Research Article

Comparison of Lateral Arm Flap and Split Thickness Skin Graft for Soft Tissue Reconstruction of Elbow in Post Burn Contractures

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Abstract: Background: Elbow contracture ranks as the second most frequent post-burn contracture following the shoulder, with reported incidence rates ranging from 21% to 40%. Surgical intervention is typically necessary to address the functional restrictions caused by scarred tissue and joint contractures.

Objective: To compare outcomes of lateral forearm flap and split thickness skin graft for soft tissue reconstruction of elbow contractures in post-burn patients.

Materials and Methods: This prospective cohort study was carried out by Plastic & Reconstructive Surgery Department, Dr. Ruth K.M. Pfau Civil Hospital, Dow University of Health Sciences, Karachi, Pakistan, during 1st November, 2024 to 31st May, 2025. The study followed the Declaration of Helsinki, was approved by the Institutional Review Board (IRB -3460/DUHS/Approval/2024/272, dated 28th September, 2024), and all participants provided written informed consent. Patients were evaluated at sixth week and three months for assessing study outcome variables. Study outcomes included range of motion, post-operative complication and recurrence of contracture.

Result: A total of 50 patients were studied per group. Operative time (in minutes) was significantly higher in LAF group than STSG group (166.8 ±28.5 versus 89.4 ± 33.3, p<0.001). ROM at sixth week (30.6° ± 3.8 versus 18.4° ± 5.8) and third month (112.9° ± 22.20 versus 54.3° ± 15.6, p<0.001) was significantly higher in LAF than STSG. Complication at sixth week (0 versus 8%, p=0.117) and third month (0 versus 10%, p=0.056) was not significantly different. Recurrence rate was significantly lower in LAF group than STSG group at sixth week (0 versus 12%, p=0.027) and third month (4% versus 20%, p=0.014).

Conclusion: The present study demonstrates lateral arm flap had better outcomes than the split thickness skin grafts in terms of reconstruction of elbow contractures, showing rapid improvement in functional recovery with lesser complication and recurrence rate in pediatric population.

Keywords: Burn, Elbow contracture, Local flap, Skin graft, Soft tissue reconstruction, Reconstructive surgery.

INTRODUCTION

Burns do not only impact the skin alone, but also impairs the underlying soft tissues, muscles and bones to render individuals vulnerable to contraction of joints. Such contractures are defined by the loss of the full range of motion (ROM) in a joint [1, 2]. Finally, post-burn contractures (PBC) occur due to a two-fold mechanism, which encompasses the aspects of wound contracture, which is mainly caused by fibroblasts in the process of natural wound healing, and scar contracture [3]. Elbow contracture is classified based on the fact that it has led to the loss of extension. The extent of less than 10 degrees of extension loss is negligible and 11-49 degrees of extension loss is mild, 50-89 degrees of extension loss is moderate, and more than 90 degrees of extension loss is severe [4].

Elbow contracture is the second commonest PBC after the shoulder and has reported incidence rates of between 21-40% [5, 6]. As the burn wounds heal, patients can also develop scars that may impact aesthetics and functionality [7]. Clinical manifestations of elbow cicatricle contracture depend on the severity and this may take a form of a linear band along the antecubital fossa to extensive sheet, which is distributed to the entire anterior surface of the elbow [8].

The cases of PBC of the elbow and shoulder joints leave a lot to be desired, primarily because of the likelihood of recurrence [9]. There are several aspects of the injury that lead to post-burn contractures i.e. site, depth,etiology as well as extent of the burn. Also, the treatment-related variables that significantly influence the management process include the type and timing of wound closure, wound bed condition, and preventive measures applied [10].

The functional impairments of scar tissue and joint contractures usually require surgical correction of the limits [11]. Moreover, achieving thickness, color, and texture matching for aesthetic purposes often becomes another objective [12, 13]. Surgical intervention adheres to the principles of the "3C" elements, which include contracture release, correction of articular position, and coverage of the resulting defect. The use of local, pedicle, or free flaps, tissue expansion, skin grafting, and rearranging neighboring tissues are examples of conventional reconstructive techniques [14, 15].

