

## Reconstruction of the Post Burn First Web Space Contractures of Hand with Square Flap: Efficacy of the technique

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### ABSTRACT

**Background:** Square flap theoretically offers 2.82 times increase in the length of contracted surface as compared to maximum of 2.23 times of Z-plasties.

**Aim:** To assess the effectiveness of this technique for the most critical first web-space contracture, this study is done to find its efficacy.

**Methods:** Case series was done in department of plastic surgery, JHL. 30 patients with first web-space contractures were included. Pre and post angle and length, and efficacy, as determined by post op angle of  $\geq 90^\circ$ , were recorded. Mean and standard deviation of numerical variables while frequency and percentages of qualitative variables were calculated. Data stratification and post stratification chi-square test was applied to check effect modifier.

**Results:** Mean age was  $17.90 \pm 9.271$  years. Male patients were 19, while female were 11. Mean duration of contracture was  $1.523 \pm 0.424$  years. Mean pre-operative length was  $2.330 \pm 0.4921$  cm, while post-operative length was  $4.470 \pm 0.8579$  cm. Mean post-operative gain was  $1.9433 \pm 0.16121$ . Pre-operative angle had a mean of  $48.20 \pm 3.576$  and post-operative  $90.90 \pm 2.917$ . Efficacy was 93.33%. Post stratification chi-square test showed  $p > 0.05$  for all variables.

**Conclusion:** Square flap is more effective than other techniques described in literature for reconstruction of first web-space contractures.

**Keywords:** Square Flap, first web-space contracture, efficacy

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### INTRODUCTION

Burn comprises a major emergency in developing countries. Even in developed countries it comprises a major disease burden, e.g., in America; around 1.25 million people are brought to emergency annually after sustaining burns, necessitating admission<sup>1</sup>. For those who sustain major burns, it is estimated that 77% develop scarring that leads to variable degree of contracture formation<sup>2</sup>. Scar contractures of upper limb are a fairly common problem encountered by a plastic surgeon<sup>3</sup>. They result in functional debilitation of the patient as upper limb is needed to perform functions in three dimensions<sup>4</sup>. The contractures also have significant impact over the patient's life with many either going jobless or changing their occupation<sup>4,5</sup>. The release of contracture signifies a challenge for a surgeon as there is soft tissue deficiency within the scarred, contracture bearing surface of the joint and flap coverage is required following adequate release when vessels, nerve, tendons or joint is exposed<sup>6</sup>. Reconstruction can be done with local, regional or free flaps<sup>7</sup>. Most of the burn injuries result from scald and flame burn, resulting in varying degree of dermal burns. When no intervention is done, they heal by scarring. In mild injuries, local skin though scarred, can be used wisely to execute local flaps. If sufficient local tissue is available, local flaps are simple to execute, easy and less traumatic method of reconstruction of the contractures as compared to other methods<sup>8</sup>. In hand surgery, loco-regional tissue provides robust tissue to reconstruct the defects. They are

recommended method of reconstruction if available, as this brings in similar tissue. Although free tissue transfer can replace like with like, but creates another defect at the donor site. Local flaps thus provide similar tissue to reconstruct the adjacent defect, providing best coverage of the released contracture and eliminates a donor site<sup>9,10</sup>. First web-space is very critical for hand function and unfortunately is readily effected by burn injury, owing to its large range of motion and lax skin. Many local, regional and distant flaps are specifically described to resurface it owing to its importance in letting thumb perform opposition<sup>10</sup>.

Classically Z-plasty and its various forms have been used to release contractures around the joints<sup>11</sup>. Depending upon the angle of triangular flaps, a Z-plasty results in elongation of the distance between two points over the scarred surface thus resulting in increased range of motion. It naturally re-orientates the contracture bands and the rearrangement breaks the scar, thus minimizing chances of recurrence. But flap necrosis, inadequate coverage necessitating addition of a graft and recurrence is inherent to their usage. The square flap, technically a 3 flap Z-plasty, serves a similar function by advancing a square flap between two triangular flaps. It thus lengthens the contracted surface and breaks the bands within the scar<sup>12</sup>. In a recent study it has been demonstrated that the square flap, although first described for cleft palate, results in a more anatomically contoured surface and a more functional joint<sup>13</sup>. As opposed to other methods which resulted in deepened but cleft like first web space, this technique resulted in a more contoured and smoothly transitioning web space across two adjacent surfaces of the index finger

