OPEN

PRS GLOBAL OPEN

ORIGINAL ARTICLE

Burns

Picosecond Nd:YAG versus Fractional CO_2 Lasers in Management of Postburn Scars

Abeer Attia Tawfik, MD, PhD*
Noha Sami Hanafy, PhD†
Rama Ahmed Ali, MD‡

Background: The picosecond laser was primarily designed to enhance tattoo removal. Because it has a new innovative mechanism for energy delivery, it has been modified to be used in other conditions such as skin resurfacing, which was usually treated with fractional CO_2 laser. Comparing both technologies in managing postburn scars has not been widely addressed.

Methods: The current prospective comparative randomized intrapatient study was done on 15 patients who presented with unsightly postburn scarring. As a split study, one-half of the affected areas were treated using the picosecond Nd: YAG laser. The other areas were treated with a fractional CO_2 laser. After three treatment sessions, the results were analyzed both objectively and subjectively.

Results: The assessment by the image analysis system (Antera camera) showed improvement in all the parameters in both groups. The melanin relative variation decreased from 11.65 ± 2.86, 15.85 ± 5.63 to 10.60 ± 1.96, 12.56 ± 3.98, respectively in picosecond laser sites and fractional CO_2 sites. The percentage change in overall opinion decreased in in favor of the fractional CO_2 laser sites, which is a statistically significant improvement. Instead, color scores revealed a greater reduction in the picosecond sites in comparison with the fractional CO_2 sites, as it decreased from 7.67 ± 1.76, 7.73 ± 1.83 to 2.87 ± 1.06, 6 ± 1.2, respectively.

Conclusions: When compared with fractional CO_2 lasers, picosecond Nd:YAG shows comparable improvements in scars' erythema, texture, and height, with some superiority in the management of hyperpigmented scars. *(Plast Reconstr Surg Glob Open 2024; 12:e5700; doi: 10.1097/GOX.0000000000005700; Published online 22 March 2024.)*

INTRODUCTION

Burns are wounds to the skin or other tissues brought on by contact with heat, radiation, chemicals, or electricity. Despite a vast range of therapy modalities (such as silicone gel, garments, corticosteroid injections, radiation, lasers, IPL, and surgery, even injecting botulinum toxin A into the lesion), clinical management is still difficult. Scars that result as a sequel of burn healing are frequently broad and constricted and affect large areas, which may impair the function of the implicated anatomical site and cause deformities. This creates a vast burden on the patient, both physically and mentally.[1–5]

To enhance the appearance and function of scars, particularly postburn ones, fractional laser therapy has proven to be a useful therapeutic option. By generating microthermal zones (MTZ) during the ablation of scars with a fractional CO_2 laser (wavelength 10,600 nm), the dermal layer of the skin can be selectively thermalized. It raises the skin's surface temperature to 70°C, denaturing and irreversibly coagulating the proteins in the dermis without damaging the epidermal layer. Starting with a molecular cascade, the surrounding healthy tissue aids in the remodeling process. Forty-eight hours after laser treatment, when the skin starts to heal, the heat shock proteins, inflammatory cytokines, and metalloproteinases become activated to displace the vaporized columns with new epidermal cells and restore the skin continuity. With a decrease in type I collagen and subsequent rise of type III collagen amount, collagen remodeling leads to the creation of new collagen, thus improving the aesthetic appearance of the scar.[6–9]

Recently, handpieces with fractionated picoseconds have been created for skin resurfacing. Picosecond

*From *Dermatology and Laser, National Institute of Laser Enhanced Sciences (NILES), Cairo University, Cairo, Egypt; †Research Department of Dermatology and Venereology, Medical Research Division, National Research Centre, Cairo, Egypt; ‡Faculty of Medicine, Cairo University, Cairo, Egypt.*

Received for publication October 29, 2023; accepted January 31, 2024.

DOI: 10.1097/GOX.0000000000005700

Disclosure statements are at the end of this article, following the correspondence information.

lasers work by targeting the melanin in the epidermal focal zone that absorbs its energy. Within these localized zones, the propagation of focal pressure waves results in electron mass breakdown, known as "laser-induced optical breakdown." Its energy is then converted into pressure waves (barotrauma) resulting in localized epidermal vacuoles, and these waves are transmitted into the dermis, initiating the tissue repair process and changing cell signaling. This barotrauma leads to dermis modifications that result in neoelastinogenesis and neocollagenesis, also resulting in improving the scar's aesthetics.[10–12]

In this study, we aimed to assess the effectiveness of the picosecond Nd: YAG laser in comparison with fractional CO_2 laser in the management of postburn scars.

PATIENTS AND METHODS

The current prospective randomized intrapatient comparative study was conducted on 15 patients with flat hyperpigmented postburn scars. Both sexes were included, with ages ranging from 15 to 25 years. Both scald and flame burns were also included.

