

# Treatment of Acne Scars Using Fractional Erbium: YAG Laser

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**Abstract** Background: Acne is a common disorder experienced by people between 11 and 30 years of age and to lesser extent by older adults. Fractional resurfacing employs a unique mechanism of action that repairs a fraction of skin at a time. The untreated healthy skin remains intact and actually aids the repair process, promoting rapid healing with only a day or two of downtime. Objective: This study is designed to evaluate the safety and effectiveness of fractional photothermolysis (fractionated Erbium: YAG laser) in treating moderate – severe atrophic acne scars. Methods: Thirty one females and 9 males with moderate to severe atrophic acne scarring were enrolled in this study that attained Beirut Private Center for Laser Treatments in Baghdad, Iraq during the period from March, 1<sup>st</sup> 2011 to September, 1<sup>st</sup> 2011. Fractional Erbium:YAG laser 2940 nm wavelength was delivered to the whole face with a single pass treatment and for the acne scar areas with two passes. Therapeutic outcomes were assessed by standardized digital photography. Results: Ten patients (25%) reported excellent improvement, twenty one patients (50%) significant improvement, six patients (15%) moderate improvement, and four patients (10%) mild improvement in the appearance of the acne scars. Conclusion: Erbium:YAG laser is an effective device for skin resurfacing with faster recovery time and fewer side effects in comparison to other treatment modalities.

**Keywords** Acne, Atrophic acne scar, Fractional Er: YAG laser

## 1. Introduction

Acne is a common disorder experienced by up to 80% of people between 11 and 30 years of age and by up to 5% of older adults [1]. Several factors are incriminated in the pathogenesis of acne including increased sebum production, follicular abnormal keratinization, colonization with *Propionibacterium acnes*, and a lymphocytic and neutrophilic inflammatory response [2]. The severe inflammatory response to *P. acnes* may result in permanent disfiguring scars. Stigmata of severe acne scarring can lead to social ostracism, withdrawal from society, and severe psychological depression [3]. Patients dislike the appearance of acne, and prevention of acne scarring is often a key motivation behind treatment.

Once scarring has occurred, patients and physicians are left to struggle with the options available for improving the appearance of the skin [4].

Acne scarring can be divided into 3 basic types: icepick scars, rolling scars, and boxcar scars [5]. Boxcar scars can be further subdivided into shallow or deep [6].

Other less common scars such as sinus tracts, hypertrophic

scars, and keloidal scars may occur after acne treatment [7]. Their treatment options include excision, cryosurgery, pulsed dye laser treatment, compression with silicone sheeting, and various other modalities [8].

Goodman proposed a qualitative global acne scarring grading system (table 1) (Greg. J. Goodman and Jennifer A. Baron) [9].

The concept of fractional photothermolysis revolutionized cutaneous laser resurfacing when introduced by Manstein et al in 2004. Using a nonablative, 1550-nm Er-doped fiber laser, full-thickness columns of thermal injury (termed microthermal treatment zones or MTZs) are created in a pixelated pattern just below the level of the stratum corneum, with the surrounding skin left intact.

Fractional resurfacing employs a unique mechanism of action that repairs a fraction of skin at a time. The laser is used to resurface the epidermis and, at the same time, to heat the dermis to promote safely the formation of new collagen. The untreated healthy skin remains intact and actually aids the repair process, promoting rapid healing with only a day or two of downtime [10]. The primary target is both the epidermis and dermis with the aim of creating small zones of micro-damage separated by zones of non irradiated tissue that assist with the rapid healing process. The aim of the fractional approach is to obtain the best possible results with the least possible damage, and the degree of thermal damage delivered to the target skin depends on the dosage, the pulse

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width of the beam, and the number of passes over the same target area [11].

Er:YAG laser is a flashlamp-excited system that emits light at an invisible infrared wavelength of 2940 nm. Its light is about 16 times better absorbed by tissue water than the 10,600 nm wavelength emitted by the CO<sub>2</sub> laser. The Er:YAG laser produces a pulse of 250-350 microseconds that is less than the thermal relaxation time of the skin, which is 1 msec. Also, the Er:YAG laser causes tissue ablation with very little tissue vaporization and desiccation. The ablation threshold of the Er:YAG laser for human skin has been calculated at 1.6 J/cm<sup>2</sup> as compared with 5 J/cm<sup>2</sup> calculated for high-energy, short-pulse CO<sub>2</sub> laser systems. Because the Er:YAG laser is so exquisitely absorbed by water, it causes 10-40 μm of tissue ablation and as little as 5 μm of thermal damage. In contrast, the high-energy, short-pulse CO<sub>2</sub> lasers cause 100-120 μm of tissue damage, which is composed of 50-60 μm of apparent tissue desiccation (ablation or coagulation) and an additional 50-75 μm of thermal damage. The precise tissue ablation and small zone of residual thermal damage results in faster reepithelialization and an improved side effect profile. Apart from water being the major chromophore of skin ablative lasers, the Er:YAG laser wavelength is also absorbed by the collagen, further supporting the ablation process within the deeper dermal layers [12].