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and thumb, which the authors have coined as "stereometric"<sup>13</sup>. The rearrangement allowed full coverage of the released surface without any need for the addition of full thickness skin graft as compared to the other methods currently in use. In none of the cases flap necrosis occurred, cementing the reliability of this technique. All patients achieved full release of contracture and in 78% cases greater than 90° radial abduction was achieved owing to its geometrical property of lengthening the contracture band 2.825 times as compared to 2.239 times of Z-plasties, thus resulting in increased range of motion<sup>13</sup>. Hence, the square flap combines the advantage of a local flap with an increased ability to lengthen the scar, permitting increased joint motion. This makes this method more effective than the conventional Z-plasty techniques.

Although its applications can be diverse, but the incorporation of the scarred tissue in the square advancement flap accounts for better flap survival than transposing scarred tissue in other z-plasties. As no undermining is done, the chances of necrosis are decreased. Thus reliable results can be obtained in post burn contractures even if there is scarring over one side of the fold. This not only increases the usefulness of this method, but excludes the need for regional and distant options in scars where common forms of z-plasty are not indicated. The dilemma with 1<sup>st</sup> web-space contractures is the same, and usually minor contractures are released by utilizing precious regional tissue when common forms of z-plasty are used<sup>14</sup>.

The square flap technique is not only potentially more effective in releasing 1<sup>st</sup> web space contractures but also more versatile as compared to other common Z-plasties. Despite this, a few international and no local papers have been published, demonstrating its efficacy. Thus, the rationale of our study was to determine the efficacy of square flap method in reconstructing first web space scar contracture in terms of immediate increase in angle of thumb abduction. It will establish evidence, that whether this method is as effective in releasing the contracture as it has been proposed and hence, will help in addition of a novel and more efficacious method in the armamentarium of a plastic surgeon. It will also be employed more confidently in practice, resulting in better outcome in terms of thumb motion for the patients.

The objective of the study was to assess the efficacy, in terms of immediate increase in 1<sup>st</sup> web space angle after use of square flap method to release scar contracture.

#### OPERATIONAL DEFINITIONS

**Square flap method:** a 3 flap Z-plasty, composed of a square advancement flap, combined with two triangular transposition flaps, as shown in figure 1.

**First web space scar contracture:** inability to perform abduction of thumb after healing of the burn by secondary intention. Classified clinically by Grishkevich as<sup>14</sup>

Type 1: Edge: Fold in which only one side is scarred, either the palmar or dorsal surface.

Type II: Medial: Fold, both sides of which are scarred.

Type III: Total: No fold

-Only type 1 contractures with duration of 1 year at least and length between 1-5cm were included.

**Efficacy:** Increase in 1<sup>st</sup> web space angle  $\geq 90^\circ$  after reconstruction with square flap method, as measured by

goniometer immediately after completion of surgery before dressing.

## MATERIALS AND METHODS

This descriptive case series was conducted for a period of 1 year from July 2015 to June 2016 in the Plastic Surgery Department, Jinnah Hospital Lahore. Sample size of 30 cases was calculated with 95% confidence level, 15% margin of error and taking respected percentage of efficacy, i.e. 78% in patients with first web-space contractures. Non-probability consecutive sampling technique was used. This study was permitted by the Ethical Committee.

#### Inclusion criteria:

Age: 2-60 yrs

Gender: Male or Female

First web space contracture: type I contractures.

Pre-op web-space angle: from 30° to 60°

Length of contracture band: 1-5 cm

Duration: 1 year or more

#### Exclusion criteria:

- History of poly trauma determined on history and clinical examination.
- Previous history of surgery for same problem.
- Type II and III contractures.

