Clinical Journal of Plastic & Reconstruction Surgery
An official Journal of Plastic Surgery Education Foundation

ORIGINAL ARTICLE

Effect of Autologous Fat Grafting on Burn Scars: An Assessment using Patient and Observer Scar Assessment (POSAS) Scale

Sudhanva Hemant Kumar, Devi Prasad Mohapatra,* Ravi Kumar Chittoria, Friji Meethale Thiruvoth, Dinesh Kumar Sivakumar, Likhitha Reddy

Keywords:
Adipose-derived stem cells, Autologous fat grafting, Burn scars, Nano-fat, POSAS scale

ABSTRACT

Context: Burns scars inversely affect the quality of life of the patients by affecting their physical, psychological, and social well-being. Autologous fat has adipose-derived stem cells with regenerative properties. Autologous fat grafting for the treatment of burns scars is a novel treatment modality that has not been studied adequately.

Aims: We have conducted this study to objectively assess the effect of autologous fat grafting on burns scars in terms of their aesthetic and functional outcomes at 6 weeks. We used the Patient and Observer Scar Assessment (POSAS) scale to record pre-procedure and post-procedure scores.

Settings and Design: Prospective non-randomized clinical study.

Methods and Material: Twenty-two (22) patients with 44 immature burn scars were treated with autologous fat by Coleman's technique and assessed by POSAS scale pre-operatively and 1,3,6 weeks, post-operatively. Statistical analysis was carried out and results were recorded.

Statistical Analysis: Data entry was done in Microsoft Excel and data analysis was done by SPSS software (version 20.0).

Results: The objective analysis by POSAS observer scale revealed a statistically significant improvement ($p < 0.001$) in vascularity, pigmentation, thickness, relief, pliability, and surface area at 6 weeks compared to its pre-operative status. The subjective analysis by POSAS patient scale revealed a statistically significant improvement ($p < 0.001$) in pain, itching, colour, stiffness, thickness, irregularity and the overall opinion of the patient and observer.

Conclusions: Autologous fat grafting was found to be a safe and effective treatment modality in the management of post-burn scars. An improvement in the aesthetic, as well as functional parameters like pain and itching, was noted.

Clinical Journal of Plastic & Reconstruction Surgery, (2023)

Department of Plastic Surgery, JIPMER, Gorimedu, Puducherry, India

***Correspondence:** *Devi Prasad Mohapatra, devimohapatra1@gmail.com*
Department of Plastic Surgery, JIPMER, Gorimedu, Puducherry, India

Support: *Intramural grant: JIPMER, Puducherry, India*
Conflicts of interest: Nil
How to cite: *Kumar SH, Mohapatra DP, Chittoria RK, Thiruvoth FM, Sivakumar DK, Reddy L. Effect of Autologous Fat Grafting on Burn Scars: An Assessment using POSAS Scale. Clinical Journal of Plastic and Reconstructive Surgery. 2023;1(1):2-12*

INTRODUCTION

Burns scars are always unsightly and tend to heal in the form of depressed, elevated, atrophic, hypo or hyper-pigmented scars. Burns wound complications like hypertrophic scar, keloid, contracture, unstable scar and functional limitations develop in 30-70% of burn patients which can further be associated with itching and/or pain.[1] Survivors are often left not only with functional impairment (drooling, corneal exposure, contractures of the neck, axilla, elbow, and perineum) but also with grotesque

appearances of burn scars and psychological consequences requiring prolonged treatment and follow-up.

The Patient and Observer Scar Assessment Scale (POSAS) was designed for a subjective evaluation with objective scoring of various types of scar and has been found to be more consistent and reliable for the assessment of burn scars than the Vancouver Scar Scale.[2] In this POSAS scale, the patient scores the scar characteristics including scar colour, pliability, thickness, relief, itching, and pain, whereas the observer scores scar vascularization, pigmentation, pliability, thickness, and relief. In this study, we have used the POSAS scale to subjectively and objectively assess our outcomes of autologous fat grafting in burn scars

MATERIALS/PATIENTS AND METHODS

A prospective non-randomized clinical study was conducted at our institute from December 2015 to July 2017. Institute ethics committee approval was obtained to conduct this study. The sample size of the study was 44 scars. Well-healed burns scars more than 21 days post burns but less than 1-year duration, patients more than 12 years of age and less than 60 years and minimum burns scar area of 3 cm x 3 cm were included in this study. Exclusion criteria included patients with lower abdominal burns, established contractures, pregnancy, and comorbid factors like Diabetes Mellitus, hypertension, hematological diseases, steroids or anticoagulant medication.

