

## Flap Selection Approach for Hand Soft Tissue Defects Reconstruction: Surgical Techniques and Outcome Evaluation

**Ghada S. Gad<sup>a</sup>, Samia M. Saied<sup>b</sup>, Mohamed Abdelshafy Mohamed<sup>c</sup>, Mahmoud A. Hifny<sup>a\*</sup>**

<sup>a</sup>Plastic Surgery Department, Faculty of Medicine, South Valley University, Qena, Egypt

<sup>b</sup> Plastic Surgery Department, Faculty of Medicine, Sohag University, Sohag, Egypt

<sup>c</sup>General Surgery Department, Faculty of Medicine, South Valley University, Qena, Egypt

### **Abstract**

**Background:** The hand is an intricate part of the body that plays an essential role in social functioning, expression, productivity, and interactions with our environment. Many flap options have been described to address the specific functional and anatomic requirements in soft tissue reconstruction of the hand.

**Objectives:** The aim of this study is to find the ideal donor tissue for coverage of soft tissue defects of the hand to achieve wound closure and maintain joint and hand function.

**Patients and methods:** A prospective study was conducted between April 2018 and May 2019, on all patients with soft tissue defects of the hand presented to plastic surgery department, Qena faculty of medicine, South Valley University.

**Results:** There were 62 hand injuries in 50 patients with a mean age of 35 years (range, 1- 69 years). The etiologies of the injuries were mostly due to post-traumatic raw areas (86%). In our study we divided cases into 4 main groups, the first group including fingertip injuries, second group proximal to fingertips, third group palm and fourth group dorsum of the hand. The distribution of the hand injuries were 48 fingertips injury, 8 injuries proximal to fingertips, palm injury in one patient and injuries over hand dorsum in 5 patients. The follow up period was ranged 1 to 6 months.

**Conclusion:** An algorithmic approach for coverage of the hand soft tissue defect seems to provide predictable results regarding flaps survival and preservation of finger length.

**Keywords:** hand; fingertip; reconstruction; flaps.

### **Introduction**

The hand is an intricate part of the body that plays an essential role in social functioning, expression, productivity and interactions with our environment (**Hegge et al., 2011**). The reconstructive ladder is a well-established tool for wound coverage in general. However, there are an ever-increasing number of flap options that have been described to reconstruct hand soft tissue defects and address the specific functional and anatomic requirements of the hand (**Chim et al., 2014**).

Conventionally, these options include a wide range of techniques such as, primary wound closure, skin grafts, local flaps, distant flaps, and micro-vascular free tissue transfer (**Friedrich et al., 2009**). Nevertheless, selecting the most suitable type of soft tissue cover for a

particular defect can be a challenging process. Furthermore, the abundance of currently available reconstructive techniques makes this task rather difficult, especially for the inexperienced surgeon. Although useful, there is no simple scheme for reconstruction as every injury is different and every patient has a unique set of medical conditions (**Maciel-Miranda et al., 2013**). The aim of the work of this study is to find the ideal donor tissue for coverage of soft tissue defects of the hand to achieve wound closure, maintain joint and hand function and obtain a satisfactory cosmetic appearance.

### **Patients and Methods**

A prospective study was conducted between April 2018 and May 2019, on patients, who had soft tissue defects of the hand and presented at

plastic surgery department, Qena faculty of medicine, South Valley University. This study was approved by and is in accordance with the ethics committee of the faculty of medicine. The exclusion criteria were the immune-compromised patients, patient refusal, patients with incomplete data, patients with concomitant injury and patients with previous history of hand injury or surgery.

All patients presented with soft tissue defects of the hand whatever the cause were subjected to full complete history including: the patients age, sex, occupation, hand dominance, mechanism of injury and the presence of comorbid illness such as a history of diabetes, Raynaud's phenomenon or tobacco use. Complete hand examinations were conducted which included evaluation of neurovascular status, tendon injuries and the evaluation of the local wound: the size of the defect, the presence of exposed bone, the geometry of the soft tissue defect, single or multiple defects, wound bed status and evaluation of tissue in proximity to the defect as potential donor sites. Digit-specific radiographs were obtained in all cases to demonstrate associated hand fractures and foreign bodies. Informed written consent and preoperative and postoperative photography were obtained from all patients.