#### Operative technique and methodology for data

**collection:** After taking informed consent, 30 consecutive patients with type 1 first web space contracture were enrolled from Plastic Surgery Department, Jinnah Hospital, Lahore. Patient's contracture were assessed in detail and reconstruction planned. Pre-operative angle of joint was documented. Contracture release was done under tourniquet control and new angle of 1<sup>st</sup> web space immediately after inseting of flaps / completion of stitching with the help of goniometer was measured. Efficacy was recorded on the pro forma. Post operatively, operated hand was elevated to reduce edema and pain. Antibiotics and pain killers were given according to the ward policy. Patient were discharged and instructed for follow up about appropriate physiotherapy and scar care. All data was recorded on pro forma.

**Data analysis procedure:** The collected data was entered and analyzed by using SPSS version 21. Mean and standard deviation were calculated for numerical variables like age, duration, length of contracture band, pre-operative angle and post operative angle. Frequency and percentages were calculated for qualitative variables like gender and efficacy of square flap. Data was stratified for age, gender, length of contracture and duration to address the effect modifier. Post stratification chi-square test was applied to check the significance with p-value  $\leq 0.05$  considered as significant.

## RESULTS AND MAIN FINDINGS

Mean age of patients was 17.90 years with SD: 9.271. Minimum age recorded among patients was 4 years and maximum was 43 years. Majority of the patients were male i.e. 19(63.33%), and female patients were 11(36.67%). Mean duration of contracture was 1.523 years, SD: 0.424. Minimum duration was 1.1 years, while maximum was 3.1

years. 19 patients had contracture for 1 to 1.5 years, while 11 patients had contracture for more than 1.5 years. Table no 1 and 2 compares pre and post operative length and angle of the cases in this study. Square flap technique was effective in majority of cases, i.e., 28(93.33%). While in only (6.67%) cases this technique was not effective, as shown in graph number 1. Chi-square test showed no significance when data was stratified for age, gender, length of contracture and duration and effect on efficacy was checked by these variables, with table 3, 4, 5 and 6 summarising these findings of the study.

Fig. 1: Square flap technique: Angle "a" are kept at 90°, angle b at 45° and angle c at 90°

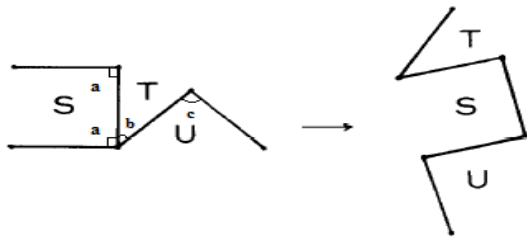


Table 1: Pre-Operative Length, Post-Operative Length and Gain In Length.

	Preop Length (cm)	Post op Length (cm)	Post operative Final Gain (post op length / pre op length )
Total cases	30	30	30
Mean	2.330	4.470	1.9433
Std. Deviation	0.4921	0.8579	0.16121
Minimum	1.4	2.7	1.60
Maximum	3.2	5.9	2.30

Table 2: Pre and Post Operative angle

	Preop Angle	Postop Angle
Total cases	30	30
Mean	48.20	90.90
Std. Deviation	3.576	2.917
Minimum	40	80
Maximum	55	95

Graph 1: Efficacy

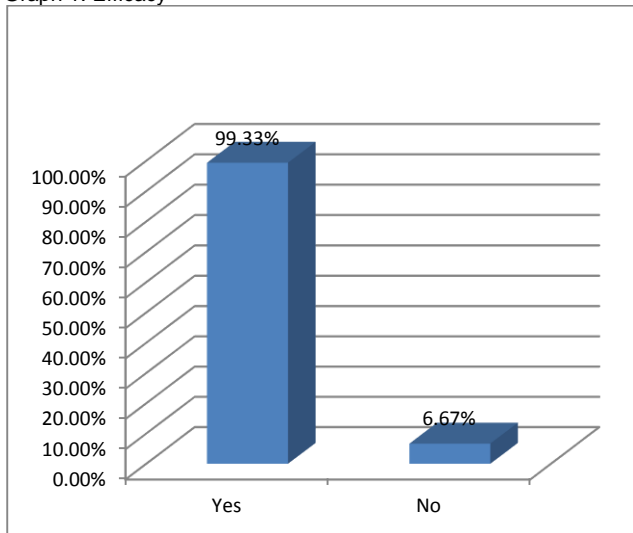


Table 3: Post Stratification Chi-Square Test according to Age

Age subjects	Efficacy		Total
	Yes	No	
< 13 years	10	0	10
	35.7%	0.0%	33.3%
14-34 years	17	2	19
	60.7%	100.0%	63.3%
35 - 43 years	1	0	1
	3.6%	0.0%	3.3%
	28	2	30

