of skin tone ranged from 5 to 90%, with a mean improvement of 60% noted at the day 7 follow-up. Overall, a mean improvement across both sites of 50% was noted at the day 30 follow-up (Fig. 4).

Textural improvement, denoted by the smoothness score, was consistently high across the range of energies used (mean value for all energies at day 90=8; (Fig. 5).

Overall patient satisfaction with the treatment was high, with a mean of 6.6 at the Day 90 time point (Fig. 6).

No significant differences in pre-treatment wrinkle scores, improvement, or healing times were noted between the patients treated at the different energy settings; that is, each cohort exhibited similar outcomes.

Some minor complications were reported during the study. One patient was noted as having a scar on the left forehead (5×20 mm) secondary to an infection in the post-treatment healing period.

A number of patients were noted as having localized/spotty hyperpigmentation at their day 90 follow-up. All patient data forms were checked, which confirmed that these patients had entered the study with a pre-existing hyperpigmentation score that has not exceeded at the day-90 time point.

Patients with pre-existing hyper or hypopigmentation noted on enrollment all demonstrated improvement at the day 90 follow-up.

Histological investigation demonstrated that PSR treatment does not cause any adverse changes in the epidermis or dermis. There was no evidence of scarring or incomplete healing related to the investigational device. The parameters measured showed no significant trends between the energy settings employed, although individual subjects demonstrated some seemingly large changes. All specimens showed complete, intact epidermis and dermis indicative of complete healing after treatment with normal epidermal and dermal architecture. Using Hart's modification of Miller's elastin stain, a clear reduction in solar elastosis was noted between days 0 and 90. This was measured microscopically using a calibrated graticule and taking ten discrete measurements across the slide; the reduction was measured as being in the region of 20%. Further biopsies taken from study patients outside of the follow-up period of the study (1-year post-treatment) demonstrated further reduction in mature, disorganized elastin fibers, along with a high incidence of new elastin fibers perpendicular to the D/E junction (Fig. 7).

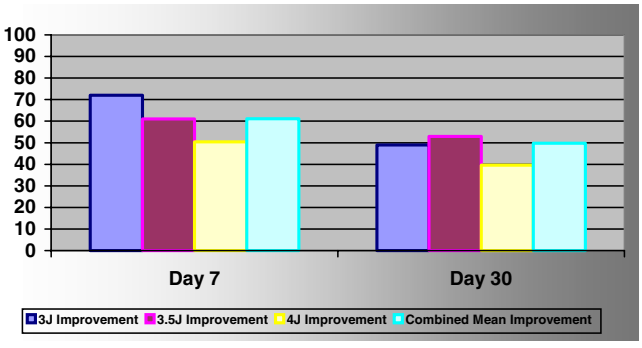

Fig. 4 VAS score of mean degree of improvement of skin tone days 7 and 30 post-treatment