### **Surgical Technique:**

All wounds underwent adequate debridement to prepare the wound bed prior to definitive wound closure. The choice of local, regional or distant flap coverage was depended on assessment of the wound location (fingertip, palm, dorsum of the hand), wound size and extent of the defect. Before proceeding with flap reconstruction, skeletal stabilization of fractures was mandatory to provide a foundation for soft tissue coverage. Also repair or reconstruction of nerve, arterial, or tendon injuries was typically performed at the same time. Soft tissue coverage was achieved within 48 hours to avoid the development of granulation tissue and no later than 10 days of injury to minimize infection risk.

All patients underwent both subjective and objective outcome evaluation. The objective patient outcome evaluations consisted of flap

survival, complications related to reconstructive procedures, range of motion of the joints, healing time, return to work and donor site morbidity. The subjective patient outcome evaluations consisted of assessment of the patient level of satisfaction which was evaluated with both functional and aesthetic means and divided into the following 5 grades: highly dissatisfied, dissatisfied, moderately satisfied, satisfied, highly satisfied.

### **Results**

There were 62 hand injuries in 50 patients with a mean age of 35 years (range, 1- 69 years). Of 50 patients, 43 were male (86%) and 7 were female (14%). The etiologies of the injuries were as follows: 43 post-traumatic raw areas (68%), 6 post-burn raw areas (12%), and 1 post-abscess evacuation (2%). Patients with right hand injury were 26 (52%), while patients with left hand injury were 24 (48%).

The distribution of the hand injuries were 48 fingertips injury (12 nearly amputated, 7 volar oblique, 4 dorsal oblique, 24 transverse, 1 radial side), 8 injuries proximal to fingertips, 5 injuries over the hand dorsum and palm injury in one patient. The follow up period was ranged between 1 to 6 months with a mean of 3 months. (**Table 1**)

According to the anatomical site of injuries, we divided our cases into 4 main groups which are:

A. First group including fingertip injuries (No. 48):

In 48 fingertip injuries, 21 fingers were reconstructed by flap techniques as follow: 13 by V-Y flap, 4 by thenar flap (Fig.1), 3 by cross finger flap (Fig.2), and 1 by bilateral V-Y flap technique; while 26 fingers were closed with revision amputation technique and 1 finger was resurfaced with full thickness graft technique.

**Fig. 1: Thenar flap**

B. Second group including finger injuries proximal to fingertips (No. 8):There were 5 fingers reconstructed by flap techniques: 3 of them were reconstructed by groin flap, 1 by abdominal flap and 1 by cross finger flap; and the other 3 fingers were closed by revision amputations.

**Fig. 2: Cross finger flap**

C. Third group including palm injury(No.1):The only hand palm injury was repaired with groin flap.

D. Fourth group including dorsum hand injuries (No.5):There were 3 cases, which repaired with groin flap (Fig.3) and the other 2 cases treated by split thickness skin graft.

**Fig. 3: Groin flap over hand dorsum****Table 1: Cases with reconstructive techniques.**

No.	Age and sex	site of the defect	Method of reconstruction
1.	M. 68 yrs.	Fingertip	Revision amputation
2.	F. 1.5 yrs.	Fingertip	Thenar flap of index finger, cross finger flap of ring finger and Revision amputation of middle finger.
3.	M. 1 yrs.	Fingertip	Revision amputation
4.	M. 18 yrs.	Fingertip	Revision amputation
5.	M. 4 yrs.	Fingertip	Revision amputation
6.	F. 48 yrs.	Fingertip	V – Y flap
7.	M. 36 yrs.	Fingertip	V – Y flap of Rtmiddle, Revision amputationof the Rt ring finger.
8.	M. 32 yrs.	Fingertip	V – Y flap
9.	M. 35 yrs.	Fingertip	V – Y flap
10.	M. 24 yrs.	Fingertip	Thenar flap
11.	M. 33 yrs.	Fingertip	Bilat. V – Y flap
12.	F. 2.5 yrs.	Fingertip	Revision amputation
13.	M. 45 yrs.	Fingertip	V – Y flap
14.	M. 40 yrs.	Fingertip	V – Y flap
15.	F. 1 yr.	Fingertip	Revision amputation
16.	M. 36 yrs.	Fingertip	Revision amputationof the middle and ring fingers & V – Y flap of the little finger.
17.	M. 28	Fingertip	V – Y flap