Pre-procedure scar assessment was recorded in POSAS scar scale by patient and observer. (Figure 1) Photographic records were maintained for clinical documentation. Autologous fat grafting of burn scars was performed on a day-care basis under tumescent anaesthesia by Coleman's technique (Figure 2). Fat was harvested from lower abdomen by syringe liposuction using blunt 3 mm cannulas and

Figure 1: Scar assessment **(A)** Thickness and Relief **(B)** checking pliability of scar tissue **(C)** Checking for hypo and hyper pigmentation by pressing against a glass slide to flatten the scar **(D)** & **(E)** checking vascularity of scar by pressing against a glass side. Note blanching of the scar followed by return of a pink hue when the glass slide is released

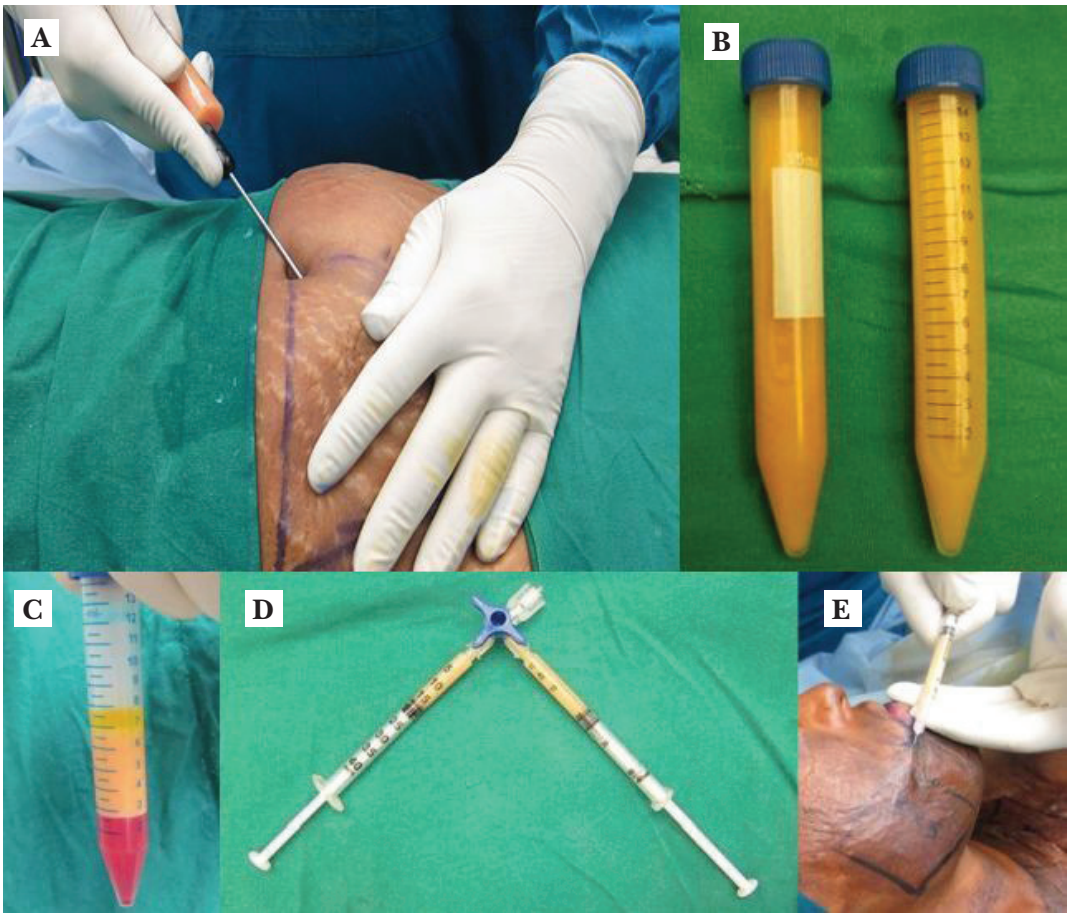

Figure 2: Preparation of fat infiltrate by coleman technique **(A)** harvest of supraumbilical fat **(B)** aspirated fat collected in tubes **(C)** centrifuged fat showing distinct layer of oil on top, fat in middle and RBC, infiltrate fluid and other debris in bottom **(D)** fat broken into nano fat by passing through a luer lock system **(E)** nano fat injected in 1-mL aliquot into subdermal plane on the scar