Exclusion criteria included lactating and pregnant women. No previous laser treatment sessions within 1 year before enrollment to the study. Patients with regular current use of medication that may induce photosensitivity, such as antihistamines, oral contraceptives, tricyclic antidepressants, and tetracycline, in the past 3 months were excluded. Other modalities of the scar treatment were prohibited during the study.

The ethical committee board of the National Institute of Laser-Enhanced Sciences at Cairo University approved the current study. All of the included patients were fully informed about the procedure. Informed consents were taken from the participants or their guardian both verbally and written. This includes written signed informed consents for their photographs to be published.

A detailed, thorough history, including participants' age, any concomitant systemic disease, scar duration, previous treatments, any history of reaction after laser treatment, and any history of retinoid intake, was obtained and recorded. A clinical examination and assessment of scars, investigations, operative procedure, and postprocedural follow-up was also obtained.

Treatment Protocol

A computer program randomly selects which area to be treated by each device with special consideration to both areas to be as similar as possible in each patient. As a split study, one-half of affected areas were treated using the picosecond Nd: YAG laser. The other areas were treated with a fractional CO_2 laser. Before starting treatment sessions, mapping and photography was done for each scar within the managed area. Application of topical pridocaine (lidocaine 2.5%, prilocaine cream 2.5%, Global Napy, Egypt) anesthetic cream 30–45 minutes before the session was applied under occlusion.

Takeaways

Question: Would picosecond Nd: YAG show comparable results if compared with fractional CO_2 lasers in the management of postburn scars?

Findings: When compared with fractional CO_2 lasers, picosecond Nd: YAG shows comparable results in scars' erythema, texture, and height, and patient's pain during the session with some superiority in the treatment of hyperpigmented scar.

Meaning: Picosecond Nd:YAG is as effective as the fractional CO_2 lasers in the management of postburn scars with better results managing the hyperpigmented scars.

Fractional CO_2 Laser

A fractional CO_2 laser (FIRE-Xel, BISON, Seoul, Korea) was applied to the lesions. The used parameters were: 25–30 J, 800 dot density in square scanning mode. The chosen setting varies according to the Fitzpatrick skin color, site, and type of lesion.

Picosecond Nd: YAG Laser

A picosecond 1064/532 nm Nd: YAG laser (Discovery PICO; Quanta System S.p.A., Samarate, Italy) was applied to the lesions. Using 8-mm spot size, a fluence between 0.7 and 1.0 J/cm^2, a repetitive rate of 5 Hz, and two passes; a 1064-nm picosecond laser was applied to the scars. Double laser passes were administered sequentially in rows, approximately 10% of the treatment area.

Each patient received three sessions separated by a 4-week interval between them. The final assessment was done 6 months after the last treatment session

Evaluation Methods

Standardized photographs were taken before starting the sessions, before every treatment session, and 6 months after completion of the treatment sessions.

A skin analysis camera system (Antera 3D; Miravex, Dublin, Ireland) uses light emitted from LEDs of different wavelengths, which is partially absorbed, scattered, and reflected by the skin. The reflected light is collected again by the camera and transferred to the specified sophisticated software to be analyzed. It was used for the assessment of three parameters: the erythema (hemoglobin variation); the pigmentation; and texture, height, and size (roughness).

Visual Analog Scale

This detected the patients' pain during the session, where 0 denoted no pain at all, and 10 denoted pain as bad as it could possibly be.

Patient Satisfaction Score

This helped evaluate both symptoms and signs associated with the postburn scar. It included the following items: itching, pain, pliability, thickness, texture, and overall opinion. The patients rated their satisfaction with both treatment modalities on a visual assisted scale

ranging from 1 to 10, where 10 denoted not satisfied and 1 denoted fully satisfied. The patients were asked to rate their scars regarding the previously mentioned items in relation to their normal skin and how their scars resemble their normal skin before and after treatment sessions. For example, how is the texture of the scar in comparison with that of your normal skin. If the texture is totally different from the normal skin texture, the score is 10; if the scarred tissue is the same as the normal skin, the score is 1.

Statistical Analysis

The statistical analysis of the current study data was done by the statistical program for social science (SPSS) 15.0.1 for Windows; SPSS Inc, Wilcoxon, Chicago, Ill. Frequency and percentage were used for nonnumerical data. The mean, range, and SD (±SD) were used for parametric numerical data, whereas median and interquartile range (IQR) were used for nonparametric numerical data. A Wilcoxon signed-rank test was used to assess the statistical significance of the difference of an ordinal variable measured twice for the same study group. The McNemar test was used to assess the statistical significance of the difference between a qualitative variable measured for the same study group. A paired *t* test was used to assess the statistical significance of the difference between two means measured for the same study group. If the *P* value is higher than 0.05, then it was nonsignificant, whereas a *P* value of less than 0.05 was considered significant and a *P* value less than 0.01 was considered highly significant. Spearman rank correlation coefficient was calculated to assess the relationship between various study variables; (+) sign indicates direct correlation and (−) sign indicate inverse correlation. Also, values near to 1 indicate strong correlation & values near 0 indicate weak correlation.

