

Study on Surgical Management of Post Burn Hand Deformities

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ABSTRACT

Context: Functionality of the hands is the major determinants of the quality of life in burns survivors. If contractures or scarring affect the dominant hand, as they do on most occasions, the vocation and there by the economic status of the patient suffer.

Aim: The aim of this study is to evaluate the different surgical procedures for resurfacing after release of post-burn hand contractures in terms of functional recovery and aesthetic outcome.

Settings and Design: It's a prospective, non-randomised study of 50 patients admitted and undergoing surgical reconstructive procedures for post burn hand contractures in our plastic surgery department.

Materials and Methods: Resurfacing procedures were done according to type of contracture with individualisation for each case. All cases were followed up with physiotherapy

and splinting advices. Functional and aesthetic outcome and recurrence of contracture for each procedure was noted at 6 months.

Results: Forty seven percent of the cases were reconstructed with skin grafting, 30% cases with Z plasties and 23% with flap coverage. Split thickness skin grafts (STSG) and full thickness graft (FTSG) reconstructed cases had good recovery of joint mobility in 43% and 75% of cases respectively. Reconstructive procedures were aesthetically acceptable to the patients in 63%, 75% and 94% of STSG, FTSG and Z plasty cases respectively. Recurrence was seen in 17% of STSG done cases.

Conclusion: Most of the cases can be resurfaced with skin grafting and few cases have clear indication for flap coverage which needs to be planned and executed cautiously. Z plasties with proper planning gives maximum length gain with no donor morbidity as other procedures. Postoperative physiotherapy and splinting is must for better outcome in all cases.

Keywords: Hand contractures, Hand reconstruction, Skin grafting, Z plasty

INTRODUCTION

Burns are the most common cause of skin contracture in the hand [1]. Several functionally limiting sequels can follow deep thermal injury to the hand [2]. Infants rolling into unprotected fires or explosions of poorly made stoves are the most common causes of these burns in developing countries. Failure to seek medical help, inadequate medical care and inadequate post-healing care are common causes of burn contractures [3]. The thin, highly mobile dorsal skin, the sensory-enriched palmar skin and the delicately balanced musculotendinous systems are all at risk with a hand burn [4]. Post burn scarring and contractures affect the function as well as aesthetic appearance of hand and remain most frustrating complication of a hand burn [5]. If contractures or scarring affect the dominant hand, as they do on most occasions, the vocation and there by the economic status of the patient suffer. Appropriate choice of procedures and timing of surgery followed by supervised physiotherapy can be a boon for a burns survivor [6]. A variety of therapeutic methods such as skin grafting, z-plasties, local flaps, regional flaps, island flaps, free flaps have been reported for treatment of post burn hand deformities. Each technique has its advantages and drawbacks. It is of paramount importance to assess the efficacy of different procedures so far as functional recovery and aesthetic improvement is concerned.

The focus of the present study was to evaluate the different surgical procedures for reconstruction of post-burn contractures of the hand in terms of functional and aesthetic outcome.

MATERIALS AND METHODS

The present study included patients with post-burn hand contracture who were admitted in our Department of Plastic Surgery. The study was conducted over a period of 20 months between April 2013 and November 2014. A total of 50 patients with post burn hand contractures of all ages that required surgical correction were included in the study. Those patients not willing for surgery, physiotherapy and follow up were excluded from the study. All patients are assessed clinically for site and type of contracture,

restriction in range of motion and classified according to McCauley [7] into four severity grades-

Grade I Symptomatic tightness but no limitation in range of motion, normal architecture.

Grade II Mild decrease in range of motion without significant impact on activities of daily living, no distortion of normal architecture.

Grade III Functional deficit noted, with early changes in normal architecture of hand.

Grade IV Loss of hand function with significant distortion of normal architecture of the hand.

Subset classification for Grade III and Grade IV contracture:

A: Flexion contractures

B: Extension contractures

C: Combination of flexion and extension contractures.

Grade I and II were managed with non-surgical scar control measures and physiotherapy.

