Comparison of a Fractional Microplasma Radio Frequency Technology and Carbon Dioxide Fractional Laser for the Treatment of Atrophic Acne Scars: A Randomized Split-Face Clinical Study

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BACKGROUND No studies have compared fractional microplasma radio frequency (RF) technology with the carbon dioxide fractional laser system (CO_2 FS) in the treatment of atrophic acne scars in the same patient.

OBJECTIVE To compare the efficacy and safety of fractional microplasma RF with CO_2 FS in the treatment of atrophic acne scars.

METHODS AND MATERIALS Thirty-three Asian patients received three sessions of a randomized split-face treatment of fractional microplasma RF or CO_2 FS.

RESULTS Both modalities had a roughly equivalent effect. Échelle d'Évaluation Clinique Des Cicatrices d'Acné scores were significantly lower after fractional microplasma RF (from 51.1 ± 14.2 to 22.3 ± 8.6, 56.4% improvement) and CO_2 FS (from 48.8 ± 15.1 to 19.9 ± 7.9, 59.2% improvement) treatments. There was no statistically significant difference between the two therapies. Twelve subjects (36.4%) experienced postinflammatory hyperpigmentation (PIH) after 30 of 99 treatment sessions (30.3%) on the CO_2 FS side and no PIH was observed on the fractional microplasma RF sides.

CONCLUSION Both modalities have good effects on treating atrophic scars. PIH was not seen with the fractional microplasma RF, which might make it a better choice for patients with darker skin.

The authors have indicated no significant interest with commercial supporters.

Atrophic facial acne scarring is a widely prevalent condition that can have a negative effect on a patient's quality of life. There has been much research into the treatment of acne scars in an attempt to minimize them. Ablative lasers such as the carbon dioxide (CO_2) laser have been considered to be the criterion standard for skin resurfacing, but the procedures are associated with long healing times, edema, prolonged erythema, post-therapy dyschromias, and scarring.[1,2] Ablative fractional resurfacing using the CO_2 fractional laser system (FS) has demonstrated significant beneficial effects on atrophic acne scars and minor side effects,[3,4] but for Asians with Fitzpatrick skin type III or, the cause of the post-therapy hyperpigmentation cannot be ignored.[5–7]

More recently, a fractional microplasma radiofrequency (RF) device has been developed that allows treatment of the face with fractional RF based on the rationale of placing a grid of high-energy foci on the skin.[8,9] The electromagnetic RF

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ISSN: 1076-0512 • Dermatol Surg 2013;39:559–566 • DOI: 10.1111/dsu.12103

energy may achieve an ablative effect along with the thermal effect. The technology was overall safe and effective in the treatment of acne scars. The objective of this prospective study was to determine whether fractional microplasma RF could provide better efficacy and patient satisfaction and fewer adverse effects than CO_2 FS in the treatment of atrophic facial acne scars in Asians.

Materials and Methods

We conducted an evaluator-blinded, randomized, comparative split-face study of fractional microplasma RF and CO_2 FS treatments for atrophic acne scars. This study was performed in accordance with the ethical guidelines of the 1975 Declaration of Helsinki and approved by Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China.

Patients

Patients with atrophic acne scars on both sides of the face were recruited for the study. Informed consent was obtained from all patients. Exclusion criteria were pregnancy; breastfeeding; history of keloid tendency; immunosuppression; photosensitivity or current use of photosensitive medication; oral isotretinoin use in the preceding 6 months; use of topical retinoids in the preceding 2 weeks; active dermatitis; infection or malignancy over the treatment area; and having received light source, RF, or laser skin resurfacing treatments in the 6 months before the study.

Laser Treatment

Facial halves were randomly to assigned to receive treatment with a CO_2 FS (10,600-nm Ultrapulse Encore; Lumenis Inc., Santa Clara, CA) on one side and fractional microplasma RF (Accent; Alma Lasers, Caesarea, Israel) on the contralateral side. For local anesthesia, after the face was cleansed with a mild soap and 70% alcohol, a topical eutectic mixture of 2.5% lidocaine hydrochloric acid and 2.5% prilocaine (Beijing Ziguang Medication Manufacture Corporation Ltd, Beijing, China) was applied to the entire face under occlusion 1 hour before the therapy. Patients with a history of herpes virus infection were prescribed oral valacyclovir hydrochloride 500 mg twice a day for 7 days commencing 2 days before each treatment.

