Early Postoperative Treatment of Surgical Scars Using a Fractional Carbon Dioxide Laser: A Split-Scar, Evaluator-Blinded Study

Sang Hee Lee, MD,*† Zhenlong Zheng, MD, PhD,*†‡ and Mi Ryung Roh, MD, PhD*†

BACKGROUND Although focus has recently been directed toward the early treatment of surgical scars, the optimal time at which to initiate treatment with fractional laser and its effect on scar remodeling remains controversial.

OBJECTIVES To assess the safety and efficacy of treating surgical scars using an ablative carbon dioxide (CO₂) fractional laser during the early postoperative period.

MATERIALS AND METHODS We performed a prospective, split-scar, evaluator-blinded study on 16 postoperative scars of 15 patients. Patients began treatment 3 weeks after surgery and were treated in two sessions of CO₂ fractional laser therapy on half of the scar at 2-week intervals. All patients were followed for 3 months after the final treatment session.

RESULTS Three months after the last treatment, a greater decrease in Vancouver Scar Scale score was noted in the treated half of the scars, especially in terms of texture and thickness. Patients also expressed a significantly greater degree of satisfaction with the treated side as assessed using a subjective 4-point scale. Only one patient experienced any adverse effect, which was the development of hypertrophy, on the treated and untreated side of the scar.

CONCLUSION CO₂ fractional laser is an effective treatment modality for surgical scars in the early postoperative period.

P atients undergo various kinds of surgery for therapeutic or cosmetic reasons, but despite careful and atraumatic surgical techniques, surgical treatment and reconstruction can result in scarring. Disfiguring postoperative scars are a common cause of patient dissatisfaction and distress.

An ablative 10,600-nm carbon dioxide (CO₂) fractional laser system (FS) has been used to treat a wide variety of dermatologic conditions such as facial rhytides, photodamaged skin, and acne scars.¹,² The use of ablative lasers based on the fractional approach has become a useful strategy for the treatment of scars.³ Specially, this approach has gained popularity because it decreases the complications of traditional CO₂ lasers by leaving an intact epidermal architecture surrounding each coagulated microtreatment area.

Although CO₂ FS has been used for scars, most previous studies were performed on mature scars at least 2 months after surgery. Therefore, optimal treatment guidelines have not been established, including the optimal time at which to start treatment and appropriate treatment settings.

*Department of Dermatology, Yonsei University College of Medicine, Seoul, Korea; †Cutaneous Biology Research Institute, Yonsei University College of Medicine, Seoul, Korea; ‡Department of Dermatology, Yanbian University Hospital, Yanji City, Jilin Province, China

© 2013 by the American Society for Dermatologic Surgery, Inc. • Published by Wiley Periodicals, Inc. • ISSN: 1076-0512 • Dermatol Surg 2013;1–7 • DOI: 10.1111/dsu.12228
Clinicians have recently emphasized the importance of early and active treatment to prevent hypertrophic scar formation. Jung and colleagues showed that early postoperative CO$_2$ fractional laser treatment of thyroidectomy scars is safe and effective, but their results were limited in that the study was performed over a limited anatomic area—the lower neck—and lacked a control group for effective comparison with the treatment group. Therefore, the present prospective study was designed to assess the safety and efficacy of treatment with ablative CO$_2$ FS for surgical scars in the early postoperative period in an evaluator-blinded, comparative, split-scar trial.

**Methods**

**Patients**

We performed a prospective, split-scar, evaluator-blinded study on the postoperative scars of 15 patients who underwent surgery on the face, neck, chest, abdomen, arm, or back for a total of 16 surgical scars (Table 1). A single surgeon (MRR) generated the scars using the same surgical procedure, namely, excision of a previous lesion and primary closure using a simple continuous suture. The underlying causes of surgery were variable and included basal cell carcinoma, epidermal cyst, congenital melanocytic nevus, blue nevus, dermatofibroma, and pilomatrixoma. The anatomic distribution of scars was seven on the face; three on the arm; three on the neck; and one each on the back, chest, and abdomen. Exclusion criteria were a history of keloid scarring, isotretinoin use, oral anticoagulant use, pregnancy, and inflammation or infection of the postoperative scar. Patients gave voluntary informed consent to participate in the study, which the Institutional Review Board of Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Korea, had reviewed and approved (IRB No. 11–0167).