Table 1. Demographic Data of the Patients

Characteristic		Study Group (n = 15)	
Age (y)		18.87 ± 4.56	
Duration of burn (mo)		19.33 ± 6.59	
Percentage of burn		11.8 ± 5.16	
Category		No.	%
Sex	Female	11	73.3
	Male	4	26.7
Cause of Burn	Flame	13	86.7
	Scald	2	13.3
Site	Arm (forearm, upper arm)	4	26.7
	Chest	1	6.7
	Face (cheek, temple, para nasal, eye)	8	53.3
	Abdomen	1	6.7
	Neck	1	6.7
Fitzpatrick classification	Skin type VI	11	73.3
	Skin type V	4	26.7

RESULTS

The current study was a randomized comparative intrapatient study done on 15 patients who presented with unsightly hyperpigmented postburn scars. It included 11 women (73.3%) and four men (26.6%). Their age ranged from 15 years to 25 years, with a mean ± SD of 18.87 ± 4.56 years. The duration of postburn scars was 19.33 ± 6.59 months. Eleven patients were of skin type 4, whereas four patients were of skin type 5. Each patient received three sessions of picosecond laser and fractional CO_2 laser. Table 1 shows the study demographics and the lesions' descriptions.

The clinical assessment regarding the scar texture and hyperpigmentation showed higher improvement on the picosecond laser side than on the fractional laser side.

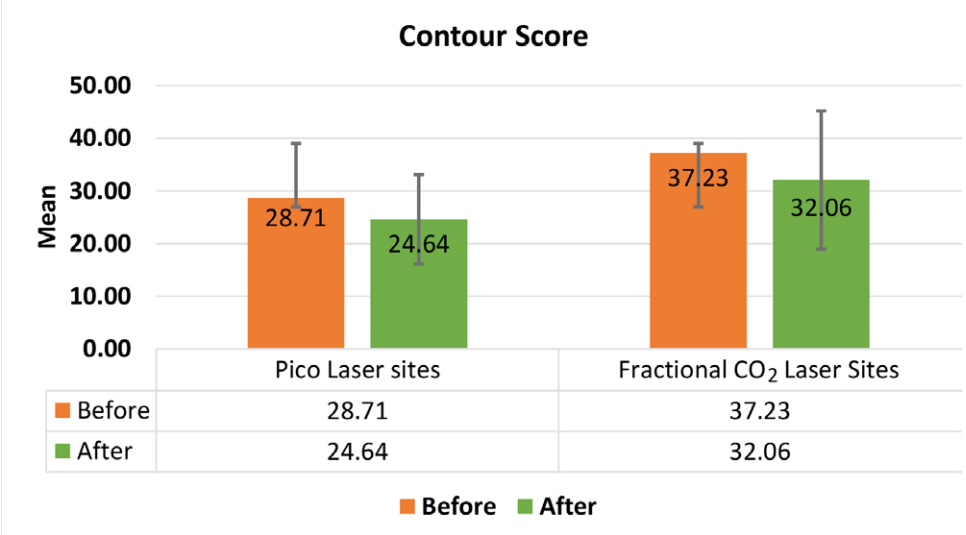

Fig. 1. Antera camera analysis of contour improvement: improvement of texture before and after treatment sessions in both groups.

Assessment by the Image Analysis System (Antera Camera)

The erythema (vascularity) is expressed in the software as hemoglobin level, and pigmentation is described by the melanin relative variation. The changes in roughness denoted the changes in the texture, height, and size of the scar.

Both picosecond laser sites and fractional CO_2 laser sites showed a significant improvement after treatment regarding the roughness (texture) individually (Fig. 1). However, there was no significant difference in the roughness, melanin relative variation, or hemoglobin average level between the two laser modalities. The melanin relative variation showed a significant decrease in pigmentation (Figs. 2 and 3). The picosecond laser showed longer postoperative oozing and crustation, which healed after 7–10 days. The fractional CO_2 laser sites showed hyperpigmentation in 10 patients, which improved after 2 weeks. Figures 4–9 illustrate the clinical improvement of the patients before and after treatment and photographs of Antera camera of the scar regarding melanin variation and roughness (texture).