The parameters for the CO_2 FS treatment were 20 to 25 mJ, density 2 to 4 (10–20% coverage/cm^2 per pass), 300 Hz, using the Deep FX mode, and one pass without overlapping. During fractional microplasma RF treatment, the face was treated with four passes of the roller tip at 50 ro 60 W. All patients received three treatment sessions at intervals of 6 to 12 (average 8) weeks. For subjects who experienced postinflammatory hyperpigmentation (PIH), the next treatment session occurred after the dyspigmentation had been completely resolved. Two board-certified dermatologists who did not participate in outcome assessments performed treatments.

Postoperatively, all patients were instructed to cleanse the treated sites gently with tap water and use a moisturizer (Cicaplast; La Roche-Posay, Paris, France) twice a day. Sun avoidance and the use of a sunscreen with a sun protection of 50 (Anthelios XL; La Roche-Posay, Paris, France) was encouraged.

Objective and Subjective Evaluations

All patients were photographed four times (before each treatment session and 6 months after the last session) in the same position, with the same lighting and camera setup and by the same photographer, using a digital camera (Nikon D90, Tokyo, Japan). Two unbiased, board-certified dermatologists conducted blinded clinical assessments of the treatment areas using comparative photographs. Acne scar improvements were quantified according to Échelle d'Évaluation Clinique Des Cicatrices d'Acné (ECCA; Clinical Evaluation Scale for Acne Scarring) scores.[10] To elucidate relationships between acne scar subtypes and response to laser treatments, we classified acne scars into five subtypes according to

shape and depth (superficial or deep rolling, superficial or deep boxcar, and icepick scars).[11] ECCA scores were calculated to compare treatment-associated changes.

Six months after final treatment, patients were asked to characterize their overall level of satisfaction as very satisfied, satisfied, slightly satisfied, or unsatisfied, with separate evaluations of each side of the face.

Patients were asked to report about the side effects of the treatment, especially post-therapy dyschromia, scaling or crusting, and erythema, also separately on each side of the face at each treatment session and follow-up visit. Immediately after each treatment, relative pain scores associated with the different modalities were evaluated using 10-cm visual analogue scales (VAS), with 0 being no pain and 10 being extremely painful.

For the histologic analysis, skin biopsies were performed using a 3-mm punch from the atrophic scars on each side of the face immediately after the first treatment. The biopsy specimens were fixed in 10% buffered formalin and embedded in paraffin. Each section was stained with hematoxylin and eosin.

Statistical Analysis

Statistical analyses were performed using the Mann-Whitney test (for comparison between two lasers) and Wilcoxon signed rank test (for comparison of before and after laser treatments) using SPSS software (version 17.0, SPSS, Inc, Chicago, IL). Data were expressed as means plus or minus standard errors, and $p < .05$ was considered statistically significant.

Results

Thirty-three Chinese subjects with mild to severe atrophic acne scars, 14 female and 19 male, aged 19 to 34 (average 26.4 $\pm$ 3.7) with Fitzpatrick skin types III and IV were enrolled in the study. The duration of scars ranged from 1 to 10 years (average 3.6 $\pm$ 2.3 years). All 33 subjects completed three treatments and a 6-month postprocedure follow-up visit.

Overall, both modalities yielded a significant atrophic acne scar improvements 6 months after three treatments (Figure 1). ECCA scores fell significantly after fractional microplasma RF (from 51.1 $\pm$ 14.2 to 22.3 $\pm$ 8.6, 56.4% improvement) and CO_2 FS (from 48.8 $\pm$ 15.1 to 19.9 $\pm$ 7.9, 59.2% improvement) treatments (both $p < .001$). The difference between the sides was not significant before ($p = .53$) or after treatment ($p = .93$). Improvement in ECCA scores were not significantly different between fractional microplasma RF and CO_2 FS (superficial rolling, $p = .92$; deep rolling, $p = .89$; superficial boxcar, $p = .32$; deep boxcar, $p = .51$; and icepick, $p = .88$).

After fractional microplasma RF treatment, patient surveys regarding overall satisfaction revealed that 22 (66.7%) were very satisfied or satisfied, nine (27.3%) were slightly satisfied, and two (6.0%) were unsatisfied (Figure 2). After CO_2 FS treatment, 20 patients (60.6%) were very satisfied or satisfied, 10 (30.3%) were slightly satisfied, and three (9.1%) were unsatisfied. The overall satisfaction levels of fractional microplasma RF and CO_2 FS were not significantly different ($p = .16$).

