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A Comparative Study between Autologous Nanofat Graft and Fractional CO_2 Laser in the Management of Post Burn Scars

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ABSTRACT

Background: Post burn scarring is a common complication that can lead to functional disability and cosmetic disfigurement. Superficial burn wounds usually heal without complications, unlike deep ones that have an increased risk for abnormal scar formation.

Aim of Study: Is to compare between autologous nanofat grafting and fractional CO_2 laser in the management of post burn scars regarding aesthetic improvement.

Patients and Methods: This is a prospective study carried out at Plastic Surgery Department, Ain Shams University Hospital from February 2020 to February 2022. The study included 20 cases of post burn scars, they were divided randomly into two equal groups; the first group was managed by 2 sessions of autologous nanofat grafting while the other group was managed by 6 sessions of fractional CO_2 laser.

Results: There was statistically significant improvement after nanofat grafting and fractional CO_2 laser. According to VSS; more statistically significant improvement of pliability was found among nanofat grafting group than fractional CO_2 laser. While POSAS observer scale showed more improvement for pigmentation and pliability scores. Moreover, POSAS patient scale found more improvement among nanofat grafting group regarding itching, color, stiffness and total scores.

Conclusion: Autologous nanofat injection and fractional CO_2 laser use resulted in a significant aesthetic improvement of post burn scars. However, autologous nanofat injection had more significant improvement than laser regarding pliability, pigmentation, itching, color and stiffness.

Key Words: *Post burn scars – Autologous nanofat – Fractional CO_2 laser – Plastic surgery.*

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INTRODUCTION

A healed burn patient may present with post burn scars that affect functional and aesthetic outcomes. Post burn scars are divided into immature or mature, stable or unstable, atrophic or hypertrophic, keloid or depigmented or hyperpigmented. Chronic cases, due to chronic irritation and inflammation, can progress to malignancy **[1]**.

There are numerous treatment options available for burn injuries that address the functional and aesthetic consequences. As surgical management, split- and full-thickness skin grafts are considered the gold standard options. Flaps can also be used to cover a skin defect in conjunction with tissue expanders, which help to reconstruct adjacent soft tissue defects. Such surgical procedures may result in a higher rate of complications and larger scars with persistent retraction **[2]**.

Nonsurgical treatment options for mild to moderate cases include intralesional corticosteroids, silicone gel sheets and pressure dressings. The problem is that these strategies do not prevent scar formation but aim to mitigate its consequences, which can result in hypopigmentation or skin atrophy **[3]**. Consequently, there is a need for a solution that provides a better cosmetic outcome, such as improved colour match, contour, thickness match and symmetry **[4]**.

Fat is composed of a variety of cell types such as adipocytes, fibroblasts, endothelial cells, smooth muscle cells and adipogenic progenitor cells known as "preadipocytes". Adipose-derived stem cells (ADSCs) are mesenchymal stem cells that have the ability to self-renew and multipotential differ-

entiate. Nanofat grafts contain large amounts of ADSCs and endothelial progenitor cell phenotypes, which may explain why nanofat grafting has potent regenerative effects with clinically significant results. These cells cause increased elasticity, collagen and elastin synthesis and remodeling. Burn scars regain characteristics that mimic normal skin, both functionally and aesthetically, even in old burn cases **[5]**.

Fractional laser resurfacing is a key concept in the laser arena because it forms a unique thermal pattern with columns of thermal damage at specific depths. The thermal effect induces a therapeutic wound healing response involving myofibroblasts, heat shock proteins, and increased collagen III production that participate in tissue remodeling **[6]**. In mature hypertrophic burn scars, fractional CO_2 laser treatment prompts its regression by suppressing the deposition of both type I and type III collagen through decreasing the expression of basic fibroblast growth factor (bFGF) and transforming growth factors (TGF-β2, -β3). The assumption behind this approach is that fractional laser apply thermal energy on fractions of the skin while leaving the intervening areas of normal skin untouched, allowing the ablated columns of tissue to rapidly repopulate. The repopulation is caused by fibroblast activity of neocollagenesis and epidermal stem cell reproduction. However, laser technology may cause skin discoloration and burns **[7]**.

There are several appropriate scales available for assessing scar improvement that have been used to evaluate burn scar quality. The Vancouver Scar Scale VSS, first described by Sullivan in 1990 **[8]**, is perhaps the most well-known method of assessing burn scars. It evaluates four factors: Vascularity, height/thickness, pliability, and pigmentation **[9]**. The Patient and Observer Scar Assessment Scale (POSAS) was introduced in 2004 in order to measure the scar tissue quality. The POSAS features a list of items based on clinically relevant scar characteristics and is comprised of an Observer and a Patient Scale. The observer assigns points for five characteristics: Vascularization, pigmentation, thickness, surface roughness, and pliability. Six items are scored by the patient: pain, pruritus, colour, thickness, relief, and pliability **[10]**.