**Treatment**

Patients began treatment 3 weeks after surgery and were followed for 3 months after the final treatment session. Two sessions of CO$_2$ FS using a 10,600-nm eCO$_2$ laser (Lutronic Corporation, Goyang, Korea) were performed on half of the scars at 2-week intervals. The scars were divided into two halves along the closure axis. For vertical scars, the lower half was treated, and for transverse scars, the left side of the scar, from the evaluator’s perspective, was treated. The treatment area was cleansed with 70% alcohol, and a topical anesthetic (eutectic mixture of 2.5% lidocaine hydrochloric acid and 2.5% prilocaine; EMLA cream, AstraZeneca AB, Södertälje, Sweden) was applied around the scar under occlusion for 1 hour before laser treatment. The treatment settings were a pulse energy of 80 mJ and a spot density of 100 spots/cm$^2$ in the static mode; two passes were delivered using a 120-density tip (coverage 15.6%). After treatment, the treated areas were cooled with ice packs for 5 to 10 minutes to relieve pain. An appropriately sized hydrocolloid dressing (DuoDERM CGF Extra Thin, ConvaTec, ER Squibb & Sons, Princeton, NJ) was then applied to the treated area for 1 week. At the conclusion of the study, patients were offered treatment for the side they felt had less improvement.

**Evaluations of Clinical Effect**

Photographs were obtained using identical camera settings, lighting, and patient positioning at baseline and 3 months after the final treatment. Two blinded dermatologists made objective clinical assessments separately using the Vancouver Scar Scale (VSS), which includes pigmentation ($0 = \text{normal}, 1 = \text{hypopigmented}, 2 = \text{mixed pigmentation}, 3 = \text{hyperpigmented}$), pliability ($0 = \text{normal}, 1 = \text{supple}, 2 = \text{yielding}, 3 = \text{firm}, 4 = \text{ropes}, 5 = \text{contracture}$), height ($0 = \text{flat}, 1–2 \text{ mm}, 2 = 2–5 \text{ mm}, 3–5 \text{ mm}$), and vascularity ($0 = \text{normal}, 1 = \text{pink}, 2 = \text{red}, 3 = \text{purple}$). Objective evaluations were made separately for each half of the scar in nonchronologic order. Three months after the last treatment, patients were asked to rate their overall satisfaction using a quartile grading scale (very satisfied, satisfied, slightly satisfied, unsatisfied) for each half of the scar. Patients were also questioned about side effects.
of the treatment, especially bleeding, oozing, post-treatment dyschromia, scaling or crusting, and erythema.

**Statistical Analysis**

We compared VSS scores, overall patient satisfaction levels, and adverse events using the paired Student t-test with SPSS version 18.0 (SPSS Inc., Chicago, IL). Linear mixed models were used in the subset analysis to compare the treatment effect on facial and nonfacial scars. Differences were considered statistically significant when \( p < .05 \).

**Results**

Mean VSS scores for the treated half of scars were 8.13 before treatment and 2.34 three months after treatment. For the control half, mean VSS scores were 8.19 before treatment and 4.25 three months after treatment (Table 1). There were no statistically significant differences in baseline VSS scores between the untreated and treated halves of the scars (CO\(_2\) FS–treated side 8.13 ± 1.49 vs control 8.19 ± 1.38; \( p = .98 \)). Three months after laser treatment, mean VSS scores were significantly lower for the treatment and control halves of the scars (CO\(_2\) FS–treated side 2.34 ± 2.27 vs control 4.25 ± 1.66; \( p < .001 \)), although greater improvements were noted in the treated half, as indicated by a greater decrease in VSS score (CO\(_2\) FS–treated side 5.78 ± 2.94 vs control 3.94 ± 1.62; \( p < .001 \); Figure 1).

In the subset analysis, significantly greater improvements were noted on the treated halves of the scars in terms of scar thickness and texture (\( p < .001 \), Figure 2). There was no significant difference in VSS score improvements after 3 months according to the scar site (facial scars 7.57 ± 1.99, \( n = 7 \) vs nonfacial scars 4.39 ± 2.81, \( n = 9 \); \( p = .35 \)). Three months after treatment completion, patients were also significantly more satisfied with the treated half of their scar according to a 4-point grading scale (\( p = .002 \); Figure 3). For the treated side of the scar, four of the 15 patients (25%) were very satisfied, six (37.5%) were satisfied, one (6.7%) was slightly satisfied, and four (26.7%) were unsatisfied with the results. For the control side, two patients (13.3%) were satisfied, seven (46.7%) were slightly satisfied.