Assessment of the deformity in each tissue component from skin to underlying bone is done to make the treatment plan. In patients with band contracture with supple skin on both sides of band were planned to resurface with Z-plasties [Table/Fig-1,2]. For contracture where z plasty or local advancement not possible, the contracture was released up to the subcutaneous tissue with fish tailing at the apices to gain full range of motion, if complete release is not achieved after release of skin contracture, release of volar plate in inter phalangeal joints and collateral ligaments and/or joint capsulotomy in metacarpo-phalangeal joint is considered. The resurfacing procedure was executed according to the size of the defect created, condition of the adjacent skin, peroperative gain in range of motion, exposed vital structures (tendon, joints and neurovascular). If the wound bed is good for graft take, then skin grafting is done. For coverage of small areas like flexor surface of single finger, full thickness skin graft (FTSG) was used [Table/Fig-3]. Otherwise thick sheet of split thickness skin graft was used [Table/Fig-4]. After skin graft stabilisation is done with internal fixation using



[Table/Fig-1]: Contracture of left little finger volar surface released with Z plasty **[Table/Fig-2]:** Release of middle finger volar contracture with seven flap Z plasty
[Table/Fig-3]: Release of right little finger volar contracture with FTSG coverage and K wire fixation



[Table/Fig-4]: Release of post burn contracture of volar surface of wrist, thumb and little finger with STSG and K wire fixation

K wire [Table/Fig-3,4]. In complex contractures involving multiple joints external fixators are used for stabilisation [Table/Fig-5,6]. If vital structures are exposed after contracture release loco-regional flaps are done depending on the availability of donor area, namely cross finger flap [Table/Fig-7], radial forearm flap [Table/Fig-8], ulnar artery flap, distal ulnar artery perforator flap (baker's flap). When loco-regional flap coverage not feasible abdominal/groin flap may be reliably used for coverage of deeper wounds. Other than skin graft, K wire is given only in cases in which resistance remains after



[Table/Fig-5]: (a) Old post burn contracture of volar surface of all fingers, palm and all webspaces released and continuous traction applied for 3 weeks with JESS; (b) STSG done after 2 weeks of traction (c), external fixators removed after 6 weeks (d) **[Table/Fig-6]:** (a) PBC dorsum of hand and wrist; (b) released; (c) stabilized with external fixators and resurfaced with STSG; (d) follow up after 3 months **[Table/Fig-7]:** Right middle finger contracture released, stabilized with K wire and resurfaced with crossfinger flap from dorsum of ring finger



[Table/Fig-8]: Dorsum of hand contracture excision release done and covered with distal radial forearm flap, donor area covered with STSG

release of the skin and ligaments and the patient is thought not to mobilize sufficient strength to overcome this resistance. K wires are removed after 3 weeks; external fixators are removed after 6 weeks and replaced with external splints. In postoperative period active physiotherapy is started as soon as possible. Scar control measures such as pressure massage, silicone sheets and pressure garments are started after 3 weeks, once healing of graft/flap were ensured. Patients are followed up weekly for 2 weeks, 2 weekly for one month and every monthly thereafter. Functional outcome is noted by measuring the range of motion in affected joints findings and scaled as good if there is improvement of more than 75% of normal range for that joint. It is graded poor if improvement is less than 50% of normal range. In between these two are graded average recovery. Recovery of joint mobility is compared with each surgical procedure. Aesthetic acceptance by the patient is questioned subjectively, whether resurfacing results are aesthetically acceptable to them or not. Results obtained are compared for each resurfacing procedure.

RESULTS

The present study prospectively analysed 50 patients with post-burn contractures of the hand who were treated in the Department of Plastic Surgery. Patient age ranged from 1.5 years to 35 years with a mean age of 14 years, and maximum number of patients belonged to the age group of 1 to 5 years (48% of all patients). There were 27 males (54%) and 23 females (46%) in the study. Out of 50 patients 3 patients were operated for contracture of both hands. [Table/Fig-9] Shows classification of burn contractures based on McCauley's severity grade. None of the cases in the study belonged to grade I or grade II. Of the 53 hand contractures studied 7 contractures

involved volar surface of the wrist, 2 contractures involved dorsum of the wrist, 6 contractures involved volar surface of thumb, and one dorsal surface of the thumb. Dorsum of hand was involved in 9 cases where as major palm was involved in 4 hand contractures. Volar surface of index, middle ring and little fingers were involved in 8, 14, 18 and 23 hand contractures respectively. Whereas 1st, 2nd, 3rd and 4th web spaces were involved in 6, 3, 5 and 2 hand contractures respectively.