PATIENTS AND METHODS

This prospective study was carried out at Plastic and Reconstructive Surgery Department, Ain Shams University Hospital from February 2020 to February 2022. The study included 20 cases of post burn scars that were divided randomly into two equal groups; the first group was managed by autologous nanofat grafting while the other group was managed by fractional CO_2 laser.

Inclusion criteria: Adult males and females between 18-60 years old with post burn scars (atrophic, hypertrophic, keloid, hypopigmented or hyperpigmented) scars with Vancouver scar scale of more than 4.

Exclusion criteria: Pregnant patients, patients with contractures, acute or chronic dermatological disorders, diabetes, collagen disorders or other comorbidities.

The first group (Nanofat grafting):

Patients received local anaesthesia injection of 5ml of lidocaine 2% at the site of cannula insertion and around the donor area of fat graft. A stab incision was done by a surgical scalpel blade No.11. Then infiltration with a standardized tumescent solution (500mL NaCl 0.9%, 0.5mL Adrenaline 1mg/mL and 10mL of Lidocaine 2%). Microfat was harvested from the abdomen (mainly the lower abdomen region) or flanks using the Tonnard Harvester (Tulip Aesthetics ™) 3mm x 20cm cannula with 1mm sharp side holes connected to a 20-mL syringe. The syringe plunger was pulled back and the locker was applied to create negative pressure. Then, syringes were supported on a stand upside down for a few minutes till the lipoaspirate was separated by gravity sedimentation into supranatant and infranatant, which were discarded (Fig. 1).

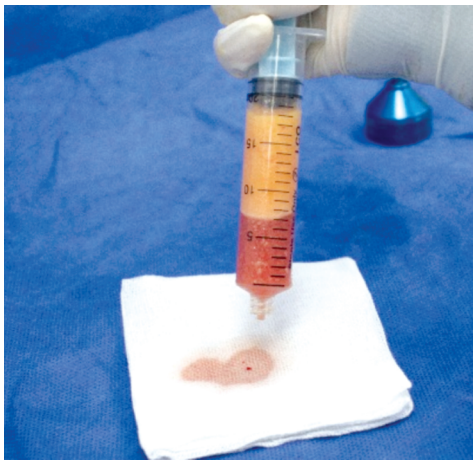

Fig. (1): Harvested microfat and removal of infranatant.

Microfat was mechanically emulsified via Tulip NanoTransfer kit (Smart Lipo™) using 2.5, 1.5 and 1-mm Tulip Transfer Luer-to-Luer con-

nectors that were placed between two syringes with 30 passes through each connector until the fat became liquefied and whitish. The fat was then passed once through NanoTransfer device with two filters of 400 and 600-µm to form the 'nanofat' which was then transferred into 1-ml syringes. About 1mL of nanofat per 10mL of aspirate was obtained.

The donor area was massaged to drain the tumescent solution remnants through the incision, which was then sutured with 4-0 polypropylene. External pressure was applied with an elastic compressive garment to reduce postoperative edema and prevent hematoma formation. Antibiotics were given to all patients for 5 days.

Patients were examined after one week and monthly for 6 months. Nanofat grafting was repeated for all patients 3 months later using the same technique.

Clinical evaluation and photographs were taken before nanofat grafting, every month and 6 months after the last session.

The second group (Fractional laser):

Patients received 6 fractional CO_2 laser sessions using (BX300, AMI Inc., Korea) at 3 weeks intervals. Topical anaesthetic cream was applied for at least 30 minutes before sessions then wiped with saline and dried. The laser settings (energy, power and pulse duration and depth level) were adjusted according to each case. As in Azzam et al., 2016 **[11]**, parameters were adjusted in cases of hypertrophic scars: 25W, 600-µs dwelling time, stack 3, 700-µm spacing for skin type III and 800-µm for skin type IV. And in keloids: 30W, 1000-µs dwelling time, stack 4 and 800-µm spacing. Topical antibiotic with steroid cream was applied twice daily for 5 days after sessions. Clinical evaluation and photographs were taken pre management and 6 months after the last session.

Scars in both groups were evaluated clinically pre management and 6 months after the last procedure using the Vancouver scar scale (VSS) regarding vascularity, pigmentation, pliability and height. The patient and observer scar assessment scale (POSAS) also were used. It consists of two scores; the observer score is based on five items: Vascularization, pigmentation, thickness, surface roughness (relief) and pliability. And the patient score is composed of six items: Pain, itching, color, stiffness, thickness and irregularity.

Ethical considerations: All patients who agreed to take part in the study provided informed consent after explanation in accordance with the local ethical committee regulation.

