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ORIGINAL RESEARCH ARTICLE

Fractional ablative CO_2 laser treatment versus scar subcision and autologous fat transfer in the treatment of atrophic acne scars: New technique

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Abstract: There are different modalities for management of atrophic acne scars which include lasers. Ablative fractional CO_2 laser was developed to address the shortcomings of traditional ablative lasers, with superior results to non-ablative fractional lasers. Autologous fat transfer has been utilized for nearly a decade in tissue augmentation and reconstruction. Present studies were designed to compare ablative fractional CO_2 laser treatment with scar subcision and autologous fat transfer in the treatment of atrophic acne scars. 20 patients with atrophic acne scars were recruited: 10 patients were treated by three sessions of ablative fractional CO_2 laser therapy, and 10 patients treated by subcision and autologous fat transfer. All patients were followed up for three months, and were assessed by digital photograph before and after treatment through the application of Goodman and Baron quantitative and qualitative grading systems, in addition to reports by three physicians committees and reports of patients' satisfaction. Analysis of both groups showed significant improvements in all types of atrophic acne scars. The mean percentage of total quantitative improvement was more significant in the case of autologous fat transfer with regard to ice-pick and total number of scars. Therefore, scar subcision with autologous fat transfer proved to be as effective as, or even more effective than, ablative fractional CO_2 laser in the treatment of atrophic acne scars with regard to the total number of scars as well as ice-pick type.

Keywords**:** Acne scars; laser; fat transfer

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Introduction

Acne scars in teenage and early adult years are common cosmetic concern. The scars are the result of compromised collagen production during natural wound healing process, resulting in topographical depressions. The desire to prevent scarring is often a reason for treating acne[1]. Atrophic acne scars were classified as rolling, ice-pick or boxcar. Rolling scars appear like hills or valleys without sharp borders, while ice-pick scars appear as rounded deep depressions culminating in a pinpoint base. On the other hand, boxcar scars are larger in size with sharply defined edge[2]. Different treatment modalities have been used to ameliorate atrophic scars with varying

degrees of success. These include chemical peels[3], subcision[4], surgical excision[5], punch grafting[5], dermabrasion[6], ablative and non-ablative laser resurfacing[7], as well as tissue augmentation with a variety of fillers[8].

Fractional ablative lasers deliver microscopic columns of energy which vaporize myriads of tiny holes covering different percentage of skin depending on the case to be treated. The majority of the epidermis is left intact, thus allowing these microscopic lesions to heal very quickly and limit complications. This modality is currently used for treatment of acne scarring, photoaging and skin laxity, among other indications. In contrast, traditional ablative laser resurfacing (with an ultra-pulsed CO_2 or Er:YAG laser) ablates 100% of the epidermal surface, which is associated with prolonged healing and an increased risk of scarring and infection. In addition, the fractional approach allows much deeper treatment (up to 1,500 µm) because of the extremely small beam diameter (100–300 µm)[9,10]. This is dramatically different from traditional ablative procedures that ablate the entire surface to approximately 300–350 µm. Few complications have been reported with fractional ablative resurfacing[11].

Subcision, also called "subdermal/incisionless undermining", is indicated for the same type of scars that might be improved with fillers or its appearance is improved with manual stretching of the skin during examination[12]. It appears to work by breaking up the attachments of these scars under the skin and releasing the surface from deeper structures[13]. Autologous fat transfer has enjoyed a renaissance in the last several years. As for other surgical approaches, renewed interest has evolved from refined techniques, enhanced instruments and knowledge gleaned by new research[14,15]. The understanding of fat physiology, stem cells and metabolism has benefited with an appreciation of longevity that is possible with fat transfer[16].

Materials and methods

This study was performed on 20 acne scar patients recruited from the Outpatient Clinic of Dermatology and Venereology Department, Tanta University Hospital, from April 2012 to October 2013. Inclusion criteria were males and females older than 18 years of age with atrophic acne scars. Patients younger than 18 years of age and patients with retinoid use in the past 6 months, systemic disease (diabetes or hypertension), collagen disease, malignancy, photosensitivity, and keloidal tendencies were excluded from the study.

After obtaining informed consent, the patients studied were subjected to detailed history taking, thorough general and dermatological examination, and assessment of acne scar severity before and after treatment through the application of Goodman and Baron quantitative and qualitative grading systems[17,18] in addition to assessment by three physicians committees and reports of patients' satisfaction. The improvement was graded as 0% to 25% (mild), 25% to 50% (moderate), 50% to 75% (marked) and 75% to 100% (excellent). All patients were photographed before and three months after the treatment. 10 patients (group A) were treated by autologous fat transfer and 10 patients (group B) were treated by three sessions of F-CO_2 laser.

