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# Rejuvenation of Facial Skin Using Fractional Er: YAG Laser

**Ali A. kadhem** [(1)] **Athir M. Al Saad** [(2)] and **Ali S. Toama** [(3)]

*(1) Al-Karkh General Hospital, Baghdad, Iraq, aliak1972@gmail.com*
*(2) Immam Ali general hospital, Baghdad, Iraq*
*(3) Balad General Hospital, Baghdad, Iraq*

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**Abstract:** Fractional Er: YAG laser resurfacing is increasingly used for treating rhytides and photo aged skin because of its favorable benefit-risk ratio. The multi-stacking and variable pulse width technology opened a wide horizon of rejuvenation treatments using this type of laser. To evaluate the efficacy and safety of the use of fractional 2940 nm Er: YAG laser in facial skin rejuvenation. Twelve female patients with mean age 48.3 years and multiple degrees of aging signs and solar skin damages, were treated with 2 sessions, one month apart by fractional Er: YAG laser. Each session consisted of 2 steps, the first step employed the use of the multi stack ablative fractional mode and the fractional long pulsed non-ablative mode settings were used in the second step. The results were assessed 4-8weeks after the last session by using the wrinkles assessment scale improvement, the improvement in the degree of dyschromia and keratosis, the degree of patients' satisfaction and rate of complications. The mean improvement in Wrinkles assessment scale was very satisfying**.** The improvement in keratosis was good to excellent in 66.7% of patients compared to 33.3% of patients who were mildly to moderately improved. Dyschromia improvement, 50% of the patients had good to excellent results versus 50% who had mild to moderate improvement. 75% of patients were well satisfied, 16.6% were moderately satisfied and 8.3% were unsatisfied. Total incidence of complications was 16.6%, where 1 patient had herpes infection and a second patient had milia. The use of Er: YAG laser in fractional ablative and fractional long pulse non ablative modes for facial rejuvenation is an effective, safe, with short down time and low complication rate.

**Keywords:** Facial rejuvenation, Fractional Er: YAG, Multi stack, Variable pulse width.

## Introduction

As the most voluminous organ of the body that is exposed to the outer environment, the skin suffers from both intrinsic and extrinsic aging factors. Skin aging is characterized by features such as wrinkling, loss of elasticity, laxity, discoloration and rough-textured appearance. This aging process is accompanied with phenotypic changes in cutaneous cells as well as structural and functional changes in extracellular matrix components such as collagens and elastin (Zhang S. 2018). Intrinsic skin aging is a process of chronologically physiological change, for the intrinsically aged skin, the most remarkable histological changes occur within the basal cell layer. Research finds that as a person ages, proliferation of cells in the basal layer reduces. The epidermis then becomes thinner, and the contact surface area between dermis and epidermis decreases, resulting in a smaller exchange surface for nutrition supply to the epidermis and further weakened ability of basal cell proliferation (Makrantonaki E.2007) In skin samples from human donors of different ages, there was an age-dependent increase in the expression of senescence marker β-galactosidase in dermal