Statistical analysis: Data coding and computing were done using statistical package for social science (SPSS) (version 18). The results were presented in tabular and diagrammatic formats before being interpreted.

RESULTS

The study included 20 patients with post burn scars, 11 females and 9 males, randomly assigned to the two study groups. Eleven cases were due to scald burn, eight flame burn and one case due to electrical burn. Their mean age was 28.9±9.01 in group 1, the nanofat grafting group, and 24.5± 7.33 in group 2, the fractional CO_2 laser treatment group.

The mean time interval since burn was 1.82± 3.24 years in the nanofat grafting group and 2.6± 3.68 years in the fractional laser group. There was no statistically significant difference between both groups (*p*-value=0.621).

The nanofat grafting group included 10 cases, they received two grafting sessions with 3 months interval.

Patients were assessed clinically using VSS and POSAS. Photographs were taken before management and 6 months after the last session (Figs. 2,3,4).

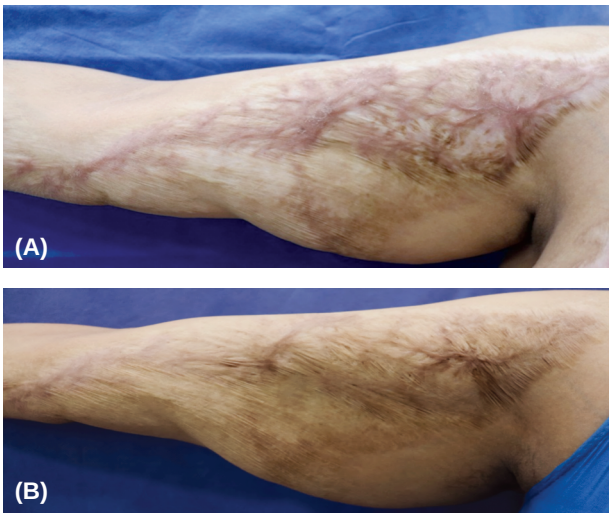

Fig. (2): (A) 40-year-old female presented with post flame burn scars. (B) 6 months after 2 nanofat grafting sessions with 3 months interval.

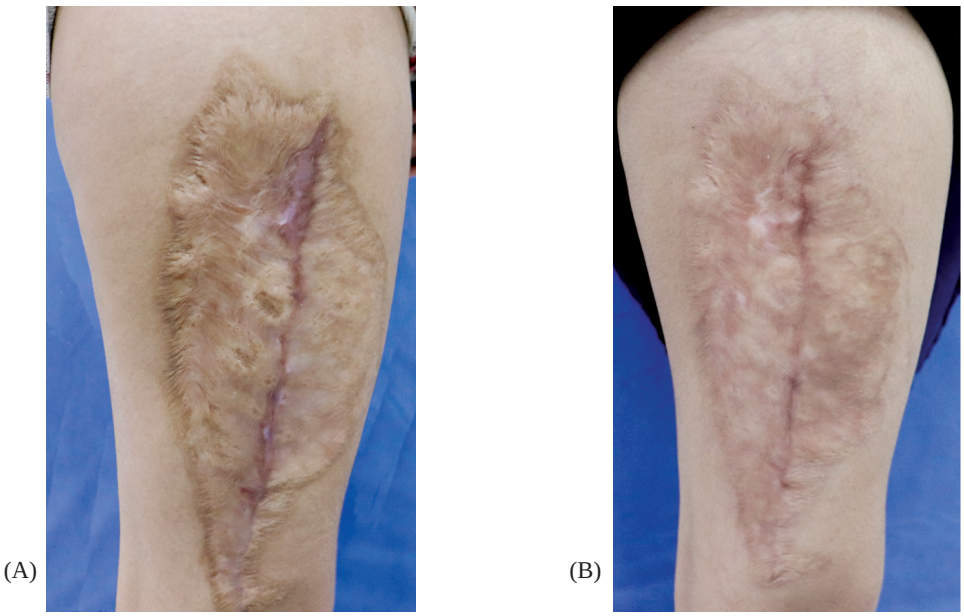

Fig. (3): (A) 19-year-old female presented with post scald burn scars. (B) 6 months after 2 nanofat grafting sessions with 3 months interval.