The lateral arm flap (LAF) was initially described by Katsaros *et al.* as a flexible option for a range of reconstructive surgeries,

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particularly upper extremity reconstruction [16]. Defects that require a thin flap are particularly well-covered by the lateral arm flap. However, because of the uniform flap harvesting process, issues at the donor site are often reported. The most frequent consequence is sensory abnormalities in the proximal forearm and lateral upper arm, which can be either transient or permanent [17]. In contrast, split-thickness skin grafts (STSG) are considered a lower-tier option in the reconstructive hierarchy but can effectively reconstruct large skin defects. Therefore, autologous STSGs remain the primary choice for treating extensive skin defects resulting from trauma and scar contracture release [18].

When conservative treatment is unsuccessful for an elbow contracture, surgery is necessary. However, the best course of action may vary depending on whether a local flap or a graft is used [2]. While STSGs are easy to harvest and use, they may be less durable than LAFs especially over joints that can be under strain and motion [3]. LAFs on the other hand give thicker vascularized coverage that is more contoured and softer than STSGs, ideally allowing for greater function and aesthetics [5, 6]. The morbidity of a donor site and complexities of the operation should also be considered. Both surgical methods are performed regularly, yet little comparative data exists and no research specifically evaluating STSGs and LAFs for elbow contractures has been published. A direct comparison is needed to make an evidence-based surgical recommendation that allows for better long-term functional outcomes. Therefore, the present study was planned with an objective to compare outcomes of lateral forearm flap and split thickness skin graft for soft tissue reconstruction of elbow contractures in post-burn patients.

MATERIALS AND METHODS

This prospective cohort study was carried out by Plastic & Reconstructive Surgery Department, Dr. Ruth K.M. Pfau Civil Hospital, Dow University of Health Sciences, Karachi, Pakistan, during 1st November, 2024 to 31st May, 2025. The study followed the Declaration of Helsinki, was approved by the Institutional Review Board (IRB No. 3460/DUHS/Approval/2024/272, dated 28th September, 2024), and all participants provided written informed consent. Patients of age 2-12 years of either gender presenting with elbow contracture of grade II-III with their consent were included. Patients with history of polytrauma, peripheral vascular diseases and those who previously underwent lateral forearm graft or thigh graft were excluded.

A pilot study was conducted enrolling 30 patients per group who were followed till 6 weeks. At sixth week, range of motion (ROM) was 29.4 ± 3.4 in LAF group whereas it was 17.1 ± 2.7 in STSG group. At 90% power and 95% confidence interval, a sample size of <30 patients was calculated using Open-Epi calculator. Therefore, for better study results, a sample of 50 patients per group was considered. Non-probability consecutive sampling technique employed to enlist patients.

Patients planned to undergo reconstruction of elbow contractures admitted a day before surgery. Pre-operatively a detailed history was taken by assigned duty doctors. As per hospital protocol, routine laboratory investigations including blood test, coagulation profiles and kidney function were carried out to assess their medical fitness for the surgery. The reconstruction procedures were performed by all those consultant plastic surgeon in our center who had at least 5 years of relevant experience. The procedure was performed under general anesthesia. Reconstruction was carried out using either lateral forearm flap or split thickness skin graft based on surgeon's preference.

Depending on the scar type, either transverse or gentle incision was given at the elbow join at volar aspect. The graft was harvested from thigh using Humby's knife. The graft was fixed using vicryl 4/0, and a tie-over was applied to fix the graft in place, and the donor site was covered with Vaseline gauze and a pressure bandage.