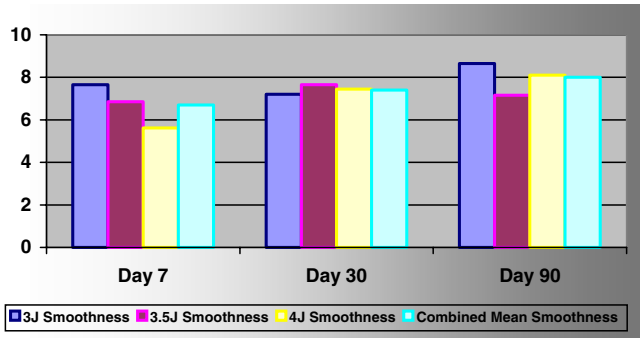

Fig. 5 VAS score of smoothness days 7, 30, and 90 post-treatment

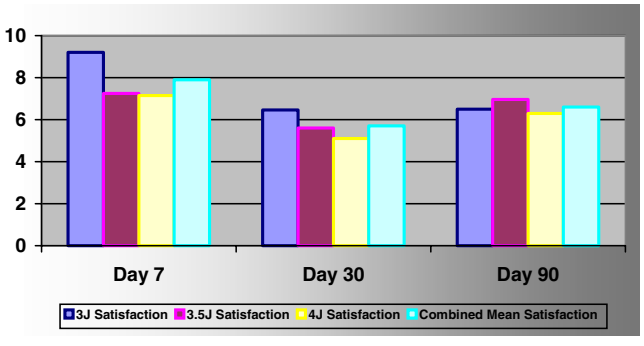

Fig. 6 VAS score for satisfaction with the treatment

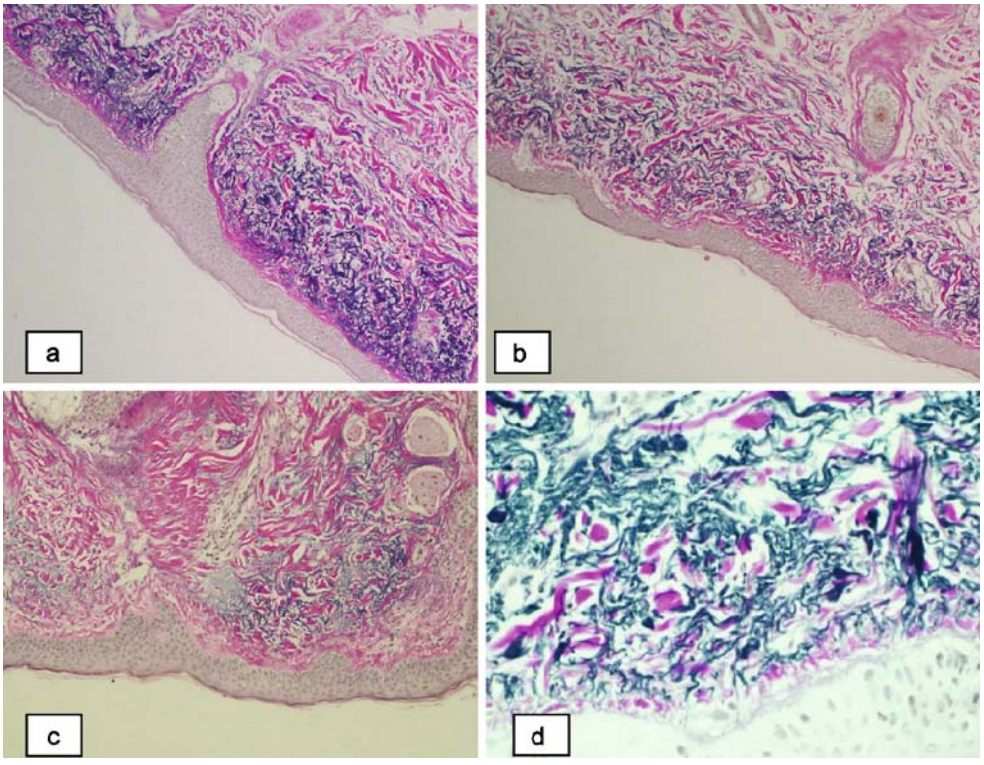

Fig. 7 Using Hart's modification of Miller's stain for elastin, the degree of solar elastosis was measured using a calibrated graticule at **a** day 0 pre-treatment, 100× magnification; **b** 90 days post-treatment, 100× magnification; **c** 1 year post-treatment, 100× magnification; and **d** 90 days post-treatment 400× magnification showing new elastin fibers perpendicular to the D/E junction

Collagen denaturation can therefore be used as a marker for thermal damage. The histological stain picrosirius red greatly enhances the natural birefringence of normal collagen fibers illuminated by polarized light, whereas denatured collagen does not exhibit birefringence. Biopsies taken from treated areas and stained with picrosirius red F3BA were characterized by:

