Original Article

Resurfacing of Facial Acne Scars With a New Variable-Pulsed Er:YAG Laser in Fitzpatrick Skin Types IV and V

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Abstract

Introduction: The Er:YAG laser, considered to be less effective than CO_2 laser in its traditional form, in its new modulated version has variable pulse technology that is claimed to be superior to the earlier versions of the laser. **Aim:** The aim of the study was to check efficacy and safety of the new variable square pulse (VSP) Er:YAG laser in the management of acne scar in patients with Fitzpatrick skin types IV and V. **Materials and Methods:** This retrospective study consisted of 80 patients (Fitzpatrick skin types IV and V) with atrophic and hypertrophic facial acne scars. Records of the patients who had undergone four treatment sessions with VSP technology equipped with Er:YAG laser were extracted. Each patient had undergone a minimum of four sessions. Fractional mode at medium laser pulse (SP) and long pulse (LP) was employed for the depressed center of the scars to stimulate neocollagenogenesis. Short laser pulse (MSP) in nonfractionated mode was used for ablating the raised scar border and hypertrophic scars. Goodman and Baron global scarring grading system was used for qualitative and quantitative assessments. Patient's satisfaction to the treatment and observer's assessment of improvement (based on photographs) was graded as poor (<25% improvement), fair (25–50% improvement), good (51–75% improvement), and excellent (>75% improvement). **Results:** At the end of the four sessions, the number of patients in grade IV postacne scarring reduced from 16 to 2 and that in grade III from 47 to 29. The mean score significantly dropped from 36.94 to 27.5. Subjective assessment revealed that 78 of 80 patients had noticed more than 25% improvement, with 50 of them showing more than 50% improvement at the end of four sessions. Eight patients perceived an excellent response and 42 reported a good response. This is notably higher than the observer's grading, which showed an excellent response in only 2 patients and a good response in 35. Adverse effects were limited to prolonged erythema (two patients), prolonged crusting (one patient), and postinflammatory hyperpigmentation (one patient). **Conclusion:** Ninety-seven percent of the subjects in our study perceived at least a fair improvement. We also saw a significant change in the objective score with a fall of the mean quantitative score from 36.94 to 27.15. This underscores the new variable-pulsed Er:YAG laser's effectiveness in the treatment of acne scars. It also has the added advantage of lesser adverse events and faster healing.

Keywords: Acne scars, modulated Er:YAG, variable pulse technology

Introduction

Acne scarring, a permanent and largely avoidable complication of acne vulgaris, most often is a source of significant psychological distress.[1] Several studies have documented the prevalence of postacne scarring to be between 11% and 14% in the general population and 49% in those affected with acne.[2,3]

Acne scars are either hypertrophic or atrophic, depending upon whether they are elevated or depressed in relation to the skin surface.[4] Depending on the shape and depth, the atrophic scars are divided into four main morphological types: ice-pick pitted scars, superficial or deep boxcar scars, rolling scars, and linear scars.[5] Most patients have more than one type of scar and treatment of each morphological scar type varies.[6]

Resurfacing with fractional lasers is currently claimed to be one of the most effective treatment options for all types of atrophic scars.[7] Fractional lasers target only a "fraction" or a column of the affected skin leaving intervening areas of skin unharmed. These

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untreated areas help in rapid re-epithelization of the skin, curtailing the chances of prolonged and serious adverse effects.[8] Ablative lasers such as Er:YAG and CO_2 lasers have been shown to be effective in the management of postacne scarring. The Er:YAG laser, hitherto considered to be less effective than CO_2 laser in its traditional form, has a new modulated form with variable square pulse (VSP) technology that is claimed to enhance its efficacy and closely approximate the effectivity of the CO_2 laser. VSP technology, by altering the pulse width and energy simultaneously, offers a superior way to control the degree of ablation and deep tissue heating. It creates precisely controlled sequences of square-shaped pulses that serve to maximize patient safety by minimizing excess laser energy absorption into the surrounding skin. VSP pulses avoid the slow rise and even longer drop-off in pulse power that is common with traditional Er:YAG laser platforms. Slow rises and long falls in pulse power transfer unnecessary laser energy to body tissues, which is then inefficiently converted to heat, increasing the risk of unwanted side effects and reducing the efficacy of the treatment. The microshort pulse (MSP) mode of nonfractionated Er:YAG is useful in ablating hypertrophic scars and raised borders of scars. Fractional Er:YAG, when used in SP and LP mode, is better suited for the depressed center of the scars to stimulate neocollagenogenesis. Another unique addition, the Turbo mode, allows multiple rapid applications of a beam to a single spot, thus increasing the ablation depth of the original beam. Here, the pulses are stacked one upon another and can be repeated upto six times. Due to the superior tissue dynamics and side effect profile, the variable-pulsed Er:YAG may prove to be more useful than the earlier versions of this laser, both in safety and efficacy.[9] The dearth of data on the efficacy and adverse effects of this novel resurfacing technique in Indian skin prompted the present study.

