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Hand Soft Tissue Defects: A 6-Month Experience of Different Reconstruction Techniques Using QuickDASH Score as a Comparative Analysis

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Abstract: ***In the management of hand injuries, one should always bear in mind the function of the hand while deciding upon the modality of treatment. In this study, we performed reconstruction of traumatic hand soft tissue defects in 40 patients during 6-month period. Five main surgical principles were applied including local flaps, regional flaps, distant pedicled flaps, distant free flaps and combined flaps. All flaps survived completely with no major complications.***

Keywords: Hand, reconstruction, soft tissue, flaps

1. Introduction

Skin defects occur in many hand injuries and usually need flap coverage to ensure a functional hand with tissue integrity [1]. While small defects can be closed with local flaps, reconstruction of larger defects needs distant flaps, free flaps or pedicle flaps [2].

The dorsal skin is more vulnerable to injury than the volar skin. The volar aspect of the hand requires a tough stable skin that can withstand the wear and tear [3].

In the management of hand injuries, one should bear in mind the function of the hand while deciding upon the modality of treatment [4].

In this study we aimed to find the ideal reconstruction plan for traumatic hand soft tissue defects while considering the extent of injury, recipient site requirements and donor site morbidity to maintain joint and hand function, maximize sensory return, allow further interferences and obtain satisfactory cosmetic appearance.

2. Materials & Methods

Reconstruction of post traumatic soft tissue defects of the hand was performed in 40 patients presented to our institute with post traumatic hand soft tissue defects during 6-month period and this work was approved by the Local Ethical Committee. All cases of post traumatic soft tissue defects of the hand were included in this study excluding cases with soft tissue defects due to burn, cases with soft tissue defects in the fingers, cases with major life threatening injuries or sever uncontrolled medical conditions and cases with upper limb injury that is candidate for amputation.

Pre-operative assessment of all patients in the form of: full history; age, occupation, hand dominance, previous hand problem and time and mechanism of trauma, general examination in order to detect any associated injuries mainly in polytramatized patients, local examination of the whole upper limb, special examination of the defect with check of plain x-ray to detect bone and joint affection, full laboratory investigations, preoperative photography, written consent and injection of broad spectrum I.V. antibiotics.

Different surgical techniques were applied for reconstruction including local flaps (e.g. perforator-based propeller flaps), regional flaps (e.g. distally-based radial forearm flap as shown in Figure 1, distally-based posterior interosseous artery flap and dorsal ulnar artery flap), distant pedicled flaps (e.g. pedicled groin flap and pedicled abdominal flap) and distant free flaps (e.g. free radial forearm flap, free anterolateral thigh flap as shown in Figure 2 and free fibular osteocutaneous flap as shown in Figure 3). For each surgical technique applied, there were certain criteria that suggest and support the choice.

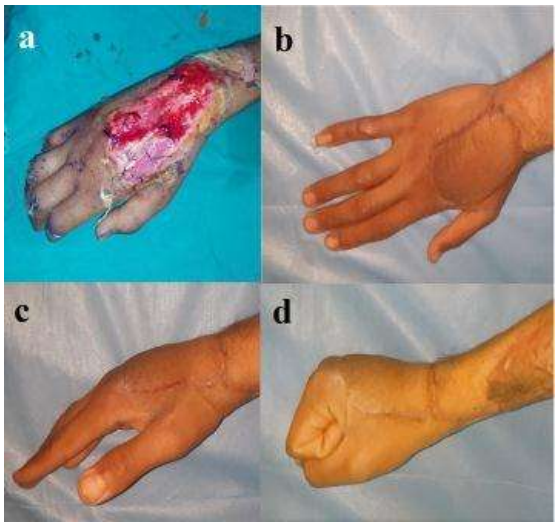


Figure 1: Distally-based radial forearm flap for medium-sized dorsal soft tissue defect of theright hand of 16 years

male; a: preoperative dorsal view, b: postoperative dorsal view, c & d: lateral view of the hand with finger extension and flexion.

Postoperative care included medical treatment in the form of antibiotics, analgesics and anti-edematous medications, fluid therapy with plasma expanders in cases of free flaps, positioning of the hand in the position of function or the indicated position according

Figure 2: Free anterolateral thigh flap for large-sized ulnar soft tissue defect of the right hand of 17 years male patient following amputation of the medial three fingers; a: preoperative defect, b: marking of the donor site, c: flap after harvest showing vascular pedicle pointed with an arrow and incorporated sensory nerve hold with jeweler forceps, d: postoperative view

to surgical technique, patients were asked to elevate upper limb to decrease the post-operative pain, minimize edema, increase venous return and avoids venous congestion of the flaps, monitoring of the flap by observing the color, capillary refilling, surface temperature, skin turgor, pinprick test and check of vascular signal with handheld Doppler in case of free flaps and donor site care and dressing.