Group A (Subcision and autologous fat transfer)

10 patients were subjected to subcision and fat grafting. The procedure was done under local anesthesia at Tanta University Plastic Surgery Unit under complete aseptic precautions. The fat was harvested using tumescent anesthesia (20 ml of 2% lidocaine + 50 ml saline + 0.25 mg 1/200,000 adrenaline) that was injected at the lower hemi-abdominal iliac crest region using 20 ml syringes. Approximately 10 min were allowed to pass for the adrenaline to be effective. A 0.5 cm stab incision was made at the donor site to introduce a 3 mm liposuction cannula connected to a 60 ml syringe with screw lock. The fat was aspirated by steady to-and-fro movements in subcutaneous tissues until the desired amount was aspirated. The syringe of aspirated fat was held with its nozzle downwards for 15 min so that the solution was settled by gravity and supernatant fat layer was separated, and then the remaining fluids were discarded. The aspirated fat was then placed on a sterile piece of gauze to be filtered and concentrated by gentle shaking. The fat was then placed in 3 ml syringes.

Infraorbital nerve block was done using 1 ml (2% lidocaine and 1/200,000 adrenaline) through buccal mucosa to provide anesthesia without causing tissue distortion. A successful infraorbital nerve block provides anesthesia to the area between the lower eyelid and the upper lip. This was helped by applying local anesthetic cream (Emla) on the involved area 20 min before the procedure. Fan-shaped subcision of the scars was done using 18-Gauge needle, creating tracts for fat placement in subdermal regions. The fat was placed using the 3-mm syringes during cannula retraction in its bed created by the subcision tracts. Molding was done against the zygoma and maxilla.

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Group B (F-CO_2 laser)

Each patient attended three sessions of fractional ablative CO_2 laser system MX7000 scanner type, manufactured by Daeshin Enterprise Co. Ltd (Seoul, Korea), spaced 4 weeks apart. Each session was performed with a single pass at the following parameters: power 12 mJ, scan scale 15 × 15 mm, depth level 2 µm, density level 3 MTZ/cm^3, repeat time off and mode selection microxel scanner.

Statistical analysis

The collected data were organized, tabulated and statistically analyzed using SPSS software version 13. For qualitative data, comparison between two groups and more was done using chi-square test (χ^2). For comparison between means of two groups, parametric analysis (*t*-test) and non-parametric analysis (Z value of Mann-Whitney *U* test) were used. For comparison between means of the same group before and after treatment, parametric analysis (paired *t*-test) and non-parametric analysis (Z value of Wilcoxon Signed Ranks test) were used. Comparison was done between percent of change after treatment and pre-treatment of the two groups using testing of proportions or Z test. Correlation between variables was evaluated using Pearson's correlation coefficient. Significance was adopted at $p < 0.05$ for interpretation of results of significance test.

Results

There was no significant difference between both groups regarding age, sex and duration of the disease. Qualitative grading system of acne scars before and after treatment of the patients studied with different types of acne scars showed significant improvement in both groups. Comparison between the two groups before treatment showed no significant difference ($p = 0.361$). Comparison between the two groups after treatment showed no significant difference ($p = 0.06$) (**Table 1**).

Quantitative assessment of acne scars in group A showed statistically significant improvement in ice-pick ($p = 0.0001$*), rolling ($p = 0.004$*), boxcar scars ($p = 0.0001$*) and the total number of scars ($p = 0.0001$*) **(Figures 1a–2b)**. Similarly, group B showed statistically significant improvement in ice-pick ($p = 0.001$*), rolling ($p = 0.002$*), boxcar scars ($p = 0.004$*) and the total number of scars ($p = 0.0001$*) **(Figures 3a-4b)**. Relations between total quantitative assessment scores of the

Table 1. Qualitative grading system of Goodman and Baron for acne scars before and after treatment by scar subcision and autologous fat transfer versus Fractional CO_2 laser

	Group A ($N = 10$)				Group B ($N = 10$)				χ^2 p	
	Before		After		Before		After		Before	After
	N	%	*N*	%	*N*	%	*N*	%		
Grade 1	0	0	0	0	0	0	0	0	0.833	3.529
Grade 2	0	0	10	100	0	0	7	70.0	0.361	0.060
Grade 3	5	50.0	0	0	3	30.0	3	30.0		
Grade 4	5	50.0	0	0	7	70.0	0	0		
χ^2	20.00				14.00					
p	0.0001*				0.001*					

