ORIGINAL RESEARCH REPORT

A split-face comparison of a fractional microneedle radiofrequency device and fractional carbon dioxide laser therapy in acne patients

JUNG U. SHIN¹, SOO HYUN LEE¹, JIN YOUNG JUNG² & JU HEE LEE¹

¹Department of Dermatology, Severance Hospital, Cutaneous Biology Research Institute, Yonsei University College of Medicine, and ²Yeouido Oracle Cosmetic and Dermatologic Surgery Clinic, Seoul, Korea

Abstract
Background: A number of lasers and light-based devices have been reported as promising treatment options for acne vulgaris. Objective: To evaluate the efficacy and safety of fractional microneedle radiofrequency (MRF) device treatment compared to CO₂ fractional laser system (FS) for the treatment of acne vulgaris. Methods: Twenty healthy subjects underwent full-face treatment for acne vulgaris with CO₂ FS and MRF device. For each subject, two passes of CO₂ FS with a pulse energy setting of 80 mJ and a density of 100 spots/cm² were used on one side, and two passes of MRF device with an intensity of 8, density of 25 MTZ/cm², and a depth of 1.5–2.5 mm were used on the other. Patients were evaluated 3 months postoperatively and were also photographed. Results: Most of the patients improved based on clinical and photographic assessments 3 months after the treatment. No significant differences in physician-measured parameters, patient ratings, or intraoperative pain ratings were found, although downtime was significantly longer for the CO₂ FS treated side. Conclusions: MRF device and CO₂ FS can be used for acne vulgaris patients and MRF device is more convenient than CO₂ FS because of its short downtime.

Key Words: acne vulgaris, fractional microneedle radiofrequency, fractional carbon dioxide laser

Introduction
Although CO₂ fractional laser system (FS) is commonly used for rejuvenation of photodamaged skin, improvement of rhytides, and scar treatment, it has also been reported to be effective in the treatment of inflammatory acne and chronic recurrent furunculosis (1). Nonablative radiofrequency device are effective against acne (2), and microneedle radiofrequency (MRF) device has been used successfully in skin rejuvenation and wrinkle reduction (3,4). Based on these reports, we could expect MRF devices to be feasible treatment options for acne vulgaris. CO₂ FS and MRF devices may both be used to apply photothermal damage to sebaceous glands and P. acnes, and therefore we evaluated and compared the efficacy and advantages of these two devices in the treatment of acne vulgaris.

Material and methods

Patients
Twenty East Asian patients with acne vulgaris (9 women, 11 men; aged 15–28; Fitzpatrick skin types III or IV) who provided informed consent were enrolled in the study. The Institutional Review Board of Severance Hospital, Yonsei University College of Medicine, Seoul, Korea approved the study protocol. Mild to moderate acne patients were included and wash out period for topical and oral medication were 2 weeks. Patient characteristics are summarised in Table I. Exclusion criteria were a history of keloid scarring, pregnancy, immunosuppressive drug use and isotretinoin use 6 months prior to treatment. Patients underwent split-face treatment using CO₂ FS and MRF device. Patients were randomised with respect to which side of the face was treated with each device.

Laser treatment
Patients underwent 1–2 sessions of treatment with CO₂ FS using a 10,600-nm Mosaic eCO₂™ device (Lutronic Corporation, Goyang, Korea) and MRF device using a ScarLet™ (Viol, Sungnam, Korea). A topical 2.5% lidocaine HCl and 2.5% prilocaine (EMLA™, AstraZeneca AB, Södertälje, Sweden)
cream was applied under occlusion 1 hour prior to treatment for local anaesthesia. Treatment parameters were as follows. For the CO₂ FS, the energy was 80 mJ with a density of 100 spots/cm², two passes. This correlates to 15.6% coverage and an ablation depth of 1168 μm. For the MRF device, the intensity was 8 with a density of 25 MTZ/cm², with a depth of 1.5 – 2.5 mm, two passes. Eyelids and the perioral region were not treated. During the follow up period, patients were prohibited to use any oral or topical medication for acne treatment.

**Evaluation**

The effects of the two devices were clinically and photographically evaluated at the first visit, before each treatment session, and 3 months after the last treatment. Photographs were obtained under standardised conditions using identical camera settings, patient positioning, and lighting for each session. Objective clinical assessments were performed by two blinded dermatologists who compared baseline and 3-month visit photos using a global improvement scale (grade 0 = worsened; grade 1, 0–25% = minimal improvement or steady state; grade 2, 26–50% = moderate improvement; grade 3, 51–75% = marked improvement; and grade 4, more than 75% = near total improvement). Also the number of papules and pustules were counted to evaluate the efficacy of both devices. Other objective assessments included improvement in sebum production using Sebumeter® SM 815, change in erythema and pigmentation using Mexameter® MX 18 connected to Multiprobe Adapter System (Courage Khazaka electronic GmbH, Köln, Germany) at each follow-up visit.

