



## Reconstruction of Post-burn Hand Contractures with Trapeze Flap and Evaluation of the SDF1 Gene Expression

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### ARTICLE INFO

#### Original paper

#### Article history:

Received: January 11, 2022

Accepted: April 03, 2022

Published: April 30, 2022

#### Keywords:

Flexion contracture, Flap necrosis, Trapeze flap, Scar, SDF1 Gene

### ABSTRACT

Finger scar flexion contractures are a leading cause of hand disability and a serious complication of hand burns. There are numerous reconstructive procedures available nowadays. Nevertheless, a large number of them produce disappointing results. The goal is to assess the Trapeze flap's ability to repair post-burn finger flexion contractures. Also, the stromal cell-derived factor 1 (SDF1) gene expression was examined for further evaluation. From April 2014 to February 2020, a prospective investigation was undertaken at Rizgary teaching and CMC private hospitals in Erbil (in Iraq) to consider the effect of Trapeze flaps on the correction of postburn flexion contracture of fingers and first web space in 67 patients (112 fingers). The viability of flaps, complications, skin graft take, and also surgeon/patient satisfaction were all recorded. Follow-up outcomes were collected from 6 months to a year after the operation. Further, the qPCR technique was used to evaluate the expression of the SDF1 gene in two groups of patients. The first group included those 67 patients treated with the trapeze flap method. The other group consisted of 50 patients with post-burn hands who were not treated by this method. Our survey found that approximately 97 percent of patients were satisfied (65 out of 67). A rare consequence included partial flap loss (one patient, 1.5 percent), and infection was detected in one case (1.5 percent). Both wounds healed with conservative treatment. The postoperative scars were practically imperceptible, without hypertrophic scars or keloid construction, and the surface texture of the flaps was similar to the texture of healthy fingers. The contractures did not occur again. Also, the expression of the SDF1 gene showed that the trapeze flap method caused a statistically increased expression. This gene stimulates collagen production during the repair of injuries. Generally, the trapeze flap is a dependable and successful local flap in recreating hand post-burn contracture, resulting in extreme patient satisfaction and achievement.

DOI: <http://dx.doi.org/10.14715/cmb/2022.68.4.20>

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### Introduction

The hand is one of the top 3 most prevalent burn scar contracture deformity sites. The functionality of the hands is a crucial predictor of the quality of life in burn survivors (1). Mc Cauley (2000) categorizes the burn scar contractures into four classes (2). Grade I is characterized by symptomatic tightness without limits in motion range, as well as normal architecture. Further, Grade II is characterized by a moderate loss in the range of motion with no substantial influence on everyday activities and minimal deformation of normal architecture. In normal hand architecture, Grade III functional deficiency is detected, with early abnormalities. Grade IV is defined as a hand function loss with severe hand architecture distortion. Flexion and extension contractures and their combinations are the subset classifications for Grade III and Grade IV contractures (2). The general aim of burn

reconstruction is to enhance the person's function and aesthetics after the burn damage. The surgeon must be precise in assessing the condition, including which tissues are inadequate and available for reconstruction (3).

Hand contractures are a common complication in hand burn, resulting in its disability and being challenging for plastic surgeons (4). The goal of surgical treatment is to eliminate the contracture completely by lengthening a finger flexion surface and resurfacing the skin, along with restoring hand function with no contracture reappearance. To complete such duties, different reconstructive procedures such as split-thickness skin transplant, Z-plasty with its modifications, full-thickness skin graft, and also combination z-plasty with V-Y flap were tried. Nevertheless, the findings were disappointing in the majority of instances (5).

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Cellular and Molecular Biology, 2022, 68(4): 170-177

In an attempt to improve the result, we used trapeze-flap for the reconstruction of post-burn hand contracture. For further evaluation, we also examined the expression of the stromal cell-derived factor 1(SDF1) gene, which stimulates collagen production during the repair of hypertrophic scars (6-8).