Side effects included pain during the treatment, post-treatment crusting or scaling, post-therapy erythema, and PIH (Table 1). The mean duration of post-therapy erythema and scaling was 5.7 days on the fractional microplasma RF sides and 10.2 days on the CO_2 FS sides ($p < .001$). The mean erythema lasting days were noted 6.8 days on the fractional microplasma RF sides and 12.3 days on the CO_2 FS sides ($p < .001$). Twelve subjects (36.4%) experienced postinflammatory hyperpigmentation (PIH) after 30 of 99 treatment sessions (30.3%) on the CO_2 FS side; no PIH was observed on the fractional microplasma RF sides ($p < .001$). All cases of PIH were graded as mild except for one moderate case (Figure 3). The average duration of PIH was 45.8 days (range 14–90 days). All subjects with PIH

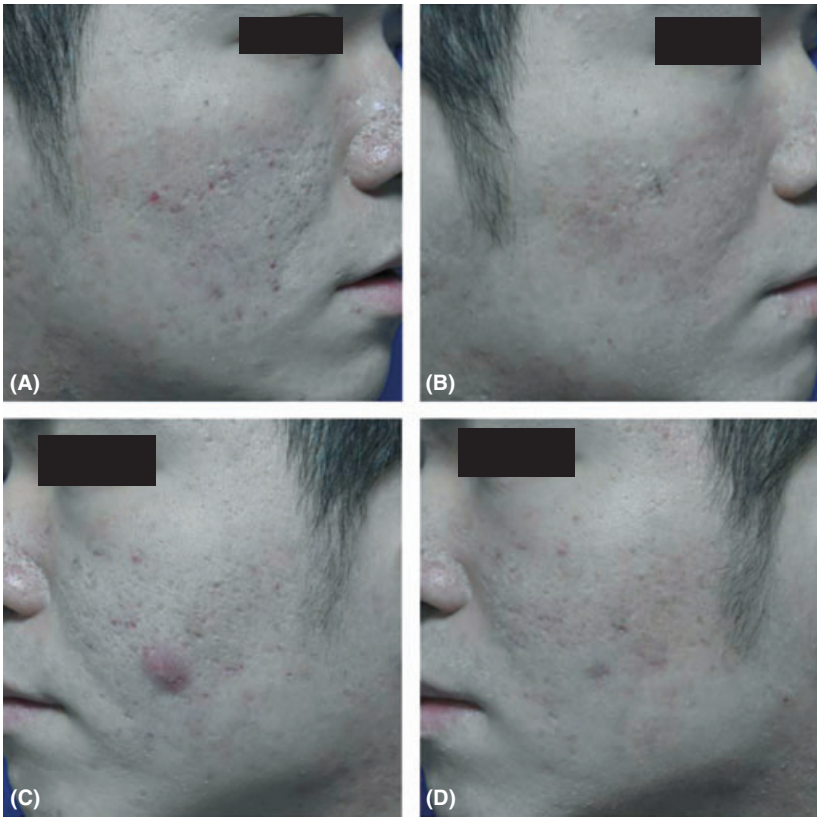

Figure 1. Atrophic acne scars of representative patients showed notable improvement at 6 months after three treatment sessions. (A and B) carbon dioxide fractional laser system treatment side versus (C and D) fractional microplasma radiofrequency treatment side (left column, baseline; right column, 6 months after three treatment sessions).

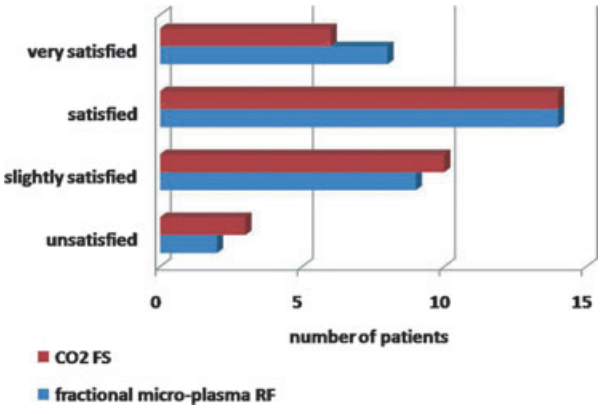

Figure 2. Patient satisfaction levels.

TABLE 1. Adverse Events After Treatment with Factional Microplasma Radio Frequency (RF) and a Carbon Dioxide Fractional Laser System (CO_2 FS)

Side Effects	*Fractional Microplasma RF*	*CO_2 FS*
Crusting, scaling, mean ± SD*	5.7 ± 2.3	10.2 ± 3.1
Erythema, mean ± SD*	6.8 ± 3.8	12.3 ± 6.8
Postinflammatory hyperpigmentation, *n* (%)†	0 (0.0)	30 (30.3)
Pain, mean ± SD‡	5.9 ± 1.7	4.3 ± 1.5

SD, standard deviation.
*Duration, days
†No. of occurrences/ total treatment session (%)
‡Visual analogue scales

were successfully treated with 20% azelaic acid cream twice daily. Mean VAS pain scores were 5.9 with factional microplasma RF treatments and 4.3 with CO_2 FS treatments (p = .003).