X<sup>2</sup>=1.241

P= 0.538

Table 4: Post Stratification Chi-Square Test according to Gender

Gender	Efficacy		Total
	Yes	No	
Male	18	1	19
	64.3%	50.0%	63.3%
Female	10	1	11
	35.7%	50.0%	36.7%
	28	2	30

X<sup>2</sup> = 0.164

P = 0.685

Table 5: Post Stratification Chi-Square Test according to Duration

Duration of Contracture (yrs)	Efficacy		Total
	Yes	No	
1-15 years	17	2	19
	60.7%	100.0%	63.3%
1.6-3.1 years	11	0	11
	39.3%	0.0%	36.7%
	28	2	30

X<sup>2</sup>=1.241,

P = 0.265

Table 6: Post Stratification Chi-Square Test according to Pre-Operative Length

Preop Length (cm)	Efficacy		Total
	Yes	No	
<b>&lt;2.3cm</b>			
Count	12	0	12
% within Efficacy	42.9%	0.0%	40.0%
Count	16	2	18
<b>2.4 - 3.2 cm</b>			
% within Efficacy	57.1%	100.0%	60.0%
Count	28	2	30

X<sup>2</sup> = 1.429

P = 0.232

Fig. 2: Post electric burn 1<sup>st</sup> web space contracture, scarring after fasciotomy is also visible. Design and execution of the square flap: full coverage of the released surface was achieved



## DISCUSSION

Burn injury is frequent in developing countries and results in aesthetic, social and psychological consequences. These consequences are directly proportional to the time required for healing and the longer the burn wound takes to heal, the more devastating the sequelae becomes<sup>14, 15</sup>. When treating burn patients a multidisciplinary team approach is adopted, while the contractures are usually treated at tertiary care hospitals requiring plastic surgery intervention<sup>30</sup>. Variables like age, gender, anatomical location and pathological severity determines the choice of surgical procedure<sup>15,16</sup>. Epidemiologically burn contractures are mostly seen in men and young children. In our study there most patients operated were male i.e. 19(63.33%), as compared to female 11(36.67%). This correlates with finding in another study where 56.4% patients were male and 43.6% patients were female<sup>15</sup>. The most common reason why males are more affected is stated to be occupation related burns<sup>17</sup>. As in developing countries, safety standards are seldom implemented, so burns through various mechanism effects male population. This accounts for the suffering of the the working class from chronic burn sequelae.

In our study most of the patients were young with mean age of 17.9 years, with range from 4 to 43 years. Similar population was found to be mostly affected in other studies, e.g it was found that people of age between 12-20 years were mostly affected, and of them 71.8% developed contractures eventually<sup>16,17</sup>. Thus young active population were mostly effected by burn injuries and developed contractures that needed reconstruction. Apart from burn contractures, it was also noted that this population developed other chronic complications of burn as well, e.g, hypertrophic scar, keloid scar and marjolin ulcer in long standing cases<sup>18</sup>. As this age group is potentially the working class of a society, so burn contractures are potentially devastating for this age group.

Once a contracture develops, it is usually recommended to surgically release it after conclusion of remodeling phase. It ends anywhere between 1 and 1.5 years<sup>19</sup>. At this stage all inflammatory activity as well as enzymatic activity has settled and there are least chances for a re-curent contracture. All of the patients operated in this case series had passed at least a year when they were operated. Mean time after which surgical intervention was done, was 1.5 years. But at times there is a dire need to operate on a developing contractures, i.e. profound loss of function. However in a study it was found that such cases developed recurrence of contracture at a higher rate as compared to those operated later on with local flaps<sup>20</sup>. For these cases a higher rung of reconstructive ladder was recommended, resulting in more complex procedures<sup>21</sup>.