## Materials and methods

### Design and sample collection

Trapeze flaps were employed to repair postburn flexion contracture of fingers and first web space in 67 patients at Rizgary Teaching and CMC Private Hospitals in Erbil between April 2014 and February 2020. (112 fingers). The average age was  $13.6 \pm 8.7$  SD years, with a range of 4 to 32. The male-female ratio was 2:3. A brief history was taken, which included the case's demographics, burn period and mechanism, hand dominance, the sort of post-burn contractures, bilateral or unilateral, fingers involved, the severity of the contractures, and their impacts on hand function limitation, and any related hand deformities. Moreover, the clinical examination includes post-burn contracture types, side and entangled fingers, and post-burn flexion contracture severity defined as mild once incomplete IPJ extension is 30 degrees, moderate once IJP extension is 31-60 degrees, and severe once incomplete IPJ extension is greater than 60 degrees. The results and potential consequences were addressed with patients or parents (in pediatric instances), and they have signed the Informed permission form. Pre-op photographs have been taken.

### Exclusion criteria

Exclusion criteria included burns that were below six months old, finger flexion contracture linked to significant syndactyly or hand extension contracture, a destroyed IPJ, and a patient who was unsuited for general anesthesia. Due to a major lack of adequate follow-up, five patients were eliminated from the research; hence, just the remaining 48 cases (103 fingers) were included in the research.

### Ethical consideration

The Medical Ethics Committee of Hawler Medical University's College of Medicine validated the research proposal. Informed consent was gained from

parents (for cases under the age of 18) and patients above the age of 18.

### The procedure of trapeze flap on post-burn hand

Finger flexion contracture is due to a scar fold on the finger flexion surface (Fig.1). The fold is shaped like a crescent. The major purpose of the planning is to make trapeze-shaped flaps from the fold crest to the joint axis on the crescent fold sheets. The first line is drawn along the fold's top. Many radial lines were then drawn along the fold's entire length, from the fold crest to the joint axis level. The incisions' endpoints should be fishtailed (Fig. 2). The distance of the radial lines is approximately 1 cm when evaluated at the fold crest. Because the fold was crescent in shape, the trapeze-shaped figure was generated. The fold was therefore changed into one or more pairs of trapezoid flaps. Moreover, the sheets are divided at the fold crest and then cross-cut with radial incisions according to the marked lines. From the fold crest to the joint axis, all the flaps are mobilized. A fat layer was included in the flaps (Fig. 3). The neurovascular bundles remain. The tendon sheet is invisible. The initial pairs of trapezoid flaps are mobilized in the fold's center, generally counter to the PIP joint. Along the fold, similar flaps are deployed. The constricted finger flexion surface is carried from the scar to the joint axis owing to flap mobilization. Based on the length of the fold, one or more pairs of flaps are mobilized (Fig. 4). The longer the fold, the more flap pairs can be generated.

Sutures were used to secure the mobilized flaps and pull them apart to the sides. The finger was slowly stretched with moderate pressure and fastened in the extended spot using K-wire. With light stress, the opposingly placed mobilized flaps were swapped one towards the other. The end of one flap frequently touches the opposite flap base. The oppositely transferred flaps covered the PIP joint flexion zone first, followed by the other flaps, counter transferred, and completely or partially covered the wound area. Any remaining raw skin was covered with a full-thickness skin graft (Fig. 5). The same principle applies to the first web space contracture fold, with a crescent shape; the fold sheets are detached by an incision along the fold's top. By making radial incisions along the fold sheets' length, they are turned

into flaps. Since the fold is crescent-shaped, the flaps might also be trapezoid-shaped (Fig. 6).

After the implicated fingers have been corrected, a circular dressing in two layers is placed on the fingers, the inner layer being paraffin impregnated gauze and the outside layer being betadine impregnated gauze wrapped around the reconstructed fingers with light compression. Dry gauze was put to the web gaps before wrapping the entire hand up to the mid-forearm in soft cotton and topped with complete POP utilizing fiberglass. The tips of the fingers were left exposed to act as a sign of healthy blood circulation. In the case of the first web space contracture repair, the dressing was applied to the first web space with maximum abduction of the thumb.