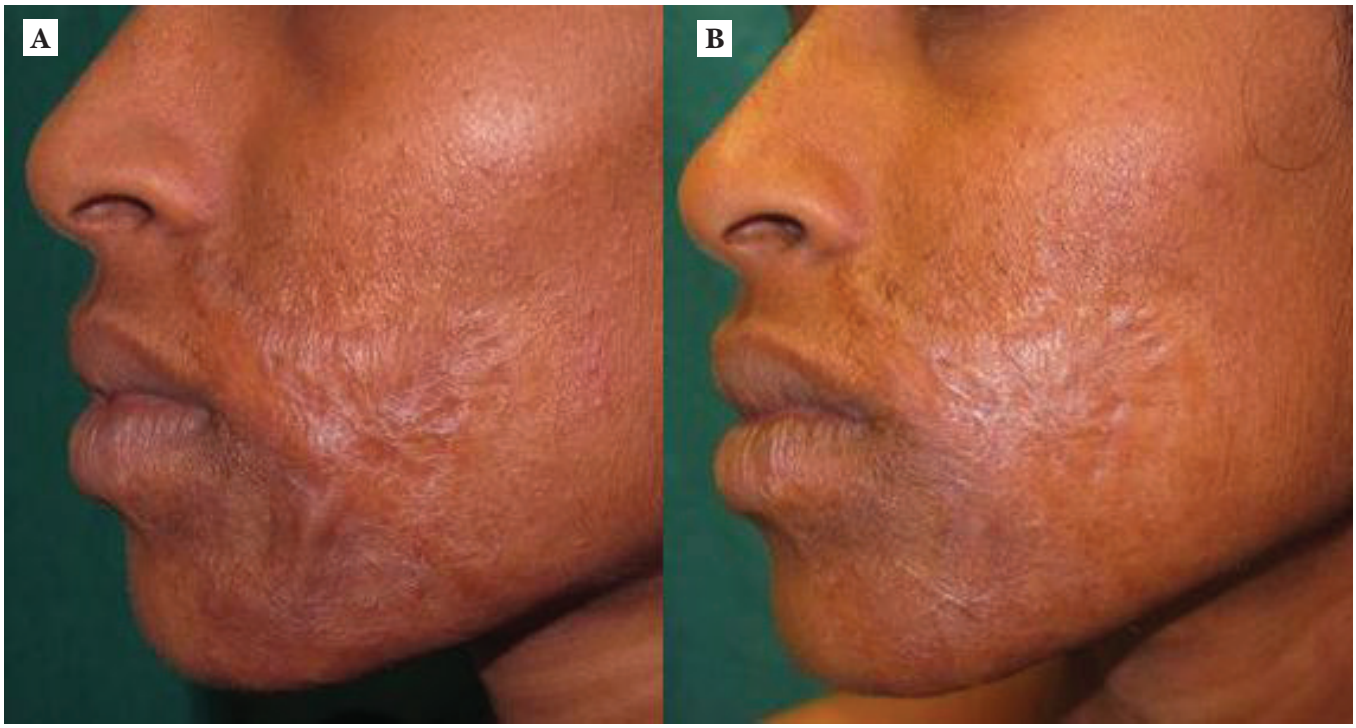

Figure 3: Improvement in scar relief and vascularity at 6 weeks following autologous nano fat injection. **(A)** Preoperative **(B)** postoperative

processed by centrifugation at 3000 rpm for 3 mins. The purified fat from the lipoaspirate was converted to nano-fat by mechanical emulsification of the micro-fat into a liquid emulsion by passing approximately 30 times through a Luer-lock connector between two 10 cc syringes till it passes smoothly indicating the formation of nano fat. The nano-fat was injected 1-1.5 mL per 3 cm^2 of burn scar area in the dermo-hypodermal junction. POSAS score was recorded post-procedure at 1, 3 and 6 weeks by the patient and the observer. Data entry was done in Microsoft Excel and data analysis was done by SPSS software (version 20.0). The distribution of categorical data was expressed as frequency and percentages. The continuous data such as scores in POSAS scale was expressed as median with range. The comparison of categorical variables mentioned above was carried out using Friedman test.

RESULTS

Twenty-two patients with 44 post burn scars were included in this study of which 19 were females and 3 were males. All patients were between the ages of 16 and 64, with mean age of 30.65 (± 11.4) years. The most common etiology was flame burns (n=16) followed by scald burns (n=6). The most common location of the burns scar in our study was found to be in the face (n=21) followed by the trunk (n=17) and upper limbs (n=6). The mean duration of the scars was 8.75 (± 2.50) months, the minimum duration being 2 months and maximum of 11 months. Only 4 scars were painful, while itching was present in 6 scars. All the painful scars were associated with itching and were noted in 4 scars in 2 patients. The mean amount of lipoaspirate collected for 44 scars was 12.7 mL with a maximum of 22 mL and a minimum of 8 mL. The mean amount of lipoaspirate injected into scars was 6.7 mL with a maximum of 12 mL and minimum of 3 mL.

Analysis of POSAS Patient Scores (Table 1)

1. **Effect of fat grafting on pain in burn scars:** Pain was present in 4 scars. An improvement in pain was noted in all 4 scars at the end of 6 weeks. The mean POSAS patient pain score changed from 6.75 pre-operatively to 3.25 post-operatively.
2. **Effect of fat grafting on itching in burn scars:** Itching was present in 6 scars. An improvement in itching was noted in all 6 scars. The mean POSAS patient itching score changed from 5.66 pre-operatively to 2.66 post-operatively.
3. **Effect of fat grafting on colour of burn scars:** The median POSAS patient colour score changed from 7 (range 10-3) pre-operatively to 5 (range 9-2) at 6 weeks.
4. **Effect of fat grafting on stiffness of burn scars:** The median POSAS patient stiffness score changed from 7 (range 9-2) pre-operatively to 6 (range 9-2) at 6 weeks.
5. **Effect of fat grafting on thickness of burn scars:** The median POSAS patient thickness score changed from 6.5 (range 9-2) pre-operatively to 5 (range 8-2) at 6 weeks.
6. **Effect of fat grafting on irregularity of burn scars:** The median POSAS patient irregularity score changed from 6.5 (range 9-2) pre-operatively to 6 (range 9-1) at 6 weeks.
7. **Effect of fat grafting on overall patient opinion of burn scars:** The median POSAS overall patient opinion score changed from 7 (range 9-3) pre-operatively to 5.5 (range 9-2) at 6 weeks.