In 1997 the FDA approved Er:YAG laser for resurfacing [13] and since then it gained more and more interest for the purpose of resurfacing procedures, such as in acne scars or in the rejuvenation of photoaged skin areas. In addition, many other skin disorders formerly treated by dermabrasion or that were indication for thermal laser coagulation or vaporization can be removed by Er:YAG skin ablation (Table 2). They comprise many superficial lesions derived from epidermal or adnexal structures, but also various circumscribed malformations and benign tumors located deeper within the dermis. In addition, certain pigmented and melanocytic lesions, as well as a variety of miscellaneous pathological conditions can be removed [14-18].

This study, was designed to evaluate the safety and effectiveness of fractional photothermolysis (fractionated Erbium:YAG laser) in treating moderate – severe atrophic acne scars.

## 2. Patients & Methods

This is an open therapeutic trial study performed at Beirut Private Center for Laser Treatments in Baghdad, Iraq during the period from March, 1<sup>st</sup> 2011 to September, 1<sup>st</sup> 2011. Forty patients (31 females and 9 males) with moderate to severe atrophic acne scarring according to Goodman's qualitative global scarring grading system were included in this study. Their age ranges from 17-48 years with a mean ± SD of 28.075 ± 6.87 years. Their skin types were III – IV (Fitzpatrick skin types). This study approved by the ethical committee in Al-Kindy teaching hospital. Written informed consent was obtained from each patient.

Exclusion criteria include known photosensitivity, pregnancy or lactation, inflammatory skin disorders or active herpes infection. Patients with hypertrophic or keloidal scarring or history of hypertrophic or keloid were driven out of the study. The use of anti-coagulants, isotretinoin or other physical acne treatments over the past 6 months, patients who had any medical illness (e.g. diabetes, chronic infections, blood dyscrasias) that could influence the wound healing process were also excluded. Patients were allowed to continue previous acne medications during the study except isotretinoin.

The whole procedure was fully explained and thoroughly discussed with the patients about the mechanism of laser treatment, the time required for the treatment, the behavior after the laser treatment, and the prospects of successful treatment and any unrealistic expectations of the end results were strongly discouraged. The patients were informed about all risks that may be caused by the laser treatment and the pre- and post-operative care.

Prior to each treatment, the face was cleansed with a mild non-abrasive detergent and gauzes soaked in 70% isopropyl alcohol.

A topical anesthetic cream (EMLA, a eutectic mixture of local anesthesia of 2.5% lidocaine and 2.5% prilocaine, AstraZenica LP, Wilmington DE) was applied under an occlusive dressing for 1 hour and subsequently washed off to obtain completely dry skin surface. Eyes were protected with opaque goggles. Systemic antiviral therapy (acyclovir 400 mg twice daily) prescribed for each patient the night before operation as prophylaxis and for five days post operatively as well as topical antibiotics and a moisturizing cream, the patients were informed to apply a sunscreen for six weeks.

Three photos were taken before treatment for each patient for both sides and the front of the face with a digital camera (Sony DSC-T99 Cyber-shot® Digital Camera, 14.1 megapixel HD) and another set of photos was taken in each visit post-treatment using identical camera settings, lighting, and patient positioning.

Fractional Erbium:YAG laser (MCL30 Dermablade, Asclepion Laser Technologies, Germany) 2940 nm wavelength was delivered to the whole face with a single pass treatment and with two passes for the acne scar areas with total fluence of 108 J/cm<sup>2</sup>, interval of 0.5 second, and the window of the laser hand piece was 9 x 9 mm supporting 169 microbeams with pulse energy on the treated site of 1.5 J. The same parameters applied for all patients. Smoke evacuator and a forced air cooling system (Zimmer MedizinSystemme, Cryo version 6) accompanied the procedure to improve patients comfort and compliance. Patients were asked to return for medical assessment 1 week after operation then followed up monthly for 3 months.