One week from the operation date, the first dressing change was performed. Two weeks, one month, three months, six months, and one year following the initial dressing change, the patients were assessed. Data including skin graft take, flap viability, and any problems including wound breakdown, flap necrosis (incomplete/complete), hypertrophic scar, skin graft loss, keloid, and contracture recurrence were documented. Patient /Surgeon satisfaction was also documented.

### Gene expression evaluations

After the first dressing change, a blood sample of 5 ml was obtained from the 67 patients for 2 weeks, 1 month, 3 months, 6 months, and 1 year. Further, samples of blood were obtained from 50 other patients who underwent surgery other than trapeze flap at the same time. A specific primer pair was designed for each gene to amplify the SDF1 gene and GAPDH gene (reference gene) sequences. Primers were designed using Gene Runner 5 and Primer Express 3.0.1 software. To prevent genomic DNA replication, primers were designed to amplify exon junctions. Table 1 presents the sequences of considered primers.

**Table1.** Primer sequences of SDF1 gene and GAPDH for real-time PCR technique; F: forward and R: reverse.

Gene		Sequence	Length
SDF1	F	5'-CTCCTCTTTGTCATCATCACGCTTCC-3'	72bp
	R	5'-GGATGAGGACACGCTGTAGAG-3'	
GAPDH	F	5'-ATGGAGGAAGGCTGGGGCT-3'	124bp
	R	5'-ATCTTGAGGCTGTCATACTTCTC-3'	

In order to extract RNA, the first 100µl of entire blood was put in a 1.5 ml microtube. cDNA synthesis and RNA extraction were carried out using RNAX-Plus and Vivantis Kit protocols. The amplification of SDF1 and GAPDH was performed using the qPCR reaction with a 20µl final volume. This 20µl comprised 1µl of cDNA, 9µl of MasterMix (Applied Biosystems, USA), 100ng Power SYBER Green PCR Master, 2µl of each pair of primers, and 6 µl of nuclease-free water. Temperature protocol was as initial denaturation for 3 mins at 95°C, 45 cycles as a denaturation for 5 s at 95°C, annealing for 30 s at 60°C. The expression of relative genes was determined by using the  $2^{-\Delta\Delta CT}$  method. Reproduction and melting curve analysis was performed based on the Applied Biosystems 7500 device. Then, a gene expression diagram was drawn using Prim5 GraphPad software.

### Statistical analysis

The SPSS V. 19 statistical software for social science was used to examine the data. To compare proportions, the Chi-square test of relations was utilized. Once the predicted sum of above 20% of the cells in the table was below 5, the test of Fisher exact was utilized. A P-value of 0.05 or below was judged significant statistically.

### Results

The severity of post-burn contractures and their distribution in fingers and first web space is shown in Table 2. Trapeze flap has been used for repairing post-burn contractures in 135 fingers and 7 first web spaces in 67 patients as shown in Table 2.

The p-values with Fisher exact test are below 0.05 in all patients with severe flexion contractures (21 patients), indicating that the trapeze flap combined with skin graft is statistically extremely significant (Table 3)

The Trapeze flap achieved a high patient satisfaction rating (97%) for categories of flexion contracture severity, with a p-value of 0.77, as statistically insignificant (Table 4).

The Trapeze flap, either alone or in conjunction with a Full-thickness skin graft, resulted in high patient satisfaction (65 cases, 96%). The test of Fisher exact has a p-value of 0.20, as statistically insignificant (Table 5).