Histopathologic experiments revealed that a fractional microplasma RF device generated cylindrical holes 120 to 150 μm deep, with diameter of 150 to

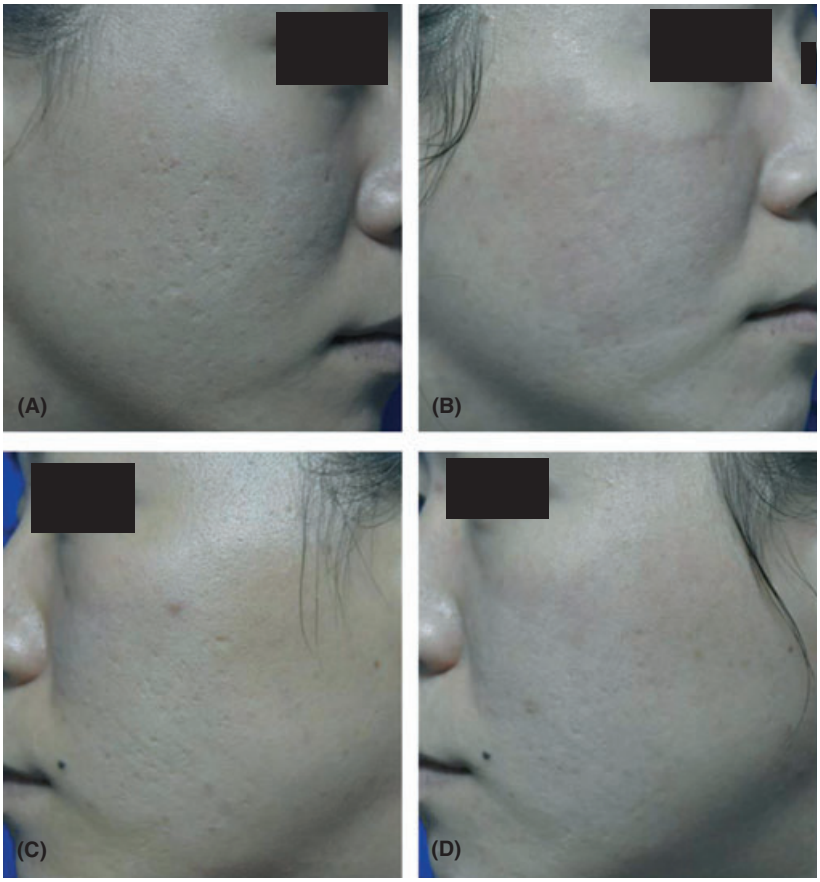

Figure 3. Atrophic acne scars of representative patients showed postinflammatory hyperpigmentation occurrence 2 months after one treatment. (A and B) carbon dioxide fractional laser system treatment side versus (C and D) fractional microplasma radio frequency treatment side (left column, baseline; right column, 2 months after one treatment).

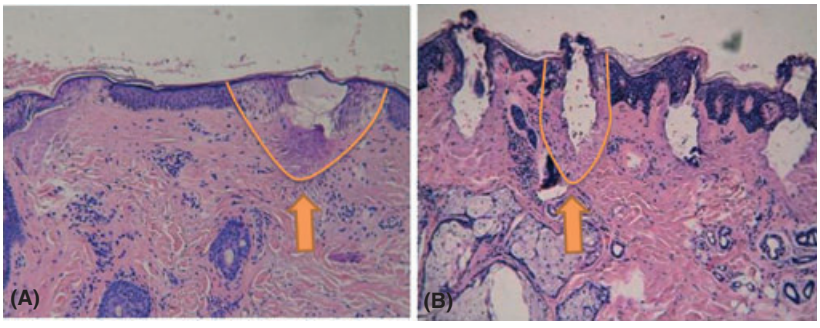

Figure 4. Histologic evaluations of atrophic acne scars immediately after the first (A) fractional microplasma radio-frequency (RF) and (B carbon dioxide fractional laser system (CO_2 FS) treatment (hematoxylin and eosin stain; original magnifications: ×400). Fractional microplasma RF resulted in a wider area of surrounding and subadjacent thermal damage than CO_2 FS did (arrow).

180 μm (Figure 4A). CO_2 FS produced bullet-shaped vaporization zones 300 to 400 μm deep, with a diameter of 100 to 120 μm (Figure 4B). Fractional microplasma RF resulted in a wider area of surrounding and subadjacent thermal damage than CO_2 FS (arrow) (Figure 4).