Table 1. Preoperative and postoperative POSAS Scores

POSAS scale scores (Mean) (n=44)	Pre-operative	6 weeks post-operative	p-value
Patient scale **Pain (n=4)**	6.75	3.25	
Patient scale **Itching (n=6)**	5.66	2.66	
Patient scale **Colour**	7	5	<0.0001
Patient scale **Stiffness**	7	6	<0.0001
Patient scale **Thickness**	6.5	5	<0.0001
Patient scale **Irregularity**	6.5	6	<0.0001
Patient scale **Overall opinion**	7	5.5	<0.0001
Observer Scale **vascularity**	6	5	<0.0001
Observer Scale **Pigmentation**	6	5	<0.0001
Observer Scale **Thickness**	4.5	3	<0.0001
Observer Scale **Relief**	5	3.5	<0.0001
Observer Scale **Pliability**	6	4	<0.0001
Observer Scale **Surface Area**	9	8	<0.0001
Observer Scale **Overall Opinion**	7	5	<0.0001

Table 2: Review of literature demonstrating effect of fat grafting on burn scars

Study and year	Procedure	Sample size in scars	Average Age of Patients (Range in years)	Follow up period	Methodology			Results		
					Tissue Analysis	Clinical Analysis	Subjective Analysis	Tissue Analysis	Clinical Analysis	Subjective Analysis
Klinger *et al.* in 2008.	Two injections at dermohypodermal junction were given at 13 months intervals.	3	24.3 (16-36)	6 months	Histopathological analysis of Punch biopsy at the time of procedure and 3 months post-procedure	Not analysed	Based on patients feelings about scar based on clinical appearance in terms of skin texture, softness, thickness, and elasticity	Dermal hyperplasia, hypervascularity and neo-collagen deposition were noted in scars treated with fat grafting	Not analysed	An improvement in skin thickness, softness, texture and elasticity was noted by the patients.
Brongo *et al.* in 2012	Three injections were given at 3 months intervals	18	Not mentioned	15 months	Histopathological analysis of Punch biopsy pre-grafting and 9 months post-procedure	By the operating surgeon, patients themselves and independent observers by clinical evaluation of texture, softness, thickness, colour, and elasticity.	By the operating surgeon, patients themselves and independent observers by a questionnaire for satisfaction score	Neo-collagen deposition, dermal hyperplasia and neovascuarisation at 9 months post fat grafting suggestive of tissue regeneration.	An improvement in the thickness, softness, texture, colour and elasticity of the scar with reduction in scar retraction was noted.	The surgeon, observer and the patient noted an average satisfaction score of 7.5.
Viard *et al* in 2012	Two to three injections at dermohypodermal junction	15	38(21-55)	6 months	Not analysed	Clinical appearance by three surgeons in terms of skin texture, thickness and pliability	Based on patients feelings about scar.	Not analysed	An improvement was noted in the skin texture, thickness and pliability of the scar with improvement in facial expressions.	86% of the patients considered the result of the procedure as good and the remaining 14% felt the results were acceptable.
Klinger *et al* 2013	1-mL of fat graft for an area of 3.5 cm^2 of scar surface	20 (evaluated using POSAS)	Not mentioned	12 months	Not analysed	By POSAS Observer scale	By POSAS patient scale	Not analysed	Statistically significant improvement in the mean value in terms of vascularity, pigmentation, thickness, relief, pliability, surface area.	Significant improvement in the mean value in terms of pain, itching, colour, stiffness, thickness, irregularity

Table 2 continued.....