**TABLE 1. Patient Characteristics and Scar Assessment**

<table>
<thead>
<tr>
<th>Patient (Scar)</th>
<th>Sex/Age</th>
<th>Scar Location</th>
<th>Vancouver Scar Scale Score (Evaluator 1/Evaluator 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Treatment Half</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Initial (Before Treatment)</td>
</tr>
<tr>
<td>1 (1)</td>
<td>M/58</td>
<td>Face</td>
<td>9/9</td>
</tr>
<tr>
<td>2 (2)</td>
<td>M/51</td>
<td>Face</td>
<td>8/7</td>
</tr>
<tr>
<td>3 (3)</td>
<td>F/50</td>
<td>Face</td>
<td>9/9</td>
</tr>
<tr>
<td>4 (4)</td>
<td>F/29</td>
<td>Arm</td>
<td>9/9</td>
</tr>
<tr>
<td>5 (5)</td>
<td>M/31</td>
<td>Face</td>
<td>5/6</td>
</tr>
<tr>
<td>6 (6)</td>
<td>F/43</td>
<td>Arm</td>
<td>8/5</td>
</tr>
<tr>
<td>6 (7)</td>
<td>F/43</td>
<td>Neck</td>
<td>9/7</td>
</tr>
<tr>
<td>7 (8)</td>
<td>M/27</td>
<td>Face</td>
<td>10/10</td>
</tr>
<tr>
<td>8 (9)</td>
<td>F/31</td>
<td>Back</td>
<td>10/9</td>
</tr>
<tr>
<td>9 (10)</td>
<td>F/51</td>
<td>Chest</td>
<td>9/7</td>
</tr>
<tr>
<td>10 (11)</td>
<td>M/62</td>
<td>Face</td>
<td>10/10</td>
</tr>
<tr>
<td>11 (12)</td>
<td>M/19</td>
<td>Arm</td>
<td>8/6</td>
</tr>
<tr>
<td>12 (13)</td>
<td>M/13</td>
<td>Face</td>
<td>9/6</td>
</tr>
<tr>
<td>13 (14)</td>
<td>M/51</td>
<td>Neck</td>
<td>9/10</td>
</tr>
<tr>
<td>14 (15)</td>
<td>F/65</td>
<td>Abdomen</td>
<td>7/7</td>
</tr>
<tr>
<td>15 (16)</td>
<td>M/53</td>
<td>Neck</td>
<td>7/7</td>
</tr>
</tbody>
</table>
and six (40%) were unsatisfied. Figure 4 shows clinical photographs of the postoperative scars of patients 1 and 8 before and after the two sessions of CO₂ FS.

All participants reported pain during the treatment and post-treatment edema, erythema, and scaling, all of which resolved within 1 week. Post-treatment hyperpigmentation developed in one patient on the treated half of the scar but resolved spontaneously within 1 month. Hypertrophic scarring developed in one patient on both halves of the scar. No other adverse events, including post-treatment blisters, scarring, secondary bacterial infection, or viral infection, were observed.

Discussion

The results of this study demonstrate that ablative CO₂ FS is effective for treating surgical scars in the early postoperative period and has positive effects especially on scar texture and thickness. There have been many studies on the use of fractional lasers to treat surgical scars, but most have focused on mature scars months to years after surgery. Although normal wound healing and scar remodeling continue to occur until 2–3 years after surgery, many patients desire treatment of scars as soon as possible, especially when the scars are located on visible sites.

Therefore, focus has recently been directed toward laser treatment for scar prevention. A number of studies have been performed using various kinds of lasers in the early postoperative period. Specifically, surgical scars have been successfully treated using pulsed dye lasers (PDLs) on suture removal day, and a nonablative, 1,550-nm fractional erbium glass laser was used on new thyroidectomy scars with positive results. In addition, ablative 2,940-nm erbium-doped yttrium aluminum garnet fractional laser treatment has been used on fresh surgical scars in combination with PDL. In another study, ablative CO₂ FS was shown to successfully treat thyroidectomy scars 2–3 weeks after surgery, although there was no control group to compare with the treatment group.

Furthermore, most
split-scar studies have compared different parameters\textsuperscript{10} or different kinds of lasers, and none has compared the effect of fractional lasers with natural scar healing and remodeling.

![Graph](image)

**Figure 3.** Patient satisfaction 3 months after final treatment.

\[\text{Very satisfied} \quad \text{Satisfied} \quad \text{Slightly satisfied} \quad \text{Unsatisfied}\]

\[\text{CO}_2\text{ FS} \quad \text{Control}\]

\[0 \quad 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8\]

CO\textsubscript{2} FS enables treatment of scars with far fewer side effects and less downtime than traditional CO\textsubscript{2} lasers. By leaving uninjured tissue around each microscopic treatment zone, CO\textsubscript{2} FS allows the intact dermis to heal rapidly around these columns of thermal damage, which in turn stimulates progressive collagen remodeling.\textsuperscript{11}

In this split-scar trial study, CO\textsubscript{2} FS was used to treat scars 3 weeks after surgery. We chose to treat patients with lasers 3 weeks after surgery because re-epithelialization would be complete at this point, and treatment initiation at this time point was shown to have positive results in a previous report,\textsuperscript{4} so it was adopted in our study. We noticed more improvement of postoperative scars after early treatment with CO\textsubscript{2} FS than on the untreated side of

![Images](image)

**Figure 4.** Clinical photographs of the surgical scar at (A) baseline and (B) 3 month after two sessions of carbon dioxide fractional laser system in patient 1 (upper) and patient 8 (lower). Lower half was treated for patient 1, and left half, from the evaluator’s view, was treated for patient 8.
The control and treated sides had statistically significant improvement in all categories of VSS score, although CO₂ FS delivered greater improvement in overall VSS score and especially in the pliability and height categories.

