Received: 19.4.2011 **Accepted: 3.9.2011**

Original Article

Comparison of Q-Switched 1064-nm Nd: YAG laser and fractional CO2 laser efficacies on improvement of atrophic facial acne scar*

Ali Asilian[1], Elias Salimi[2], Gita Faghihi[3], Farideh Dehghani[4], Nabet Tajmirriahi[2], Sayed Mohsen Hosseini[5]

Abstract

BACKGROUND: Acne scarring is treatable by a variety of modalities. Ablative carbon dioxide laser (ACL), while effective**,** is associated with undesirable side effect profiles. Newer modalities using the principles of fractional photothermolysis (FP) produce modest results than traditional carbon dioxide (CO_2) lasers but with fewer side effects. A novel ablative CO_2 laser device use a technique called ablative fractional resurfacing (AFR)**,** combines CO_2 ablation with a FP system. This study was conducted to compare the efficacy of Q-switched 1064-nm Nd: YAG laser and that of fractional CO_2 laser in the treatment of patients with moderate to severe acne scarring.

METHODS: Sixty four subjects with moderate to severe facial acne scars were divided randomly into two groups. Group A received Q-Switched 1064-nm Nd: YAG laser and group B received fractional CO_2 laser. Two groups underwent four session treatment with laser at one month intervals. Results were evaluated by patients based on subjective satisfaction and physicians' assessment and photo evaluation by two blinded dermatologists. Assessments were obtained at baseline and at three and six months after final treatment.

RESULTS: Post-treatment side effects were mild and transient in both groups. According to subjective satisfaction ($p = 0.01$) and physicians' assessment ($p < 0.001$), fractional CO_2 laser was significantly more effective than Q-Switched 1064- nm Nd: YAG laser.

CONCLUSIONS: Fractional CO2 laser has the most significant effect on the improvement of atrophic facial acne scars, compared with Q-Switched 1064-nm Nd: YAG laser.

KEYWORDS: Laser, Acne, Scar.

J Res Med Sci 2011; 16(9): 1189-1195

Acne is a common disease affecting 80% of individuals between 11 and 30 years old and 5% of elderly people.[1,2]

Acne vulgaris is a multifactorial disease.[3] Although the combination of hyperkeratinization, sebum production and propionibacterium acnes are the proposed factors, the principle abnormality is comedone formation by hyperkeratinization.[4,5]

Atrophic acne scar is one of the most dramatic consequences of inflammatory acne.[6] Due to the fact that physical disfigurement and psychological burden of these scars are noticeable, patients frequently seek medical treatment.[7,8] Although acne scarring was indeed a complicated problem for the physicians, new treatment techniques showed promising results.[9]

---

* This paper derived from a speciality thesis NO:388286 in Isfahan University of Medical Sciences.

1- Professor of Dermatology, Department of Dermatology, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.
2- Resident of Dermatology, Department of Dermatology, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.
3- Associate Professor of Dermatology, Department of Dermatology, School of Medicine, Isfahan. University of Medical Science, Isfahan, Iran.
4- Assistant Professor of Dermatology, Department of Dermatology, School of Medicine, Yazd University of Medical Sciences, Yazd, Iran.
5- Associate Professor of Biostatistics, Department of Biostatistics and Epidemiology, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.
Corresponding Author: Elias Salimi
E-mail: s_ salimi @ resedent.mui.ac.ir

Acne scars can be corrected through a variety of modalities, including soft tissue augmentation,[10] deep chemical peels,[11,12] surgical treatment, dermabrasion[13], ablative and non-ablative laser resurfacing.[14]

Non-ablative laser such as the Q-switched Nd: YAG laser (1064 nm) was shown to induce wound healing via subtle thermal effect on the dermis with little or no effect on the epidermis.[15-19]

The world of lasers undoubtedly has been changed over the past 40 years. The arrival of new models of ablative resurfacing lasers over the past two decades, carbon dioxide and erbium marked an important turning point in the treatment field for the acne scars by introducing more efficacy in comparison with non-ablative lasers.[20]