The operative procedure was chosen according to the type and severity of hand contracture, size of the defect after contracture release, structures exposed after release of contracture and condition of the surrounding skin. The various reconstructive procedures used for resurfacing after hand contracture release in the study were shown in [Table/Fig-10]. Total of 57 resurfacing procedures were done in 53 hand contractures. Out of 57 resurfacing procedures k wire was used following 33 procedures, external splints in the form of POP slab or thermostatic splints were used following 21 procedures. External fixators (JESS) were used following STSG in 3 cases of severe hand contractures.

Functional recovery of joint mobility was assessed by measuring

McCauley's grade	Number of hands	Percentage (%)
Grade III A	25	47
Grade IIIB	2	3.7
Grade IIIC	3	5.6
Grade IVA	11	20.75
Grade IVB	6	11.3
Grade IVC	6	11.3
Total	53	100

[Table/Fig-9]: Classification of burn contractures based on McCauley's severity grade

Surgical procedures	Number of procedures
STSG	23
FTSG	4
Z plasties	17
Cross finger flaps	5
Local transposition flap	2
Radial fore arm flap	2
Ulnar artery flap	1
Baker's flap	1
Abdominal flap	2
Total	57

[Table/Fig-10]: Resurfacing procedures done following contracture release in the study

the gain in the angle of maximum range of motion possible at 6 months after surgery and scaled as good if there is improvement of more than 75% of normal range for that joint. Recovery of joint mobility is compared with each surgical procedure. Overall functional improvement in the study was satisfactory, with good recovery after 38 (66%) resurfacing procedures, average recovery in 15 (27%) procedures and poor recovery in only 4 (7%) procedures. However, the functional results varied slightly across the different surgical procedures with better recovery after Z plasty and loco-regional flaps. The contracture recurrence rate was 17.4% in the split thickness skin graft group in spite of prolonged use of extension splint; there was however no recurrence of contracture in the other procedures.

Overall, the complications were minimal and there was only one case of partial flap loss. There was minimum donor area and recipient site morbidity. The aesthetic results were acceptable to majority of patients (77.2%), with better patient acceptability of 94% in Z plasty group compared to 65% patient acceptability in the STSG group.

DISCUSSION

The hands account for less than 5% of total body surface area [2], but loss of the hand constitutes a 57% loss of function for the whole person [8,9]. Whether the burned hand is an isolated injury or part of a large total body surface area burn, its loss represents a major functional impairment [10]. Treatment of the hands receives high priority because the patient's ability to perform useful work after recovery is to a great degree determined by residual hand function. The functional importance of the hand cannot be overemphasized in as much as severe hand burns may leave individuals unable to work or even care for themselves [5]. Post-burn contractures are distressingly common and severe in developing nations and are a significant problem in developed countries as well [3]. Hands are involved in more than 80% of all severe burns [11]. First-degree and superficial second-degree burns typically heal satisfactorily within about two weeks and have good functional and aesthetic results. Deep second degree (partial skin thickness), third degree (full skin thickness) and fourth- degree (tendon, bone, nerve, or joint involvement) burns take longer than 2 weeks to heal. These injuries predictably heal by scar tissue formation [2]. As a result at the time of acute management, deep burns can be resurfaced with skin grafts or skin substitutes to hasten wound healing, facilitate early motion and minimizes contracture formation [12]. At the time of initial treatment the hand should be splinted in an anti-deformity position. A supervised passive motion protocol should be initiated by a hand therapist as soon as possible after injury and within first 2 weeks of acute surgical management. At this early sub-acute phase, patient should also be fit for pressure garments and Silicone sheets. These therapies decrease scar formation through a pressure effect and a state of relative tissue hypoxia [13]. Once functionally limiting contractures have developed, little nonsurgical treatment can be offered to reverse the scarring process. As a result efforts to minimize contracture development are of paramount importance [2].