Patients scored their overall rates of satisfaction (0 = unsatisfied, 1 = slightly satisfied, 2 = satisfied, 3 = very satisfied) and described the duration of erythema on each side of the faces. Patients also reported other side effects of the treatment, also on each side of the faces. Pain levels were asked immediately after the treatment using 10-point VAS scale (0 = no pain, 10 = severe pain).

**Statistical analysis**

The effects of treatment were analysed using the Wilcoxon signed rank test to assess changes in the number of inflammatory lesions, sebum production, erythema and pigmentation change from baseline to the 3-month visit. Global improvement score, mean reduction of inflammatory lesions, patient satisfaction score, pain assessment and duration of erythema between two groups were also analysed using the Mann-Whitney U-test. SPSS version 18.0 (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. Differences were considered statistically significant when the p value was less than 0.05.

**Results**

**Efficacy of treatment**

Twenty patients completed the study. There were notable improvements after treatment with both CO₂ FS and the MRF device based on photographic assessments (Figures 1 and 2). Improvement assessed by physicians showed moderate improvement but there was no significant difference between two devices (MRF device-treated...
side $2.33 \pm 0.65$ vs. CO$_2$ FS-treated side $1.9 \pm 0.71$; $p > 0.05$, Figure 3). The number of papules (from 4.85 to 2.35 on the MRF device-treated side, $p \leq 0.0001$; from 4.60 to 1.70 on the CO$_2$ FS-treated side, $p = 0.001$, Figure 4) and pustules (from 1.25 to 0.30 on the MRF device-treated side, $p = 0.007$; from 1.25 to 0.30 on the CO$_2$ FS-treated side, $p = 0.005$, Figure 4) were significantly reduced on both sides after the treatment, however, there were no significant difference between MRF and CO$_2$ FS-treated sides. Also no significant differences between MRF device-treated vs. CO$_2$ FS-treated side were found in the mean reduction of papule counts (49% on the MRF device-treated side vs. 54% CO$_2$ FS-treated side) and mean reduction of pustule counts (36% on the MRF device-treated side vs. 41% CO$_2$ FS-treated side).

After MRF device treatment, surveys evaluating overall patient satisfaction revealed that three of 20 patients (15%) were very satisfied, eleven (55%) were satisfied, five (10%) were slightly satisfied, and one (5%) was unsatisfied (Table I and Figure 5). After CO$_2$ FS treatment, two of 20 patients (10%) were very satisfied, eight (40%) were satisfied, seven (35%) were slightly satisfied and three (15%) were unsatisfied. The overall satisfaction levels of MRF device and CO$_2$ FS were not significantly different ($p = 0.435$).

Sebum production was additionally measured to evaluate the efficacy of therapy using a multiprobe adaptor system. The erythema index and melanin index were also measured to evaluate the posttreatment erythema and pigmentation. Sebum production was decreased on both sides, although the difference was not statistically significant (from 149 to 103 on the MRF device-treated side, $p > 0.05$; from 145 to 100 on the CO$_2$ FS-treated side, $p = 0.273$, Figure 6A). The erythema index and melanin index were not increased at 3 months after the last treatment (Figures 6A and 6B).

**Adverse events**

The duration of erythema on the CO$_2$ FS-treated side lasted significantly longer than the MRF device-treated side (mean $\pm$ SD: MRF device-treated side $2.35 \pm 1.04$ vs. CO$_2$ FS-treated side $11.75 \pm 12.67$; $p < 0.001$, Figure 7), although all patients experienced transient oedema and erythema immediately after treatment. No patients experienced noticeable adverse events such as severe crusting, bullae, infection, or atrophic scarring on either of the treated areas. Two patients (Case 4 and Case 8) reported transient hyperpigmentation on the CO$_2$ FS-treated site which was spontaneously resolved before a 3-month visit. Due to the longer period of erythema, most patients refused to repeat the split face treatment, which resulted in only one or two sessions of treatment in this study. Pain during the treatment was assessed on a 10-point VAS. The CO$_2$ FS-treated side demonstrated a higher pain score than the MRF device-treated side, but the difference was not statistically significant (mean $\pm$ SD: MRF device-treated side $5.7 \pm 1.72$ vs. CO$_2$ FS-treated side $6.45 \pm 2.21$; $p = 0.327$).
Discussion

Nonablative radiofrequency device is an effective device for the treatment of acne vulgaris (2). Combining the fractional technique with a classical nonablative radiofrequency device, the MRF device is a novel fractional RF device that utilises a minimally invasive microneedle delivery system for the treatment of various skin lesions. Using the microneedle delivery system, it is possible to deliver an exact amount of RF energy at accurate depths at the discretion of the operator. The system delivers RF energy directly within the dermis via 25 microneedle electrodes and creates a microthermal zone (MTZ) providing zones of sparing between MTZs. With the advantages of the fractional energy delivery system of MRF device and evidence of cytokine alteration after treatment, we expect a comparable effect and less pain and downtime compared to a nonablative radiofrequency device in the treatment of acne vulgaris.