This development creates vast new modalities for both patients and physicians. In fact these lasers cause collagen and elastin remodeling by removing the epidermis and varying depth of dermis.[21] However, ablative resurfacing lasers are accompanied by conspicuously lengthy recovery time and postoperative erythema that last for weeks to months.[22] In addition, these modalities may be associated with permanent dyspigmentation especially in individuals with darker skin phenotypes.[23]

To overcome the above mentioned side effects, fractional laser resurfacing technique on the basis of principle of fractional photothermolysis has been introduced in 2003.[24] These new lasers were able to overcome the debilitating aspects of both ablative (side effects) and nonablative (limited efficacy) lasers.[25] In fact, using columns of coagulation in a pixilated pattern (microthermal zones) with no destructive effect on the epidermis, not only leaves intact skin between these tiny cores of coagulation, also preserves the epidermis integrity.[23]

As a result, the healing time is more rapid on the ground that two sources of healing exist now (adnexa and skin margins around the microthermal zones).[26] However, the use of ablative lasers in a fractional mode was developed in 2006.[22] By this method, the enhanced efficacy of ablative modalities combines the safety with the reduced recovery period associated with fractional photothermolysis.[26]

Several studies on comparison between ACL and AFR have been performed. This study is the first, to our knowledge, to measure quantitatively the difference between the efficacy of AFR and Q switched 1064 nm Nd: YAG laser. Both have no significant adverse effects. Also, the sample size was large to reach the conclusion.

Methods

In this randomized blinded clinical trial, sixty four subjects (skin type II-IV, aged 19-43 years) presenting with moderate to severe atrophic facial acne scars[16]were enrolled between March 2009 and October 2010. Grade of post-acne scarring was determined with a qualitative scarring grading system.[27]

This study was initially approved by the ethical committee of Isfahan University of Medical Science. The research Project Number was 388286. Written informed consent was obtained from all participants before enrollment.

The patients were divided into two different treatment groups, using a table of random numbers. Inclusion criteria included any type of moderate to severe facial atrophic acne scar (rolling, boxcar, ice pick). Patients with pregnancy, lactation, history of keloid formation, immunosuppressant or isotretinoin use, and filler substance injections or skin resurfacing by dermabrasion or lasers within the preceding 6 months were excluded from the study.[28]

32 patients were enrolled in each group. The patients in group A received Q-Switched 1064-nm Nd: YAG laser and the patients in group B received fractional CO2 laser.

Each patient in group A received laser treatment of the entire face by a single operator. A 1064-nm Q-switched Nd: YAG laser (Venus 3, Input Voltage 22v/50Hz, April 2003, Korea) was used with an average fluence of 2.5 J/cm^2, spot size: 7 mm. A total of 4 treatments at 4-week intervals were administered (3 pass in every session).

In a similar way, each patient in group B received laser treatment of the entire face by a single operator. A fractional Co_2 laser (Pixel Alma 10600nm) was used. A 3-pass treatment was then performed using pulse width of 110 msec (on-time), 600 msec (off-time) and pulse duration of 350 µs. The diameter of each individual MTZ was 350 µm. A total of 4 treatments at 4-week intervals were administered (3 pass in every session).

Evaluation of the severity of acne scarring was conducted by the optical imaging system at baseline and 3 and 6 months after the fourth treatment session. All digital photographs were performed by a facial photo fixture using a Canon Power shot G12 stand-off camera.

Assessments of the treatment areas using comparative photographs were performed by patient based satisfaction and two blinded dermatologists, 3 and 6 months after the fourth session of treatment. Then, the improvement of acne scars was graded by a quartile grading scale: less than 25%: mild, 25% to 50%: moderate, 51% to 75%: good, and 76% to 100%: excellent response.[29]

The statistical analysis was done by SPSS for Windows software (SPSS Inc., Chicago, IL, USA, version 18.0) by using Chi-square, t-test, Man-Whitney and Kruskal-Wallis analyses. The significance level was set at P value of less than 0.05.

Results

Sixty-four subjects (100%) were completed four treatment sessions and all of them were followed for 6 months after the last session.