Materials and Methods

This was a retrospective study consisting of 80 patients who had undergone four sittings of Er:YAG laser treatment between January 2015 and February 2016 for facial acne scars and were identified from the patient database. All the patients were aged 15 and older and had Fitzpatrick skin types IV to V with atrophic and hypertrophic acne scars (Goodman and Barron grade 2, 3, and 4). The device used was Fotona laser system with VSP technology that alters the pulse width and energy simultaneously, thus offering a way to control the degree of ablation and deep tissue heating. The patients were suitably primed with sunscreens, depigmenting agents, and emollients before initiating the treatment. Eyes were protected with eye shields and topical anesthesia was used in patients prior to use of ablation. Parallel to the application of thermal laser pulses, cooling was provided with a constant flow of cold air.

The floor of the atrophic scars were treated in the fractional mode whereas the nonfractionated ablative mode was used for shouldering of the raised edges when present and leveling hypertrophic scars. During each session, the normal skin was also treated for an overall rejuvenated appearance. The parameters used are mentioned in Table 1.

Following the procedure, strict photo-protection was advised and topical antibiotic–steroid combination was applied for 3 days after the procedure if there was undue erythema. Topical acne medications were resumed after 5 days in those with active disease and oral acne medication, if any, was continued. An interval of 6 weeks was maintained between the treatment sessions.

Assessment

Assessment was documented by the treating consultant and the doctor performing laser surgery at baseline and following every session which was 6 weeks apart. The final follow-up was 6 weeks after the last (fourth) session.

Qualitative assessment was done using the Goodman and Baron qualitative global scarring grading system comprising four levels: macular, mild, moderate, and severe.[10] A quantitative grading system developed by the same authors was also used for assessment.[11] This system involved scars being given increasing scores based on the type and severity and then multiplied based on the number of scars in each type giving a maximum score of 84.

Table 1: Parameters for the treatment of different types of scars

	Superficial atrophic scars	Deep atrophic scars	Raised edges and hyperplastic scars	Rejuvenation
Fractional	Yes	Yes	No	Yes
Pulse mode	Short pulse mode, 0.3 ms; Turbo* 4–6	Short pulse mode, 0.3 ms; Turbo* 6–12	Microshort pulse mode, 0.175 ms; Turbo* 6	Long pulse mode, 0.6 ms
Fluence	40–70 J	70–180 J	37–40 J	2.4 J
Ablation depth	140–220 μm	250–370 μm	115 μm	<5 μm
Spot size	2–3 mm	2–3 mm	2–3 mm	7 mm
No. of passes	1	1–2	3	1

*"Turbo" mode enables sequences of identical pulses to be emitted within the same treatment spot, thus enhancing the ablation depth and creating better defined microchannels than with single pulses of equivalent fluence.

Digital photographs were taken using identical settings before initiating the treatment and at every follow-up visit. During the last follow-up visit, which was 6 weeks after the last treatment, the final assessment of the photographs was made by an observer not related to the study, and a quartile grading scale was used to assess the response. A score of 0, 1, 2, and 3 was thus given if the response was <25%, 25–50%, 51–75%, and >75%, respectively. The response was documented as excellent if the score was 3, good if the score was 2, and fair if the score obtained was 1. Patients getting a score of <1 were documented as "poor" responders.

In addition to the photographic and clinical assessment, the patient's satisfaction to the treatment was also recorded during each visit and at the final visit. The documented data and photographs were also evaluated for adverse effects such as erythema, hyperpigmentation, edema, and scarring.

Result

Patient demographics

A total of 80 patients with acne scars, 49 belonging to Fitzpatrick skin photo type IV and 31 to type V were included in the study. The study population was within the age group of 18–40 years with a mean age of 27 years and comprised of 42 males (52.5) and 38 females (47.5). The duration of scars ranged from as less as 6 months to 20 years.