.....continued

Study and year	Procedure	Sample size in scars	Average Age of Patients (Range in years)	Follow up period	Methodology			Results		
					Tissue Analysis	Clinical Analysis	Subjective Analysis	Tissue Analysis	Clinical Analysis	Subjective Analysis
Bruno *et al.* in 2013	Minimum 200 cm^2 divided into two halves, for fat injection and control.	93	43 (18-92)	3 months and 6 months	Immunohistochemical staining of biopsy specimen taken pre-operatively and 3, 6 months post-operatively.	By Vancouver scar scale assessing pigmentation, vascularization, thickness, pliability and relief on the skin surface.	By a questionnaire assessing symptoms, appearance and satisfaction	Significant improvement in the general structure of burn scars was noted. There were increased amounts of elastic fibers and collagen fibers resulting in fibrillar collagen. A reduction in melanogenic activity with increased proliferative activity in the basal and spinous layers was noted.	Vancouver scar scale pre-treatment score ranged from 34-49 with a mean score of 41. 3 months post treatment it ranged from 22-35 with a mean score of 29. The 6 months scores ranged from 9-18 with a mean score of 15.	The average satisfaction scores were 31 preoperatively, 64 at 3 months and 95 at 6 months. It ranged from minimum score of 28 suggesting maximum dissatisfaction to maximum score of 112 suggesting maximum satisfaction. The maximum clinical improvement correlated with maximum histological improvement noted at 6 months post treatment and was also confirmed by the satisfaction scores of patient at 6 months.
Piccolo *et al* in 2015	Upto 4 injections in total at every 8 to 12 weeks intervals	87	Not mentioned	Not mentioned	Not analysed	In terms of appearance, suppleness, thickness, elasticity and pliability of scars	Not analysed	Not analysed	Visible improvement was noted in the suppleness, thickness, elasticity and pliability of the scars after one injection itself except in one patient where the scar improved with subsequent injections	Not analysed.

Table 2 continued.....

.....continued

Study and year	Procedure	Sample size in scars	Average Age of Patients (Range in years)	Follow up period	Methodology			Results		
					Tissue Analysis	Clinical Analysis	Subjective Analysis	Tissue Analysis	Clinical Analysis	Subjective Analysis
Gal *et al.* in 2016	Enrolled pediatric patients less than 21 years of age. Scars of size 10 x 5 cm were divided into two halves, one injected with autologous Fat and other injected with normal saline	10	13 (15-20)	6 to 12 months post-procedure	Not analysed	By the surgeon, blinded independent observer by the Vancouver Scar Scale in terms of Pigmentation, Vascularity, Pliability and Height	the blinded patient themselves in terms of "Looks" "Feels" and with the help of a questionnaire		As per the Vancouver Scar Scale, the surgeon could not appreciate any improvement in the scars. The blinded observer also could not notice any difference in pigmentation, height and vascularity of the scars compared with control arms. The differences in pliability noted was similar in both groups as well.	The blinded patients failed to notice any difference to favour the fat grafted or control group
Fredman et. in 2016	Patients were treated with fat grafting twice, 2 months apart. 1ml per cm^2 fat was injected.	7	34.42 (20-59)	1-month. 3-6 months and 6-12 months post 2^{nd} injection	Not analysed	Not analysed	Patient-Reported Outcomes Measurement Information System (PROMIS) was used for pain assessment. (Questionnaire based)	Not analysed	Not analysed	An improvement in the neuropathic pain was noted in 6 out of 7 patients with Tinel's sign disappearing post procedure in all patients. Statistically significant improvement in neuropathic pain outcomes at 1 year post fat grafting was noted.
Present Study 2017	A single injection to minimum 3 cm x 3 cm well-healed burn scars less than 1-year duration.	44	30.65 (16-64)	1,3 and 6 weeks post procedure	Not analysed	By POSAS Observer scale by single independent observer based on vascularity, pigmentation, thickness, relief, pliability, surface area.	By POSAS Patient scale based on pain, itching, colour, stiffness, thickness, irregularity& overall opinion of patient and observer	Not analysed	Objective assessment done by POSAS observer scale revealed statistically significant improvement in the mean value in terms of vascularity, pigmentation, thickness, relief, pliability, surface area.	Subjective assessment done by POSAS scale revealed significant improvement in the mean value in terms of pain, itching, colour, stiffness, thickness, irregularity & overall opinion of patient and observer

Analysis of POSAS Observer scores (Table 2)

1. **Effect of fat grafting on vascularity of burn scars:** The median POSAS observer vascularity score changed from 6 (range 9-3) pre-operatively to 5 (range 9-2) at 6 weeks.
2. **Effect of fat grafting on pigmentation of burn scars:** The median POSAS observer pigmentation score changed from 6 (range 9-3) pre-operatively to 5 (range 8-2) at 6 weeks.
3. **Effect of fat grafting on thickness of burn scars:** The median POSAS observer thickness score changed from 4.5 (range 9-2) pre-operatively to 3 (range 9-1) at 6 weeks.
4. **Effect of fat grafting on relief of burn scars:** The median POSAS observer relief score changed from 5 (range 8-2) pre-operatively to 3.5 (range 8-1) at 6 weeks.
5. **Effect of fat grafting on pliability of burn scars:** The median POSAS observer pliability score changed from 6 (range 9-2) pre-operatively to 4 (range 9-1) at 6 weeks.
6. **Effect of fat grafting on surface area of burn scars:** The median POSAS observer surface area score changed from 9 (range 10-4) pre-operatively to 8 (range 10-3) at 6 weeks.
7. **Effect of fat grafting on observer overall opinion of burn scars:** The median POSAS observer overall opinion score changed from 7 (range 9-3) pre-operatively to 5 (range 9-2) at 6 weeks.