While the patient was in a supine position, their lateral arm was lifted. All flap were reverse with an average flap size of 8x6 cm. The flap was harvested from the lateral aspect of the same extremity. The lateral arm flap's blood supply comes from the posterior radial collateral artery (PRCA), a branch of the radial collateral artery. The lateral intermuscular septum of the arm is traversed by the PRCA. The position of this septum can be found by drawing a line from the deltoid muscle's insertion site to the lateral epicondyle. The brachialis and brachioradialis muscles border the intermuscular septum anteriorly, whereas the triceps muscle borders it posteriorly. A line was drawn from the lateral epicondyle to the radial styloid in situations when an extended lateral arm flap (ELAF) was required. The first cut was made from the back. After that, the triceps muscle was found by cutting the skin and fascia. Next, the perforators that were penetrating the skin was identified. The intermuscular septum between the triceps and anterior muscles was then be discovered by lifting the skin and fascia anteriorly over the triceps muscle. The septum contains the posterior radial collateral artery. The superior vessel was traced and isolated, and an incision performed. When the posterior radial collateral artery reaches the deltoid region, it could be located. After that, the posterior flap was raised all the way to the triceps' muscle fascia. Little muscle perforators were found as the flap is lifted towards the septum; these could be ligated with hemoclips or coagulated using bipolar forceps. Together, the pedicle and septum wererecognized and revealed, moving from the distal to the proximal regions. Elevating the anterior flap might cause the fascia to stick to the muscle a little bit more. The flap could then be elevated from the distal to the proximal position. The artery and vein were split and ligated at the distal aspect. The flap from the humerus was released by dividing the septum as it descended deeply to these arteries. The distance between the arteries and the humerus grows as dissection moves closer to the proximal end, making the process easier. The radial nerve was eventually show proximally. The incision can be extended proximally to lengthen the pedicle and acquire broader caliber vessels. To expose the proximal pedicle and ligate any branches, the triceps and brachialis muscles were retracted. During retraction, care was taken to avoid pressure on the radial nerve. The flap was placed over the flaw once it has been lifted. The donor site was managed with STSG and bolster dressing.

The first dressing change was performed on post-operative day 2 in lateral flap group and on post-operative day 5 in STSG group. After that dressing was changed after every day. During dressing change, post-operative complications were assessed. Patients were evaluated at sixth week and three months for assessing study outcome variables. As post-operative care, patients were advised to receive physiotherapy and wear splint. Physiotherapy included range of motion and strengthening exercise, scar management techniques and night-time extension splinting.

Study outcome variables include assessment of range of motion and post-operative complications. A universal goniometer was used to measure the range of motion in the affected elbow joint using a standardized technique defined by Chalpleu and coworkers [19]. All measurements were taken by a single trained clinician to reduce inter-observer variability and were done in a similar standardized position pre-operatively and at final follow-up (sitting or supine arm in anatomical position). Active elbow flexion and extension were each measured in degrees of motion, and the ROM was calculated as the difference between maximum flexion and extension. Post-operative complications were evaluated clinically and through direct physical examination at follow-up visits. Graft loss was evaluated with direct visual inspection of the graft site. Complete loss was identified by signs of necrosis, black discoloration, or detachment of the graft from the wound bed, while partial graft loss was defined as incomplete take of the graft with regions of necrosis or non-adherence impacting less than 50 % of the grafted area. Assessment of elbow contractures recurrence was performed through measurement of elbow ROM at follow-up. A decrease in ROM of >20 degrees compared to immediate post-operative was considered recurrence. Physiotherapy compliance was defined as attending physiotherapy for at least 6 days in a week. All the measurements were taken by the same clinician, using a standard goniometer, for consistency.

Patients' demographic variables such as age and gender and their clinical profile including type of contracture (linear, medial and edge), duration since burn and contracture and operative timings were also recorded.

STATISTICAL ANALYSIS

Data was analyzed using SPSS version 27. Categorical variables were summarized through frequencies and percentages. Numerical variables were first assessed for assumption of normality using Shapiro-Wilk test. Variables were found to be normally distributed and thus were expressed as mean ± standard deviation. Categorical variables were compared among two groups using Chi-square or Fisher-exact test. Independent t-test was applied to compare numerical variables. Paired t-test was applied to compare ROM at sixth week and third month. P-values less than or equal to 0.05 was deemed as statistically significant.