fibroblasts and epidermal keratinocytes, indicating that aged skin contains more senescent cells (Dimri GP. 95). There is down regulation of the TGF-β/Smad signaling and its downstream connective tissue growth factor (Quan T.2010).The most important extrinsic factors that influence skin aging are **UV radiation smoking** and **other environmental factors**. As early as 1969, it was proposed that besides intrinsic factors, Exposure to UV radiation is the primary factor of extrinsic skin aging; it accounts for about 80% of facial aging (Friedman O.2005). In contrast to the thinner epidermis in intrinsically aged skin, UV-radiated epidermis thickens (Kligman LH. 1989). In basal cells, the expression of cell-surface protein β1-integrin, which interacts with extracellular matrix proteins and is regarded as one of the epidermal stem cell markers, is greatly reduced, indicating that proliferation in the aged basal keratinocytes is also impaired. The expression of type VII collagen in keratinocytes decreased in UV- radiated skin areas. Type VII collagen is the anchoring fibrils at the dermal–epidermal junction. This contributes to wrinkles due to the weakened connection between dermis and epidermis (Contet-Audonneau JL 1999). Collagen type I diminishes in photo-aged skin for photo aged skin, a striking characteristic is the accumulation of abnormal elastic tissue deep in the dermis results in solar elastosis (Bonta M. 2013). **Cigarette smoking** is strongly associated with elastosis in both sexes, and telangiectasia mostly in men. Smoking causes skin damage primarily by decreasing capillary blood flow to the skin, which, in turn, creates oxygen and nutrient deprivation in cutaneous tissues other **environmental factors** that influence skin aging are temperature and humidity. An increase in skin temperature of 7–8 C° doubles the evaporative water loss. Low temperature stiffens skin and decreases evaporative water loss even with plenty of humidity in air (Farage MA 2008). Irregularities in surface texture, pigmentation, and wrinkling are hallmarks of aged skin. Lasers used in skin resurfacing and rejuvenation are either ablative or non-ablative and can be full field or fractionated. Fractional photo-thermolysis delivers treatment in core sections or micro-thermal zones, leaving untreated areas in the skin to promote more rapid healing (Deniz Basci 2019). A major advancement in skin resurfacing was the development of the erbium-yttrium-aluminum-garnet (Er:YAG) 2940-nm wavelength laser. The 2940 nm wavelength has an affinity for water that is nearly 12 to 15 times higher than that of the CO2 laser. This affinity allows Er:YAG to deliver energy to specific depths in the skin without heating the surrounding tissue (cool ablation mode using short pulse width in the range of 100-200 μ sec.), thus causing less collateral damage. However, the limited photo-thermal effects of this laser also lead to significantly reduced collagen contraction. Newer Erbium-devices have lengthened the laser pulse duration (0.1-1.1 sec.) to induce better tissue contraction (Variable pulse width technology) (Deniz Basci 2019). With each additional pass of the CO2 laser, there is a diminishing or plateaued response because the residual carbonized tissue acts as a heat sink. Erbium lasers create less coagulated tissue to absorb heat and make it easier to drill deeper wounds into the skin with each pass.

An increasing number of rejuvenation techniques for facial wrinkles and folds points to the need for objective measurements of their effectiveness. Patient satisfaction is the goal, but proof of the value of a particular product require objective measurement. A **wrinkle assessment scale (WAS)** was developed originally as a simple tool to assess the changes resulting from injecting filler materials and it can be used reliably to assess the result for other rejuvenation techniques. By correlating the grade of the wrinkle in the reference photographs with the wrinkle in a patient's face, a classification of 0 to 5 according to the severity of the wrinkles and folds for each part of the face such as the forehead, crow's feet, perioral and cheek wrinkles (Lemperle 2001), (figures 1). The aim of the study is to evaluate the efficacy and safety of fractional Er:YAG laser in facial rejuvenation.

**Fig. (1):** Wrinkle assessment scale forehead (**WAS**) (A), Perioral (B), crow's feet (C), Cheeks (D) (Lemperle 2001)

## Patients & Methods

This study was done in private clinic in Baghdad – Iraq, from 1st of June to the 15th of October 2019. This study was conducted on 12 female patients with age ranging from 39 years to 64 years (mean=48.3 years). (Table 1). Fitzpatrick skin types II~IV, (table 2). Glogau photo aging scale of II~IV,(table 3) ,and collective wrinkles assessment scale for the forehead ,crow's feet ,peri oral and cheek wrinkles ranges from 9~16 points five of them had upper blepharoplasty between the sessions and during the follow up.

**Table (1)** Age group distribution of the patients

| Age group | No. of patients | % |
|---|---|---|
| 35-40 y. | 2 | 16.66 |
| 40-50 y. | 6 | 50 |
| 50-60 y. | 3 | 25 |
| 60-70 y. | 1 | 8.33 |
| Total | 12 | 100% |

**Table (2)** Fitzpatrick skin type distribution of the patients

| Fitzpatrick type | No. Of patients | % |
|---|---|---|
| Type II | 3 | 25 |
| Type III | 7 | 58 |
| Type IV | 2 | 17 |
| Total | 12 | 100 |

**Table (3)** Glogau photo aging grades

| Grade | No. | % |
|---|---|---|
| 0 | 0 | 0 |
| I | 5 | 41.7 |
| II | 6 | 50 |
| IV | 1 | 8.3 |
| Total | 12 | 100 |