	yrs.		
18.	M 37 yrs.	Fingertip	V – Y flap
19.	M. 17 yrs.	Fingertip	Cross finger flap
20.	M. 22 yrs.	Fingertip	Revision amputation
21.	M. 33 yrs.	Fingertip	V – Y flap
22.	M. 43 yrs.	Fingertip	Revision amputation
23.	M. 26 yrs.	Fingertip	Revision amputation
24.	M. 32 yrs.	Fingertip	V – Y flap
25.	M. 11 yrs.	Fingertip	Thenar flap
26.	M. 35 yrs.	Fingertip	Revision amputation
27.	F. 50 yrs.	Fingertip	Cross finger flap
28.	M. 33 yrs.	Fingertip	Revision amputation
29.	F.21 yrs.	Fingertip	Full thickness graft
30.	M. 25 yrs.	Fingertip	Revision amputation(3 fingers)
31.	M. 39 yrs.	Fingertip	Revision amputation
32.	M. 28 yrs.	Fingertip	Revision amputation
33.	M. 10 yrs.	Fingertip	Revision amputation
34.	M. 46 yrs.	Fingertip	Revision amputation of middle and ring fingers.
35.	M. 20 yrs.	Fingertip	Revision amputation
36.	M. 50 yrs.	Fingertip	Thenar flap.
37.	M. 34 yrs.	Prox to fingertip	Groin flap.
38.	M. 37 yrs.	Prox to fingertip	Revision amputation
39.	M. 35 yrs.	Prox to fingertip	Groin flap
40.	M. 28 yrs.	Prox to fingertip	Abdominal flap
41.	M. 56 yrs.	Prox to fingertip	Revision amputation of middle and ring fingers.
42.	M. 13 yrs.	Prox to fingertip	Revision amputation
43.	M 20 yrs.	Prox to fingertip	Groin flap
44.	M. 16 yrs.	Prox to fingertip	Groin flap
45.	M. 52 yrs.	palm	Groin flap
46.	M. 40 yrs.	Dorsum	Groin flap
47.	M. 30 yrs.	Dorsum	Groin flap
48.	M. 10 yrs.	Dorsum	Split thickness skin graft.

49.	F. 45 yrs.	Dorsum	Split thickness skin graft.
50.	M 55 yrs.	Dorsum	Groin flap.

All flaps survived completely (30 injuries). Ptrial flap dehiscence complication was found in 12 cases (24%): 2 with thenar flap, 2 with cross finger flap, 5 with V-Y flap, and 3 cases with groin flap. All flaps healed by secondary intention within 2-4weeks without any surgical intervention except two cases of groin flap which needed debridement and re-stitch.

In 36 patients, there was full range of motion of the joints while 14 patients had a mild restriction of range of motion mainly due to k-wire fixation or long period of immobilization. There were 28 patients that could return to work after 2 weeks and 22 patients could return to work after 6 weeks. Twenty-four patients were moderately satisfied with functional and aesthetic outcome, 20 patients were satisfied, and only 6 patients were dissatisfied.

## Discussion

Soft tissue defects of the hand can result from a variety of mechanisms including trauma, infection, and malignant disorders. Reconstructive surgeons who encounter these conditions must be aware of the unique requirements and challenges of soft tissue coverage specific to the hand. The optimal soft tissue reconstruction protects against the development of contractures and facilitates tendon and joint mobility, as well as maintaining durability and sensibility of the hand (**Biswas et al., 2014**). Conventionally, these included a range of options such as, revision amputation, skin grafts, local flaps, distant flaps, and micro-vascular free tissue transfer (**Friedrich et al., 2009**).However, the most suitable type of soft tissue cover for a particular defect can be a challenging process.