RESULT

A total of 50 patients were studied in both the groups. Mean age of patients was 10 ± 2.8 years and 9.4 ± 2.4 groups respectively. Majority of patients were males in LAF group than STSG group (72% versus 28%). Two groups did not differ on the basis of age (p=0.264), gender (p=0.096), duration since injury (p=0.865), and duration of contracture (p=0.947). Frequency of linear type of contracture was significant higher in STSG group whereas frequency of total type of contracture was higher in LAF group (p<0.001). Operative time was significantly higher in LAF group than STSG group (p<0.001) (Table **1**).

Table 1. Comparison of Patients' Sociodemographic and Clinical Features among the Study Groups.

Variables	LAF	STSG	p-value
Age (in years), mean ± SD	10 ± 2.8	9.4 ± 2.4	0.264
Gender			
Male, n(%)	36(72)	28(56)	0.096
Female, n(%)	14(28)	22(44)	
Type of Contracture			
Linear, n(%)	12(24)	24(48)	*<0.001
Medial, n(%)	2(4)	10(20)	
Edge, n(%)	8(16)	8(16)	
Total, n(%)	28(56)	8(16)	
Duration since burn injury (in months), mean ± SD	17.4 ± 4.7	18.2 ± 5.3	0.865
Duration of contracture (in weeks), mean ± SD	6.5 ± 1.2	6.2 ± 1.8	0.947
Operating times (in minutes), mean ± SD	166.8 ±28.5	89.4 ± 33.3	*<0.001

*p-value was considered significant at 5% level of significance.

Mean range of motion was significantly higher in LAF group at sixweeks (p<0.001) and third month (p<0.001) as compared to STSG group. Complication incidence was not significantly different between the two groups at six weeks (p=0.117) and third month (p=0.056). There was no recurrence in LAF group at six weeks whereas recurrence rate was 12% in STSG group at six weeks (p=0.027). Recurrence rate remained significantly higher in STSG at third month than LAF group (p<0.001) (Table **2**).

Table 2. Comparison of Functional Outcomes, Complication and Recurrence at Sixth Weeks and Third Month among the Study Groups.

Variables	LAF	STSG	p-value
At Sixth Weeks			
Range of motion, mean ± SD	30.6 ± 3.8	18.4 ± 5.8	*<0.001
Complication, n(%)	0(0)	4(8)	0.117
Recurrence, n(%)	0(0)	6(12)	*0.027
At Third Months			
Range of motion, mean ± SD	112.9 ± 22.20	54.3 ± 15.6	*<0.001
Complication, n(%)	0(0)	5(10)	0.056
Recurrence, n(%)	2(4)	10(20)	*0.014

*p-value was considered significant at 5% level of significance.

Mean gain in ROM was higher in LAF group than STSG (82.3±22.6 versus 35.9±15.8, p<0.001). Table **3** shows comparison of ROM at sixth week and third month for two study groups based on recurrence status, complications and physiotherapy compliance. For both of the study groups mean gain in ROM at three months was lower for those who developed recurrence than those who did not. Similarly, mean difference for ROM was lower for those who developed complication than those who did not experience any complication. Mean difference of ROM was lower for patients who were non-compliant to physiotherapy than those who were compliant to physiotherapy.

Table 3. Comparison of ROM at Sixth Week and Third Month for Two Study Groups Based on Recurrence Status, Complications and Physiotherapy Compliance.

Variables	Frequency (%)#	Range of Motion (in degrees)			p-value
		Sixth Week	Third Month	Mean Difference	
LAF Group					
With recurrence	2(4)	32.5 ± 3.5	41 ± 1.4	8.5 ± 2.1	-
Without recurrence	10(20)	30.6 ± 3.8	116 ± 16.6	85.4 ± 11.9	*<0.001
Complication	0(0)	-	-	-	-
Without complication	50(100)	30.6 ± 3.8	112.9 ± 22.20	82.3 ± 22.6	*<0.001
Physiotherapy compliance	41(82)	30.7 ± 3.8	121.2 ± 13.5	90.5 ± 14.1	*<0.001
Physiotherapy non-compliance	9(18)	30.6 ± 3.9	75.2 ± 12.6	44.5 ± 14.5	*<0.001
STSG Group					
Recurrence	10(20)	16.9 ± 6.8	29.5 ± 5.5	12.6 ± 3.4	*<0.001
Without recurrence	40(80)	18.7 ± 5.6	60.5 ± 10.01	41.8 ± 7.4	*<0.001
Complication	5(10)	16 ± 5.4	51.0 ± 22.2	35.0 ± 18.4	*0.018
Without complication	45(90)	18.6 ± 5.9	54.7 ± 14.9	36.1 ± 15.5	*<0.001
Physiotherapy compliance	46(92)	17.4 ± 4.7	56.7 ± 13.7	38.1 ± 14.5	*<0.001
Physiotherapy non-compliance	4(8)	15.0 ± 4.1	26.3 ± 2.5	11.3 ± 6.3	*<0.001