**Table 2.** The severity of post-burn contractures and their distribution in fingers and first web space

Severity of PBC	Number of the fingers – first web space affected					
	One finger	Two fingers	Three Fingers	Four fingers	1 <sup>st</sup> web space	Total No of patients
Mild	2 (22.2%)	1 (11.1%)	4 (44.4%)	2 (22.2%)	0	9 (100%)
Moderate	10 (27%)	12 (32.4%)	6 (16.2%)	4 (10.8%)	5 (13.5%)	37 (100%)
Severe	4 (19%)	8 (38.1%)	5 (23.8%)	2 (9.5%)	2 (9.5%)	21 (100%)
Total	16 (23.9%)	21 (31.3%)	15 (22.4%)	8 (11.9%)	7 (10.4%)	67 (100%)

**Table 3.** The type of used repair vs. severity of contractures

Severity of contracture	Repair type			P-Value
	Trapeze flap alone	Combined Trapeze flap and skin graft	Total No of patients	
Mild	9 [ 100% ]	0	9	0.00
Moderate	25 [ 67.6% ]	12 [ 32.4% ]	37	
Severe	0	21 [ 100% ]	21	
Total	34 (50.7%)	33 (49.3%)	67	

**Table 4.** Patient satisfaction based on the PBC severity

Severity of PBC	Patient Satisfaction				P-Value
	Highly Satisfied	Satisfied	Unsatisfied	Total	
Mild	8 [ 88.9% ]	1 [ 11.1% ]	0	9 [ 100% ]	0.77
Moderate	28 [ 75.7% ]	8 [ 21.6% ]	1 [ 2.7% ]	37 [ 100% ]	
Severe	14 [ 66.7% ]	6 [ 28.6% ]	1 [ 4.8% ]	21 [ 100% ]	
Total	50 [ 74.6% ]	15 [ 22.4% ]	2 [ 3% ]	67 [ 100% ]	

**Table 5.** Patient satisfaction based on the repair type

Type of Repair	Patient Satisfaction				P-Value
	Highly Satisfied	Satisfied	Unsatisfied	Total	
Trapeze flap alone	30 [ 88.2% ]	4 [11.8%]	0	34 [ 100% ]	0.20
Combined Trapeze flap and skin graft	20 [ 60.6% ]	11 [ 33.3% ]	2 [ 6.1% ]	33 [ 100% ]	
Total	50 [74.6 % ]	15 [22.4%]	2 [ 3% ]	67 [ 100% ]	

With Fisher's exact test, the p-value is 0.20, as statistically insignificant.

**Table 6.** The complications of Trapeze flap

Complications	Frequency	Percent
No complication	65	97
Infection	1	1.5
Partial flap necrosis	1	1.5
Total	67	100

There was one incidence of wound infection and one partial flap necrosis; hence, the complication rate was relatively low (Table 6). There was no hypertrophic scarring and contracture recurrence. In this study, to investigate the specificity of primers and Syber Green Fluorescence dye and to ensure the amplification of specific fragments and the absence of

non-specific pieces, a melting curve diagram was drawn for SDF1 and GAPDH genes. It was used to confirm the correct binding of primers to the SDF1, and the PCR product is precisely for the gene (Figure 1). The results showed that the gene was correctly expressed.

The molecular assessment showed the SDF1 gene expression to increase over time in both groups (groups with or without trapeze flap)(Fig. 2). But the amount varies between the two groups. Two weeks after the first dressing change, the expression level in both groups was almost the same, and no statistically significant difference was detected ( $P < 0.05$ ). As compared to the first two weeks, the expression rate increased in the first month in the groups, and no statistically significant difference was detected ( $p < 0.05$ ). But from the first trimester, although the amount of expression was increasing in both groups,

this rise between the groups was significant statistically and higher in the first group (with trapeze flap) ( $P = 0.033$ ). In the next six months, an increase was seen in both groups, and this increase was also significant ( $P = 0.009$ ). One year after the first dressing change, the expression level decreased in the first group (with trapeze flap) but increased in the second group (with trapeze flap). However, the amount of expression was significantly different among the groups ( $P = 0.049$ ).