The precise management of a fingertip injury depends on the degree of injury, therefore there are several operative and non-operative techniques that can be successfully employed. A study done by Sindhu et al., revealed that up to 90% of fingertip amputations were treated with non-replant techniques(**Sindhu et al., 2017**).

Moreover, Hadi Hassinee and his colleagues, who studied 130 cases of hand trauma, showed that revision amputation was the most practiced primary surgery (82% of primary surgeries) (**HadjHassinee et al., 2018**). Comparing with our study, there were 26 fingertip injuries reconstructed with revision amputation (51.1%). Also digits amputated, proximal to the insertion of the flexor digitorum superficialis, in zone 2 are generally not replanted due to subsequent risk of finger stiffness, which may hinder hand function (**Sebastin, 2011**).

There are many advantages of revision amputation that are reported by several authors. It is simple, cheap, and associated with better functional outcomes than replantation (**El-Diwany et al., 2015**). Furthermore, patients recover well from the procedure more quickly and return to their work faster when compared to replantation (**Ozcelik et al., 2008**). Revisions may also be considered in older patients and in those with complex systemic co-morbidities (**Sarafand Tiwari 2007**). In addition, revision amputations have been found to have a better outcome, regarding sensation and function, than local flap treatments. A systematic review by Yuan et al., found no significant differences between patients who have treated by conservative, revision amputation, or local flap procedure (**Yuan et al., 2015**). Although Peterson et al., stated that replantation has better functional outcomes than revision amputation (**Peterson et al., 2014**). We found that replantation is a difficult technique that needs special team and preparations and as a result, it is not preferred in our unit.

Regarding the use of local flap approach in fingertip injuries, it was found that the choice of the flap utilized depends primarily on the digit involved and the wound size and shape (**Peterson et al., 2014**). Atasoy flaps or the terminal pulp V-Y flaps are most effective technique in repairing of small dorsal oblique and transverse injuries; however, they cannot be used for volar oblique injuries (**Panattoni et al., 2015**) (**Germann et al., 2017**). When it is used to cover volar oblique defects, it seems to become necrotic, which is most probably occurred due to too much advancement (**Karjalainen et**

**al., 2019**). In our unit, V-Y flap is the most common (66.6%) local flap that used for fingertip injuries and is strictly reserved only for dorsal oblique and transverse fingertip amputations.

In case of more extensive volar oblique tip injuries, cross-finger and thenar flaps are usually used for coverage, which require 10–14 days of post-procedure immobilization and show a higher re-operation rate (**Panattoni et al., 2015**). Thenar flaps, however, are generally utilized for second and third digits injuries, while cross-finger flaps can be used for injuries to any digit. The thenar flap is first created with its radial border parallel to the crease of the MCP joint. During distal flap elevation, it is mandatory to remain superficial to avoid injury to the radial digital nerve (**Panattoni et al., 2015**). In contrast, the cross-finger flap is a rectangular flap that is designed over the middle phalanx adjacent to the injured digit. It is elevated, hinged and reflected to resurface the primary defect. The donor site is repaired by a full-thickness skin graft (**Panattoni et al., 2015**).

Rabarin et al. reported that cross-finger flaps are an easy and reliable flap and show positive long-term outcomes (**Rabarin et al., 2016**). The rate of re-operations was 10% as reported by Woon et al., who presented 30 cross finger flaps to resurface thumb hemi-pulp defects (**Woon et al., 2008**). Chong et al., utilized cross finger flaps on 13 fingers and revealed that 11 of the flaps survived completely. The 2 failed flap were caused by injuries in the donor fingers, hindering the blood supply of the flaps (**Chong et al., 2017**). In our series, two patients had partial flap dehiscence, which healed by secondary intention and did not require re-operation. Other complications including pain, limited range of motion, sensory disturbances or loss of skin graft at the donor site were not reported in our series. The donor sites of all cross finger flaps in our study were closed with skin grafts, which is still an aesthetic problem.

Defects over the dorsum of the hand that revealed big surgical defects and can't be repaired using primary closure or secondary intention could be repaired with the use of a graft or cutaneous flap (**Manna et al., 2017**).