All the POSAS patient and observer scale values were found to be statistically significant with p value of <0.0001.

The objective analysis by POSAS observer scale allowed us to assess the scars post procedure and compare them with their pre-operative values in terms of vascularity, pigmentation, thickness, relief, pliability and surface area. No improvement in the mean value of the parameters could be noted at 1-week post fat grafting. At 3 weeks post procedure, an improvement in the mean value could be noted in the pliability and thickness of scars with no improvement in the vascularity, pigmentation, relief, and surface area (Figure 3).

A statistically significant improvement compared to the pre-operative status was noted in the mean value of POSAS scores at 6 weeks for all the parameters assessed by the POSAS observer scale.

The subjective analysis by POSAS patient scale assessed the scars in terms of pain, itching, colour, stiffness, thickness, irregularity, overall opinion of the patient and the observer. No improvement in the mean value of the parameters could be noted at 1week post fat grafting. At 3 weeks post procedure an improvement in the mean value could be noted in terms of pain, itching, colour, thickness, overall patient and observer opinion of the scars with no improvement in the irregularity and stiffness. A statistically significant improvement compared to the pre-operative status was noted in the mean value of POSAS scores at 6 weeks for all the above-mentioned parameters. The improvement in the overall opinion of scars at 6 weeks according to both patient and observer scale correlated with the improvement in the individual parameters.

DISCUSSION

Burns injuries are extremely devastating injuries with a very high mortality and morbidity rate. It is one of the leading causes of trauma related deaths after vehicular accidents. Even though survival is the immediate concern post burns, early recovery without any functional deficit with restoration and rehabilitation into the society is the ultimate goal of the treatment. However, most burn injuries heal by scarring leaving behind varying degrees of aesthetic and functional abnormalities. Burns scars inversely affect the quality of life, affecting the physical, social and psychological well-being of the individual.[3,4] Physical symptoms include aesthetic problems, itching, pain, contracture and functional limitation. Psychological & social effects include stigmata due to scars leading to low self-esteem, depression & anxiety.

Fat grafting has been a part of the armamentarium of aesthetic surgeons for over a hundred years; however, recent research into the regenerative properties of adipose tissue and adipose-derived stem cells has resulted in a wide variety of applications of fat grafting. Fat grafting has been used as a novel treatment modality to treat burn scars. A decrease in surface area, wound depth of burns, and apoptotic activity may be seen in early burn wounds following fat grafting.[5] It promotes healing by the adipose-derived stem cells and the growth factors from the injected adipose tissue resulting in reduced fibrosis and inflammation.[6] An improvement in the microenvironment by neovascularisation, collagen deposition with dermal adipogenesis with a decrease in neuropathic pain is noted.[7] Accelerated wound healing with minimal hypertrophic scarring, decreased fibrosis across joints with an improvement in the aesthetic appearance in terms of skin

texture, thickness, colour, pliability, and function may be noted.[8,9] An improvement in the quality of surrounding skin as well as functional limitations like pain and itching in burns scars maybe also be noted.

Even though fat transfer was first performed as early as 1893 by Adolf Neuber,[10] it has gained popularity only in the last three decades after the advent of liposuction. Sydney Coleman popularized fat grafting by standardizing the technique of fat grafting.[11] Studies have well established that adipose tissue is rich reserve of Mesenchymal Stem Cells (MSCs) which are capable of dividing indefinitely and producing various cellular lines.[12] These ADSCs have a wide range of regenerative properties.[13] The regenerative capability of Adipose-Derived Stem Cells (ADSCs) obtained from autologous fat is being explored for a wide variety of indications by almost every medical specialty including cardiology to improve cardiovascular function in cardiovascular disease, in gastroenterology to heal chronic fistula's Crohn's disease, and in neurosurgery to repair calvarial defects.[14] In the case of scars, the cells lost in atrophied scar tissue may be physiologically replaced by fat grafts and improve their biological and mechanical properties. The role of autologous fat grafting and its effect on burn scars has not been studied adequately, moreover in the Indian population. The few studies that have been reported on the use of autologous fat grafting on burns scars have reported improvement in texture, thickness, colour, elasticity & volume replacement of burns scars.[15] A decrease in the neuropathic pain of burn scars has also been reported.[16]

We searched the English language literature for studies demonstrating the role of fat grafts in burn scars in the previous fifteen years and identified 8 such studies (Table 2).[15,17-23] All studies treated post-burn scars including hypertrophic and keloid scars with autologous fat grafting. Coleman's technique of fat grafting was followed by all the authors.

The results of our study were consistent with all the studies on fat grafting for burn scars except the study by Gal *et al*. The possible reasons for the negative result in their study as discussed by Gal *et al* are the use of 1-mL for 5 cm^2 of burns scar surface area, technical skill leading to fat graft loss, single session of fat grafting. They also suggested that needle size and the number of needle passes can also alter the result as needle trauma itself may help improve the scars. The improvement of scars in our study may be attributed to the new collagen deposition, increase in elastic fibers, neo-angiogenesis, dermal hyperplasia, reduced fibrosis and inflammation as suggested by the above-mentioned studies. The improvement in pain may be attributed to mechanical cushioning provided by fat grafting around the nerve endings and neuromas, the release of the fibrotic scar with improvement in the microenvironment and the regenerative effect of adipose-derived stem cells as suggested by Fredman *et al*.