We did not experience secondary scarring after treatment, except in one patient who noticed further elevation and widening of the scar on the chest. In this patient, the volume increase was observed on both sides of the scar, so it is difficult to say that the fractional laser was the sole cause of the scar elevation, although the treated side became thicker and wider than the untreated side, and thus the risk of developing hypertrophic scarring after CO₂ FS treatment cannot be excluded. One of the main concerns with ablative fractional lasers in scar treatment has been the trigger of an overzealous healing response resulting in a hypertrophic scar. Lee and colleagues reported two patients treated using CO₂ FS wherein one patient developed hypertrophic scar after treatment, whereas another achieved clinical improvement of previously existing hypertrophic scar. Although these were burn scars, the report emphasizes the importance of selecting the most appropriate treatment settings, because it appears that the same laser can treat or induce hypertrophic scars. From our experience, we feel that the CO₂ FS can be safely used in early postoperative scars with control of energy and coverage. A previous study with CO₂ FS (Fraxel Repair laser; Solta Medical, Hayward, California) suggested that densities of 30% to 50% coverage can be safely used for scars on the face and 20% to 30% for those off the face and that more-favorable results are obtained using lower fluences for off-face sites. Although density settings are different between ablative fractional devices, these findings suggest that treatment settings used for scars should vary according to location, although in our study, the same treatment settings were used for scars on and off the face, which resulted in one case of secondary hypertrophic scarring on an off-face area, namely, the anterior chest. Secondary hypertrophy developed in one scar in the nine nonfacial scars included in our study (11%). We think that lower density and lower energy would have been more appropriate for this patient. Further research to compare treatment energy and densities needs to be done in a prospective split-scar fashion to understand the development of hypertrophic scarring according to different parameters of CO₂ FS.

In the subset analysis, we investigated efficacies in terms of pigmentation, vascularity, pliability, and thickness. The CO₂ FS–treated group had significantly greater improvement in pliability and thickness than the control group, although the degree of improvement in vascularity and pigmentation was not significantly different between the two groups.

Physicians are reluctant to use conventional ablative lasers because of the significant risks of prolongation of post-treatment erythema and possible permanent pigmentary changes. Nevertheless, although we did not experience any of these side effects, previous studies have shown that post-treatment erythema and permanent pigmentary changes can be minimized by using the lowest effective energy for the treatment of scars. We achieved proper energy and density to bring out the beneficial effects on the pliability and thickness while avoiding prolonged erythema and permanent pigmentation in Asian patients (Fitzpatrick skin types III and IV).

The improvement in VSS score was not significantly different between facial and nonfacial scars. This result may differ in a larger population study because our study included only seven facial scars and nine nonfacial scars. Nevertheless, although possibly less efficacious, we feel that lower densities and fluences should be used for off-face scars to avoid the potential side effects discussed above.

The limitations of this study include the variability in the anatomic sites of the scars, with the majority of scars on the face (n = 7, 43.7%) and a smaller number on the neck (n = 3, 18.7%), arm (n = 3, 18.7%), back (n = 1, 6.2%), chest (n = 1, 6.2%), and abdomen (n = 1, 6.2%). Second, although
Attempts were made to select scars with uniformity in both halves of the scar, several scars demonstrated asymmetry in one or more variables assessed. Third, we used the same parameter for all scars located on different parts of the body. Also, we treated the same side for all patients, the left or lower half of the scar, instead of randomizing it. One could argue that factors such as gravity might have an effect on scar healing, especially for the vertical scars, whose lower half was treated. Lastly, longer-term follow-up is needed to compare the course of treated and untreated scars.

In conclusion, early treatment using CO₂ FS may help scars to improve more rapidly and may prevent scar formation. Controlled studies with ablative fractional lasers at various settings should be conducted to better understand the efficacy of lasers in scar prevention. Further studies combining two or more lasers may also be helpful in determining the most appropriate treatment approach for surgical scars.

References


Address correspondence and reprint requests to: Mi Ryung Roh, MD, PhD, Department of Dermatology and Cutaneous Biology Research Institute, Yonsei University College of Medicine, Gangnam Severance Hospital 146–92, Eonjuro 712, Gangnam-gu, Seoul 135–720, Korea, or e-mail: karenroh@yuhs.ac