Although a simple skin graft is sufficient to achieve good healing, a local cutaneous flap provides better color, texture, minimal tissue contraction and a higher survival rate, and is appropriate in case of tendon or bone exposure.(**Biswas et al., 2014**).The advancement and transposition flaps could not be used with wide surgical defects as their vascular pedicle would not be sufficient to supply the distal part of the flap properly with subsequent risk of flap necrosis(**Manna et al., 2017**).Loco-regional flaps such as interosseous and radial forearm flaps may not be possible because of injury on the forearm and also free flaps are not technically possible in our center. As a result, our choice is then limited to pedicled distant flaps such as groin or abdominal flaps. Although it can be uncomfortable and often needs further surgery to thin it, the donor site scar is less conspicuous(**Voulliaume et al.,2005**) and it is generally quickly harvested with a reliable blood supply(**Amouzou et al., 2017**).

A study was done by Abdelrahmanet.al, to discuss the different techniques of groin flap to reconstruct the hand and it revealed that 6.5% of his patients developed distal flap necrosis that is probable due to a local surgical site infection and not intrinsic flap insufficiency (**Abdelrahman et al., 2018**).While 3 out of 7 cases of groin flaps in our study showed apatral flap dehiscence without flap necrosis. Another study was done by Jokuszies et al., with a pedicled groin flap in 14 patients and revealed complete soft tissue coverage and flap survival with satisfactory functional and aesthetic result in all cases(**Jokuszies et al., 2010**).However, we should bear in mind that physiotherapy plays an important role in this treatment, not only for the hand but also for the shoulder and elbow which are immobilized during the first part of the procedure (**Xia et al., 2015**).In our study 20% of cases suffer from stiffness that needs physiotherapy from 2 to 6 months duration.In Matsumura et al.'s study, patients had physiotherapy for six months to one year (**Matsumura et al., 1999**).

### **Conclusion:**

Our recommended clinical algorithm is to use V-Y flap for distal dorsal oblique or

transverse fingertip amputation, while thenar flap should be used in oblique volar fingertip defect and cross finger flap should be reversed for a larger volar soft tissue defects. The dorsal soft tissues of the hand are thin, which intimately associated with the underlying extensor tendon exposure. Therefore, we favor an algorithmic approach that involve groin flap to cover defects not amenable to local flap coverage.We believe that this strategy seems to provide predictable results regarding flaps survival and preservation of finger length.

### **References**

- Abdelrahman M, Zelken J, Huang RW, Hsu CC, Lin CH, Lin YT, Lin CH.(2018)**.Suprafascial dissection of the pedicled groin flap: A safe and practical approach to flap harvest. *Microsurgery*,38(5):458-465. .
- Amouzou KS, El Harti A, Kouevi-Koko TE, Abalo A, Dossim A.(2017)**. Treatment of an acute deep hand burn in a low income country with no available microsurgery: a case report. *Annals of burns and fire disasters*, 29(3): 228–230.
- Biswas D, Wysocki R., Fernandez J., Cohen M. (2014)**.Local and Regional Flaps for Hand Coverage.*The Journal of hand surgery*, 39(5):992e1004
- Chim H, Zhi Y, CarlselP, Mohan A, Saint-Cyr M. (2014)**.Hand Flaps. *Hand Clinics*,(30) 487-499.
- Chong CW, Lin CH, Lin YT, Hsu CC, Chen SH. (2017)**.Refining the cross-finger flap: Considerations of flap in setting, aesthetics and donor site morbidity. *Journal of plastic, reconstructive & aesthetic surgery*, 71(4):566-572.
- El-Diwany M, Odobescu A, Bélanger-Douet M, Berbiche D, Arsenault J, BouMerhi J, et al. (2015)**.Replantation vs revision amputation in single digit zone II amputations.*Journal of plastic, reconstructive & aesthetic surgery*, 68(6):859–63,
- Friedrich JB, Katolik LI, Vedder NB.(2009)**.Soft tissue reconstruction of the hand.*The Journal of hand surgery*, 34(6):1148–55.