Therapeutic outcomes were assessed by standardized digital photography by the patient himself and by two blinded dermatologists. The dermatologists' evaluation and self-assessment level of improvement of the patients were evaluated using the following five-point scale:

0 = no change;

- 1 = slight improvement (0–25%);
- 2 = moderate improvement (26–50%);
- 3 = significant improvement (51–75%);
- 4 = excellent improvement (>75%).

The two assessors were blinded to the order of the photographs. The evaluators were asked to perform two actions. First, to identify the photograph that showed better scar appearance. Second, to rate the difference in the severity of the acne scars using the above mentioned scale.

In addition, the participants were asked to report any cutaneous or systemic side effects associated with laser

treatment. In particular, a pain scale of 0–3 was used to determine the level of discomfort during the procedures as following:

- 0 = no pain
- 1 = mild pain
- 2 = moderate pain
- 3 = severe pain

Statistical data were analyzed by *Chi test* using Software Minitab V.16 and *P* value < 0.05 is considered statistically significant descriptive data by frequency, percent, figure and table.



**Figure 1.** Patient no.1 pre- and 3 months post-operatively



**Figure 2.** Patient no.2 pre- and 3 months post-operatively



**Figure 3.** Patient no.3 pre- and 3 months post-operatively

**Table 1.** Goodman's qualitative global scarring grading system [9]

Grade	Level of Disease	Clinical Features	Examples of Scars
1	Macular disease	Erythematous, hyper- or hypo-pigmented flat marks visible to patient or observer irrespective of distance	Erythematous, hyper- or hypo-pigmented flat marks
2	Mild disease	Mild atrophy or hypertrophy that may not be obvious at social distances of 50 cm or greater and may be covered adequately by makeup or the normal shadow of shaved beard hair in males or normal body hair if extrafacial	Mild rolling, small soft papular
3	Moderate disease	Moderate atrophic or hypertrophic scarring that is obvious at social distances of 50 cm or greater and is not covered easily by makeup the normal shadow of shaved beard hair in males or body hair if extrafacial, but is still able to be flattened by manual stretching of the skin	More significant rolling, shallow "box car," mild to moderate hypertrophic or papular scars
4	Severe disease	Severe atrophic or hypertrophic scarring that is obvious at social distances of 50 cm or greater and is not covered easily by makeup or the normal shadow of shaved beard hair in males or body hair (if extrafacial) and is not able to be flattened by manual stretching of the skin	Punched out atrophic (deep "boxcar"), "ice pick", bridges and tunnels, gross atrophy, dystrophic scars, significant hypertrophy or keloid

**Table 2.** Patients predominant scars types

Patients Number	Type of scar
10 (25%)	significant rolling
16 (40%)	shallow boxcar
8 (20%)	Deep boxcar
6 (15%)	icepick scars

**Table 3.** Response to treatment by Er:YAG laser for the level of improvement assessed by dermatologists

	Score	0	1	2	3	4	P value
Weeks	1 wk		12 (30%)	18 (45%)	8 (20%)	2 (5%)	0.002
	4 wk		10 (25%)	15 (37.5%)	10 (25%)	5 (12.5%)	
	8 wk		6 (15%)	8 (20%)	16 (40%)	8 (20%)	
	12 wk		4 (10%)	6 (15%)	20 (50%)	10 (25%)	

**Table 4.** Response to treatment by Er:YAG laser for the level of improvement assessed by the patient

	Score	0	1	2	3	4	P value
Weeks	1 wk		15 (37.5%)	20 (50%)	4 (10%)	1 (2.5%)	0.001
	4 wk		13 (32.5%)	17 (42.5%)	7 (17.5%)	3 (7.5%)	
	8 wk		9 (22.5%)	11 (27.5%)	13 (32.5%)	7 (17.5%)	
	12 wk		8 (20%)	7 (17.5%)	17 (42.5%)	8 (20%)	

### 3. Results

Forty patients (31 females and 9 males) were included in the study. All patients completed the study, including the 3-month follow-up period. All patients had mixed types of atrophic acne scars, including ice pick, boxcar, and rolling scars, although, some particular type predominates and therefore is used to classify the patients accordingly (Table 2).

According to dermatologists' assessment (Table 3) the results were escalating dramatically from 5% in 1<sup>st</sup> week to 25% for excellent improvement after 3 months; although, this group is not the major group who shows improvement. Significant improvement group shows increase from 20% after 1 week to 50% after 3 months, it gives us a strong indicator of the overall results.