$p < 0.05$ is considered statistically significant

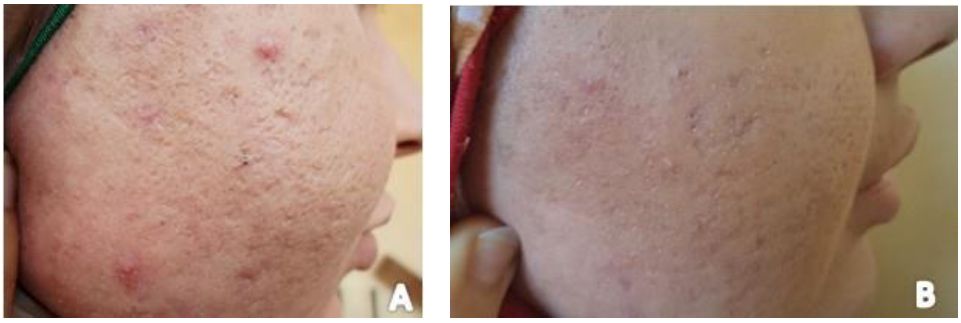

Figure 1. (A) Right side of the face of female patient with mixed atrophic acne scars; (B) The same patient three months after scar subcision with autologous fat

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Figure 2. (A) Left side of the face of male patient with mixed atrophic acne scars; (B) The same patient three months after scar subcision with autologous fat transfer

Figure 3. (A) Right side of the face of female patient with mixed atrophic acne scars; (B) The same patient three months after the last session of fractional ablative CO_2 laser

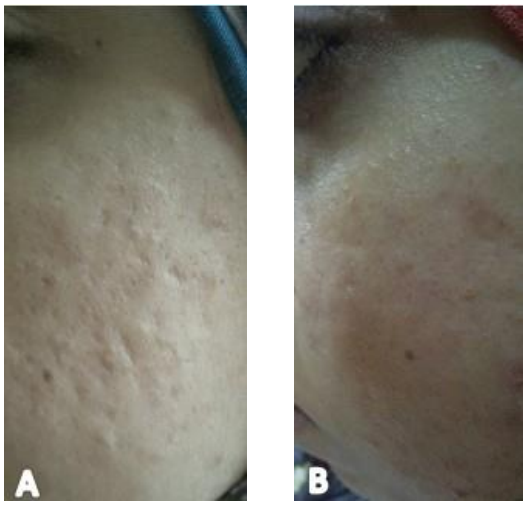

Figure 4. (A) Left side of the face of patient with mixed atrophic acne scars; (B) The same patient three months after the last session of fractional ablative CO_2 laser

acne scar patients studied (treated by subcision with autologous fat transfer versus fractional ablative CO_2 laser), their ages and duration of disease showed no significant difference.

Comparison between both groups showed statistically significant improvement in group A compared to group B in ice-pick scars (p = 0.028*) and boxcar scars (p = 0.002*), but not in rolling scars (p = 0.421) and the total number of the scars (p = 0.278) (**Table 2**). The mean percentage of improvement in after-treatment compared to before-treatment scores of quantitative assessment showed that the number of ice-pick scars decreased after treatment with scar subcision and autologous fat transfer by 59.85% and decreased after F-CO_2 laser by 39.76%, with significant difference between both groups (p = 0.011*). The total number of scars decreased after treatment with autologous fat transfer by 57.78% and decreased after fractional CO_2 laser by 41.97%, with significant difference between both groups (p = 0.020*). Mean percentage of improvement of rolling and boxcar scars decreased after treatment with autologous fat transfer by 58.31% and 46.37%, respectively, and decreased after fractional CO_2 laser by 42.21% and 42.28%, respectively. There were no significant difference between both groups regarding rolling and boxcar scars (p = 0.251 and p = 0.713, respectively) (**Table 3**). No significant difference was found between patients' and physicians committees' opinions on the improvement of different types of acne scars in the patients studied (p = 0.656 and p = 0.371, respectively) (**Table 4**).

Group A patients tolerated their procedure well. Mild oedema was temporary and faded within one week. Pain was relieved by analgesics and the patients were able to attend their daily routines. Group B patients tolerated their procedure well. However, they were not able to attend their daily duties as all of them were advised to avoid the sun for 5–7 days after the session and all patients experienced grainy crusts that resolved after a maximum of 5 days, which increased the downtime post session.