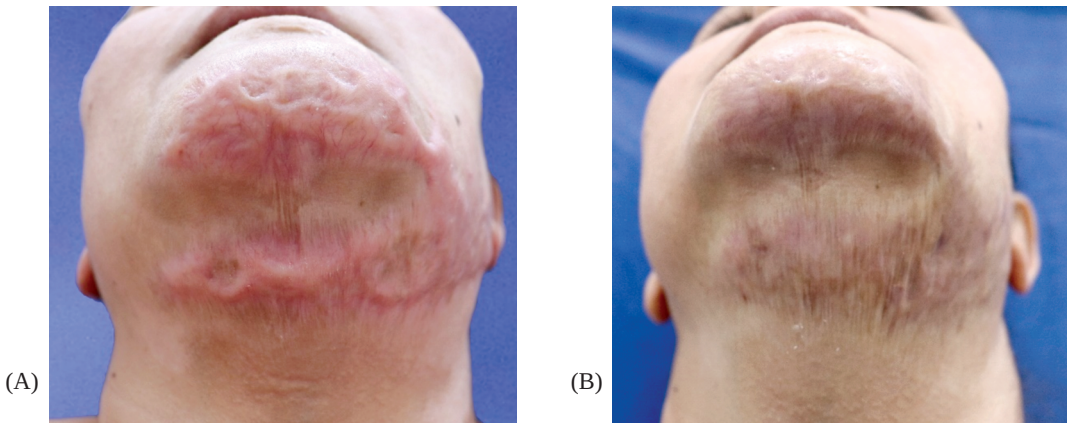

Fig. (4): (A) 47-year-old female presented with post scald burn scar. (B) 6 months after 2 nanofat grafting sessions with 3 months interval.

There was statistically significant improvement regarding vascularity, pliability and height VSS scores after nanofat grafting. Meanwhile, pigmentation score of VSS did not show statistically significant difference between pre and post treatment.

There was a statistically significant improvement of the total VSS score pre than post treatment, with mean value 9.80 and 5.50 respectively, p=0.000 (Table 1).

Regarding POSAS observer scale, the mean value of nanofat grafting group was statistically better regarding vascularization, pigmentation, thickness, relief and pliability scores pre than post management. Mean value of total POSAS observer scale score among nanofat grafting group was statistically higher pre than post management, 32.20 versus 17.20 respectively, p=0.000 showing improvement after nanofat grafting (Table 2).

According to POSAS patient scale, the improvement of the mean value of nanofat grafting group was statistically significant regarding pain, itching, color, stiffness, thickness and irregularity scores pre versus post management showing improvement after nanofat grafting. The improvement of the mean value of total POSAS patient scale score among nanofat grafting group was statistically significant pre versus post management, 43.10; 20.30 respectively, p=0.000 showing improvement after nanofat grafting (Table 3).

Fractional laser group included 10 cases, they received six fractional CO_2 laser sessions with 3 weeks interval. Patients were assessed clinically and photographs were taken before management and 6 months after the last session (Figs. 5,6,7).

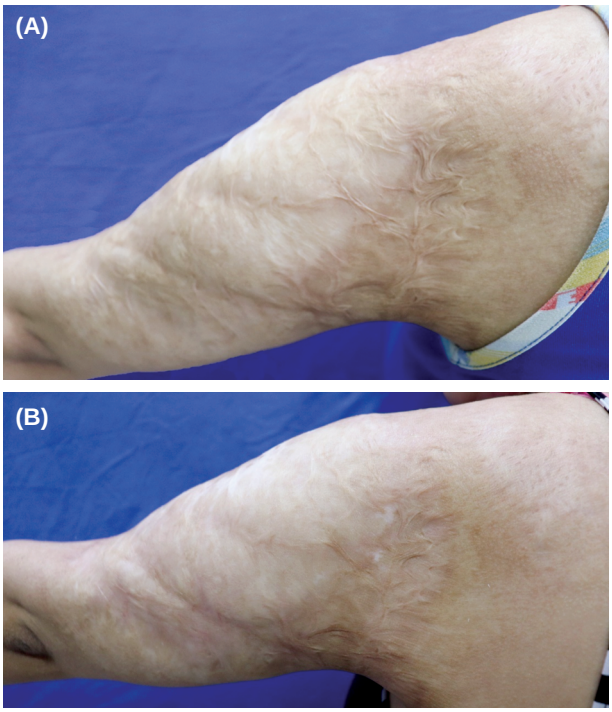

Fig. (5): (A) 24-year-old female presented with post scald burn scar. (B) 6 months after receiving 6 fractional CO_2 laser sessions with 3 weeks interval.