Visual Analogue Scale

Using the pain visual analogue scale to assess the severity of pain of session regarding each modality. The

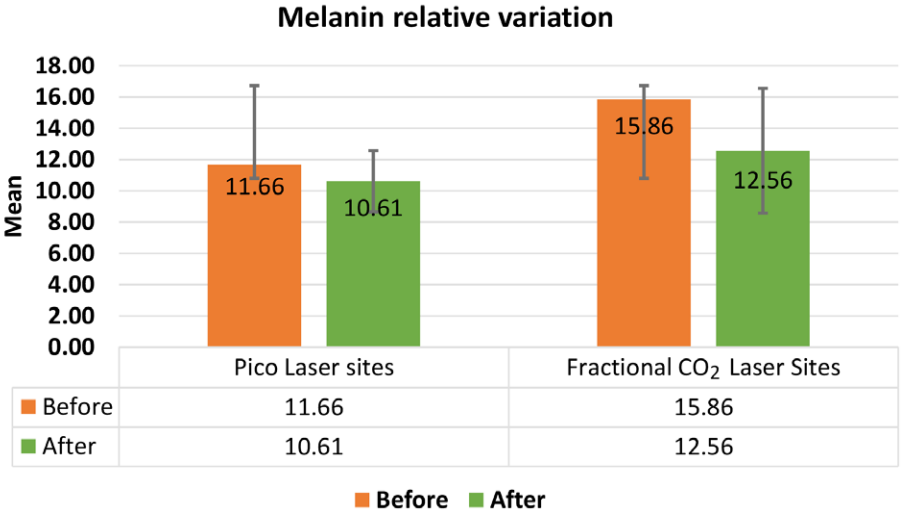

Fig. 2. Antera camera analysis of melanin relative variation: improvement of melanin relative variation before and after treatment sessions in both groups.

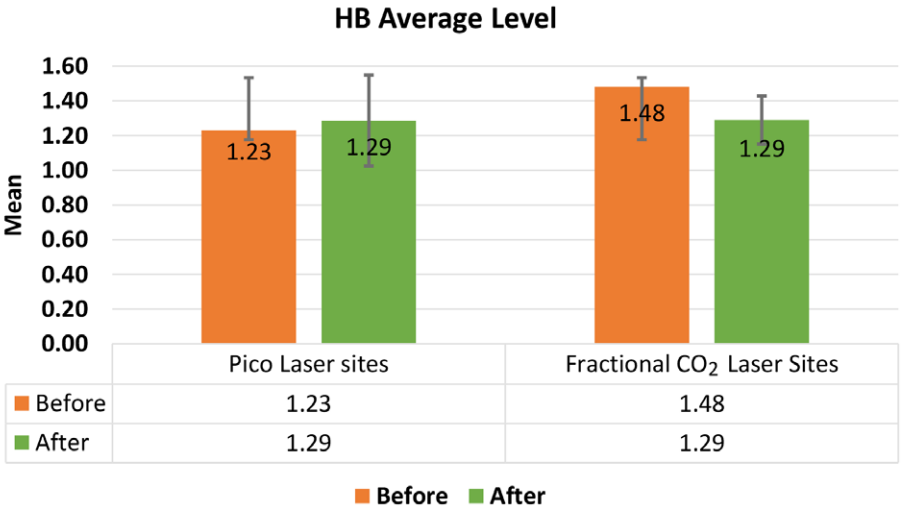

Fig. 3. Antera camera analysis of hemoglobin average level: improvement of hemoglobin average level before and after treatment sessions in both groups.

Fig. 4. Patient with postburn scar affecting the cheek. A, Before picosecond laser sessions. B, After end of treatment sessions.

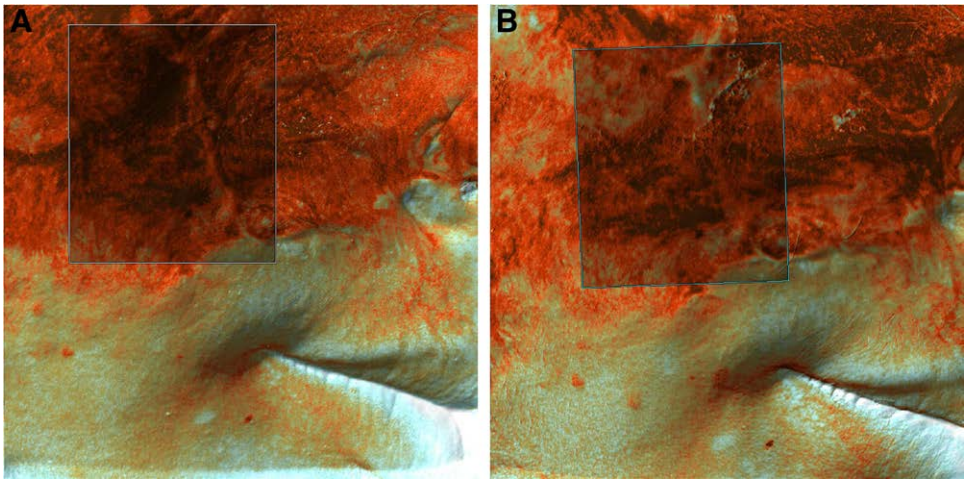

Fig. 5. Antera camera of melanin changes. A, Antera camera showed the melanin changes before treatment. B, After treatment, a decrease in the melanin could be noticed.

picosecond laser group had higher mean scores than the fractional CO_2 group, resulting in a statistically significant difference between both groups ($P < 0.001$). This was illustrated in Figure 10.