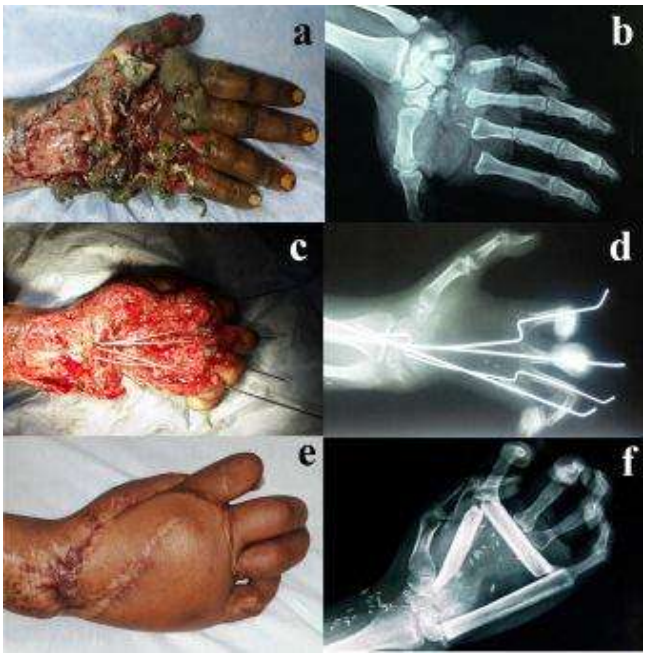


Figure 3: Free fibular osteocutaneous flap for large-sized dorsal bone and soft tissue defect of the right hand of 24 years male patient; a & b: preoperative clinical and x-ray photos, c & d: postoperative after debridement (1st stage) clinical and x-ray photos, e & f: late postoperative (2nd stage) clinical and x-ray photos.

Follow up of the patients was performed at two weeks, three and six month's intervals to evaluate healing of the recipient and donor sites, early and late postoperative complications, patients' compliance to physiotherapy plan, evaluation of hand function (Using QuickDASH score) and postoperative photography.

3. Results

This study was conducted on 40 patients; their age ranged from 4 to 62 years with a mean age of 23.2 ± 13.8 years. Most of them were in the second and third decades of life. Male patients were 35 while female patients were 5. According to this study, road traffic accidents (RTA) were the most common cause of hand injury and represented 57.5%.

According to Tic-Tac-Toe (T-T-T) classification, the most common type of injury was dorsal mutilation and represented 50% of the cases. Studying the effect of the site of injury according to T-T-T classification on Quick DASH score; the combined injury showed the worst Quick DASH score values (50.7 ± 29.1) as shown on Table 1.

Table 1: Effect of site of injury according to T-T-T score on Quick DASH score

Site T-T-T	*Mean ± SD*	*P value*
Combined	50.7 ± 29.1	0.017*
Dorsal	18.5 ± 24.3	
Palmar	8.3 ± 9.2	
Radial	22.0 ± 0.0	
Transverse	47.0 ± 16.4	
Ulnar	26.5 ± 27.6	

* Statistically significant difference ($p<0.05$)

Defect size ranged from 20 to 200 cm^2 with mean of 84.3 ± 49.7 cm^2. Those sizes were classified into small (<30 cm^2), medium (30- 70 cm^2) and large (>70 cm^2) and found most of the patients had large sized defects with percentage 47.5%. The study of relation between size of the defect and surgical technique performed revealed that local flaps were performed in small-sized defects, regional flaps were performed mostly in medium-sized defects while in large-sized defects we mostly performed distant pedicled and distant free flaps.

In 29 patients there was associated tendon and/or skeletal injury, while the other patients were presented only with soft tissue defects. On studying the relation between associated tendon and/or skeletal injury and Quick DASH score in different age groups; there was significant relation only in patients with soft tissue defect alone. This relation showed the best Quick DASH values in the fourth decade of life while the worst values was in the age group above 50 years as shown in Table 2.