The mean age of patients was 26.3 ± 5.5 years in group A and 26.9 ± 5.8 years in group B. 10 (21%) were male and 22 (69%) were female in both groups. Demographic and baseline clinical characteristics of patients (age, sex, and skin type) were well balanced in two groups. Chi-square and t-test revealed no significant difference between the two treatment groups for any of these characteristics ($p > 0.05$).

The patients reported continuing clinical improvement following each consecutive treatment. Patient satisfaction surveys at the end of the study revealed that of patients in group A, 25% (8 out of 32) rated themselves as having less than 25% of overall improvement, 65.6% (21 out of 32) judged themselves as having 25% to 50% improvement and 9.4% (3 out of 32) rated improvement of 50% to 75%. Nobody reported improvement of more than 75% (excellent).

Although the number of patients with mild and moderate improvement reduced in group B, there was an increase in the number of subjects with more than 50% response.

Man-Whitney analysis revealed significantly greater improvement of scars in patients of group B (p-value = 0.01, Table 1).

Mean percent of scar improvement at six months follow up was 46.6% in group B and 31.9% in group A. In other words, patients in group B (95% confidence interval [CI] (39.87-53.25, P-value = 0.01) more likely experienced improvement than patients in group A (95% CI28.02-35.73, p-value = 0.01).

In a similar manner, clinical improvement was assessed by two blinded dermatologist. Although their evaluation confirm greater efficacy of fractional CO2 vs. Nd: YAG, Man-Whitney test with P-value of 0.06 (Table1).

We used Man Whitney test to evaluate differences between the sexes in each group in the percentages of improvement but there was no statistically significant difference between them ($p > 0.05$). Also, Kruskal-Wallis analysis did not show meaningful difference among skin types in each group in the percentages of improvement ($p > 0.05$).

Immediate transient post-treatment burning was seen in all patients in group A that resolved without any treatment. Mild post-inflammatory hyperpigmentation, noted in 19.6% of subjects (n=6) in group A. This complaint was transient and resolved spontaneously after 2-3 weeks. Although the burning sensation in patients of group B was more severe, it did not remain more than some hours. Almost the same as patients in group A, post- inflammatory hyperpigmentation lasting for 3 weeks was observed in 31.2% (10 subjects) of group B.

Table 1. Patients and blinded investigators' evaluations of treatment

	Laser	response				P value
		Mild *N (%)	Moderate N (%)	Good N (%)	Excellent N (%)	
Patients' evaluations	Q-Switched Laser	8 (25%)	21 (65.6%)	3 (9.4%)	0 (0%)	0.01
	fractional CO_2 Laser	4 (12.5%)	16 (50%)	11 (34%4)	1 (3.1%)	
Blinded investigators	Q-Switched Laser	8 (25%)	20 (62.5%)	4 (12.5%)	0 (0%)	>0.05
	fractional CO_2 Laser	6 (18.8%)	14 (43.8%)	11 (34.4%)	1 (3.1%)	

*N shows number of patients in each group that classified according to the quartile grading scale

Discussion

Atrophic acne scarring occurs because of the impaired resolution or healing of damaged caused in and around pilosebaceous follicles during active inflammation. These scars are usually classified according to the shape and depth as ice-pick, rolling, and boxcar scars; they often involve deeper structures and draw in surface layers to cause indention or atrophy. Although laser skin resurfacing has revolutionized the treatment of atrophic acne scars, they still present a major therapeutic challenge.

Ablative laser resurfacing using CO_2 or Er: YAG lasers has an efficacy of 25% to 90% for treating acne scars and is considered the "gold" standard. However, postoperative erythema, infection, scarring, and pigmentary alteration are not uncommon complications. In particular, postoperative hyperpigmentations, although usually transient, are relatively common in patients with darker skin types.