Timing and indications for surgical release

The classic rule of burn surgery is to delay secondary procedures until scar have fully matured, which takes approximately 1 year. Achauer et al., noted that surgery on immature hypertrophied scar requires careful consideration because of the possibility of recurrence [14]. It is believed that in many cases the deformity is not usually completely corrected. This group advocated a conservative approach to all such active scars. Whereas other authors advice to operate earlier [15-17]. Greenhalgh et al., have shown that early release is not associated with a worse outcome and argues that, waiting for maturation of the scar is not necessary [18]. Early release should especially be performed if secondary deformity is occurring with functionally limiting hand contracture. The definition of functional limitation may be distinct for each patient based on his or her personal and professional requirements and may even include aesthetic consideration. For excision of a purely hypertrophic scar without functionally limiting contracture surgical management is delayed until scar has fully matured. Surgical intervention may be indicated before the scar has fully matured in cases of severe skin contracture with limitation of motion, to prevent secondary tendon and joint contractures. Watson emphasizes that it is important to focus the reconstructive efforts on what the patient desires and requires and not to attempt an over-optimistic goal of normal form and function [19].

Operative strategy

Evaluation of the deformity in each of the components of skin, tendons, joints and bones was done while making the treatment plan. Often multiple limbs are involved. Salisbury [20] stresses that it is important for the surgeon to make an overall plan and to perform as many procedures at each operative session as is reasonable to minimize the number of anaesthetics. S Rajasabapathy emphasizes

while reconstructing a burnt hand [6], the burn surgeon must concentrate on restoring function than just on increasing the range of movement of individual joints. When a hand is severely involved, choose the first set of procedures that will bring the maximum benefit to the patient. Correction of the deformity depends on the excision of the scar tissue and correcting the deforming forces than on the type of skin cover provided. SC Tucker in an illustrative series of reconstruction of severe hand contractures states that [21]: The soft tissue reconstructions in just over half of the cases were with a split or full thickness skin graft; however, it is far from the case that these are simple cases that "just need a skin graft". Good surgical judgment and a sound knowledge of the available flaps are needed to identify and successfully treat those hands that will benefit from flap coverage.

Before surgically addressing the problem, a thorough analysis is mandatory. Several questions have to be answered [5]:

1. What is the nature of the contracture or the limiting scarring?
2. Are there any underlying joint problems (e.g., shrinking of the ligaments or capsules, cartilage destruction)?
3. Are soft tissue procedures sufficient?
4. Which type of coverage is adequate after contracture release?
5. Where should harvest skin grafts or flaps be harvested?

Kucan and Bash stress that the well-described reconstructive ladder should be followed, choosing the most simple method that will achieve the reconstructive goals [15]. In order of increasing complexity, the relevant reconstructive methods are Z-plasty, skin grafts, local flaps, regional flaps, distant flaps, free flaps, and cross-limb flaps

Release and grafting

The release is usually by a fish mouth type of incision [22]. The literature would suggest that the remaining defect is surfaced with full-thickness skin graft if at all possible. Several authors have shown that split-thickness plantar skin grafts will give similarly excellent colour matching with minimal contraction [23,24]. Both will give a more durable and cosmetically pleasing result than a split-thickness graft and will be much less likely to contract [25-27]. However, full-thickness grafts take less readily than do split-thickness grafts and may suffer the setback of limited availability with larger burns [28]. Pensler et al., compared full thickness skin grafts with split thickness skin grafts for reconstructing the palms of 25 children with follow up between 3 and 9 years duration [26]. Their results showed that 1.2 operations per hand were required for the split thickness graft group and 1.3 per hand for the full thickness group. Although this shows no significant difference for the two groups, it does illustrate that at least every fifth child had recurrence that merited re-operation in their series. So, we prefer to use full thickness graft in very small area coverage with a very good wound bed otherwise we use split thickness skin graft because of its good chance of graft take. Since we use thick sheet of unmeshed split skin graft, cosmetically and functionally results were comparable with full thickness skin graft.