Patients' Satisfaction Score

There was a statistically significant difference when comparing both groups regarding color score postsessions ($P < 0.05$), as fractional CO_2 laser sites showed a higher color score than the picosecond laser sites. The patients were more satisfied with the picosecond site regarding the appearance of skin lesions at the end of their sessions (Table 2).

On the other hand, the patients expressed no difference between the two treatment modalities concerning the improvement of the symptoms associated with their burn scars, such as itching and pain. The patients stated that both treatment modalities have similar effects on the

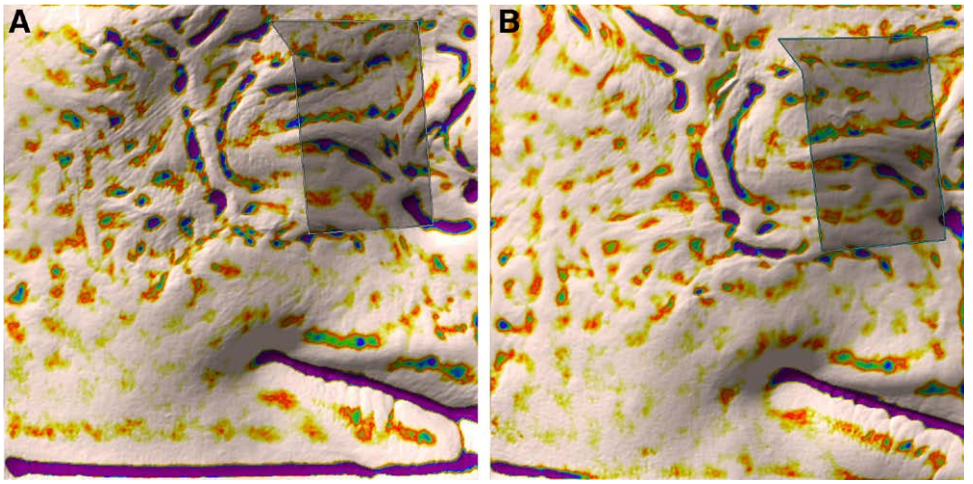

Fig. 6. Antera camera view. A-B, Antera camera showed the changes in the texture of the scar before and after treatment. A change in the violet color (A) to the green color (B) denoted much improvement in the texture after picosecond Nd: YAG laser treatment (right).

Fig. 7. Patient with postburn scar affecting the left upper arm. A, Before picosecond laser sessions. B, After end of treatment sessions.

improvement of pliability, thickness, texture, and overall opinion (Table 2).

Also, there was a statistically significant decrease in the percentage change in overall opinion when comparing both groups in favor of the fractional CO_2 laser sites (Table 2).

There were no significant correlations between the percentage of overall patient score, change, age, and duration of burn in both treatment modalities (Tables 3 and 4).

DISCUSSION

A hypertrophic scar is a common pathologic scar and the main skin complication of burns. Recent studies suggest that lasers can be a more favorable option over surgery for improving the scars' appearance.[13]

As far as we know, our study is the first randomized, intrapatient study comparing ablative 1064-nm picosecond Nd: YAG laser and fractional carbon dioxide laser in the treatment of postburn scars in the Egyptian population.

In this study, we assessed and compared the effects of two types of lasers for the treatment of postburn keloid scars: picosecond lasers and fractional carbon dioxide lasers. Using a split-side study method, we eliminated all personal variation discrepancies. After only three sessions, subjectively, both groups showed significant improvement of the scar's texture and hyperpigmentation, whereas no modality was superior to the other. Using the Antera camera for objective image analysis, both modalities improved the scar's roughness, pigmentation, and vascularity. And still, no modality was superior to the other. The patients were more satisfied with the picosecond site regarding the appearance of skin lesions at the end of their sessions. The downside of picosecond laser was the oozing and crust that disappeared in less than 10 days, while fractional CO_2 laser worsened the hyperpigmentation for 2 weeks, and that was the second reason most patients gave it lower scores in their patient satisfaction survey. These findings could be explained on the basis that skin color of the patients was dark, which in turn leads to post laser hyperpigmentation. On the other hand, the picosecond ND: YAG laser acted through photomechanical effect, so improvement of the pigmentation could be achieved.