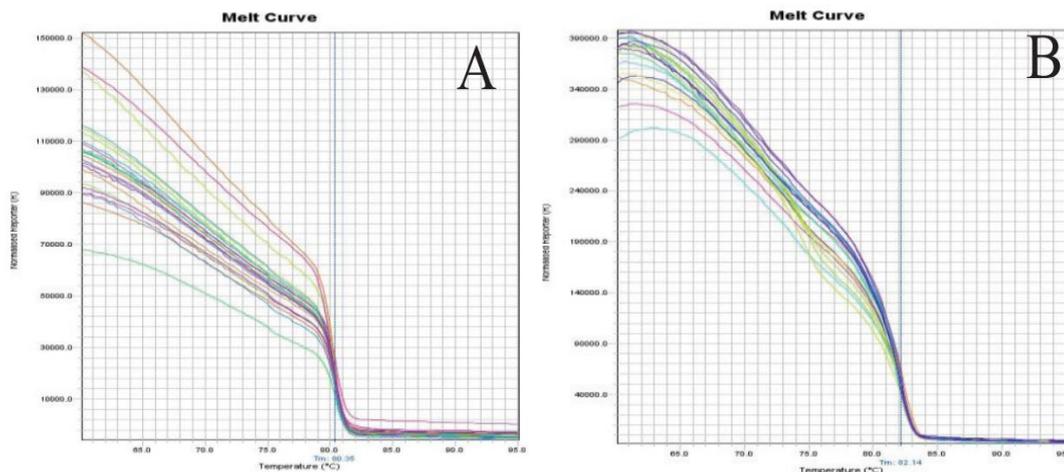


Figure 1. Melting diagram of SDF1 and GAPDH genes; A: GAPDH melting curve; B: Melting curve of SDF 1 gene

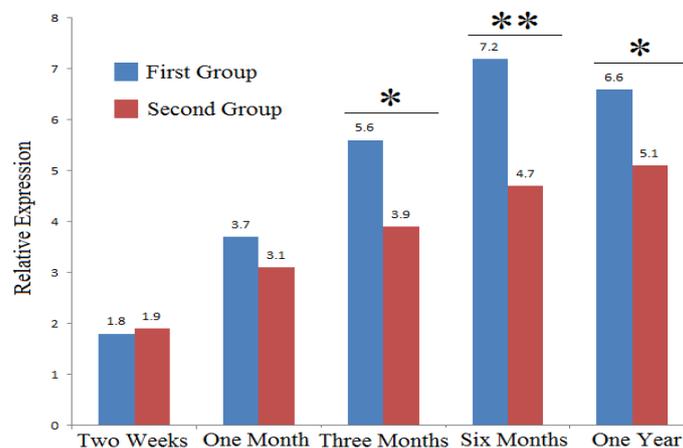


Figure 2. The relative expression of the SDF1 gene in two groups (groups with or without trapeze flap) overtime after the first dressing change; First group: patients with trapeze flap, second group: patients without trapeze flap

### Discussion

Various methods are now employed to repair postburn hand contractures, with varying results; thus, the hunt for a superior treatment continues. Despite the technique's limited capabilities, Z-plasty is a

commonly utilized operation (9, 10). The method's disadvantage is that the flaps are small in size, have acute tip angles, and rotate. Because of such characteristics, the flaps frequently necrose, and the contracture could reappear. Referring to Alexander et al. (11), Z-plasty could only eliminate a contracture in

10 percent of instances. Due to the restricted V–Y-plasty development and its modification (12, 13), a mixture of V–Y plasty with skin grafting (14) and Z-plasty (15) is suggested. The subdermal pedicle rhomboid flap simply is a V–Y and Y–V operation combined. The lengthening is accomplished by changing the shape of a rhomboid-shaped flap. Because the rhomboid flap is small and the lengthening is insufficient, a combined Z-plasty is suggested. (16).