Objective analysis

Based on the qualitative global scarring grading system, at the onset of treatment of first session, patients with grade 3 acne scars comprised 59% (47 cases) of our study population, followed by 21.3% with grade 2 (17 cases) and 20% with grade 4 (16 cases). After completing four sessions, during the last follow up, 41 (51.3%) of our patients were in grade 2, 29 patients (36.3%) in grade 3, 8 (10%) in grade 1, and 2 (2.5%) in grade 4 [Figure 1A, B]. The descent in the grading, as seen in Table 2, is statistically significant with a *P* value of 0.00 (Wilcoxon signed rank test).

Prior to the treatment, the quantitative scores of the patients ranged from 22 to 56, with a mean score of 36.94. After four sessions, the scores dropped down to a range of 11–50, with a mean score of 27.5. This drop is statistically significant with a *P* value of 0.00 (*T*-test). There was no significant variance in the outcome with respect to age, sex, and skin phototype.

Subjective analysis

Patient satisfaction scores were higher in comparison to the observer's grading with a fairly higher percentage of improvement in the good and excellent categories, as seen in Table 3. At the end of four sessions, 8 patients graded their improvement as excellent, 42 patients reported good improvement, 28 patients were fairly satisfied with the improvement, and 2 patients did not notice any improvement. The observer found the improvement to be excellent in 2 patients, good in 35 patients, fair in 41 patients, and none in 2 patients. Among the eight patients who perceived excellent improvement, only two were graded similarly by the observer [Figure 2A, B]. Also, the observer documented good improvement in just 29 among the 42 patients who noticed good improvement.

Postprocedure course

The mean duration of posttreatment erythema and crusting was 3 and 6 days, respectively. Prolonged erythema (extending beyond 4 days) was encountered in two patients and was managed conservatively with topical steroid and sunscreen application. In another patient, crusting persisted upto 10 days and was managed similarly. Posttreatment hyperpigmentation lasting 1 month occurred in one patient necessitating the initiation of de-pigmentary creams which resulted in its resolution. In addition to these, another finding noticed was the shrinkage of facial pores, which was observed in 24% of our study population.

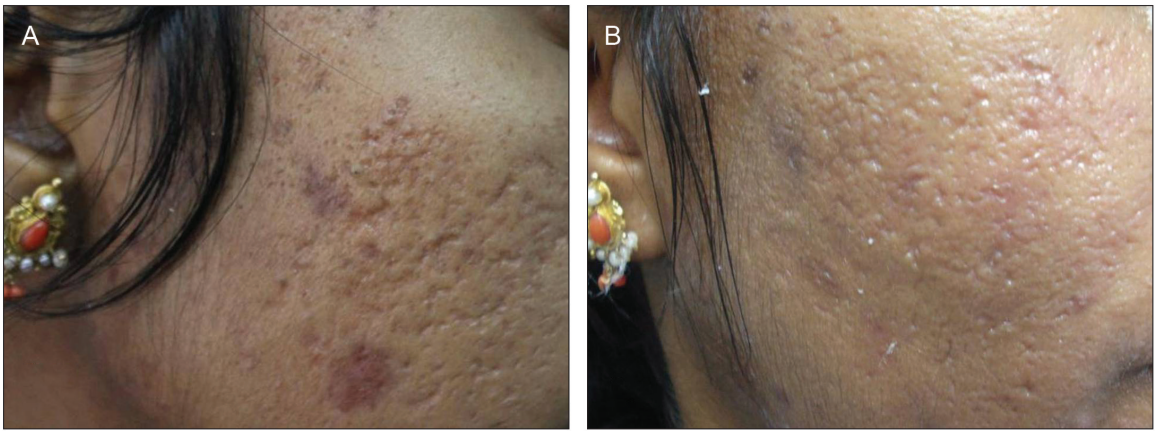

Figure 1: (A) Patient with Grade IV scarring before treatment. (B) After 4 sessions of treatment, patient has descended to grade III

Discussion

Acne and the ensuing scarring is a common affliction of the young that tremendously hamper the psychosocial aspect of an individual.[12] Once formed, management of these scars pose a challenge and has to be dealt with by using a combination of different treatment modalities, keeping in mind the type and severity of the scars. Ablative lasers such as Er:YAG and CO_2 lasers represent a significant advancement in the management of superficial and medium-depth boxcar scars, rolling scars, and hypertrophic scars. Conventional Er:YAG lasers are short pulsed and are so selective for water that their action is almost exclusively ablative. The close approximation of the wavelength of Er:YAG laser (2,940 nm) with the absorption peak of water (3000 nm) results in absorption of nearly all of the energy in the epidermis and papillary dermis yielding superficial ablation and less underlying thermal damage. In comparison, CO_2 lasers present lower selectivity for water as their wavelength is 10,600 nm. Hence, besides causing ablation they are also capable of causing considerable denaturation, coagulation, and reversible thermal damage in the tissues surrounding the zone of ablation.[13] Although this thermal injury results in collagen remodeling through heat-mediated contraction and stimulation of dermal matrix proteins, it is a double-edged sword as it can cause adverse effects such as scarring, hyperpigmentation, and hypopigmentation.