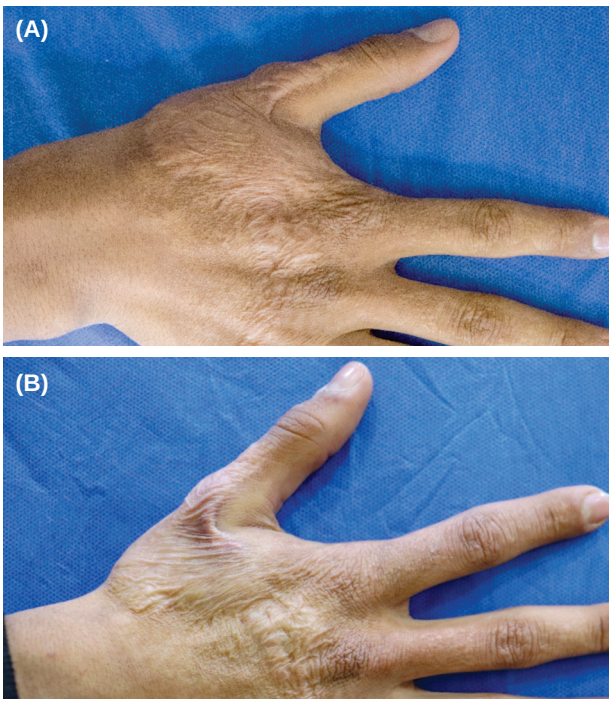

Fig. (6): (A) 21-year-old male presented with post flame burn scar. (B) 6 months after receiving 6 fractional CO_2 laser sessions with 3 weeks interval. ??? A & B.

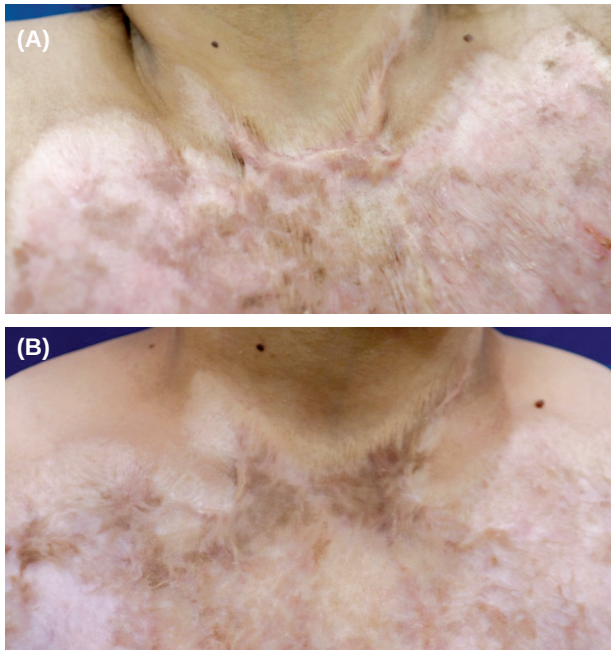

Fig. (7): (A) 35-year-old female presented with post flame burn scar. (B) 6 months after receiving 6 fractional CO2 laser sessions with 3 weeks interval.

Regarding VSS, mean value of vascularity, pliability and height scores were higher among fractional laser group pre than post management showing statistically significant improvement after fractional laser. Also, mean value of total VSS score was higher pre than post management (9.90; 7.40) p=0.000 showing statistical improvement after fractional laser (Table 4).

According to POSAS observer scale, mean value of vascularization, pigmentation, thickness, relief and pliability scores were higher pre than post management showing statistically significant improvement after fractional laser.

Mean value of total POSAS observer scale score was statistically higher pre than post management, 32.50; 21.40 respectively, p=0.000 showing improvement after fractional laser (Table 5).

Regarding POSAS patient scale, mean value of pain, itching, color, stiffness, thickness and irregularity scores were statistically higher pre than post management showing improvement after fractional laser.

Mean value of total POSAS patient scale was statistically higher pre than post management, 44.00; 29.20 respectively, p=0.000 showing improvement after fractional laser (Table 6).

Comparing between the two groups before sessions regarding VSS, there was no statistically significant difference (Table 7).

6 months after last session, mean value of pliability score of VSS Post management was lower among nanofat grafting group than fractional laser group (0.738; 1.10) p=0.028, that means statistically significant improvement of pliability after nanofat grafting than fractional laser.

Regarding the other VSS items, the two groups showed no statistically significant difference post management (Table 8).

Regarding POSAS observer scale, both groups showed no statistically significant difference before sessions (Table 9).

Table (1): Comparison between VSS Pre and Post management among nanofat grafting group.

Nanofat grafting group	Mean ± SD	Paired *t*-test	*p*-value
Vascularity:			
Pre	1.50±1.17	3.207	0.011
Post	.70±.675		
Pigmentation:			
Pre	2.40±.699	1.000	.343
Post	2.10±.994		
Pliability:			
Pre	3.40±.699	10.776	0.000
Post	1.10±.738		
Height:			
Pre	2.50±.527	5.014	0.001
Post	1.60±.843		
Total:			
Pre	9.80±1.75	12.836	0.000
Post	5.50±2.06		

Table (2): Relation between POSAS observer scale pre and post management among nanofat grafting group.