Numerous papers exist about postburn finger flexion contracture restoration using skin transplantation (17-19). Scars are cross-cut or excised at the proximal interphalangeal (PIP) joint zone or in many locations, and the wound is covered with a skin graft. Full-thickness skin grafts produce greater results than split-thickness skin grafts (20). Following skin grafting, the contracture frequently recurred, according to follow-up assessments (21). We could indeed draw the conclusion from a careful review of the literature that the methods as mentioned above are not the best for repairing finger post-burn contracture since they do not consider the complete use of the crescent shape scar fold as the major contracture cause, and have several limits, such as acute flap tips with a high risk of flap necrosis, small flap size, and a high risk of recurrence.

As a result of a crescent-shaped scar fold positioned along the finger flexion surface, hand contractures develop. In the Trapeze flap, fold sheets are both entirely turned into flaps up to the joint rotation axis, releasing finger flexion surface tension up to the IP joint rotation level, resulting in complete contracture removal. The lengthening obtained was equal to the sum of the flaps' middle width distances minus the length of the fold's crest turned into flaps. Surface lengthening was occurring at a rate of nearly 150 percent (4). The flaps are large, encompass fatty tissue, lack acute angles, have a lower risk of flap necrosis, are mobile, rotate minimally, have stable blood circulation, and continue growing in children. The tendon sheets are unexposed, and the neurovascular bundles remain in place. The same is true for initial web space contracture since both fold sheets are entirely changed into trapeze flaps, resulting in total contracture eradication (Fig. 6). The trapeze flap can be used to treat all levels of finger flexion contracture (Table 2). Trapeze flap is alone

sufficient to cover the raw parts generated by contracture release in mild and moderate finger flexion contractures (34 cases, 50.7%). In contrast, the Trapeze flap combined with a full-thickness skin graft (Fig. 9) considered the raw parts in severe contractures and some moderate contractures (33 cases, 49.3%; Table 3). Our analysis revealed a very high patient satisfaction percentage of almost 97 percent (65 patients out of 67). This is consistent with the findings of V.M. Grishkevich, who reported a 98 percent patient satisfaction rate. An unusual complication was partial flap loss (in one case), as did infection in one case. Wounds healed both with conservative treatment. Postoperative scars were practically imperceptible, without hypertrophic scar or keloid creation, and the surface texture of the flaps was similar to that of unaffected fingers (Fig. 10). The contracture did not occur again. We could indeed draw the conclusion that Trapeze flap, alone or combined with a full-thickness skin graft, is the best technique for hand post-burn contracture reconstruction due to the advantages discussed above, it has very high patient satisfaction and success in the management of post-burn hand contracture and applicability to all grades of the contractures with low complication.

Also, the results of expression of the SDF1 gene showed that the trapeze flap method caused a statistically increased in gene expression. SDF1 (stromal cell-derived factor 1) is a chemokine protein with a gene on the long arm of chromosome 10 in humans (22). This protein is present in almost all tissues and cells of the body and has two types of alpha and beta, both of which activate white blood cells in times of need (23). This protein production is also stimulated by some pro-inflammatory factors, including the interleukin-1 family, tumor necrosis factor, and lipopolysaccharide (24, 25). This protein is produced during hypertrophic scarring, a complication of burn injury (26). This scar usually develops four weeks after the skin injury and gradually recedes within 12 to 18 months. Several non-invasive methods are available to prevent and treat hypertrophic scars, including silicone gel, topical vitamin E, topical retinoids, etc. Invasive treatments for hypertrophic scars include corticosteroid injections, surgical resection, cryotherapy, and laser therapy (27). The results showed that the trapeze flap method increased

the expression of the SDF1 gene to increase collagen production in patients' hands, which has helped treat this scar.

### Conclusions

Trapeze flap is an effective and reliable local flap for repairing hand post-burn contracture with high patient satisfaction and achievement. It is acceptable to all grades of contractures with low complication, being substituted by other reconstruction techniques in my practice.

### Acknowledgments

Not applicable.

### Interest conflict

The authors declare that they have no conflict of interest.

### Author's contribution

All authors responsible for the manuscript equally.

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