The CO₂ FS is as effective as traditional CO₂ lasers but has much more favourable side effects and reduced downtime. Furthermore, it achieves controlled tissue vaporisation and dermal coagulation, but penetrates to a greater depth than nonablative fractional devices. With these advantages, CO₂ FS has been used in the treatment of a wide range of cutaneous lesions, including, facial rejuvenation, wrinkle reduction and scar improvement. We also noted improvements in suppurative diseases like acne vulgaris with CO₂ FS, possibly due to physical breakage and thermal stimulation of acne lesions (1). Follicular plugging and excess sebum production by the sebaceous glands, which are major pathogenic factors in acne vulgaris, may be affected by laser irradiation through the use of the fractional photothermolysis technique (1).

Our result showed that both devices, MRF and CO₂ FS were associated with moderate improvements in most patients and the number of active acne lesions was significantly decreased in both sides. However, there was no significant difference between two treatment devices in terms of changes in papule and pustule counts. To get more than moderate improvement, multiple treatments might be necessary as in other laser devices. In some patients, a dual benefit from the treatment was noticed: a decrease in acne lesions plus an improvement in previous scarring. However, the mean downtime after CO₂ FS irradiation was 11.8 days, which was 5 times longer than 2.4 days after the treatment with the MRF device. We attempted to treat patients twice with same protocol, but most patients refused because of the downtime and wanted to be treated only with the MRF device.

In terms of complications, treatment of acne using the MRF device and CO₂ FS was generally safe and tolerable in our Korean patients. Apart from immediate erythema, edema and transient hyperpigmentation, other severe side-effects such as blister formation, or atrophic scarring were not observed with either treatment. However, transient...
hyperpigmentation was reported after CO\textsubscript{2} FS treatment although it was spontaneously resolved before the 3-month visit.

The possible mechanisms of the MRF device are similar to those of other lasers and light devices. Prieto et al. (5) reported that the combination of pulsed light and RF reduces average areas of sebaceous glands and perifollicular lymphocytic infiltration. Hantash et al. (6) observed increases of TGF-β, MMP-1, 13, HSP72 and HSP47 after fractional radiofrequency treatment leading to neocollagenesis and neoelastogenesis. Cytokine alteration not only leads to extracellular matrix formation but also can affect sebaceous glands. Ruiz-Esparza et al. (16) suggested that deep dermal heating with noninvasive radiofrequency treatment might inhibit the activity of sebaceous glands and help to stimulate dermal remodelling. Collectively, these results can explain the effects of the MRF device on both scarring and active acne lesions.

A number of lasers and light-based devices have been evaluated for use in treatment for acne, with promising results (2,7–23). Pulsed dye lasers (PDL), infrared diode lasers, potassium titanyl phosphate (KTP) lasers, broad spectrum continuous-wave visible light sources (blue light, blue-red light) and photodynamic therapy (PDT) with methyl-aminolevulinic acid (MAL) or aminolevulinic acid (ALA) have been tried for treatment of acne vulgaris. PDL showed 49% reduction of inflammatory lesions and 50% reduction of non-inflammatory lesions (21). KTP laser was revealed to reduce total acne lesion scores by 35% (22). MAL-PDT showed 54% reduction of inflammatory lesions (23). In other study, blue light reduced overall acne severity by 50%. In our study, compared to previous lasers and light-based devices, MRF device (49% of mean reduction of papule counts and 36% of mean reduction of pustule counts) and CO\textsubscript{2} FS (54% of mean reduction of papule counts and 41% of mean reduction of pustule counts) showed comparable improvement in active acne lesions.

Although our results suggest that the MRF device and CO\textsubscript{2} FS may lead to favourable clinical outcomes in treating acne vulgaris and acne scars, the major limitation of our study was the lack of comparison with other commonly used treatments such as topical and oral medication or PDL. Another limitation of this study was that single treatment session was not enough to obtain moderate to marked improvement for acne patients. Larger studies that compare MRF and CO\textsubscript{2} FS with other conventional treatment options will be needed to obtain firmer evidence of the superiority of the MRF device in treating active acne vulgaris. Also, histological evidence and a molecular basis to explain the mechanism of action of two devices are needed. Further studies are in progress to determine the effects on molecular levels after treatment.

In conclusion, we found that MRF device and CO\textsubscript{2} FS can be used for acne vulgaris patients and MRF device with short downtime is more convenient than CO\textsubscript{2} FS. Because of lack of evidence to demonstrate the superiority of MRF device than conventional treatments for acne, we suggest MRF device to be a novel treatment option for selected patients not suitable for current standard treatments of acne (e.g. non-responders to drug therapy).
**Declaration of interest:** The authors state no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

**Funding:** This study was supported by Viol (Sungnam, Korea).

**Financial Disclosure:** This study was supported by Viol, Sungnam, Korea.

**References**