Patients who were excluded from this study were those who had resurfacing procedure whether laser or conventional resurfacing techniques, Patients who received Botulinum A toxin within the last six months. Fitzpatrick skin phenotype V and VI, patients on anti-coagulants ,steroids ,none steroidal anti-inflammatory drugs, Oral and topical isotretinoin and retinoic acid derivatives for the last 20 days, Patients with cancer or other malignant diseases, Active herpes simplex, Healing disorders such as those caused by connective tissue diseases, radiation therapy, or chemotherapy, Photo sensitive skin ,Psych-neurotic patients, Skin allergy to local anesthetics, Patients who are unable or unwilling to follow the post treatment instructions, patients with unrealistic expectations regarding the clinical outcomes of the treatment and Pregnancy. The treatment consisted of two sessions with 1 month apart, each session consisted of two steps, the 1st step done by using the fractional hand piece with multi stacking and short pulse duration to induce fractional ablation and the 2nd step also done by using the fractional hand piece but with long pulse mode and sub ablative fluence. The parameters and laser system specifications are shown in Tables (4, 5 and 6). At both visits reexamination of the patients was done. Taking notes regarding the course of the healing after the first session taking into consideration any adverse event or side effect, such as prolong redness, scaring or unwanted pigmentary changes that may necessitate changing the parameters or discontinue the treatment.

**Table (4)** 1st step parameters,* micro pulse energy in the fractional mode represents the micro beam energy per pulse.

| Hand piece | Fractional(9*9) |
|---|---|
| Mode | Fractional |
| Micro pulse energy(mJ)* | 8~12 |
| Multi shot | 2~3x |
| Interval(sec, Hz) | Single,1s (=1Hz) |
| Pulse width (micro sec.) | 200 |

**Table (5)** 2nd step parameters.

| Hand piece | Fractional |
|---|---|
| Mode | Long pulse |
| Pulse width(sec.) | 0.6~1 |
| Fluence (J/cm$^2$) | 7~11 |
| Interval(sec, Hz) | Single,0.2sec(=5Hz) |

**Table (6)** Laser system specifications.

| Performance | System Specification |
|---|---|
| Wav length | 2940 nm |
| Aiming beam | 650nm <5mW |
| Medium | Er:YAG |
| Transfer method | Articulated arm |
| Pulse rate | Single,1,2,5,10 Hz |
| Pulse duration | |
| Normal, fractional, multiple mode | 200µs~300µs |
| Long pulse | 200µs~1.0s |
| Interval | |
| Normal | 50ms,0.2,0.5,1,1.5[s] |
| Long pulse fractional mode | 100ms,0.2,0.5,1,1.5[s] |
| Classification | |
| CDRH class. | Class IV |
| App. Part class | B |
| MDD class | IIb |
| Fractional hand piece | Ø 12,9*9,6*6(mm) |
| Max. Output power | 3.7 J |

The patients were rechecked 1 week after each session and 4~8 week after the 2nd session for final assessment. The photographs that were taken immediately before the first session are reviewed to documents the **WAS** by comparing the photographs with the reference photographs

and taking the mean score of the right and left side of each area. The reviewing was done by two observers to give the score, the degree of patient satisfaction, and the improvement of keratosis and dyschromia which was assessed by the physician were documented.

**Results**

**The patient's satisfaction** (Table 7) and the degree of dyschromia and keratosis improvement (Tables 8 and 9) were checked after 6~8 weeks (mean=6.4 weeks) after the final session. The improvement in the **wrinkles assessment scale** was calculated by taking the mean score of the right and left sides, before and after the treatment of the forehead (FH), crow's feet (CF), peri oral (PO) and cheeks (C) (Table 10), the average improvement for the aforementioned areas and the total score down grade was calculated by subtracting the averages of the post treatment for each area of all patients from the pretreatment averages and the same done for the total score, (Table 11). Regarding adverse effects and complications, the procedure was basically painless, except of uncountable burning sensation that lasts for 60~90 minutes which was effectively alleviated by ice packs, all patients had redness that was subsided within 2~3 days, no prolonged erythema was encountered, neither hyper-pigmentation nor hypo-pigmentation was detected. Milia recorded in one patient, one patient had flare up of herpes simplex in the upper lip which was subsided within 7 days. Bacterial infections, fungal infections, burns and scaring were not encountered. (Table 12)