Many authors advocate the use of flaps in reconstructing the burned hand in order to reduce the recurrence rate [29,30]. Local and regional flap choices include, posterior interosseous artery flap [31], reverse radial forearm flap [32], the reverse ulnar forearm flap, radial artery perforator flap [32], ulnar artery perforator flap [33]. Free flaps that have been recommended for use in reconstruction of burnt hand include medial plantar artery flap for palmar defects [30], the anterolateral thigh perforator flap, either as a fasciocutaneous flap or adipofascial flap with skin graft [34], serratus fascial flap with skin graft [35] and the temporo parietal fascial flap with split thickness skin graft [36]. Abdominal flap and groin flaps serves as reliable source of donor area for flap coverage of hand defects, but carry a limitation of prolonged immobilisation. Choice of above mentioned flaps should be made cautiously keeping in mind following factors

such as, availability of donor area, how much improvement in hand function can be gained after procedure, future reconstructive procedures that may be required and one's expertise in particular flap.

CONCLUSION

In surgical management of post-burn hand deformities, whenever applicable Z plasties and their modification gives best functional and aesthetic outcome, otherwise most of the defects can be covered with skin grafts. Needless to say strict postoperative regimen of physiotherapy and splinting are a must for optimum outcome. In patients requiring flap, proper selection of flap depending on defect and availability of donor area are a prerequisite for optimum outcome.