Table 2: Staging of patients before and after treatment based on Qualitative Global Acne Scarring System

Qualitative Global Acne Scarring System		
Grade	% of patients before treatment	% of patients after treatment
1	Nil	10
2	21.3	51.3
3	59	36.3
4	20	2.5

Table 3: Comparison of grading of improvement by the observer and the patients (final assessment done 6 weeks after the fourth session)

Grading of improvement	Photographic assessment by the observer	Self-assessment by the patient
None	2	2
Fair	41	28
Good	35	42
Excellent	2	8
Total	80	80

The newer modified Er:YAG, equipped with variable pulse duration technology, promises to bridge the gap between a conventional Er:YAG laser and CO_2 laser. The principle employed is that the pulse duration is directly proportional to the depth of coagulation and thermal injury. For shorter pulses, the time span for thermal diffusion is short, and the heat energy does not reach very deep into the tissue. For longer pulses, the heat has sufficient time to spread deeper into the tissue. When Er:YAG is used for longer pulse duration, it mimics CO_2 laser in inducing collagen contraction and coagulation of small dermal vessels. Shortening the pulse duration produces superficial ablation with minimal thermal effect, simulating conventional Er:YAG laser. Therefore, the short pulse mode can be used to smooth the scar and the long-pulse mode used to tighten the tissue. In addition to this dual benefit, the wavelength specificity of Er:YAG decreases the risk of deleterious effects often seen with CO_2 laser.[9] Employing fractional Er:YAG laser further reduces the risk and the downtime as it is based on a concept of producing an array of microscopic wounds on the skin surface that are rapidly re-epithelialized by the surrounding, undamaged tissue. Since the integrity of the epidermis is not compromised, healing is faster with lesser side effects.[4]

The basic principle of treating atrophic acne scar is reducing the depth of the scar borders and stimulating neo-collagenosis to fill in the depressions. When used at

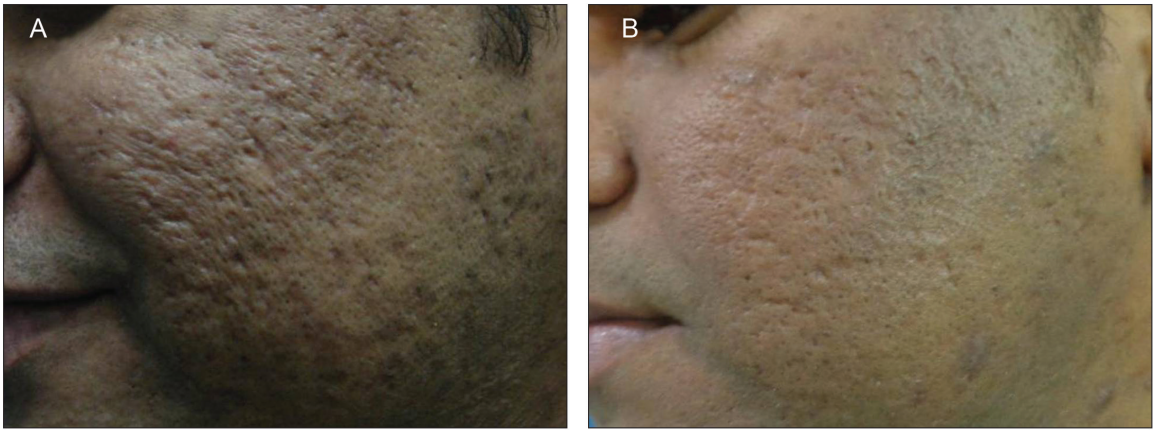

Figure 2: (A) Patient with Grade IV scarring before treatment. (B) After 4 sessions of laser, patient perceived excellent improvement

short laser pulse (MSP), the nonfractionated Er:YAG is useful in ablating raised borders of scars as well as hypertrophic scars. Fractional Er:YAG at medium laser pulse (SP) and long pulse (LP) is best suited for the depressed center of the scars to stimulate neo-collagenosis. Turbo mode enables sequences of identical pulses to be emitted rapidly within the same treatment spot, thus enhancing the ablation depth and creating better defined microchannels than with single pulses of equivalent fluence.