Table 2: Relation between Quick DASH score and associated tendon and/or skeletal injury in different age groups

Age groups	*Associated tendon or skeletal*	
	Yes (mean ± SD of Quick DASH score)	*No (mean ± SD of Quick DASH score)*
≤10 years	38.67 ± 16.49	-
10-20 years	33.5 ± 27.75	5.6 ± 2.3
20-30 years	28.4 ± 29.04	3.5 ± 0.58
30-40 years	7 ± 0	2 ± 0
40-50 years	70.5 ± 9.19	-
>50 years	35 ± 43.84	75 ± 0
P value	0.398	<0.001**

** Statistically significant difference ($p<0.01$)

In 8 patients, there was future need for toe to hand transfer while the remaining 32 patients showed no need. Comparing future need to toe to hand transfer and surgical technique applied, it was found that most of the patients with future need had performed distant pedicled flaps.

Patients in this study group were classified into five main groups; the largest group was regional flaps group (17 patients) followed by distant pedicled flaps group (15 patients) and sub grouped according to the applied surgical technique as shown in Table 3.

Table 3: Surgical technique groups and subgroups

Surgical technique subgroups		*No.*	*%*
Group I: Local flaps group	Perforator- based propeller flap	2	5.0
	Distally-based posterior interosseous artery flap	9	22.5
Group II: Regional flaps group	Distally-based radial forearm flap	7	17.5
	Dorsal ulnar artery flap	1	2.5
Group III: Distant pedicled flaps group	Pedicled groin flap	12	30.0
	Pedicled abdominal flap	3	7.5
Group IV: Distant free flaps group	Free anterolateral thigh flap	3	7.5
	Free radial forearm flap	1	2.5
	Free fibular osteocutaneous flap	1	2.5
Group V: Combined flaps group	Combined Distally-based posterior interosseous artery & pedicled groin flaps	1	2.5

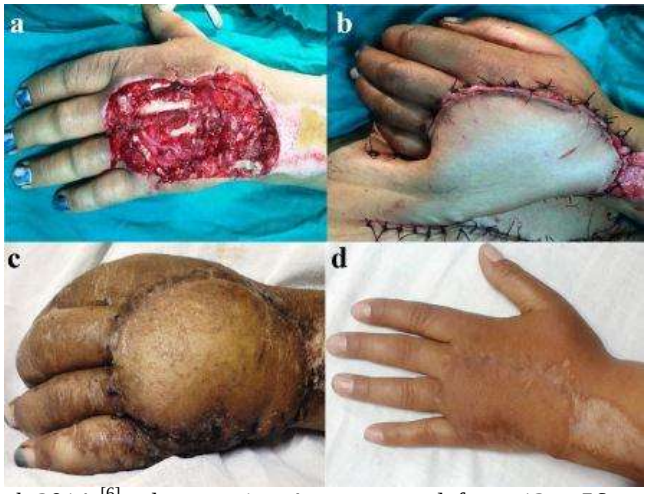
Comparing the relation between surgical technique groups and Quick DASH score; the best result was for local and regional flaps groups. The overall complication rate was 12.5%. The most common complication was partial skin necrosis and represented 10% of all complications. Three patients were unsatisfied due to the bulkiness of the flap and later on two of them underwent debulking as shown in Figure 4. Twenty five patients were unsatisfied about their hand functions and represented 62.5%.

4. Discussion

The objective in the management of soft tissue injuries of the hand is to achieve primary wound healing that minimizes the inflammatory reaction, scar formation and joint stiffness [5].

The age of the patients ranged from 4 to 62 years with a mean age of 23.2 ± 13.8 years. Most of them were in the third decade of life. This is consistent with *Aboelatta et al.,2014* [6] whose patients' ages ranged from 12 - 56year with a mean of 25 years and the most affected age group was 20 - 30 years. These figures markedly alert to the magnitude of socio-economic impact these injuries have. The great economic burden is exemplified by the loss of working man power, unemployment, time lost from work, sick-leave with payment, compensations, dependency on charity funding and others.

Figure 4: Pedicled groin flap for large-sized dorsal soft tissue defect of the left hand of 35 years female; a: preoperative defect, b: Immediate postoperative after 1st stage (Flap inest), c:Recent postoperative after 2nd stage (Flap separation), d: Late postoperative after debulking.



There male to female ratio of 7:1 which is similar to the results of *Elias, 2010* [7] who mentioned male to female ratio of 7 : 1. According to this study, road traffic accidents (RTA) were the most common cause of injury which is different from *Elias, 2010* [7] who had machine injuries as the most common cause of injury followed by RTA with percentage of 55.7% and 11.9% respectively. From this comparison, it appears that RTA are on top list of hand injuries' causes in Egypt and it could be preventable. It has been noted that a factor for prevention of hand injury with car accident is to avoid putting hand outside the windows of vehicles.