Discussion

Facial scarring has always been a challenge to treat. There are different modalities for the management of these scars including various types of resurfacing which have the disadvantages of either being too mild and ineffective or being too aggressive and complicated[19]. Autologous fat transfer has enjoyed a renaissance in the last several years. In particular, the micro droplet approach offers the surgeon an opportunity to address superficial

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Table 2. Quantitative acne scars assessment scores of Goodman and Baron before and after treatment by subcision with autologous fat transfer versus fractional ablative CO_2 laser

Scar type		Group A (N = 10)		Group B (N = 10)		Before	After
		Before	After	Before	After		
Ice-pick	Range	70–100	17–45	45–158	20–94	0.529	2.395
	Mean ± SD	81.80 ± 11.67	32.80 ± 9.61	87.50 ± 31.99	52.40 ± 24.04	0.603	0.028*
	Median	80.50	34.00	85.00	54.00		
	Paired *t*-test P	14.819 0.0001*		4.650 0.001*			
Rolling	Range	6–45	2–14	1–24	0–12	1.064	0.805
	Mean ± SD	18.50 ± 15.73	7.10 ± 4.91	9.40 ± 6.38	4.60 ± 3.31	0.288	0.421
	Median	9.00	5.00	8.00	4.50		
	Z value▪▪ P	2.873 0.004*		4.474 0.002*			
Boxcar	Range	12–27	6–15	1–17	0–11	5.397	3.615
	Mean ± SD	20.70 ± 5.25	10.60 ± 4.09	7.70 ± 5.52	4.40 ± 3.56	0.0001*	0.002*
	Median	21.50	11.00	8.00	3.00		
	Paired *t*-test P	5.779 0.0001*		3.851 0.004*			
Total scars number	Range	96–172	36–74	55–167	23–107	1.232	1.119
	Mean ± SD	121.00 ± 28.41	50.50 ± 13.75	104.60 ± 31.05	61.10 ± 26.61	0.234	0.278
	Median	115.00	47.50	107.50	62.50		
	Paired *t*-test P	10.936 0.0001*		5.905 0.0001*			

$p < 0.05$ is considered statistically significant

Table 3. Mean percentage of change in after-treatment compared to before-treatment scores of quantitative assessment of ice-pick, rolling, boxcar and total number of scars treated by subcision with autologous fat transfer versus fractional ablative CO_2 laser

Quantitative assessment of acne scars	Mean percent of change in after-treatment compared to before-treatment scores among the patients studied with acne scars (N = 20)		*Z*-test	*p*
	Group A (N = 10)	Group B (N = 10)		
	Range Mean ± SD	Range Mean ± SD		
●Ice-pick assessment	↓77.33%–↓48.57% ↓59.87 ± 10.88	↓71.83%–↓18.57% ↓39.76 ± 19.45	2.854	0.011*
● Rolling assessment	↓68.89%–↓44.44% ↓58.31 ± 10.65	↓100%–↓60.00% ↓42.21 ± 41.62	1.185	0.251
● Boxcar assessment	↓73.91%–↓30.00% ↓46.73 ± 19.51	↓100%–0.00% ↓42.28 ± 32.23	0.373	0.713
Total number of scars	↓67.59%–↓45.83% ↓57.78±9.02	↓71.59%–↓20.15% ↓41.97 ± 17.42	2.548	0.020*

$p < 0.05$ is considered statistically significant

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Table 4. Physicians committees' opinions versus patients' opinions regarding improvement of acne scars of the patients studied treated by subcision with autologous fat transfer versus fractional ablative CO_2 laser

Degree of improvement of acne scars		Opinions about improvement of acne scars of patients studied with different types of acne scars (N = 20)								χ^2 p	
		Group A (N = 10)				Group B (N = 10)					
		Physicians committee		Patients opinions		Physicians committee		Patients opinions		Physicians committee	Patients opinions
		N	%	N	%	N	%	N	%		
Mild	(0–<25%)	0	0	0	0	0	0	0	0	1.986	0.843
Moderate	(25%–<50%)	3	30.0	2	20.0	5	50.0	3	30.0	0.371	0.656
Marked	(50%–<75%)	5	50.0	3	30.0	2	20.0	4	40.0		
Excellent	(75%–100%)	2	20.0	5	50.0	3	30.0	3	30.0		
	χ^2	5.56				1.17					
	p	0.062				0.558					

$p < 0.05$ is considered statistically significant

skin problems such as acne scars and relatively shallow rhytids[20]. Ablative fractional CO_2 laser has been developed to address the shortcomings of traditional ablative lasers and non-ablative fractional resurfacing (NAFR) treatments. With the ability to achieve deep dermal ablation and coagulation, clinical results superior to non-ablative fractional lasers could be obtained[21, 22].