**Table (7)** Patients satisfaction percent.

| Patient 's no. | Unsatisfied | Moderately satisfied | Well satisfied |
|---|---|---|---|
| 1 | - | - | + |
| 2 | - | - | + |
| 3 | - | - | + |
| 4 | - | + | - |
| 5 | - | - | + |
| 6 | - | - | + |
| 7 | - | + | - |
| 8 | - | - | + |
| 9 | + | - | - |
| 10 | - | - | + |
| 11 | - | - | + |
| 12 | - | - | + |
| % | 8.4% | 16.6% | 75% |

**Table (8)** Degree of dyschromia improvement

| Patient's no. | Mild | Moderate | Good | Excellent |
|---|---|---|---|---|
| 1 | - | - | + | - |
| 2 | - | - | + | - |
| 3 | - | - | - | + |
| 4 | + | - | - | - |
| 5 | - | + | - | - |
| 6 | - | - | + | - |
| 7 | - | + | - | - |
| 8 | - | - | - | + |
| 9 | + | - | - | - |
| 10 | - | + | - | - |
| 11 | - | - | + | - |
| 12 | - | + | - | - |
| % | 16.7 % | 33.3% | 33.3 % | 16.7% |

**Table (9)** Degree of keratosis improvement

| Patient's no. | Mild | Moderate | Good | Excellent |
|---|---|---|---|---|
| 1 | - | - | - | + |
| 2 | - | - | + | - |
| 3 | - | - | + | - |
| 4 | - | + | - | - |
| 5 | - | + | - | - |
| 6 | - | - | + | - |
| 7 | - | + | - | - |
| 8 | - | - | - | + |
| 9 | + | - | - | - |
| 10 | - | - | - | + |
| 11 | - | - | + | - |
| 12 | - | - | + | - |
| % | 8.3 % | 25% | 41.7 % | 25 |

**Table (10)** Wrinkles assessment scale before and after treatment

| | Before | | | | | After | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No. | FH | CF | PO | C | Sum | FH | CF | PO | C | Sum |
| 1 | 2.5 | 2.5 | 2 | 3 | 10 | 1.5 | 1.5 | 1 | 1.5 | 5.5 |
| 2 | 3.5 | 3 | 3 | 2.5 | 12 | 1.5 | 1.5 | 2 | 1 | 6 |
| 3 | 3.5 | 4 | 3.5 | 4 | 15 | 1.5 | 2 | 2.5 | 2 | 8 |
| 4 | 3 | 3.5 | 4 | 3.5 | 14 | 2 | 2 | 3 | 1.5 | 8.5 |
| 5 | 2.5 | 3 | 3.5 | 3 | 11.5 | 1.5 | 1 | 2 | 1 | 5.5 |
| 6 | 3 | 3.5 | 4 | 3.5 | 14 | 1 | 1.5 | 2.5 | 2 | 7 |
| 7 | 2.5 | 3.5 | 3.5 | 2.5 | 12 | 1.5 | 2 | 2.5 | 1.5 | 7.5 |
| 8 | 3.5 | 4 | 4 | 3.5 | 15.5 | 2 | 2 | 2.5 | 1.5 | 8 |
| 9 | 4 | 4 | 4.5 | 3.5 | 16 | 2 | 3.5 | 3.5 | 2.5 | 11.5 |
| 10 | 3 | 3.5 | 3.5 | 4 | 14.5 | 1.5 | 1.5 | 2.5 | 2 | 7.5 |
| 11 | 2.5 | 3 | 2 | 1.5 | 9 | 1 | 1 | 1 | 0.5 | 3.5 |
| 12 | 2.5 | 3.5 | 3.5 | 3 | 12.5 | 1.5 | 1.5 | 2 | 2 | 7 |
| AVERAGES | 3 | 3.42 | 3.42 | 3.125 | 13 | 1.5 | 1.75 | 2.25 | 1.58 | 7.125 |
| | Mean= 3.24 | | | | | Mean= 1.77 | | | | |