Studying the effect of the site of injury according to T-T-T classification on Quick DASH score; the combined injury showed the worst Quick DASH score values followed by the transverse mutilation group which had quite similar values, while the least affected group were the patients with palmar mutilation. This can be explained as the combined injury and the transverse mutilation affected both the hand skeleton and soft tissue while the palmar mutilation mostly involved soft tissue only. This result could be assured by the study done between the types of injury according to T-T-T classification and whether there was associated tendon and/or skeletal injury or not, from which we noticed that the incidence of associated tendon and/or skeletal injury was 100% in both combined and transverse injury while it was only 25% with palmar mutilation.

The relation between presence of tendon and/or skeletal injuries and Quick DASH score values in different age groups was studied and there was significant difference patients presented with soft tissue defect only. Patients in the 4th decade of life had significantly better Quick DASH score values (2 ± 0) compared to patients above the 5th decade who had very bad Quick DASH score values (75 ± 0). This gets attention to the important role of patient compliance to the postoperative physiotherapy program which was much better with younger adults.

In this study; the largest group of patients was regional flaps group and included 17 patients (42.5%) and the smallest was the combined flaps group which had only one patient (2.5%).

The large number of patients in the regional flaps group in spite of the recent era of microvascular surgery can be explained by their numerous advantages which include relatively constant and reproducible vascular anatomy, allow for variation in size, shape, and design with tissue that is thin, pliable, quite similar and often hairless. They can be harvested under regional block and they enable early start of physiotherapy so improve the net result of hand function.

In comparing the three regional flaps used, we found that distally-based posterior interosseous artery flap was the most commonly used and this is due to its numerous advantages over the distally-based radial forearm flap. The distally-based posterior interosseous artery flap doesn't require sacrifice of any major vessel essential for perfusion of hand, the muscular bed of the donor defect is more readily accepting a skin graft than the donor defect seen in the radial forearm flap and it can also be used in situations where a radial forearm flap would be inappropriate as in crush injuries or when the vascular arcade should be maintained for future anastomosis, such as toe to hand.

The distally-based posterior interosseous artery flap was performed in nine patients in whom it survived completely and only one patient suffered partial skin necrosis due to venous congestion which healed conservatively with repeated dressings. This is consistent with the results of *Fujiwara et al., 2003* [8] and *Balakrishnan et al., 2003* [9] who reported similar flap survival rates and a similar range of complications.

The dorsal ulnar flap was applied only in one patient because in spite of its numerous advantages -as it doesn't sacrifice any of the major pedicles for hand vascularity, suitable for large defects, has good venous drainage with less incidence of venous congestion and no visually exposed donor site defect- it has important drawbacks which include short vascular pedicle, suitable only for proximal hand defects, relatively small arc of rotation and the donor of the flap is very close to the hand so only suitable for limited injuries.

The second main group is the distant pedicled flaps group which were performed in 15 patients of this study. Despite the known disadvantages of the pedicled groin and abdominal flaps -as relatively thick flap especially in obese patients that sometimes needs secondary debulking, multi-stage procedure (harvesting and inset, separation and debulking), unfavorable immobilization for prolonged period (at least three weeks) and high risk of infection- but they still have irreplaceable characteristics which are providing large donor to cover even major defects with still preserving the vascular arcade of the hand if it should be maintained for future anastomosis, such as toe to hand transfer and also very simple surgical technique that can be performed without special needs like distant free flaps. This is consistent with *Hurren& Cormack, 2000* [10] who mentioned that the distant pedicled flaps were proven useful in closing defects on the dorsum of the hand providing aesthetically and functionally excellent results and *Harii, 1998* [11] who considered the groin flap one of the most versatile flaps for coverage of skin and soft tissue defects of the hand in spite of development of many other conventional methods.

One of the groups with limited number of patients is the distant free flaps group which had five patients. This limited use of distant free flaps is due to their complex surgical technique which needs microsurgery training and special equipment, extended operative time that may be not suitable with the patient general condition and the need for close postoperative monitoring. The value of free flaps also confirmed by *Willcox & Smith, 2000* [12] who mentioned that free flaps were considered a highly complex procedure, but now it is the option of choice. In our study; distant free flaps represented an excellent solution for certain complex defects such as the free fibular osteocutaneous flap in case of composite defects including large segment bone loss(four medial metacarpals) along with the whole dorsal aspect skin. The free anterolateral thigh flap -performed in three patients- provided a very wide surface flap that can be less bulky than pedicled abdominal and groin flaps with extra option of incorporated sensory supply to design a neurocutaneous flap as in one of our patients who had sensate anterolateral thigh flap for coverage of ulnar side of the hand and proximal forearm after medial three fingers amputation. The size of the defect in these three cases ranged from 11 x 7 cm to 20 x 8 cm which is consistent with the results of *Javaid& Cormack, 2003* [13] who reported defect sizes ranged from 10 x 7 cm to 20 x 10 cm in a series of seven patients.