Analysis of current research up to recent dates showed that this study was the first to perform subcision for atrophic facial acne scars with fat injection directly under the scars to act as filler and a source of stem cells at the same time. This showed significant improvement in acne scars, ice-pick type in particular, which were evaluated three month after the procedure. This differs from results of Azzam *et al.* which showed no improvement of ice-pick scars after the fat grafting and they recommended punch excision or chemical reconstruction techniques to treat ice-pick scars[23]. This can be attributed to their different technique in which autologous fat transfer was done through 0.5 cm stab incision pre-auricular in the hair line or in an already existing scar for cheek augmentation, followed by a fan-shaped subscision of atrophic acne scars. Rohrich *et al.* also considered that fat transfer alone was not generally effective for individual bound down ice-pick scars[24].

On the other hand, Goodman *et al.* observed that once the scar is freed, fat may be satisfactorily injected[13]. Moreover, Donofrio focused on lipocyte stem cells rather than mature adipocytes as the driving force in long term clinical benefit for post-radiation depressed scars[25]. He stated that adipose tissue contains a clonogenic pool of stromal cells having the same functional and immunophenotypic properties of bone marrow mesenchymal stem cells. The longevity of fat transplants has been extensively studied although consistent results in the literature vary[26,27]. Theories include replacement fibrosis, neovascularization of transplanted fat, and differentiation of lipocyte stem cells into mature adipocytes[14,28,29]. Duration has not been specifically studied in acne scars. However, one study of depressed post-surgical scars in 30 patients utilizing a subcision technique followed by autologous fat grafting through 4 mm cannula, revealed 27 patients with very good results at three years. Two patients required additional treatment at 6 months due to partial recurrence[30]. Adipose-derived stem cells (ADSCs) are considered a powerful source of skin regeneration because of their capability to provide cellular elements and cytokines. It seems that autologous ADSCs have great promise for applications in wound healing and scar remodeling[6]. Stem cell therapy can improve the quality of the skin, reduce the formation of scars and re-establish the normal function of the skin and its appendages[31].

In the present study, it was found that three sessions of ablative fractional CO_2 laser showed significant qualitative and quantitative improvement of atrophic acne scars, which was consistent with previous reports of Chapas *et al.*[32], Manuskiatti *et al.*[33] and Cho *et al.*[34]. However,

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Azzam *et al*. reported that patients with boxcar scars showed no improvement using (15 mJ) power by fractional CO_2 laser with appearance of pixilated pattern and acne activation in some cases[24]. This can be attributed to different power used in current work (12 mJ).

On comparing the results of both groups, both methods were equally effective in improving atrophic acne scars quality and quantity. The mean percentage of scar improvement between before- and after-treatment quantitative assessments showed that autologous fat transfer is more effective in improving ice-pick scars and there were no significant differences in the total number of scars from fractional CO_2 laser for rolling and boxcar scars. Previous histologic and immunohistologic studies demonstrated a large difference in results between fat grafting and fractional ablative CO_2 laser for the treatment of acne scars, and favored fat grafting[35]. Histologic and immunohistologic experimental study compared biopsies taken from nude mice before and after fat graft, and showed an increased density of extracellular matrix surrounding the fatty tissue and between the fatty tissue and the dermis[32]. In another study on mice, skin changes with fat grafting were investigated in skin biopsies eight weeks after the graft, which revealed that fat graft caused increased collagen fibers neosynthesis at the recipient site and thickened the dermis. Regarding skin color and scar quality, marked improvement could be seen after fat graft[36].

The current study concluded that a single session of acne scar subcision with autologous fat transfer proved to be as effective as or even more effective than three sessions of ablative fractional CO_2 laser one month apart, with regard to the total number of scars, in the treatment of atrophic acne scars as well as ice-pick type – which is considered in general the most difficult type in its treatment – with minimal downtime and almost no complications when done in the proper setting, technique and patient selection, and is also considered as a non-expensive technique which can be done with a few equipment.

Ethics Statement

This research was approved by the research ethics committee of Tanta Faculty of Medicine (approval code 1700 /03 /13).

Conflict of interest

The authors declared no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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