Although the follow-up period in our study is 6 weeks, we have noted significant improvement in scar characteristics within this period. It appears that a longer follow-up might produce a more pronounced scar improvement. Only 4 patients presented with complaints of pain and only 6 patients complained of itching within the scar, hence results in improvement of pain and itching cannot be validated. Bigger sample size and randomized controlled design would help in studying the improvement in pain and itching.

CONCLUSION

Autologous fat grafting is a safe and effective procedure with minimal morbidity and a relatively small learning curve. It improves both aesthetic and functional parameters of the burn scars. An improvement in the colour, stiffness, thickness, irregularity, vascularity, pigmentation, thickness, relief, pliability, and surface area of the burn scars is noted. POSAS tool is an invaluable aid in measuring outcomes of therapy from both the patient's and observer's perspectives. Pain and itching in the scars are noted to improve with fat grafting.

Since it is a novel treatment modality, and as no guidelines regarding the use of this procedure for burns scars are available, further research should be carried out to standardize the procedure of application of autologous fat grafting for burn scars. In addition, research in molecular mechanisms of this treatment modality will aid in better understanding the process and increase its utility in aesthetic surgery.

Key Messages:

1. Autologous fat grafting in early burn scars is a novel treatment modality to improve scar outcomes.
2. Improvement in scar quality as well as improvement in subjective symptoms may be expected following autologous fat grafting in burns
3. POSAS scar assessment tool is invaluable in providing a subjective and objective measure of burn scar outcomes following therapy

Acknowledgement

We would like to acknowledge the support (in form of intramural grant) of Jawaharlal Institute of Medical Education and Research (JIPMER) towards the conduct of this study.