Our results concur with those of several previous studies that prove the efficacy of fractional CO_2 (Azzam et al, 2016; Elzawahry et al, 2015) and picosecond Nd: YAG lasers individually for scar treatment and postacne scars (Tonaree et al, 2022; Dai et al, 2020).[14–17] Ablative lasers

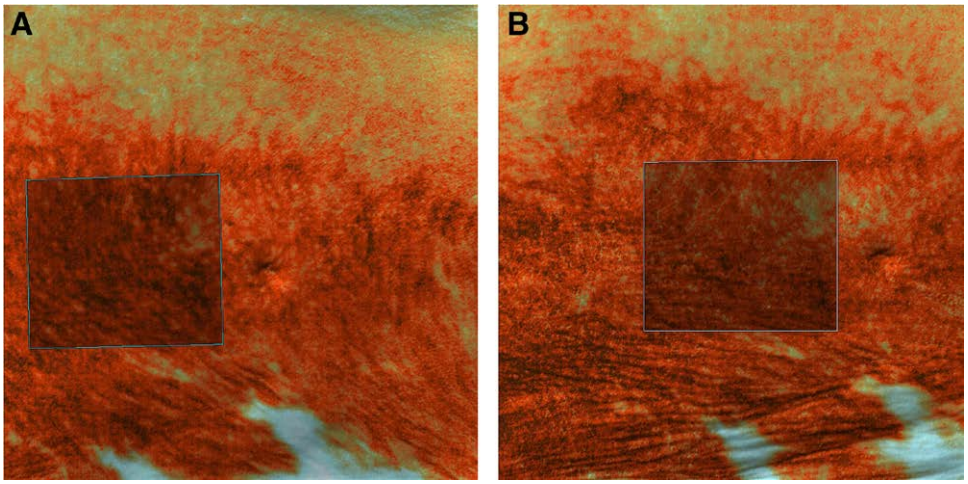

Fig. 8. Antera camera of melanin changes. A, Antera camera showed the melanin changes before treatment. B, After treatment, a decrease in the melanin could be noticed.

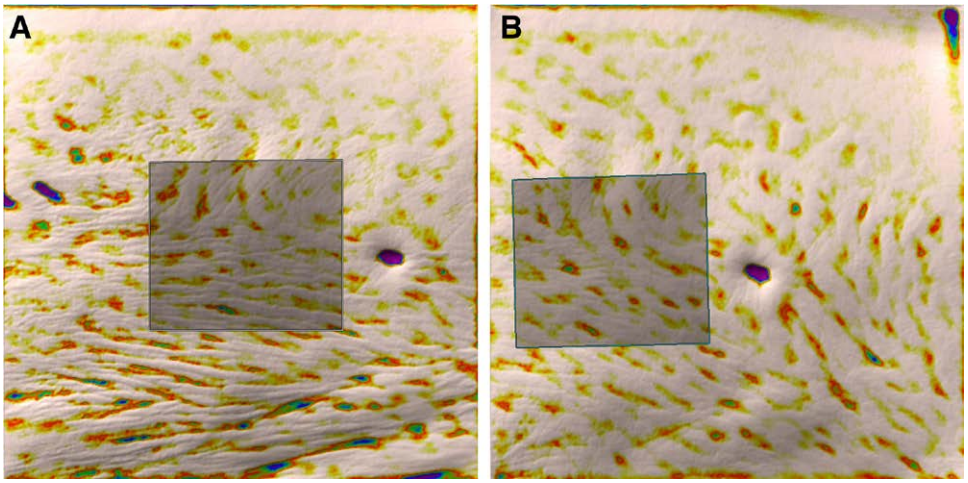

Fig. 9. Antera Camera view. A-B, Antera camera showed the changes in the texture of the scar before and after picosecond treatment.

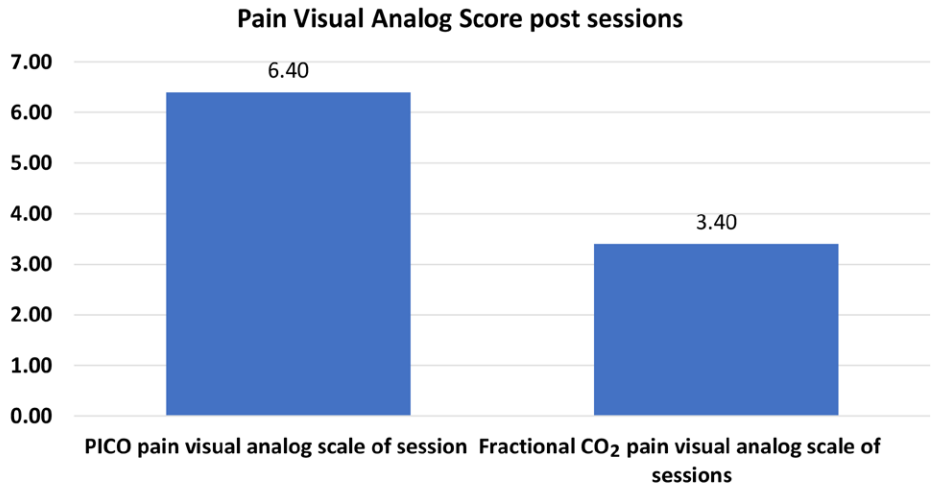

Fig. 10. Difference of pain visual analogue score of sessions between both groups.