On the other hand, nonablative lasers (e.g., the 585-nm PDL, the 1064- and 1,320-nm Nd: YAG laser, and the 1,450-nm diode laser) are known to ameliorate acne scar appearance by stimulating collagen production and dermal remodeling. Clinical improvements in scar appearances of 40% to 50% have been observed following such nonablative laser treatments, and minimal downtime and a low risk of adverse events compensating for the lower efficacies of these modalities.[28]

In the present study to our knowledge we provide the first clinical evidence that compares the effectiveness of nonablative1064-nm Q-switched Nd: YAG and fractional CO2 laser in the treatment of atrophic acne scars.

No comparative study on the efficacy and safety of fractional CO2 and Nd: YAG laser for the treatment of acne scars has been previously conducted. In our study, most of patients in group A, judged themselves as having 25% to 50% improvement and 9.4% (3 out of 32) rated improvement of 50% to 75%. Although number of patients with mild and moderate improvement reduced in group B, there was an increase in the number of subjects with more than 50% response.

Previous studies showed that Nd: YAG laser was most effective at treating superficial boxcar and rolling scars and was less effective at treating deep boxcar, deep rolling, and ice-pick scars.[30,31] In another study, Friedman et al. treated eleven patients with mild to moderate atrophic acne scarring with nonablative 1064-nm Q-switched Nd: YAG laser. Improvement increased to 23.3%, 31.6%, and 39.2% at 1, 3, and 6 months after the fifth treatment, respectively. Patients reported mild to moderate pain with treatment. The only adverse effects noted were transient erythema and mild pinpoint petechiae. No dyspigmentation or scarring was seen in any patient.[32]

In our study, 31.9% improvement after six months of treatment reported that was not very much. In addition, we had post-inflammatory hyperpigmentation in both groups that improved after few weeks. Lack of dyspigmentation in Friedman's study can be due to patients' skin type that was I-III.

Badawi et al. evaluated the safety and efficacy of a sub-millisecond 1,064 nm Nd: YAG laser for the treatment of atrophic scarring in 22 patients. Degree of improvement was graded using a four-point scale: 0 = <25%, 1 = 25-50%, 2 = 51-75%, 3 = 76-100%. Based on blinded photo assessments by three independent reviewers, clinically and statistically significant median improvement of 2 in scarring, 2.3 in texture, and 2 in pigmentation were observed (one-sample Wilcoxon signed rank test, $p < 0.001$).[30]

According to mounting evidences of this study, fractional CO_2 laser is not only an effective method, also is safe because of short downtime period and transient PIH lasting for 3 weeks at the maximum in 31.2% of subjects. Previous studies confirmed our results.

In another study, Manuskiatti et al. evaluated the efficacy and safety of carbon-dioxide ablative fractional resurfacing on atrophic acne scars in 13 Asian individuals. Of the subjects, 62% rated themselves as having at least 50% improvement in their scars. Mild post-inflammatory hyperpigmentation was the most common adverse effect observed in 92% of the subjects or 51% of treatment sessions, and was completely resolved in an average of 5 weeks.[33]

Huang and his colleague studied the therapeutic effect, safety and risk of fractional resurfacing with ablative laser in the treatment of superficial scar. 88 cases of superficial scar, including 66 cases of acne scar, 12 cases of burn scar and 10 cases of other scars were treated. All the patients were treated with Pixel (Er: YAG 2940 nm, ≥ 3 times), or Encore (Ultrapulse CO_2 10600 nm, ≥ 2 times), or a combination of Pixel and Encore (≥ 3 times).

The effective result was achieved in 80% of the patients. Good effect was achieved in 50% of the patients. Persistent hyperpigmentation was happened in one case with Encore treatment, which relieved four months later. No other complication was happened.[34] The above-mentioned studies performed in Asia and had similar results to our investigation in improvement rate and side effects.

The conjectural hypothesis that fractional CO_2 laser yields such more positive results than non-ablative lasers in the treatment of acne scars is likely due to the fact that in these lasers the enhanced efficacy of ablative modality is combined with the safety of fractional photothermolysis. In spite of the fact that ablative lasers by removing the epidermis and varying depth of dermis cause collagen and elastin remodeling, the epidermis integrity is preserved and thus, the adverse effects are reduced by fractional CO2 laser.[35]

In our study, according to subjects ($p = 0.01$) and investigators' evaluation, fractional CO_2 laser was significantly more effective than Q-Switched 1064-nm Nd: YAG laser.