The other group with limited number of patients is the local flaps group. We used perforator-based propeller flaps in only two patients. Although perforator-based propeller flaps have many advantages as mentioned by *Ono et al., 2011* [14] that it combines the advantages of pedicled local flaps (good tissue match), pedicled regional flap (180° arc of rotation), pedicled distant flap (reliable), and free flap (tissue away from zone of injury) but their major drawback is that the perforator must be intentionally twisted to allow the flap to rotate and they are only suitable for small-sized defects.

A special surgical technique group is the combined flaps group which had only one patient with special situation of amputated medial four fingers along with dorsal and palmar soft tissue loss. In this case we needed a very large donor for coverage beyond the limits of any single flap without compromising the vascular arcade of the hand, so we used the distally-based posterior interosseous artery flap for

dorsal coverage along with pedicled groin flap for palmar coverage in the same setting.

To study the effect of type of surgical technique applied on the hand function, a correlation made between the type of the flap applied and the Quick DASH score of the patients and there were significantly lower values obtained with local and regional flaps (3.5 ± 7.0 and 14.7 ± 20.1 respectively) which permit earlier start of physiotherapy than values obtained with distant pedicled flaps (39.9 ± 28.6).

On studying the effect of the size of the defect on the surgical techniques applied; there was considerable relation as local flaps were performed in small-sized defects only, regional flaps were performed in medium-sized defects mostly (70%), distant pedicled flaps were mostly performed with large-sized defects (73.3%) and distant free flaps were done in cases with large-sized defects only.

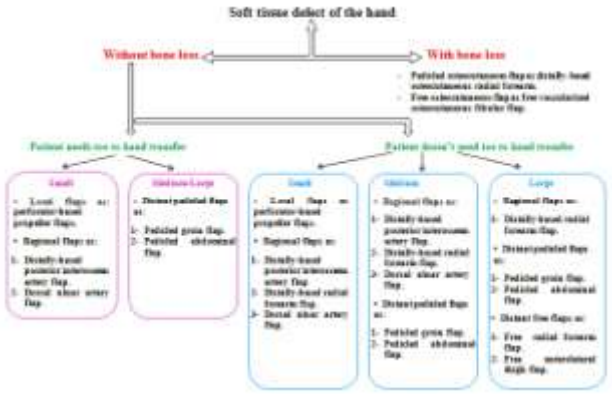
Concerning regional flaps group, our results are consistent with that of *Sami & Kadry, 2013* [15] who transferred flaps of size range between 60 - 120 cm^2 and concluded that distally-based axial pattern radial forearm flap is reliable, easy to execute and represents a good indication not only for small and medium sized defects but also for large defects of the hand.

Patient satisfaction was evaluated from two points of view. The first was the aesthetic result of the hand following soft tissue reconstruction, and for this point we had three unsatisfied patients due to the bulkiness of the flap; two of them underwent secondary debulking.

The second point is the net result of hand function at the time of evaluation (six months postoperatively) and we had 25 unsatisfied patients (represented 62.5%). We correlated between this large number of unsatisfied patients and their Quick DASH score and found significant difference of their values (33.4 ± 11.7) comparing them to the score values of satisfied patients (19.1 ± 6.8). This result with that of *Elias, 2010* [8] who mentioned 143 unsatisfied patients (represented 56.5%) and this indicates how challenging is treating hand injuries.

As a final result; reconstruction of post-traumatic soft tissue defects of the hand can be summarized in the form of the diagram shown in Figure 5.

Figure 5: Diagram summarizing reconstruction of post-traumatic soft tissue defects of the hand.



Resulting from this work, we can conclude that every method has its advantage and disadvantage and that all methods are important and should be kept in mind to reach the proper decision for soft tissue reconstruction of the hand. Also; proper postoperative physiotherapy and rehabilitation is essential to improve the functional outcome of the hand and to ensure good results.

Although of all efforts presented, the management of untidy hand injuries stills a challenging problem that arouses the skill of a multi-displinary approach to obtain the maximal functional and cosmetic result.

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