The improvement scale was so obvious from first week (30% mild to 5% significant) through 4<sup>th</sup> – and 8<sup>th</sup> -week to become more satisfactory (10% mild to 25%) after three months of operation.

The final results after 3 months were as follows: Ten patients (25%) reported excellent improvement, twenty one patients (50%) significant improvement, six patients (15%) moderate improvement, and four patients (10%) mild improvement in the appearance of the acne scars. The results were significant as indicated by the *P* value which was 0.002.

The patients self assessment of improvement was also remarkable and showed a great amount of satisfaction (Table 4). The results were almost comparable to the dermatologists' assessment and were considered significant as indicated by the *P* value which was 0.001.

Table (3) shows that the two factors (scores and weeks) are not independent, in another words there is a relationship between two factors (chi-square value 25.591 df=9 P=0.002). Similar conclusion can be reported for Table (4) (chi-square

value 27.30 df=9 P=0.001)

The laser treatment was generally well tolerated. All participants underwent treatment-related pain, but there was no need for extra anesthesia (Table 5).

All participants reported mild erythema for approximately 2-3 days, and 80% of patients experienced edema for <24 hours following laser treatment. Peeling occurs from the second day and completed in the fifth day in 90% of the patients and in 10% last for 7 days. Social activity could commence as early as 3 days after the laser treatment. Other possible adverse events related to laser treatment in general, such as pigmentary alterations (hyperpigmentation), bleeding, vesiculation, crust, scarring, and infection were not observed. (Table 6)

**Table 5.** Patients pain scale during operation

Degree of pain	Number of patients
0	0
1	11 (27.5%)
2	25 (62.5%)
3	4 (10%)

**Table 6.** Adverse effects related to treatment by Fractional Er: YAG Laser

Adverse effects	No.&% of patients
treatment-related pain	(40) 100%
mild erythema	(40) 100%
Edema	(32)80%
Severe peeling	(4)10%
Bleeding	-
Hyperpigmentation	-
Vesiculation	-
Crust	-
Scarring	-
Infection	-

## 4. Discussion

In this open therapeutic trial study, patients received fractional Er:YAG laser in a single treatment session. The final outcome was evaluated after three months period by two blinded dermatologists and by the patient's self-assessment using standardized digital photography. The results were very satisfactory as more than 60% of patients showed moderate to significant improvement. The patients' self assessment is slightly lower than that of the dermatologists; this might be attributed to the fact that the patients usually use more subjective than objective scales, and they show a higher level of expectations of end results than the actual outcome. The results of both assessment groups (the patients and the dermatologists) are significant as indicated by the *P* values which were 0.001 and 0.002 respectively.

According to best of our knowledge in fractional photothermolysis, studies that investigate the role of Erbium:YAG laser as a sole option in the treatment of atrophic acne scars are lacking or very limited. There were no controlled trials but few case series which reported the effects of either the carbon dioxide or erbium:YAG laser. All of the studies were of poor quality. The types and severity of scarring were poorly described and there was no standard scale used to measure scar improvement. There was no reliable or validated measure of patient satisfaction; most improvement was based on visual clinical judgment, in many cases without blinded assessment [25]. This might be partially attributed to the fact that Er:YAG laser is considered as a superficial laser and is usually not substantial for the treatment of the relatively deep lesions of acne scars.

In a series of 78 patients, Weinstein [26] reported 70-90% improvement of acne scarring in the majority of patients treated with a modulated Er:YAG laser. He proposed that pitted acne scars may require ancillary procedures, such as subcision or punch excision, for optimal results. These procedures can be performed either prior to or concomitant with Er:YAG laser resurfacing.

The effect of fractional CO<sub>2</sub> laser on skin resurfacing is fully considered worldwide. However, there have been limited studies comparing the clinical outcome and adverse effects of these two lasers (CO<sub>2</sub> vs. Er:YAG). In two studies, one conducted in Iraq [29] and another one in Thailand [30], investigating the efficacy of fractional CO<sub>2</sub> laser for the treatment of acne scars, 75% of the CO<sub>2</sub> laser sites were graded as having moderate to significant improvement of scars. Their end-results were not significantly different from our results after 3 months follow-up (65% showed moderate to significant improvement) but taking in consideration the duration of operation which was much shorter for Er:YAG laser than the time needed to operate with CO<sub>2</sub> laser (less than 10 minutes for Er:YAG compared to 45 minutes for CO<sub>2</sub> laser). The post-operative pain, edema, erythema and duration of peeling were less and more tolerable and acceptable than that were associated with CO<sub>2</sub> laser

treatment. In contrast to CO<sub>2</sub> laser resurfacing, the narrower zone of necrosis produced by the Er:YAG laser will allow the skin to recover faster [31]. Pigment alteration, which is a common side effect of CO<sub>2</sub> laser, was not reported with Er:YAG laser in any of our patients even with those who don't commit to strict sunscreen.