#Frequency was computed at 3 months is given, *p-value was considered significant at 5% level of significance.

DISCUSSION

The lateral forearm flap (LAF) and split thickness skin graft (STSG) have significant differences in the level of complexity and the time required to perform. The LAF includes detailed dissections of vascular pedicles, flap elevation, inset and closure of the donor site, making it a technically more challenging operation [20]. In contrast, STSG is much simpler and requires release of the contracture site and the harvesting of graft from a donor site, usually requiring less time. This technical difference is illustrated in our study, where the mean operating time for LAF was significantly longer than STSG (166.8 ± 28.5 minutes versus 89.4 ± 33.3 minutes). We attempted to maintain the focus of the study on these inherent differences in procedural demand, given the context of post-burn elbow contracture. The indication for either intervention is often determined by the surgeon in terms of depth of defect, quality of tissue, and guarantee of coverage, meaning that STSG is often faster and easier, but LAF might be indicated to provide robust, well-vascularized soft tissue reconstruction.

Postoperative examination of range of motion (ROM) and functional recovery is an important part of assessing successful soft-tissue flap reconstruction for the post-burn elbow contractures [21]. The mean ROM for the lateral arm flap (LAF) group at the 6th week after surgery in our study was 30.6 ± 3.8 degrees, which is consistent with a similar study reporting early recovery of elbow movement following flap-based reconstruction [7]. El Kashty SM *et al.* [22] presented their experience in treating a series of 8 cases of post-burn contracture with reverse flow LAF, and reported that 6 weeks after surgery their flaps provided stable coverage with approximately a 30° extension loss. In our study, however, the mean elbow range of motion (ROM) at 6 weeks after surgery for the split thickness skin graft (STSG) group was 17.8 ± 6.0 degrees. In the literature, we were not able to find directly comparable studies reporting functional outcomes based on early (6-week) assessments after STSG for post-burn elbow contractures. However, there are studies that show flap based approaches had better ROM than patients managed with skin grafts, even at three months follow-up [23, 24].

In this study, one noteworthy observation was the marked increase in ROM from the 6th week to 3 months in both groups. However, the amount of increase was much greater in the LAF group at each follow-up time point. The evidence that LAF performed better than STSG is again a reflection of the biomechanical advantage of the flap being able to preserve joint movement, most likely due to its better elasticity, bulk, and higher shear forces. These findings are in line with previous literature supporting flap-based reconstructions of joints. Studies demonstrate without failure, that flap reconstructions have better outcomes for functional recovery, lower rates of re-contracture, and earlier mobilization than grafting methods [25, 26].

The findings demonstrate that patients who did not comply with the physiotherapy had a significantly lower gain of ROM than those who did comply. An explanation for this issue is likely the behavioral tendency in our local patient population, once people observed improvements in ROM, they tended to discontinue their physiotherapy. However, this unfavorable effect to compliance pattern limits functional recovery as these accelerated early benefits were quite possibly not sustained over the long term. The issue of non-compliance was lower in the STSG group than LAF group as ROM improvements were slow. Patients managed with STSG who received limited functional gains were most likely to have complied with the rehabilitation program as they were still struggling to gain desirable improvements. The information proves not only how the two unlike methods of reconstructive technique are biologically different, but how the aspect of perceived functional recovery (positive patient behavior), all of which eventually determine the final outcomes.