1. A reactive epidermis,
2. A zone of new collagen underlying the D/E junction,
3. A ZTD in the papillary dermis, the extent of which varied according to the energy employed, containing islands of deeper neocollagenesis in a matrix arrangement,

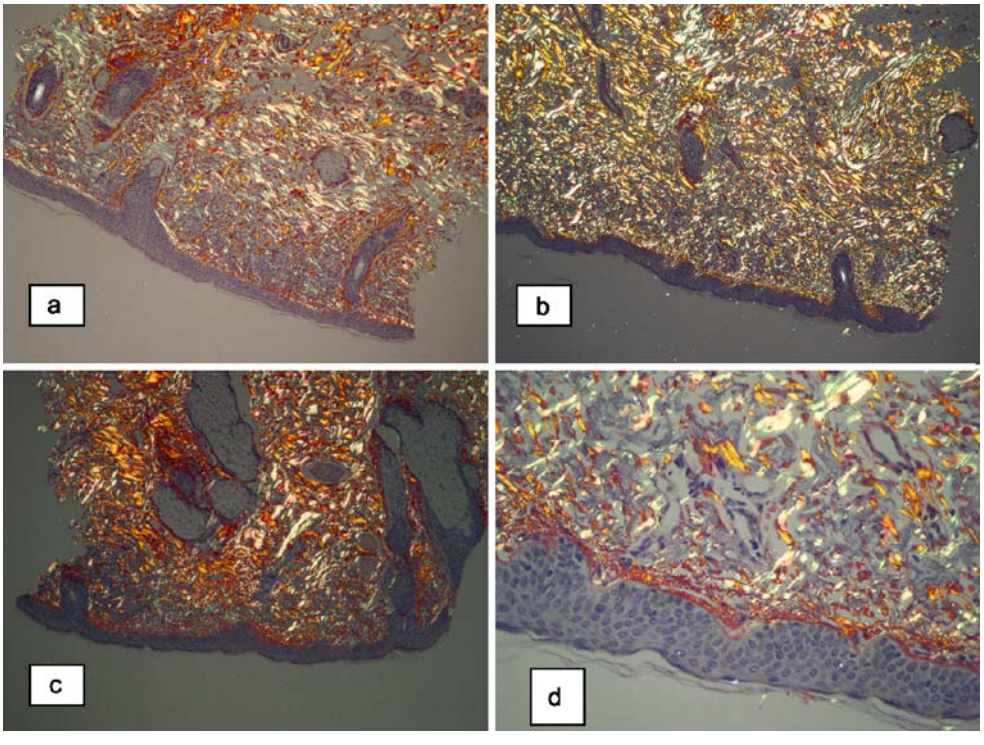

Fig. 8 Biopsies stained with Picrosirius Red F34B demonstrating viable collagen **a** pre-treatment, 100× magnification; **b** 90 days post-treatment, 100× magnification; **c** 1 year post-treatment, 100× magnification; and **d** 1 year post-treatment, 400× magnification. Healthy epidermis is denoted in **d** by an increase in rete ridges and new collagen in the grenz zone

4. Beyond this ZTD, the dermal architecture was normal, characterized by old, large, disorganized bundles of collagen (Fig. 8).

Discussion

Currently available treatments for facial wrinkling and skin laxity include CO_2 and Er:YAG laser resurfacing. These technologies are used to vaporize the epidermal layer of the skin to varying depths, according to setting and technology employed, resulting in an open wound. They are associated with a recovery period that includes a 10–14 day re-epithelialization time, an average of 2–3 months of post-operative erythema, with the potential risk of prolonged erythema, dyspigmentation, and scarring [1–3]. Hyperpigmentation has been noted as the most common side effect of CO_2 laser resurfacing, with an average incidence of 46% noted and a mean duration of 12.7 weeks. In this context, the incidence of transient, mild inflammatory hyperpigmentation noted during the PSR study was significantly lower than what has previously been reported in cutaneous resurfacing studies [1].