**Table (11)** Averages of grades before and after treatment and grades of improvement

| Area | Pre | Post | Improvement |
|---|---|---|---|
| FH | 3 | 1.5 | 1.5 |
| CF | 3.42 | 1.75 | 1.67 |
| PO | 3.42 | 2.25 | 1.17 |
| C | 3.125 | 1.58 | 1.545 |
| Total | 13 | 7.125 | 5.875 |

| Complications | No. of patients | % |
|---|---|---|
| Prolonged erythema | 0 | 0 |
| Hyper-pigmentation | 0 | 0 |
| Hypo-pigmentation | 0 | 0 |
| Milia | 1 | 8.3 |
| Infections | 1 | 8.3 |
| Scaring | 0 | 0 |
| Total | 2/12 | 16.6 |

**A** **B**

Figure 2 case no.1, 47 years old patient, before

**A** **B**

Figure 3 case no.2, 45 years old

(A), after treatment with upper blepharoplasty (B). Patient, before (A), after (B)

A B

Figure 4 case no.3, 64years old patient before (A), after (B)

A B

Figure 5 case no.4, 59 years old patient, before, (A), after treatment with upper blepharoplasty

## Discussion

The mean age of the patients in this study was 48.3 years which is relatively not very old, this is related to the effect of climate especially the highest UV index throughout the year, pollution, bad dietary habits, high prevalence of smoking and the lack of the idea or the concepts of the early skin care, protection and healthy lifestyle. All the patients in this study were females, this is partly due to the fact that females are seeking cosmetic procedures more than males and can comply with the post treatment instructions better than males, and especially 75% of the patients in this study were retired or unemployed. Although males were not excluded from the study but all of them were unable to be committed with the avoidance of sun exposure. Regarding the results of this study (Table 7), they show that 75% of patients were well satisfied, 16.6% were moderately satisfied and 8.3% were unsatisfied. Because the results were below their expectations. This is comparable to published studies (Batra RS 2003 and Kohl E 2015).

The degree of dyschromia improvement (Table 8), 50% of the patients had good to excellent results versus 50% who had mild to moderate improvement. This is due to the fact that the Erb:YAG laser is more effective in ablating the epidermal pigmentary lesions, whereas the deeper junctional and dermal melanosis such as melasma and post inflammatory Hyperpigmentation may require deeper full field ablation with high rate of complications, or the use of Q switched Nd:YAG 1064 nm laser in multiple low fluenc sessions (Nathanial R. 2019, Metelitsa 2010).

The improvement in keratosis was good to excellent in 66.7% of patients compared to 33.3% of patients who were mildly to moderately improved. The hyper keratotic lesions are epidermal and therefore are more prone to the ablation (de Vries 2015).

The mean improvement in Wrinkles assessment scale was 1.5 points for the forehead, 1.67 points for the crow's feet, 1.17 points for the peri oral region, 1.545 points for the cheeks and the overall improvement was 5.875 points and mean improvement of all regions 1.47 points, (table 10 and 11). The results are close to each other except for the peri oral region which was the lowest to improve this is due to the strong effect of the orbiculares muscle, mentalis muscle and the depressor anguli oris muscle those muscles accentuate the vertical lines around the lips, deepening the labiomental crease and slanting down the lateral oral crease, another factor bad vertical around the lips in females is the lack of the mustache hair follicles which give support to this area makings these lines are much less prevalence in males compared to females. So the resurfacing alone is not enough to improve this area, additional neurotoxin, filler or fat grafting can give excellent results (Deniz Basci 2019 and Trelles MA 2009).

Complications raised after the Erb:YAG laser rejuvenation was16.6%, one patient (8.3%) had herpes simplex infection although she did

not gave a history of previous infection and one patient(8.3%) had milia. Hyper pigmentation, hypo pigmentation, prolong erythema and scaring were not recorded. Our results were variable and they were irrelevant to compare to published articles.