Nanofat grafting group	Mean ± SD	Paired *t*-test	*p*-value
Vascularization:			
Pre	4.60±2.31	4.975	0.001
Post	2.40±1.89		
Pigmentation:			
Pre	6.70±1.82	8.913	0.000
Post	3.50±1.17		
Thickness:			
Pre	6.30±1.49	7.667	0.000
Post	4.00±2.10		
Relief:			
Pre	7.00±1.05	6.021	0.000
Post	4.30±2.00		
Pliability:			
Pre	7.60±.966	17.250	0.000
Post	3.00±1.33		
Total:			
Pre	32.20±5.53	14.230	0.000
Post	17.20±6.87		

Table (3): Relation between POSAS Patient scale pre and post management among nanofat grafting group.

Nanofat grafting group	Mean ± SD	Paired *t*-test	*p*-value
Pain:			
Pre	4.70±3.56	3.139	0.012
Post	1.90±1.52		
Itching:			
Pre	6.30±3.12	5.237	0.001
Post	1.50±.707		
Color:			
Pre	7.40±1.57	9.160	0.000
Post	4.00±1.33		
Stiffness:			
Pre	8.30±1.05	12.348	0.000
Post	3.50±1.08		
Thickness:			
Pre	7.90±1.44	6.377	0.000
Post	4.60±2.27		
Irregularity:			
Pre	8.50±1.35	9.348	0.000
Post	4.80±1.61		
Total:			
Pre	43.10±8.99	11.102	0.000
Post	20.30±6.01		

Table (4): Relation between VSS pre and post management among fractional CO_2 laser group.

Fractional laser group	Mean ± SD	Paired *t*-test	*p*-value
Vascularity:			
Pre	1.50±1.35	2.449	0.037
Post	1.10±1.10		
Pigmentation:			
Pre	2.70±.483	1.000	0.343
Post	2.60±.516		
Pliability:			
Pre	3.30±.823	6.000	0.000
Post	2.10±1.10		
Height:			
Pre	2.40±.699	4.000	0.003
Post	1.60±1.17		
Total VSS:			
Pre	9.90±3.03	8.135	0.000
Post	7.40±3.47		

Table (5): Relation between POSAS observer scale pre and POSAS observer scale post management among fractional CO_2 laser group.

Fractional laser group	Mean ± SD	Paired *t*-test	*p*-value
Vascularization:			
Pre	4.50±3.17	3.498	0.007
Post	3.40±2.27		
Pigmentation:			
Pre	6.80±1.93	4.025	0.003
Post	5.30±2.35		
Thickness:			
Pre	7.00±2.70	8.216	0.000
Post	4.00±2.62		
Relief:			
Pre	6.90±2.13	8.908	0.000
Post	3.80±1.61		
Pliability:			
Pre	7.30±2.26	9.000	0.000
Post	4.90±2.13		
Total:			
Pre	32.50±10.57	12.686	0.000
Post	21.40±9.41		

Table (6): Relation between POSAS patient scale score pre and post management among fractional CO_2 laser group.

Fractional laser group	Mean ± SD	Paired *t*-test	*p*-value
Pain:			
Pre	5.60±3.59	3.431	0.008
Post	3.90±3.14		
Itching:			
Pre	6.50±3.44	2.667	0.026
Post	4.90±2.96		
Color:			
Pre	8.00±1.56	3.943	0.003
Post	6.10±2.47		
Stiffness:			
Pre	8.00±1.41	12.650	0.000
Post	5.30±1.33		
Thickness:			
Pre	7.60±1.71	9.391	0.000
Post	4.10±1.66		
Irregularity:			
Pre	8.30±1.56	6.530	0.000
Post	4.90±1.59		
Total:			
Pre	44.00±10.99	8.032	0.000
Post	29.20±11.26		

Table (7): Comparison between nanofat grafting group and fractional laser group regarding Vancouver Scar Scale (VSS) before sessions.

	Nanofat grafting group	Fractional laser group	*t*-test	*p*-value
Vascularity: Mean ± SD	1.17±.373	1.35±.428	.000	1.00
Pigmentation: Mean ± SD	.699±.221	.483±.153	-1.116-	0.279
Pliability: Mean ± SD	.699±.221	.823±.260	.293	0.773
Height: Mean ± SD	.527±.167	.699±.221	.361	0.722
Total: Mean ± SD	1.75±.554	3.03±.960	-.090-	0.929

Table (8): Comparison between nanofat grafting group and fractional laser group regarding VSS 6 months after last session.

	Nanofat grafting group	Fractional laser group	*t*-test	*p*-value
Vascularity: Mean ± SD	.675±.213	1.10±.348	-.980	0.340
Pigmentation: Mean ± SD	.994±.314	.516±.163	-1.411	0.175
Pliability: Mean ± SD	.738±.233	1.10±.348	-2.387	0.028
Height: Mean ± SD	.843±.267	1.17±.371	.000	1.00
Total: Mean ± SD	2.06±.654	3.47±1.09	-1.487	0.154

Table (9): Comparison between nanofat grafting group and fractional laser group regarding The Patient and Observer Scar Assessment Scale (POSAS) observer scale before sessions.