REFERENCES

- [1] Kurtzman LC, Stern PJ. Upper extremity burn contractures. *Hand Clinics*. 1990;6:261-79.
- [2] Fufa DT, Chuang SS, Yang JY. Post burn contractures of the hand. *Journal of Hand Surgery*. 2014;39(9):1869-76.
- [3] Richard J. Schwarz, Management of Post burn Contractures of the Upper Extremity. *Journal of Burn Care Res*. 2007;28:212-19.
- [4] Moor, et al. Rehabilitation of the Burned Hand. *Hand Clinics*. 2009;25:529-41.
- [5] Germann G, Philipp K. The burned hand. In: Scott W. Wolfe, Robert N. Hotchkiss, William C. Pederson, Scott H. Kozin editors Green's Operative hand surgery, 6th ed. New York: Churchill Livingstone; 2011.
- [6] Sabapathy SR, Bajantri B, Bharathi RR. Management of post burn hand deformities. *Indian journal of Plastic surgery*. 2010;43(3):72-79.
- [7] McCauley RL. Reconstruction of the pediatric burned hand. *Hand Clin* 2000;16:249-59.
- [8] American Medical Association: Guides to the Evaluation of Permanent Impairment, 4th ed. Chicago: American Medical Association, 1994.
- [9] Engrav LH, Dutcher KA, Nakamura DY. Rating burn impairment. *Clin Plast Surg*. 1992;19:569-98.
- [10] Malachy E A, Robert L McCauley, Rocco C. Piazza II, Reconstruction of the Burned Hand. In: Robert L. McCauley editor. Functional and Aesthetic Reconstruction of Burned Patients: Boca Raton; 2005.
- [11] Pruitt BA Jr, Dowling JA, Moncrief JA. Escharotomy in early burn care. *Arch Surg*. 1968;96:502-07.
- [12] Stern PJ, Yakuboff KP. Burn contractures. In: Chapman MW. Editor. Chapman's orthopedic surgery. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2011
- [13] Kreymerman PA, Andres LA, Lucas HD, Silverman AL, Smith AA, Reconstruction of burned hand. *Plastic Reconstructive Surgery*. 2011;127(2):752-59.
- [14] Achauer BM, Vanderkam VM. Burn reconstruction. In: Achauer BM, editor Plastic Surgery: Indications, Operations, and Outcomes, Vol 1. St. Louis: Mosby; 2000.
- [15] Kucan JO, Bash D. Reconstruction of the burned foot. *Clin Plast Surg*. 1992;19:705-19.
- [16] Schwarz RJ, Joshi KD. Treatment of post-burn contractures. *J Nephrol Med Assoc*. 2004;43:211-17.
- [17] Baux S, Mimoun M, Kirsch JM, Zumer L, Berard V. Treatment of elbow contractures in burns. *Burns Inc Therm Inj*. 1987;13:241-44.
- [18] Greenhalgh DG, Gaboury T, Warden GD. The early release of axillary contractures in pediatric patients with burns. *J Burn Care Rehabil*. 1993;14:39-42.
- [19] Watson S. Hand burns. *Repair Reconstr*. 2001;2:2-4.
- [20] Salisbury RE. Reconstruction of the burned hand. *Clin Plast Surg*. 2000;27:65-69.
- [21] Tucker SC. Reconstruction of severe hand contractures: An illustrative series. *Indian journal of Plastic surgery*. 2011;44(1):59-67.
- [22] Pandya AN. Principles of treatment of burn contractures. *Repair Reconstr*. 2002;2:12-13
- [23] Bunyan AR, Mathur BC. Medium thickness plantar skin graft for management of digital contractures. *Burns*. 2000;26:575-80.
- [24] Tanabe HY, Aoyagi A, Tai Y, et al. Reconstruction for palmar skin defects of the digits using plantar dermal grafting. *Plast Reconstr Surg*. 1998;101:992-5.
- [25] Iwagwu FC, Wilson D, Bailie F. The use of skin grafts in PBC release. *Plast Reconstr Surg*. 1999;103:1198-204.
- [26] Pensler JM, Steward R, Lewis SR, Herndon DN. Reconstruction of the burned palm: full-thickness versus split-thickness skin grafts- long-term follow-up. *Plast Reconstr Surg*. 1988;81:46-51.
- [27] Alexander JW, MacMillan BG, Martel L, Krummel R. Surgical correction of postburn flexion contractures of the fingers in children. *Plast Reconstr Surg*. 1981;68:218-26.
- [28] McGregor IA: Fundamental Techniques of Plastic Surgery and Their Surgical Applications, 8th ed, Edinburgh: Churchill Livingstone; 1989.
- [29] Ulkur E, Uygur F, Karaoz H, Ceikoz B. Flap choices to treat complex severe postburn hand contracture. *Ann Plast Surg*. 2007;58:479-83.
- [30] Uygur F, Duman H, Ulkur E, Ceikoz B. Chronic postburn palmar contractures reconstruction using the medial pedis perforator flap. *Ann Plast Surg*. 2008;61:269-73
- [31] Puri V, Mahendra S, Rana R. Posterior introsseous artery flap, fasciocutaneous pedicle technique: A study of 25 cases. *J Plast Reconstr Aesthet Surg*. 2007;60:1331-37.

- [32] Hansen AJ, Duncan, Smith AA, Shin AY, Moran SL, Bishop AT, et al. Reverse radial fore arm fascial flap with radial artery preservation. *Hand*. 2007;2:159-63.
- [33] Ignatiadis IA, Mavrogenis AF, Avram AM, Georgescu AV, Perez ML, Gerostathopoulos NE, et al. Treatment of complex Hand trauma using the distal ulnar and distal radial artery perforator based flaps. *Injury*. 2008;39:116-24.
- [34] Hsieh CH, Yang CC, Kuo YR, Tsai HH, Jeng SF, Free anterolateral thigh adipofascial perforator flap. *Plast Reconstr Surg*. 2003;112:976-82.
- [35] Fotopoulos P, Holmer P, Leicht P, Elberg JJ. Dorsal hand coverage with free serratus fascia flap. *J Reconstr Microsurg*. 2003;19:555-59.
- [36] Rogachefsky RA, Ouellette EA, Mendieta CG, Galpin P. Free temporoparietal fascial flap for coverage of a large palmar forearm wound after hand replantation. *J Reconstr Microsurg*. 2001;17:421-23.

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