Table 2. Patient Satisfaction Pre- and Postsessions between and within the Studied Groups

Characteristic		Picosecond Laser Group (n = 15) Mean ± SD	Fractional CO_2 Laser Group (n = 15) Mean ± SD	Test t/z	*P*
Pain score median (IQR)	Before	1 (1–3)	1 (1–1)	–0.962	0.336
	After	1 (1–1)	1 (1–1)	–0.948	0.343
Wilcoxon signed ranks test	Test	–2.041	–1.414		
	P	**0.041***	0.157		
Itching score median (IQR)	Before	2 (3–4)	3 (4–5)	–1.444	0.149
	After	1 (1–2)	1 (1–2)	–0.925	0.355
Wilcoxon signed ranks test	Test	–3.130	–3.331		
	P	**0.002***	**0.001***		
Color score	Before	7.67 ± 1.76	7.73 ± 1.83	–0.102	0.920
	After	2.87 ± 1.06	6 ± 1.2	–7.596	**<0.001***
Paired samples test	Test	10.439	5.773		
	P	**<0.001***	**<0.001***		
Pliability score	Before	6.27 ± 1.87	7.47 ± 2.36	–1.545	0.134
	After	4 ± 1.41	4.2 ± 1.97	–0.319	0.752
Paired samples test	Test	7.549	7.789		
	P	**<0.001***	**<0.001***		
Thickness score	Before	6.67 ± 1.63	6.53 ± 2.61	0.167	0.868
	After	4.8 ± 1.21	4 ± 1.85	1.402	0.172
Paired samples test	Test	4.525	6.971		
	P	**<0.001***	**<0.001***		
Texture score	Before	5.8 ± 2.11	7.13 ± 2.36	–1.632	0.114
	After	4.93 ± 1.58	4.13 ± 1.92	1.245	0.223
Paired samples test	Test	3.166	7.685		
	P	**<0.001***	**<0.001***		
Overall opinion score, median (IQR)	Before	7 (6–8)	8 (7–9)	–1.086	0.277
	After	5 (3–6)	3 (2–5)	–1.621	0.105
	% of change	28.57 (25–50)	50 (42.9–66.7)	–2.373	**0.018***
Wilcoxon signed ranks test	Test	–3.453	–3.428		
	P	**0.001***	**0.001***		

(z), Mann-Whitney U test; (t), independent samples test.
*$P > 0.05$ is considered significant.

Table 3. Correlation between the Percentage of Change of Overall Satisfaction Score, and Different Parameters within the Picosecond Laser Group (n = 15)

Variables		Percentage of Change Overall Score
Age	Rho	–0.244
	P	0.382
Percentage of burn %	Rho	–0.212
	P	0.449
Duration (mo)	Rho	–0.090
	P	0.750

Table 4. Correlation between Percentage of Change of Overall Satisfaction Score, and Different Parameters within Fractional CO_2 Laser Group (n = 15)

Variables		Percentage of Change Overall Score
Age	*r*	0.184
	P	0.511
Percentage of burn %	*R*	–0.049
	P	0.861
Duration (mo)	*R*	0.005
	P	0.987

also improved vascularity, pliability, pigmentation, and scar height outcomes in the meta-analysis performed by Ma et al in 2023.[18]

The mechanism by which laser devices exert therapeutic effects on keloid and hypertrophic scars remains to be explained. Suggested mechanisms include coagulation necrosis of vessels by selective photothermolysis and other thermal effects produced by the laser energy, leading to collagen breakdown, readjustment of collagen fibers, new collagen synthesis, and the release of histamine.[19]

Picosecond lasers differ from traditional lasers in that they deliver ultra-short pulse durations, which allows for more photoacoustic effects and less nonspecific photothermal damage. As a picosecond Nd: YAG laser is an ablative device that targets hemoglobin, water, and melanin, any thermal effects on dermal tissue result in reduced capillary blood flow in the dermal papillae. This results in selective photothermolysis that is responsible for collagen breakdown and production of neocollagen (normal, not keloidal collagen) and remodeling of collagen by thermal damage, resulting in the clinical improvement of keloids and hypertrophic scars.[20–22]

CONCLUSIONS

In conclusion, in our study, the picosecond Nd: YAG laser has been proven to be effective for the treatment of pigmented postburn scars even in comparison with a stable modality like fractional CO_2 laser. This means that

the picosecond Nd: YAG laser might also be a promising treatment for pigmented postburn scars because the 532/1064-nm wavelength is close to the oxyhemoglobin absorption peak and absorbs melanin as well.