	Nanofat grafting group	Fractional laser group	*t*-test	*p*-value
Vascularization: Mean ± SD	2.31±.733	3.17±1.00	.080	0.937
Pigmentation: Mean ± SD	1.82±.578	1.93±.611	-.119-	0.907
Thickness: Mean ± SD	1.49±.473	2.70±.856	-.716-	0.483
Relief: Mean ± SD	1.05±.333	2.13±.674	.133	0.896
Pliability: Mean ± SD	.966±.306	2.26±.716	.386	0.704
Total: Mean ± SD	5.53±1.75	10.57±3.34	-.079-	0.938

Six months after the last session, mean value of pigmentation and pliability scores of POSAS observer scale post management were statistically lower among nanofat grafting group than fractional laser group showing more improvement among nanofat grafting group.

While there was no statistically significant difference between both groups regarding other observer scale items post management (Table 10).

According to POSAS patient scale, both groups showed no statistically significant difference before sessions (Table 11).

Table (10): Comparison between nanofat grafting group and fractional laser group regarding POSAS observer scale 6 months after last session.

	Nanofat grafting group	Fractional laser group	*t*-test	*p*-value
Vascularization: Mean ± SD	1.89±.600	2.27±.718	-1.069	0.299
Pigmentation: Mean ± SD	1.17±.373	2.35±.746	-2.158	0.045
Thickness: Mean ± SD	2.10±.667	2.62±.830	.000	1.00
Relief: Mean ± SD	2.00±.633	1.61±.512	.614	0.547
Pliability: Mean ± SD	1.33±.422	2.13±.674	-2.390	0.028
Total: Mean ± SD	6.87±2.17	9.41±2.97	-1.139	0.270

Table (11): Comparison between nanofat grafting group and fractional laser group regarding POSAS Patient scale before sessions.

	Nanofat group	Fractional group	*t*-test	*p*-value
Pain: Mean ± SD	3.56±1.12	3.59±1.13	-.562-	0.581
Itching: Mean ± SD	3.12±.989	3.44±1.08	-.136-	0.893
Color: Mean ± SD	1.57±.499	1.56±.494	-.854-	0.404
Stiffness: Mean ± SD	1.05±.335	1.41±.447	.537	0.598
Thickness: Mean ± SD	1.44±.458	1.71±.542	.423	0.677
Irregularity: Mean ± SD	1.35±.428	1.56±.496	.305	0.764
Total: Mean ± SD	8.99±2.84	10.99±3.47	-.200-	0.843

Six months after the last session, mean value of itching, color and stiffness scores were statistically lower among nanofat grafting group than fractional laser group showing more improvement among nanofat grafting group.

Mean value of total score was statistically lower among nanofat grafting group than fractional laser group (6.01; 11.26) p=0.041 showing more improvement among nanofat grafting group.

While the two groups showed no statistically significant difference regarding thickness and irregularity (Table 12).

Table (12): Comparison between nanofat grafting group and fractional laser group regarding POSAS Patient scale 6 months after last session.

	Nanofat grafting group	Fractional laser group	*t*-test	*p*-value
Pain: Mean ± SD	1.52±.482	3.14±.994	-1.811-	0.047
Itching: Mean ± SD	.707±.224	2.96±.936	-3.532-	0.002
Color: Mean ± SD	1.33±.422	2.47±.781	-2.366-	0.029
Stiffness: Mean ± SD	1.08±.342	1.33±.423	-3.311-	0.004
Thickness: Mean ± SD	2.27±.718	1.66±.526	.562	0.581
Irregularity: Mean ± SD	1.61±.512	1.59±.504	-.139-	0.891
Total: Mean ± SD	6.01±1.90	11.26±3.56	-2.204-	0.041

DISCUSSION

Burn scars frequently cause functional as well as cosmetic issues. Furthermore, scar disfigurement can have an impact on a patient's social and emotional well-being **[12]**. For the treatment of post-burn scarring, various therapeutic modalities are available, including pressure garments, topically applied silicone, intra-lesional steroids injection, scar revision, scar excision and skin grafting, tissue repositioning, contracture release and Z plasty, tissue expansion, autologous nanofat grafting, and laser therapy **[13]**. The latter two modalities have gained much interest recently.

The fractional ablative resurfacing technique has been used successfully to treat acne scarring, photoaged skin, and it is also an effective treatment method for burn scars.

Because of its wide availability and biocompatibility, autologous fat grafting has become a widespread technique in both the reconstructive and aesthetic fields **[14]**. Tonnard et al., recognized the mechanical procedure of emulsifying and filtration of fat to obtain "nanofat" in 2013. Nanofat is thought to be a significant source of ADSCs, which can promote wound healing and tissue reconstruction by releasing growth factors **[15]**. Fat grafting has been proposed to improve the quality of scars, including those caused by radiation and thermal injury **[16]**.