Mean pre-operative length was 2.33 cm in this case series. As the length of the fold is smaller in children, hence the length of the contracture band was also smaller in this age group. Minimum length recorded was 1.4 cm in a pediatric patient. Mean postoperative length achieved was 4.47 cm and this again was less in pediatric patients. The number of times the length was gained, was also recorded. The mean gain in length was 1.943 and the maximum was 2.30 times that was achieved in this series. The theoretical

gain in length i.e. 2.8, was found to be more than that gained practically. Similar findings were noted in another study as the computer generated models predicted more length that was achieved per-operatively<sup>22</sup>. This less than predicted gain in length can be due to a number of reasons, e.g recoiling of tissues as flaps are separated and limitation of abduction due to basal joint of thumb itself so that flaps are inset without being fully stretched, resulting in less gain in length. The first fact was noted in contracture release of various regions, and frequently resulted in addition of skin grafts in contractures which were amiable to release and primary closure with local flaps<sup>23</sup>. Nevertheless, complete release, full coverage and satisfactory results were obtained in properly selected cases in this study. Otherwise in cases, were contractures are severe and there is moderate to severe loss of tissue at the web-space an algorithm is proposed to address the contracture<sup>24</sup>. But this too stresses that contracture release be done by incising along the marking of a local flap design and progressively skin graft be added, or if defect is large or vital structures are exposed, regional flaps or distant flaps be used for complete coverage of the defect<sup>25, 26</sup>. No classification was found in literature that directly proposed a guideline for selection of procedure according to the morphology and severity of contracture, rather treatment according to anatomical basis is described.

The pre-operative angle of abduction was measured in all cases and similarly the post-operative angle. The mean pre-operative angle was 48.2° and post-operative angle was 90.9°. For adequate hand function, thumb should be positioned in radial and palmar abduction. Hand function is mild-moderately affected when abduction decreases to 60° and moderate-severely affected when angle decreases to 30° or less<sup>27</sup>. Maximum abduction noted in normal subjects in this study was ≥ 90°. Thus most of the cases achieved full abduction, a pre-requisite for proper function, in my study.

Efficacy was assessed if final abduction angle was ≥ 90°. In this study, square flap was effective in 28 out of 30(93.33%) cases. In the case series where square flap was exclusively used for reconstruction of 1<sup>st</sup> web-space contractures, 78% cases achieved abduction ≥ 90°<sup>13</sup>. The authors included patients with mild to moderately severe contractures and found that greater angle was achieved in the cases with mild contractures, i.e. simple band rather than multiple / complex bands at the first web-space<sup>13</sup>. On their observation, they recommended the indication of this technique exclusively for simple contracture bands. In my study, as cases with simple contracture band where local flaps are exclusively indicated were selected, this resulted in good outcome as compared to their results. When comparing the efficacy to other techniques, less optimal results were obtained when exclusively patients with simple contracture bands were included. For example, when five flap z-plasty was used, 81% cases achieved excellent result, i.e. ≥ 90° abduction<sup>28</sup>. When a modification of five flap z-plasty was used, reported to have more favorable geometry, 92.8% cases achieved abduction ≥ 90°<sup>29</sup>. Similarly, when simple z-plasty was used, 64.2% cases achieved this much abduction, and multiple simple z-plasties in a single row too resulted in less better outcome as compared to square flap technique, i.e 86.3% cases

achieving  $\geq 90^\circ$ <sup>30</sup>. But some of the cases in this last study were of recurrent contractures, hence results cannot be compared definitely. No study was found that used four flap z-plasty specially for simple contracture bands at the first web-space. An angle of  $\geq 90^\circ$  is only achievable in contracture bands with complex geometry with use of regional or distant flap<sup>30</sup>. This signifies, that not only there is need for a practical classification for first web-space contractures, but a randomized control trial is needed to assess the outcome of these techniques, rather than relying on theoretical values for comparison.

Data was stratified according for age, gender, length of contracture and duration to check whether these variables affected the efficacy. Chi-square test was done, and none of these variables were found to be affecting the efficacy of the square flap technique as p values were found to be  $\geq 0.05$ , as stated in the results section

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