In procedures aiming at aesthetic improvement, patient perception of the treatment outcome appears to be most important because it has a direct impact on patients' body image and self-esteem, which can be obtained superbly by the CO<sub>2</sub> laser but when the Er:YAG laser is used for resurfacing in the fractional mode, the results are noteworthy, recovery time is considerably shortened and traditional post-resurfacing sequelae are absent. Consequently this allows the patients a rapid return to their social or work environment [27].

Using the parameters mentioned earlier in this study, all patients show different level of improvement ranging from mild to excellent results after only one session of laser treatment even in patients with icepick or deep boxcar scars which are usually resistant to other conventional laser treatment. Furthermore, many patients mentioned they experienced a remarkable improvement in 'skin quality' and subsequently can wear more natural makeup.

The final outcome of our treatment is best read after 3-6 months post-operatively. This time is usually needed for new collagen remodeling [28] and it was the same time interval we use to follow up our patients and read their end-results which were significantly different from the results after one week post-operatively.

Most types of acne scars will benefit to some degree by laser resurfacing techniques. In acne scars the precision of sculpturing with excellent visual control and minimal heat damage can make Er:YAG laser ablation superior to CO<sub>2</sub> laser. Moreover, thermal damage to follicles and sebaceous glands can be avoided, so that acne flare ups, as reported after CO<sub>2</sub> laser is not reported [32].

In general, Erbium:YAG laser is an effective device for skin resurfacing and has faster recovery time and fewer side effects when compared to the CO<sub>2</sub> laser resurfacing [33].

## 5. Conclusions

1. Fractional Erbium:YAG photothermolysis can be a safe and effective option for the treatment of acne scars in Iraqi patients by offering faster recovery time and fewer side effects
2. Fractional Erbium:YAG photothermolysis was associated with substantial improvement in the appearance of all types of acne scar, which includes the softening of scar contours as well as the reduction of scar depth.
3. Most patients began to show a visible improvement following only one session. According to visual assessments of patients and dermatologists, patients' improvement continues to occur even after 3 months of operation.

## 6. Recommendations

We need further studies with:

1. higher fluence and more passes.
2. more treatment sessions.
3. further follow up for 6-12 months.