The therapeutic results obtained using high energy PSR would appear comparable with single pass CO_2 laser, whereas being associated with a significantly shorter recovery time. The preservation of the epidermal layer on top of the thermally modified papillary dermis during the first 24–48 h post-procedure offers the same benefit as a biological dressing, with an associated improvement in healing time [4].

Other modalities, such as medium chemical peels performed with trichloroacetic acid (TCA), are available as treatment for skin tone, texture, and fine lines. However, although fine wrinkles may be improved, TCA peels offer no improvement in dynamic wrinkles and, to maintain results, require two or more peels at 3 monthly intervals, with dissipation in results 6 months post-treatment. TCA peels can take up to 60 min to perform on the full face, with a post-treatment profile that includes the superficial layers of the skin turning dark, becoming stiff, and resembling leather. This then cracks, flakes, and peels over 7 days. Although this post-treatment profile is similar to high energy, single pass PSR treatment, their use does not promote the generation of new collagen and elastin, necessary if improvement in dynamic wrinkles is required. PSR has been shown to stimulate the generation of new collagen, with progressive improvement of results over time.

Variation in results seen in the histology analysis raises questions with regard to the biopsy sites selected by the investigators. Given that there was little difference in patient outcomes between the San Diego site and the Sacramento site, there was clearly an inconsistency in the histological results observed at the Sacramento site. It is possible that the tissue in the pre-auricular area received lower energy and therefore suboptimal treatment in some patients, as the device is pulled back to decrease delivered energy in the lateral cheek in an effort to feather the treated area into the surrounding untreated area.

The thermal modification of the papillary dermis necessary to induce dermal collagen remodeling and neocollagenesis, which is required to sustain improvement in deep wrinkles [5], was noted in some but not all of Fitzpatrick's samples that were sent for staining with Picrosirius Red 5b. Histologically, the average change in density of solar elastosis was a decrease of 7% ($n=12$).

EMLA cream is a 5% eutectic mixture of lidocaine and prilocaine and is the most widely used topical agent with proven efficacy from several clinical trials [6]. Dermal analgesia has been noted after application under an occlusive dressing for 60 min [7–9], with increased dermal analgesia seen with up to 2 h of occlusion [7]. For this reason, EMLA was chosen as the topical agent of choice for this study, with a 2-h application under occlusion recommended.

This standard protocol, routinely employed at the Sacramento site, i.e., EMLA application under occlusion for 2 h pre-treatment in conjunction with an anti-anxiolytic (Valium) and analgesic (Vicodin), was found to be satisfactory by the patients treated at this site. The use of adjunctive oral analgesia was implemented at the San Diego site from patient 6 onwards. A subsequent improvement in pain scores was then noted at this site.

Conclusion

From the results of this two-site prospective study using a single pass high energy treatment protocol, the following conclusions may be drawn.

1. The treatment is well tolerated under a combination of topical anesthesia and oral medication.
2. Treatment of the face can be achieved in 10 min, with a mean of 14.3 min noted.
3. The recovery phase post-treatment was rapid compared to alternative treatments.
4. Significant erythema is not observed beyond 14 days.
5. There was a consistent degree of improvement in skin quality across the range of energies employed.
6. Histological evidence of collagen remodeling observed in patients treated at the San Diego site was consistent across the range of energies used in the study and for the reasons given above is representative of the study as a whole.
7. Healing and outcomes were consistent across the range of energies used in the study.
8. A mean improvement of 50% was noted at the day 30 follow-up (range, 5–90%).
9. The investigational device is safe and effective in the treatment of mild to moderate photodamage of the facial unit.

It should be noted that although regional treatments in humans had been performed before this investigation, this is the first preliminary evaluation of the new Portrait® PSR^3 technology in the treatment of the full-

facial unit. The need for additional investigations and the application of objective assessment methods to objectify and specify the encouraging results obtained are required to validate the clinical outcomes obtained by the investigators.

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