The results were long lasting and continued to the six-month follow-up, which confirmed ongoing collagen remodeling after completion of the laser treatment.

Conclusion

This prospective study outlined here suggested that AFR using a combination of ablative technology with fractional photothermolysis provides an effective option for treatment of moderate to severe acne scar with minimal side effects.

Acknowledgement

We thank all the patients who participated in this study and the staff of the Spadana Laser Center. We also thank Dr. Adibi for her contribution to this study and valuable helps.

Conflict of Interests

Authors have no conflict of interests.

Authors' Contributions

AA was the chief supervisor. AA and ES carried out the design, coordinated in the study, and participated in most of the experiments. GF was the second supervisor and helped improving the data and the protocol. NT and FD were responsible for data analysis and writing the manuscript. All authors have read and approved the content of the manuscript.

References

1. Jacob CI, Dover JS, Kaminer MS. Acne scarring: a classification system and review of treatment options. J Am Acad Dermatol 2001; 45(1): 109-17.
2. Layton AM, Henderson CA, Cunliffe WJ. A Clinical evaluation of acne scarring and its incidence. Clinical and Experimental Dermatology 1994; 19(4): 303-8.
3. Norris JF, Cunliffe WJ. A histological and immunocytochemical study of early acne lesions. Br J Dermatol 1988; 118(5): 651-9.
4. Hirsch RJ. The future of acne treatment with lasers. Cosmet Dermatol 2002; 15: 73-4.
5. Leyden JJ, McGinley KJ, Mills OH, Kligman AM. Propionibacterium levels in patients with and without acne vulgaris. J Invest Dermatol 1975; 65(4): 382-4.
6. Sadick NS, Schecter AK. A preliminary study of utilization of the 1320-nm Nd:YAG laser for the treatment of acne scarring. Dermatol Surg 2004; 30(7): 995-1000.
7. Rogachefsky AS, Hussain M, Goldberg DJ. Atrophic and a mixed pattern of acne scars improved with a 1320-nm Nd:YAG laser. Dermatol Surg 2003; 29(9): 904-8.
8. Goodman GJ. Postacne scarring: a review of its pathophysiology and treatment. Dermatol Surg 2000; 26(9): 857-71.
9. Goodman GJ. Management of post-acne scarring. What are the options for treatment? Am J Clin Dermatol 2000; 1(1): 3-17.
10. Krauss MC. Recent advances in soft tissue augmentation. Semin Cutan Med Surg 1999; 18(2): 119-28.
11. Pinski KS, Roenigk HH, Jr. Autologous fat transplantation. Long-term follow-up. J Dermatol Surg Oncol 1992; 18(3): 179-84.
12. Varnavides CK, Forster RA, Cunliffe WJ. The role of bovine collagen in the treatment of acne scars. Br J Dermatol 1987; 116(2): 199-206.
13. Moritz DL. Surgical corrections of acne scars. Dermatol Nurs 1992; 4(4): 291-9.
14. Eiseman G. Reconstruction of the acne-scarred face. J Dermatol Surg Oncol 1977; 3(3): 332-8.
15. Levit E, Daly D, Scarborough DA, Bisaccia E. The case for non ablative laser resurfacing. Cosmetic Dermatol 2002; 15(1): 39-44.
16. Sadick NS. Update on non-ablative light therapy for rejuvenation: a review. Lasers Surg Med 2003; 32(2): 120-8.
17. Cisneros JL, Rio R, Palou J. The Q-switched neodymium (Nd):YAG laser with quadruple frequency. Clinical histological evaluation of facial resurfacing using different wavelengths. Dermatol Surg 1998; 24(3): 345-50.
18. Bernstein EF, Ferreira M, Anderson D. A pilot investigation to subjectively measure treatment effect and side-effect profile of non-ablative skin remodeling using a 532 nm, 2 ms pulse-duration laser. J Cosmet Laser Ther 2001; 3(3): 137-41.
19. Tanzi EL, Alster TS. Comparison of 1450nm diode laser and 1320 Nd: YAG laser in treatment of atrophic facial scars. Lasers Surg Med 2002; 14(suppl): 28.
20. Apfelberg DB. Ultrapulse carbon dioxide laser with CPG scanner for full-face resurfacing for rhytids, photoaging, and acne scars. Plast Reconstr Surg 1997; 99(7): 1817-25.
21. Chiu RJ, Kridel RW. Fractionated photothermolysis: the Fraxel 1550-nm glass fiber laser treatment. Facial Plast Surg Clin North Am 2007; 15(2): 229-37, vii.
22. Alster TS, Tanzi EL, Lazarus M. The use of fractional laser photothermolysis for the treatment of atrophic scars. Dermatol Surg 2007; 33(3): 295-9.
23. Rivera AE. Acne scarring: a review and current treatment modalities. J Am Acad Dermatol 2008; 59(4): 659-76.
24. Cassuto DA, Scrimali L, Sirago P. An innovative device for fractional CO2 resurfacing:a preliminary clinical study. Laser Surg Med 2008; 32: 120-8.
25. Chrastil B, Glaich AS, Goldberg LH, Friedman PM. Second-generation 1,550-nm fractional photothermolysis for the treatment of acne scars. Dermatol Surg 2008; 34(10): 1327-32.
26. Biotech Week Publication. Reliant Technologies Announces FDA Clearance of the Fraxel(R) Laser for the Treatment of Acne and Surgical Scars; Physicians Report Fractional Laser Resurfacing Achieves Dramatic Improvement [Online]. 2006; Available from: URL: http://www.cosmeticsurgery-news.com/article2829.html/