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## REFERENCES

- [1] Kraning KK, Odland GF. Prevalence, morbidity, and cost of dermatological diseases. *J Invest Dermatol* 1979; 73(Suppl): 395-401.
- [2] Goulden V, Stables GI, Cunliffe WJ. Prevalence of facial acne in adults. *J Am Acad Dermatol* 1999;41:577-80.
- [3] Leeming JP, Holland KT, Cunliffe WJ. The pathological and ecological significance of micro-organisms colonizing acne vulgaris comedones. *J Med Microbiol* 1985;20:11-6.
- [4] Norris JFB, Cunliffe WJ. A histological and immunocytochemical study of early acne lesions. *Br J Dermatol* 1988;118:651-9.
- [5] Knaggs HE, Holland DB, Morris C, Wood EJ, Cunliffe WJ. Quantification of cellular proliferation in acne using the monoclonal antibody Ki-67. *J Invest Dermatol* 1994;102:89-92.
- [6] Koo JY, Smith LL. Psychologic aspects of acne. *Pediatr Dermatol* 1991;8:185-8.
- [7] Alster TS, West TB. Treatment of scars: a review. *Ann Plast Surg* 1997;39:418-32.
- [8] Tsau SS, Dover JS, Arndt KA, et al. Scar management: keloid, hypertrophic, atrophic, and acne scars. *Semin Cutan Med Surg* 2002;21:46-75.
- [9] Goodman GJ, Baron JA. Postacne scarring a quantitative global scarring grading system. *J Cosmet Dermatol* 2006;5:48-52.
- [10] Tierney EP, et al: Review of fractional photothermolysis: treatment indications and efficacy. *Dermatol Surg* 2009 Oct; 35(10):1445-1461.
- [11] Brightman LA, et al: Ablative and fractional ablative lasers. *Dermatol Clin* 2009 Oct; 27(4):479-489, vi-vii.
- [12] Roland Kaufmann, Christian Beier. Erbium:YAG laser therapy of the skin lesions. *Med Laser Appl* 2001; 16:252-263.
- [13] Khatri KA. Ablation of cutaneous lesions using an erbium:YAG laser. *J Cosmetic and Laser Ther* 2003;5:1-4.
- [14] Dmoevsk-Olup B, Vedlin B. Use of Er:YAG laser for benign skin disorders. *Laser Surg Med* 1997;21(1):13-19.
- [15] Kaufman R, Hibst R. Pulsed erbium:YAG laser ablation in cutaneous surgery. *Laser Surg Med* 1996; 19:324-30.
- [16] Beier C, Kaufman R. Efficacy of erbium:YAG laser ablation in Darrier disease and Hailey-Hailey disease. *Arch Dermatol* 1999;135:423-7.
- [17] Alora MB, Arndt KA. Treatment of café-au-lait macule with erbium:YAG laser. *Arch Dermatol* 2001;45:566-8.
- [18] Ammirati CT, Giancola JM, Hruza GJ. Adult-onset facial colloid millium successfully treated with the long-pulsed Er:YAG laser. *Dermatol Surg* 2002;28:215-19.
- [19] Manstein D, Herron GS, Sink RK, Tanner H & Anderson RR. Fractional photothermolysis: a new concept for cutaneous remodeling using microscopic patterns of thermal injury. *Lasers Surg Med* 2004;34:426-38.
- [20] Glaich AS, Rahman Z, Goldberg LH, Friedman PM. Fractional resurfacing for the treatment of hypopigmented scars: A pilot study. *Dermatol Surg*. 2007; 33: 289-94.
- [21] Behroozan DS, Goldberg LH, Dai T, Geronemus RG, Friedman PM. Fractional photothermolysis for the treatment of surgical scars: A case report. *J Cosmet Laser Ther*. 2006;8:35-8.
- [22] Alster TS, Tanzi EL, Lazarus M. The use of fractional laser photothermolysis for the treatment of atrophic scars. *Dermatol Surg* 2007;33(3):295-299.
- [23] Holland DB, Jeremy AH, Roberts SG, Seukeran DC, Layton AM, Cunliffe WJ. Inflammation in acne scarring: A comparison of the responses in lesions from patients prone and not prone to scar. *Br J Dermatol*. 2004;150:72-81.
- [24] Jacob CI, Dover JS, Kaminer MS. Acne scarring: A classification system and review of treatment options. *J Am Acad Dermatol*. 2001;45:109-17.
- [25] Jordan R, Cummins C, Burls A. Laser resurfacing of the skin for the improvement of facial acne scarring: A systematic review of the evidence. *Br J Dermatol*. 2000;142:413-23.
- [26] Weinstein C, Schefflan M. Simultaneously combined ER:YAG and carbon dioxide laser (derma K) for skin resurfacing. *Clin Plast Surg*. Apr 2000;27(2):273-85, xi.
- [27] Mario AT, Serge M, Mariano V. Results of fractional ablative facial skin resurfacing with the Er:YAG laser 1 week and 2 months after one single treatment in 30 patients. *Laser Med Sci* 2009; 24 (2):186-94.
- [28] Sukal Sa, Geronemus RG. Fractional photothermolysis. *J Drug Dermatol* 2008;7:118-122.
- [29] Mohammad Y. The efficacy and safety of ablative fractional CO2 laser for treatment of acne scar. *JSMC* 2012; 2 (1): 30-5.
- [30] W. Manuskiatti. Comparison of Fractional Er:YAG and Carbon Dioxide Lasers in Resurfacing of Atrophic Scars in Asians. *Dermatol Surg* 2013; 39(1 pt 1): 111-20.
- [31] Adrian RM. Pulsed carbon dioxide and erbium-YAG laser resurfacing: a comparative clinical study. *J Cutan Laser Ther* 1999;1:29-35
- [32] Roland K. Christian B. Erbium:YAG laser therapy of skin lesions. *Med Laser Appl* 2001;16:252-253.
- [33] Khatri KA. Ablation of cutaneous lesions using an erbium:YAG laser. *J Cosmetic and Laser Ther* 2003;5:1-4.