In our case, no complications were experienced in the lateral arm flap (LAF) group with 6-weeks and at 3 months follow-up, indicating that our method of conduction of reconstruction is relatively safe and reliable. It can also be supported by the literature, whereby fasciocutaneous flaps like LAF always have a lower complication rate. This probably happens because it is well-vascularized, stronger to shears and can be safely placed into early mobilization without graft-take failures and healing [23-25]. The complication rate of STSG group was 8% at 6 weeks and 10% at 3 months. This agrees with the prior literature where STSGs have been noted to have high complication rates when placed and especially when placed over the joints, with partial graft loss, slow healing, infection, or early contracture being the leading complications [24, 25]. Not having dermal support, and the consistent gear of both mobility of the joint and adherence of the graft, STSG would be more susceptible to complications in the post-operative periods around high movement locations such as the elbow. The comparison between both methods shows that LAF had a statistically lower complication profile over STSG, which again confirms that LAF enhances the surgical durability and strength of the tissue. Although there was no significant difference in the current cohort, the difference had clinical significance.

Even greater dramatic differences existed in recurrence rates. At 6 weeks, no recurrences were observed in LAF group and STSG group had 20 percent recurrence rate. The initial low recurrence (2%) was also observed among the LAF group by 3rd month whereas the STSG group had been on a constant increase up to a rate of 36%. This is a very drastic contrast and brought out a long term benefit of contracture release under LAF. The benefit of the flap design is that it provides the benefactors with the advantage of being more elastic, having a thicker structure of a coverage and accepts contracture. The STSG constructions are more prone to secondary tightening with time, particularly hard to carry out in the younger pediatric or active populations. These results were in line with the literature reviewed on long-term stability and recurrence rate in flap-based reconstruction which further justifies the use of LAF in functional results of post-burn elbow contracture reconstruction [24, 25].

LIMITATIONS

This paper has certain weaknesses which should be mentioned. The size of the sample was small that can have impact on generalizability and power of statistics of various outcomes, especially complications. It was also single-center research and may have induced institutional bias as far as surgical practice and postoperative treatment. Thirdly, we measured functional outcomes at 3 months only after operation; this time frame could not be considered sufficient to determine both the sustainability of contracture release and late recurrence. Furthermore, we did not objectively measure rehabilitation compliance using an objective measure, but we did observe that it may have shaped recovery trajectories, and specifically in the LAF group. It is important to note that patient-reported outcomes incorporating satisfaction, pain, and aesthetics were not the focus of this study; as such, we miss considerable insight into the psychosocial and cosmetic variables associated with either reconstruction. Finally, since all study participants were pediatric, direct extrapolation of the findings to adults would be inappropriate, as their tissue response and rehabilitation dynamics will differ considerably.

CONCLUSION

The present study demonstrates a lateral arm flap had better outcomes than the split thickness skin grafts in terms of reconstruction of elbow contractures, showing rapid improvement in functional recovery with lesser complication and recurrence rate in pediatric population.

AUTHORS' CONTRIBUTION

Asma Ishtiaq: Conceptualization, Study Design, Writing Draft, Final approval, final proof to be published.

Faisal Akhlaq Ali Khan and **Maryam Noor**: Study Design, Critical review and revision the manuscript.

Waqas Sami and **Hiba Khan**: Writing draft.

Kinza Imam: Methodology, Data analysis and interpretation.

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Declared none.

ETHICAL DECLARATIONS

Data Availability Statement

Data will be available from the corresponding author upon a reasonable request.

Ethical Approval

The study followed the Declaration of Helsinki, was approved by the Institutional Review Board (IRB No. 3460/DUHS/Approval/2024/272, dated 28th September, 2024), and all participants provided written informed consent.

Consent to Participate

Informed written consent taken from the participants of the study.

Consent for Publication

All authors provide consent for publication of this work.

Conflict of Interest

Declared none.

Competing Interest/Funding

Declared none.

Use of AI-Assisted Technologies

The authors declare that Claude AI were utilized in the language editing and grammar correction in the article.

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