27. Goodman GJ, Baron JA. Postacne scarring: a qualitative global scarring grading system. Dermatol Surg 2006; 32(12): 1458-66.
28. Lee DH, Choi YS, Min SU, Yoon MY, Suh DH. Comparison of a 585-nm pulsed dye laser and a 1064-nm Nd:YAG laser for the treatment of acne scars: A randomized split-face clinical study. J Am Acad Dermatol 2009; 60(5): 801-7.
29. Cho SB, Lee JH, Choi MJ, Lee KY, Oh SH. Efficacy of the fractional photothermolysis system with dynamic operating mode on acne scars and enlarged facial pores. Dermatol Surg 2009; 35(1): 108-14.
30. Badawi A, Tome MA, Atteya A, Sami N, Morsy IA. Retrospective analysis of non-ablative scar treatment in dark skin types using the sub-millisecond Nd:YAG 1,064 nm laser. Lasers Surg Med 2011; 43(2): 130-6.
31. Min SU, Choi YS, Lee DH, Yoon MY, Suh DH. Comparison of a long-pulse Nd:YAG laser and a combined 585/1,064-nm laser for the treatment of acne scars: a randomized split-face clinical study. Dermatol Surg 2009; 35(11): 1720-7.
32. Friedman PM, Jih MH, Skover GR, Payonk GS, Kimyai-Asadi A, Geronemus RG. Treatment of atrophic facial acne scars with the 1064-nm Q-switched Nd:YAG laser: six-month follow-up study. Arch Dermatol 2004; 140(11): 1337-41.
33. Manuskiatti W, Triwongwaranat D, Varothai S, Eimpunth S, Wanitphakdeedecha R. Efficacy and safety of a carbon-dioxide ablative fractional resurfacing device for treatment of atrophic acne scars in Asians. J Am Acad Dermatol 2010; 63(2): 274-83.
34. Huang LP, Zhang CH, Chen J, Chen L, Luo JL. Application of fractional laser resurfacing in the treatment of superficial scar. Zhonghua Zheng Xing Wai Ke Za Zhi 2010; 26(3): 182-5.
35. Metelitsa AI, Alster TS. Fractionated laser skin resurfacing treatment complications: a review. Dermatol Surg 2010; 36(3): 299-306.