In the current study we aimed to compare autologous nanofat grafting and fractional CO_2 laser in the management of post burn scars regarding aesthetic and symptomatic improvement.

In the nanofat grafting group, we found statistically significant improvement after nanofat grafting according to VSS except for pigmentation score. The improvement also was found statistically significant using POSAS for both observer and patient scale in all parameters including pigmentation.

This is compatible with the findings of Bollero et al., 2014, **[16]** who used autologous fat grafting to treat 19 patients with burn, traumatic and surgical scars. They found that scar quality was improved with restored contouring. In addition, Gu et al., 2018, **[17]** noticed a significant improvement in scar pigmentation after using nanofat for post burn and atrophic facial scars using POSAS.

Other types of scars have been studied regarding nanofat such as Lee et al., 2018, **[18]** who conducted a study to clinically demonstrate that simultaneous injections of fat and highly condensed stromal vascular fraction (SVF) in contracted and depressed scar revision surgeries can improve the surgical outcomes of scar formation. There was a significant difference in scars pliability based on VSS score.

In the same line, Jan et al., 2019 **[19]**, compared the quality of postburn facial scars before and after injection of unfiltered nanofat and found a statistically significant improvement in all items of the patient scale of the POSAS. Ishaque et al., 2020, **[20]** also supported the finding that nanofat grafting improves scar appearance and is considered an effective way to manage face and hands post burn scars as the mean POSAS score of both observer and patient scales showed significant decrease.

On the contrary, Gal et al., 2017, **[21]** concluded that mature pediatric burn scars did not get improved after a single treatment with autologous fat grafting when compared to normal saline using the VSS score. That may result from the imperfect volume of fat grafted. They used 5ml of fat for an area of $25cm^2$, so only 1ml was used for every $5cm^2$.

Brown et al., 2020 **[22]** also compared the effects of injecting fat versus saline in treatment of surgical, post burn and post traumatic scars. Fat and saline-injected areas showed no significant differences in inflammation, vascularity and epidermal thickness histologically.

In the fractional CO_2 laser group, we found statistically significant improvement after fractional CO_2 laser regarding VSS except for pigmentation score (no statistically significant improvement). By using POSAS, the fractional CO_2 laser showed post management improvement for both observer and patient scales in all parameters including pigmentation.

This is in harmony with Ozog et al., 2013 **[23]** prospective study of patients with burn scars who received three fractional carbon dioxide laser sessions, showing significant improvement regarding VSS and POSAS. Lee et al., 2013 **[24]** assessed the effects of using an ablative CO_2 fractional laser to treat surgical scars during the early post-operative period (3 weeks after surgery). They conducted an evaluator-blinded prospective study on 16 post-operative scars and concluded that fractional CO_2 laser is an effective option for surgical scars treatment during the early postoperative period.

Majid and Imran 2015, **[25]** managed 25 patients with non-hypertrophic traumatic and burn scars using four fractional CO_2 laser sessions at six weeks intervals. Their conclusion was that fractional CO_2 laser along with fractional photothermolysis give good outcomes in cases of post burn scars with minimal adverse effects.

Also, El-Hoshy et al., 2017 **[5]** who treated twenty patients with mature burn scars, by three fractional CO_2 laser sessions. Both POSAS and VSS resulted significant reduction post treatment ($p<0.001$).

In comparing both groups, we found more improvement of pliability in the nanofat grafting group than fractional CO_2 laser group by VSS as well as, more improvement of pigmentation score by POSAS observer scale. Moreover, POSAS patient scale found more improvement in the nanofat group regarding itching, color, stiffness and total scores.

Though both groups showed scar improvement, the better results obtained by nanofat grafting might be attributed not only to the presence of stem cells, but also to the availability of other cells such as preadipocytes, endothelial cells, and cells of hemopoietic lineage, as well as fibroblasts. The inflammation during pretunneling and hypoxia during suctioning trigger the SVF to secrete growth factors in a paracrine manner **[26]**.

This could explain the improvement in pigmentation as reported by Mailey et al., 2013 **[27]** who used autologous fat grafting, they owed this improvement to the presence of the SVF with its antioxidant and wound healing properties.

This was also proved by Gu et al., 2018 **[17]** who used Image J (Java-based graphic design program used to analyze images) to assess pigmentation improvement after injection of condensed (used without filtration and applied for centrifugation twice to discard the oily layer) nanofat.

Conclusion:

In conclusion, autologous nanofat grafting and fractional CO_2 laser use resulted in a significant aesthetic and symptomatic improvement of post burn scars. However, autologous nanofat injection had more significant improvement than laser regarding pliability, pigmentation, itching, color and stiffness.

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