References

1. Gangemi, E. N., Gregori, D., Berchialla, P., Zingarelli, E., Cairo, M., Bollero, D., Ganem, J., Capocelli, R., Cuccuru, F., Cassano, P., Risso, D., & Stella, M. (2008). Epidemiology and risk factors for pathologic scarring after burn wounds. *Archives of facial plastic surgery*, *10*(2), 93–102.
2. Draaijers, L. J., Tempelman, F. R., Botman, Y. A., Tuinebreijer, W. E., Middelkoop, E., Kreis, R. W., & van Zuijlen, P. P. (2004). The patient and observer scar assessment scale: a reliable and feasible tool for scar evaluation. *Plastic and reconstructive surgery*, *113*(7), 1960–1967
3. Goel, A., & Shrivastava, P. (2010). Post-burn scars and scar contractures. Indian journal of plastic surgery : official publication of the Association of Plastic Surgeons of India, 43(Suppl), S63–S71.
4. Monstrey, S., Middelkoop, E., Vranckx, J. J., Bassetto, F., Ziegler, U. E., Meaume, S., & Téot, L. (2014). Updated scar management practical guidelines: non-invasive and invasive measures. *Journal of plastic, reconstructive & aesthetic surgery : JPRAS*, *67*(8), 1017–1025.
5. Loder, S., Peterson, J. R., Agarwal, S., Eboda, O., Brownley, C., DeLaRosa, S., Ranganathan, K., Cederna, P., Wang, S. C., & Levi, B. (2015). Wound healing after thermal injury is improved by fat and adipose-derived stem cell isografts. *Journal of burn care & research : official publication of the American Burn Association*, *36*(1), 70–76.
6. Sultan, S. M., Stern, C. S., Allen, R. J., Jr, Thanik, V. D., Chang, C. C., Nguyen, P. D., Canizares, O., Szpalski, C., Saadeh, P. B., Warren, S. M., Coleman, S. R., & Hazen, A. (2011). Human fat grafting alleviates radiation skin damage in a murine model. *Plastic and reconstructive surgery*, *128*(2), 363–372.
7. Marino, G., Moraci, M., Armenia, E., Orabona, C., Sergio, R., De Sena, G., Capuozzo, V., Barbarisi, M., Rosso, F., Giordano, G., Iovino, F., & Barbarisi, A. (2013). Therapy with autologous adipose-derived regenerative cells for the care of chronic ulcer of lower limbs in patients with peripheral arterial disease. *The Journal of surgical research*, *185*(1), 36–44.
8. Piccolo, N. S., Piccolo, M. S., & Piccolo, M. T. (2015). Fat grafting for treatment of burns, burn scars, and other difficult wounds. *Clinics in plastic surgery*, *42*(2), 263–283.
9. Condé-Green, A., Marano, A. A., Lee, E. S., Reisler, T., Price, L. A., Milner, S. M., & Granick, M. S. (2016). Fat Grafting and Adipose-Derived Regenerative Cells in Burn Wound Healing and Scarring: A Systematic Review of the Literature. *Plastic and reconstructive surgery*, *137*(1), 302–312.
10. Mazzola, R. F., Cantarella, G., Torretta, S., Sbarbati, A., Lazzari, L., & Pignataro, L. (2011). Autologous fat injection to face and neck: from soft tissue augmentation to regenerative medicine. *Acta otorhinolaryngologica Italica : organo ufficiale della Societa italiana di otorinolaringologia e chirurgia cervico-facciale*, *31*(2), 59–69.
11. Strong, A. L., Cederna, P. S., Rubin, J. P., Coleman, S. R., & Levi, B. (2015). The Current State of Fat Grafting: A Review of Harvesting, Processing, and Injection Techniques. *Plastic and reconstructive surgery*, *136*(4), 897–912.
12. Zuk, P. A., Zhu, M., Ashjian, P., De Ugarte, D. A., Huang, J. I., Mizuno, H., Alfonso, Z. C., Fraser, J. K., Benhaim, P., & Hedrick, M. H. (2002). Human adipose tissue is a source of multipotent stem cells. *Molecular biology of the cell*, *13*(12), 4279–4295.
13. Koźlik, M., & Wójcicki, P. (2014). The use of stem cells in plastic and reconstructive surgery. *Advances in clinical and experimental medicine : official organ Wroclaw Medical University*, *23*(6), 1011–1017.
14. Tobita, M., Orbay, H., & Mizuno, H. (2011). Adipose-derived stem cells: current findings and future perspectives. *Discovery medicine*, *11*(57), 160–170.
15. Brongo, S., Nicoletti, G. F., La Padula, S., Mele, C. M., & D'Andrea, F. (2012). Use of lipofilling for the treatment of severe burn outcomes. *Plastic and reconstructive surgery*, *130*(2), 374e–376e.
16. Huang, S. H., Wu, S. H., Lee, S. S., Chang, K. P., Chai, C. Y., Yeh, J. L., Lin, S. D., Kwan, A. L., David Wang, H. M., & Lai, C. S. (2015). Fat Grafting in Burn Scar Alleviates Neuropathic Pain via Anti-Inflammation Effect in Scar and Spinal Cord. *PloS one*, *10*(9), e0137563.
17. Klinger, M., Marazzi, M., Vigo, D., & Torre, M. (2008). Fat injection for cases of severe burn outcomes: a new perspective of scar remodeling and reduction. *Aesthetic plastic surgery*, 32(3), 465–469.
18. Viard, R., Bouguila, J., Voulliaume, D., Comparin, J. P., Dionyssopoulos, A., & Foyatier, J. L. (2012). La lipostructure dans les séquelles de brûlures faciales [Fat grafting in facial burns sequelae]. *Annales de chirurgie plastique et esthetique*, *57*(3), 217–229.
19. Bruno, A., Delli Santi, G., Fasciani, L., Cempanari, M., Palombo, M., & Palombo, P. (2013). Burn scar lipofilling: immunohistochemical and clinical outcomes. *The Journal of craniofacial surgery*, *24*(5), 1806–1814.
20. Gal, S., Ramirez, J. I., & Maguina, P. (2017). Autologous fat grafting does not improve burn scar appearance: A prospective, randomized, double-blinded, placebo-controlled, pilot study. *Burns : journal of the International Society for Burn Injuries*, *43*(3), 486–489.
21. Fredman, R., Edkins, R. E., & Hultman, C. S. (2016). Fat Grafting for Neuropathic Pain After Severe Burns. *Annals of plastic surgery*, *76 Suppl 4*, S298–S303.
22. van de Kar, A. L., Corion, L. U., Smeulders, M. J., Draaijers, L. J., van der Horst, C. M., & van Zuijlen, P. P. (2005). Reliable and feasible evaluation of linear scars by the Patient and Observer Scar Assessment Scale. *Plastic and reconstructive surgery*, *116*(2), 514–522.
23. Klinger, M., Caviggioli, F., Klinger, F. M., Giannasi, S., Bandi, V., Banzatti, B., Forcellini, D., Maione, L., Catania, B., & Vinci, V. (2013). Autologous fat graft in scar treatment. *The Journal of craniofacial surgery*, *24*(5), 1610–1615.

Contribution Details:

	SHK	DPM,*	RKC	FMT	DKS	LR
Concepts	✓	✓	✓	✓		
Design	✓	✓	✓	✓		
Definition of intellectual content	✓	✓	✓	✓		
Literature search	✓	✓			✓	✓
Clinical studies	✓	✓			✓	
Experimental studies	✓	✓				
Data acquisition	✓	✓			✓	✓
Data analysis	✓	✓	✓	✓		
Statistical analysis	✓				✓	✓
Manuscript preparation	✓	✓	✓	✓		
Manuscript editing	✓	✓	✓			
Manuscript review	✓	✓	✓	✓	✓	✓
Guarantor		✓				