Discussion

Atrophic acne scars, one of the common complications of acne, can be physically challenging and psychologically devastating.[12,13] A number of options are available for the treatment of atrophic acne scars, including chemical peeling, dermabrasion, ablative and nonablative laser resurfacing, dermal fillers, and surgical techniques such as subcision and punch excision.[14,15] There are no methods of completely removing acne scars, so everything is a compromise. Ablative laser resurfacing using CO_2 or erbium-doped yttrium aluminum garnet lasers is the conventional treatment for acne scars, but laser treatment is associated with long recovery periods and possible serious adverse effects of infection, pigmentary changes, and scars.[1,16,17] An ablative 10,600-nm CO_2 fractional laser system has recently been introduced to maximize the effect of ablative laser therapies and minimize side effects by adopting fractional laser technology,[18] but for Fitzpatrick skin types III and IV in Asian populations, there is a risk of post-therapy hyperpigmentation.[5]

Fractional microplasma RF is a novel technology for skin resurfacing, skin remodeling, and the treatment of acne scars.[8,9] The Accent is a unipolar-based, RF-energy delivery device with fractional microplasma RF technology. With this technology, multiple RF plasma microdischarges are created in a gap between the applicator and the skin surface. When the applicator is a certain distance from the skin, the electromagnetic RF energy excites a grid of microsparks that cause mild epidermal ablation and perforate the dermis superficially. In addition, when the applicator contacts the skin, it creates unipolar RF effects. The combined ablative and thermal effects is effective for the treatment of atrophic acne scars.

To our knowledge, the present study provides the first clinical and histologic comparison of the efficacy and safety of fractional microplasma RF with that of CO_2 FS on atrophic acne scars in a split-face manner. The results indicated that both modalities had good effects on treating atrophic scars at 6 months after three treatments. The improvement in ECCA scores and overall satisfaction between the fractional microplasma RF and CO_2 FS treatment sites were not significantly different. The most optimal parameter to characterize the effect of ablative fractional treatment is the percentage of ablated skin.[19] In this study, the coverage that the two modalities provided was similar (10% coverage with fractional microplasma RF, 10–20% coverage with CO_2 FS). The higher-energy (20–25 mJ), lower-coverage (10–20%) setting was selected for CO_2 FS treatments based on previous studies, especially those conducted in Asian population.[6,20,21] We agree that increasing coverage would result in better therapeutic effects, but it would also result in severe adverse effects such as PIH. PIH is a potential complication of CO_2 FS treatments in an Asian population. It was suggested that although energy and coverage parameters are both important considerations in reducing PIH in Asians, coverage is of particular importance. These studies concluded that high-energy, low-density treatment is more likely to prevent PIH.

The histopathologic results showed that CO_2 FS caused deeper ablation zones than the fractional microplasma RF device did, but fractional microplasma RF resulted in a wider area of surrounding and subadjacent thermal damage than CO_2 FS did. Hence, the therapeutic effects are correlated not only with the necrotic columns, but also with the surrounding thermal coagulated areas. Also, ECCA scores were not significantly different after fractional microplasma RF and CO_2 FS treatments according to scar type (superficial or deep rolling, superficial or deep boxcar, icepick).

Regarding complications, there was significantly more duration of crusting and erythema with CO_2 FS than fractional microplasma RF, which can enable earlier return to work and increase the patient's adherence to the treatment. Twelve

subjects (36.4%) experienced PIH after 30 of 99 treatment sessions (30.3%) on the CO_2 FS side, although PIH with the CO_2 FS treatment was mild and short lived. This result was in good correspondence with previously published data in Asian patients.[5,7] No PIH was observed after the fractional microplasma RF treatment. Several studies have demonstrated that PIH has not been observed in patients treated using fractional RF or fractional microplasma RF.[8,22–25] We hypothesized that the superficial subepidermal ablation generated by fractional microplasma RF therapy may reduce the inflammatory reaction, which facilitates re-epithelialization and results in lower incidence of PIH. Although there was more severe pain on the fractional microplasma RF sides than on CO_2 FS sides, it was not too severe (5.9/10) and lasted for just minutes.

In conclusion, we demonstrated the efficacy of the treatment of atrophic acne scars using fractional microplasma RF and CO_2 FS in Asian patients in a randomized, split-face, evaluator-blinded study. At the parameters selected for this study, PIH was not seen with the fractional microplasma RF, which is particularly important for patients with darker skin, so it is a good choice for treating atrophic acne scars in Asian patients. We believe that our study could be used as an essential reference when choosing laser modalities for scar treatment.

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