However Metelitsa et al (Metelitsa 2010) reviewed fractionated lasers complication on a MIDLINE search and they found that prolonged erythema (in the term of more than one month) rate was 12.5% and patients with Fitzpatrick phenotype I were very prone to this complication. The rate of herpes simplex virus (HSV) infection, the most common type of infection after fractional laser skin resurfacing, has been reported in 0.3% to 2% of cases. The rate of bacterial infection with fractionated skin resurfacing, with only 0.1% of all treated cases documented to develop impetigo, although rarely seen, cutaneous candidiasis induced by Candida albicans is the most common fungal infection reported after fractional laser skin resurfacing, incidence of milia development has been reported in as many as 19% of treated patients with fractional lasers. Post inflammatory hyper pigmentation is much less frequent with fractional laser skin resurfacing than with other ablative procedures but is observed in 1% to 32% of patients, depending on the system used, treatment parameters applied, and skin photo types.

**Conclusions**

Combining fractional ablative and fractional non ablative long pulse Erb:YAG laser is effective and reliable rejuvenation tool. The procedure is safe with short down time

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# تجديد شباب الوجه بأستخدام ليزر ال Erb:YAG المجزء

**علي عبدالجليل كاظم[1] أثير محمود السعد[2] علي صادق طعمة [3]**

1- مستشفى الكرخ العام، بغداد ، العراق

2- مستشفى ألأمام علي، بغداد ، العراق

3- مستشفى بلد العام ، صلاح الدين ، العراق

**الخلاصة:**ان استعمال ليزر ال Erb:YAG المجزأ في علاج التجاعيد و شيخوخة الجلد الناتجة عن التعرض لضوء الشمس في تزايد مستمر، وذلك بسبب قلة نسبة الخطورة الى نسبة الاستفادة من استعمال هذا الليزر.أن تقنية النظام المتعدد الضربات و تقنية النبضة المتغيرة الطول فتحت آفاق واسعة في طرق استعمال هذا الليزر في مجال اعادة الحيوية والشباب لبشرة الوجه.ان الهدف **من الدراسة هو** لتقييم فعالية وأمان استعمال ليزر ال Erb:YAG المجزئ ذو الطول الموجي ٢٩٤٠نانومتر في عمليات تسطيح الجلد واعادة الحيوية للوجه. تضمنت الدراسة ١٢ سيدة معدل أعمارهن ٤٨,٣ سنة يعانين من دراجات متفاوتة من علامات شيخوخة الجلد وتضرر الجلد الناتج عن التعرض لاشعة الشمس، جميعهن خضعن لجلستين علاجيتين تفصل بينهما مدة شهر واحد، كل جلسة تضمنت خطوتين ،الخطوة الأولى كانت بأستعمال نظام الليزر المجزأ الحتي المتعدد الضربات والخطوة الثانية باستعمال نظام الليزر المجزأ طويل النبضة غير الحتي. تم تقييم النتائج بعد مرور ٤ الى ٨ أسابيع بعد الجلسة الثانية عن طريق استعمال مقياس تقييم التجاعيد ،نسبة تحسن التصبغات، نسبة تحسن التقرن السفعي، نسبة رضا المرضى عن النتائج و نسبة المضاعفات المصاحبة للعلاج. وقد كان معدل تحسن مقياس تقييم التجاعيد مرضي جدا وتحسن التقرن السفعي كان جيد الى ممتاز بنسبة ٦٦،٧٪ وقليل الى متوسط بنسبة ٣٣،٣٪ ، اما نسبة تحسن التصبغات فقد كانت ٥٠٪ جيد الى ممتاز و٥٠٪ قليل الى متوسط، ٧٥٪ من السيدات المشاركات في الدراسة كنّ راضيات جدا عن النتائج، ١٦،٦ كنّ راضيات بصورة متوسطة و ٨،٣ منهن لم يكنّ راضيات عن النتائج،اما بخصوص المضاعفات المصاحبة للعلاج فقد كانت نسبتها ١٦،٦٪ حيث كانت هناك حالة إصابة بقوباء الشفة وحالة إصابة بالدُخَينات. ان إستعمال ليزر ال Erb:YAG بنظام الليزر المجزأ الحتي و المجزأ طويل النبضة غير الحتي في عملية إعادة الحيوية والشباب للوجه هو إستعمال آمن، فعال، وذو فترة نقاهة قصيرة مع نسبة مضاعفات منخفضة.