- Germann G, Rudolf KD, Levin SL, Hrabowski M. (2015).** Fingertip and Thumb Tip Wounds: Changing Algorithms for Sensation, Aesthetics, and Function. *The Journal of hand surgery*, 42(4):274-284.
- HadjHassinee Y, Hmid M, Baya W. (2018).** Trauma of the hand from circular saw table: a series of a 130 cases. *La Tunisie Medicale*, 94(12):851.
- Hegge T, Henderson M, Amalfi A, Bueno RA, Neumeister MW.(2011).** Scar contractures of the hand. *Clinics in Plastic Surgery*, 38(4):591–606.
- Jokuszies A, Niederbichler AD, Hirsch N , Kahlmann D, Herold C , Vogt PM. (2010).** The pedicled groin flap for defect closure of the hand. *OperativeOrthopadie und Traumatologie*, 22(4):440-451.
- Karjalainen T, Sebastin SJ, Chee KG, Peng YP, Chong AKS.(2019).** Flap Related Complications Requiring Secondary Surgery in a Series of 851 Local Flaps Used for Fingertip Reconstruction. *Journal of hand surgery Asian-Pacific volume*, 24(1):24-29.
- Maciel-Miranda A, Morris SF, Hallock GG. (2013).** Local flaps, including pedicle perforator flaps: anatomy, technique, and applications. *Plastic and Reconstructive Surgery*, 131(6):896e–911e.
- Manna MLQ, Ucelli JLR, Ajuz NCC, Sampaio FMS.(2017).** Reconstruction of surgical defect of the dorsum of the hand. *Anais Brasileiros de Dermatologia*, 92(5 Suppl 1):132-134.
- Matsumura H, Engrav LH, Nakamura DY, Vedder NB. (1999).** The Use of the Millard “Crane” Flap for Deep Hand Burns With Exposed Tendons and Joints. *The Journal of Burn Care & Rehabilitation*, 20(4):316–317.
- Ozcelik IB, Purisa H, Mersa B, Sezer I, Erturer E, Ergun O. (2008).** Late results of replantations in tip amputations of the thumb. *Acta Orthopaedica et Traumatologica Turcica*, 42(4):252–7.
- Panattoni JB, De Ona IR, Ahmed MM. (2015).** Reconstruction of fingertip injuries: surgical tips and avoiding complications. *The Journal of hand surgery*, 40(5):1016-24.
- Peterson SL, Peterson EL, Wheatley MJ.(2014).** Management of fingertip amputations. *The Journal of hand surgery*, 39(10):2093–101.
- Rabarin F, Saint Cast Y, Jeudy J, Fouque PA, Cesari B, Bigorre N, et al. (2016).** Cross-finger flap for reconstruction of fingertip amputations: long-term results. *Orthopedic Traumatology Surgery and Research*, 102(Suppl. 4):S225–8,
- Saraf S; Tiwari V. (2007).** Fingertip injuries. *Indian Journal of Orthopedic*, 41(2):163–8,
- Sebastin SJ.(2011).** A systematic review of the outcomes of replantation of distal digital amputation. *Plastic and Reconstructive Surgery*, 128:723–37.
- Sindhu K, DeFroda SF, Harris AP, Gil JA. (2017).** Management of partial fingertip amputation in adults: Operative and non-operative treatment. *Injury*, 48(12):2643-2649.
- Voulliaume D,Mojallal A, Comparin JP , Foyatier JL. (2005).** Severe hand burns and flaps: indications. *Annales de Chirurgie Plastique et Esthetique*, 50(4):314-319.
- Woon CY, Lee JY, Teoh LC. (2008).** Resurfacing hemipulp losses of the thumb: the cross finger flap revisited: indications, technical refinements, outcomes, and long-term neurosensory recovery. *Annals of Plastic Surgery*, 61(4):385-91.
- Wang KA, Sun Y, Wu GS, Wang YR, Xia ZF. (2015).** Epidemiology and outcome analysis of hand burns: A 5-year retrospective review of 378 cases in a burn center in Eastern China. *Burns*, 41(7):1550-5.
- Yuan F, McGlenn EP, Giladi AM, Chung KC. (2015).** A systematic review of outcomes after revision amputation for treatment of traumatic finger amputation. *Plastic and Reconstructive Surgery*, 136(1):99–113.