This study demonstrates that Er:YAG laser with variable pulse technology, using a combination of ablative and fractional mode, can effectively improve acne scars with minimal risks and downtime. The outcome was assessed both subjectively and objectively. Subjective scoring was based on photographic assessment by the observer and patient satisfaction and objective scoring was done using Goodman and Baron Qualitative and Quantitative global scarring grading systems. Since postacne scarring is variable with respect to texture, type, depth, and the number, there would be no similarity of scars on both cheeks. Scoring methods therefore concentrate on global scars and not on each cheek. Split face studies therefore lack weightage. Very few studies of this type are available, and hence our study did not carry out separate assessments of each cheek. Split face studies and scoring for each cheek separately would be relevant only if different treatments are being compared on either side and has been tried in some studies.[14,15]

At the end of four sessions, significant number of patients slipped down a grade or two from the time of initial evaluation which was based on qualitative global acne grading system developed by Goodman and Baron. In comparison with the initial score based on the Goodman and Baron quantitative global acne grading system, all the 80 patients had a drop in the total score at the end of four sessions. The mean score significantly dropped from 36.94 to 27.5. However, only 37 patients were found to have more than 50% improvement at the end of 4 sessions.

In contrast, subjective assessment revealed that 78 of 80 patients had noticed more than 25% improvement, with 50 of them showing more than 50% improvement at the end of 4 sessions. This observation is consistent with the findings of Nirmal *et al.* and Kutlubay *et al.*, who studied the efficacy of Er:YAG laser on a study population similar to ours.[16,17] Thus, patients seemed to be overestimating the benefit.

This phenomenon of the patient overestimating the benefit was also seen in the study by Nirmal *et al.* The discrepancy between the patient's perception of improvement and the improvement documented by the observer is probably because of the additional benefits of fractional laser in decreasing pigmentation, skin tightening, and pore reduction.[18] The fact that 24% of the patients also noticed an improvement in the overall texture of the skin along with shrinkage of pores substantiates this.

The two poor responders in this study had a large number of ice-pick scars along with atrophic scars. They underwent TCA CROSS treatment subsequently. The patients who benefitted the most had predominantly rolling and superficial boxcar type scars. These observations, that ice-pick scars respond poorly to Er:YAG laser whereas superficial boxcar and rolling scars respond favorably, are in tune with previously reported studies.[7,19,20] In deeper boxcar scars, fractional form of Er:YAG laser was used for the center of the scar and ablative form to shoulder the raised edges.

Jeong *et al.* used long-pulsed Er:YAG laser for the treatment of pitted facial acne scars in 35 patients with Fitzpatrick skin phototypes III–V and noticed excellent response in 10 patients (36%), good in 16 patients (57%), and fair in 2 patients (7%).[21] Posttreatment, they encountered prolonged erythema in 15 patients and postinflammatory hyperpigmentation (PIH) in 8 patients. The higher incidence of side effects in the study by Jeong *et al.* can be attributed to the long pulse used resulting in more thermal damage.

In our study, prolonged erythema was seen only in two patients (2.5%), and crusting and hyperpigmentation in one patient each (1.25%). Strict photoprotection, topical steroids, and sunscreens along with skin lightening creams took care of all the side effects. Reduced incidence of PIH found in our study is consistent with the findings of a study by Nirmal *et al.*, where they noticed PIH in only 2% of the 25 patients. Thus, our study establishes the safety of Er:YAG resurfacing in darker-skinned individuals.

Unlike Nirmal *et al.* and Jeong *et al.*, we did not notice acneiform eruption in our patients. Fisher *et al.* studied 60 patients with skin types ranging from I to IV and the use of fractional photothermolysis for side effects. They found that side effects were transient and limited to erythema, edema, dry skin, flaking skin, superficial scratches, pruritus, increased sensitivity, and acneiform eruption. They did not see the development of posttreatment scarring, herpetic activation, hypopigmentation, hyperpigmentation, persistent erythema, persistent edema, or infection.[22] In our study, factors like gender, age, or skin photo-type did not bear significant influence on the final outcome.

Conclusion

The new variable-pulsed Er:YAG laser is at an advantage as it allows the largest range of thermal depth control and therefore the most complete range of treatments. In our study, not only did 97% of the subjects rate themselves as having at least fair improvement, we also saw a significant change in the objective score. Minimal postlaser adverse events and truncated healing time add to the credibility

of Er:YAG laser with variable pulse technology. Thus, it can be said that the versatile Er:YAG laser is a safe and effective modality in the treatment of acne scars.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Registration number of clinical trials

Nil.

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Conflicts of interest

There are no conflicts of interest.

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