Rama Ahmed Ali, MD
Plastic Surgery
Faculty of Medicine
Cairo University
Egypt
E-mail: ramaahmed163@gmail.com

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

REFERENCES

1. Tawfik A, Ali R. Intense pulsed light in the management of postburn keloid and hypertrophic scar: a comparative study. *Eur J Plast Surg.* 2023;46:1323–1329.
2. Khedr MM, Mahmoud WH, Sallam FA, et al. Comparison of Nd:YAG laser and combined intense pulsed light and radiofrequency in the treatment of hypertrophic scars: a prospective clinico-histopathological study. *Ann Plast Surg.* 2020;84:518–524.
3. Willows BM, Ilyas M, Sharma A. Laser in the management of burn scars. *Burns.* 2017;43:1379–1389.
4. Abd El-Dayem DH, Nada HA, Hanafy NS, et al. Laser-assisted topical steroid application versus steroid injection for treating keloids: a split side study. *J Cosmet Dermatol.* 2021;20:138–142.
5. Tawfik AA, Ali RA. Evaluation of botulinum toxin type A for treating post burn hypertrophic scars and keloid in children: an intra-patient randomized controlled study. *J Cosmet Dermatol.* 2023;22:1256–1260.
6. Alhamzawi NK. Efficacy of fractional carbon dioxide laser (FCO_2) with intralesional 5-fluorouracil (5-FU) in the treatment of keloids. *J Cutan Aesthet Surg.* 2021;14:323–329.
7. DeBruler DM, Blackstone BN, Baumann ME, et al. Inflammatory responses, matrix remodeling, and re-epithelialization after Fractional CO_2 laser treatment of scars. *Lasers Surg Med.* 2017;49:675–685.
8. Chen SX, MD, Cheng J, MD, Watchmaker J, MD, et al. Review of lasers and energy-based devices for skin rejuvenation and scar treatment with histologic correlations. *Dermatol Surg.* 2022;48:441–448.
9. Ozog DM, Liu A, Chaffins ML, et al. Evaluation of clinical results, histological architecture, and collagen expression following treatment of mature burn scars with a fractional carbon dioxide laser. *JAMA Dermatol.* 2013;149:50–57.
10. Zhou Y, Hamblin MR, Wen X. An update on fractional picosecond laser treatment: histology and clinical applications. *Lasers Med Sci.* 2023;38:38–45.
11. Brauer JA, Kazlouskaya V, Alabdulrazzaq H, et al. Use of a picosecond pulse duration laser with specialized optic for treatment of facial acne scarring. *JAMA Dermatol.* 2015;151:278–284.
12. Chayavichitsilp P, Limtong P, Triyangkulsri K, et al. Comparison of fractional neodymium-doped yttrium aluminum garnet (Nd:YAG) 1064-nm picosecond laser and fractional 1550-nm erbium fiber laser in facial acne scar treatment. *Lasers Med Sci.* 2020;35:695–700.
13. Choi KJ, Williams EA, Pham CH, et al. Fractional CO_2 laser treatment for burn scar improvement: a systematic review and meta-analysis Burns. *Burns.* 2021;47:259–269.
14. Azzam OA, Bassiouny DA, El-Hawary MS, et al. Treatment of hypertrophic scars and keloids by fractional carbon dioxide laser: a clinical, histological, and immunohistochemical study. *Lasers Med Sci.* 2016;31:9–18.
15. El-Zawahry BM, Sobhi RM, Bassiouny DA, et al. Ablative CO_2 fractional resurfacing in treatment of thermal burn scars: an open-label controlled clinical and histopathological study. *J Cosmet Dermatol.* 2015;14:324–331.
16. Tonaree W, Eimpunth S, Kamnerdnakta S, et al. Prospective study of Q-switched Nd: YAG laser treatment of hyperpigmented split-thickness skin grafts. *Lasers Med Sci.* 2022;37:2381–2386.
17. Dai YX, Chuang YY, Chen PY, et al. efficacy and safety of ablative resurfacing with a high-energy 1,064 Nd-YAG picosecond-domain laser for the treatment of facial acne scars in Asians. *Lasers Surg Med.* 2020;52:389–395.
18. Ma Y, Barnes SP, Chen YY, et al. Influence of scar age, laser type, and laser treatment intervals on adult burn scars: a systematic review and meta-analysis. *PLoS One.* 2023;18:e0292097.
19. Ramadan H, Saber M, Salah M, et al. Handling keloid and hypertrophic scars by long-pulsed Nd: YAG laser: evaluating effectiveness. *Int J Health Sci.* 2022;6(S2):10075–10083.
20. Bai Y, Yiqiu Z, Wei N, et al. Laser, intense pulsed light, and radiofrequency for the treatment of burn scarring: a systematic review and meta-analysis. *Euro Burn J.* 2023;4:142–162.
21. Manuskiatti W, Punyaratabandhu P, Tantrapornpong P, et al. Objective and long-term evaluation of the efficacy and safety of a 1064-nm picosecond laser with fractionated micro lens array for the treatment of atrophic acne scar in Asians. *Lasers Surg Med.* 2021;53:899–905.
22. Tawfic SO, El-Tawdy A, Shalaby S, et al. Evaluation of fractional CO_2 versus long pulsed Nd: YAG lasers in treatment of hypertrophic scars and keloids: a randomized clinical trial. *Lasers Surg Med.* 2020;52:959–965.