Original Research Article

Radial Forearm Flap versus Radial Adipofascial Perforator Based Flap for Reconstruction of Hand Soft Tissue Defects.

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Background: **Reconstruction of soft tissue defects of the hand possesses a challenge to the plastic and reconstructive surgeons. In recent years, the radial forearm fasciocutaneous flap has been used extensively to cover hand soft tissue defects. With the routine use of this flap some drawbacks have become apparent. The need to sacrifice the radial artery during the harvest of the flap and the donor site morbidities. The limitations of the radial forearm flap and further understanding of the vasculature of the forearm have led to the development of other pedicled forearm flaps based on the perforators from the radial, artery. This study aimed to compare the radial forearm flap with the radial adipofascial perforator based flap for reconstruction of hand soft tissue defects.** *Methods:* **This study included twenty patients with post-burn and post-traumatic soft tissue defects in the hand were randomized into a prospective, double-blind, controlled clinical trial. They were placed into two equal groups: Group A(Chinese flap group) for whom distally based radial forearm flap was used for coverage of hand soft tissue defects and group B(Perforator flap group) for whom distally based radial adipofascial perforator based flap was used. Operative time, length of hospital stay, incidence of complications, donor site morbidity and patient satisfaction were assessed for all patients.** *Results:* **There were no significant differences between both groups as regard to age, sex, aetiology and site of soft tissue defects. On the other hand, the operative time (68±3.4 mins versus 80±4.2 mins), length of hospital stay (8.8±0.8 days versus 13.6±1.5 days) and the incidence of complications (30% versus 80%) decreased significantly in the Chinese flap group versus the perforator flaps group. While there was an increase in the cosmetic satisfaction in the perforator flaps group, but didn't reach the significant level (p=0.074).** *Conclusion:* **Distally based radial forearm flap remains the cornerstone for reconstruction of hand soft tissue defects with acceptable cosmetic results and low incidence of complications provided that adequate preoperative vascular assessment. The radial adipofascial perforator based flap is a new innovative technique requires further anatomic studies for more accurate assessment of the forearm perforators with their angiosome distribution and regarding the matter of immediate or delayed skin graft, it is obvious that delayed grafting has superior results but further evaluation studies are recommended.**

Keywords: Radial forearm flap, Perforator flap, Adipofascial flap, Hand defects

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INTRODUCTION

Adequate soft-tissue coverage is a cornerstone for successful hand reconstruction allowing for hand mobilization and rehabilitation to yield the best functional result.[1,2] Multiple options of local, regional and distant flaps exist to cover the soft tissue defects of hand injuries.[3,4] The forearm is a suitable candidate for vascularized flaps to cover the hand soft tissue defects.[5,6]

Since the original description of the radial forearm flap (chinese flap) in 1978 by Yang and Yuzhi [7], this versatile flap has found numerous applications in plastic and reconstructive surgery. Its value in head and neck reconstruction [8,9] and lower extremity reconstruction is well documented.[10] Also, this flap gained a great popularity in hand and finger soft-tissue reconstruction being a thin, pliable and having rich vascular network after first used by Lin et al. in 1984.[11]

The use of the traditional chinese flap encountered with hand ischemia [12] digital ischemia [13], chronic vascular insufficiency [14] following radial artery division and a skin graft may present a problem at the donor site, particularly if the paratenon of the exposed tendons was not well preserved. Traditionally, cosmesis of the donor site was unsatisfactory. [15]

Over the past decade, the distal radial artery perforator flap based on the small perforators around the radial styloid process and the longitudinal chain-linked vascular plexuses was described.[16-19] It has been used both as a fasciocutaneous flap and as an adipofascial flap, either alone or in combination with a skin grafting for hand wound coverage.[20,21]

In 1988, Chang et al.[16] described a radial forearm reverse fasciocutaneous flap that did not include the radial artery. In their report, this procedure was successful in all 10 cases of hand reconstruction in which it has been applied. To elucidate the vascular basis of this new flap, Chang and Chen [22,23] performed an anatomic study in 1990 of 14 fresh cadaver forearms, then designed a distally based radial forearm fascial flap for hand reconstruction. In this study, they found about 10 small branches (0.3 to 0.8mm in diameter) extending from 1.5cm above the radial styloid process to the bifurcation of the radial artery. These perforators pass through the septum, fan out on both surfaces of the deep fascia, and form a rich, chain-linked longitudinal plexus of the integument along the course of the main artery, the septum, the fiber of the deep fascia, and the superficial vein. The venous system of the deep fascia drains blood to the profunda venae comitantes directly through the concomitant perforating veins. [24]

Fascial and adipofascial flaps have the obvious double advantage of allowing direct donor-site closure with no sacrifice of the radial artery, eliminating the two traditional drawbacks of the radial forearm flap donor site. [25,26]

This study was undertaken to compare the radial forearm flap with the radial adipofascial perforator based flap for reconstruction of hand soft tissue defects.

MATERIALS AND METHODS

This study included twenty adult patients, of both sexes, aged between 20-55 years, who were admitted for soft tissue defects in the hand either due to trauma, deep burn debridement or surgical release of post-burn contracture scar. These patients were admitted to the Plastic and Reconstructive surgery Unit of Tanta university Hospital between July 2011 and July 2013. Patients with major forearm vessel injury and those with defects can be closed primarily or by using STSG were also excluded from the study. All patients were subjected to full history taking, detailed clinical examination to determine the extent of the missing tissues, X-rays were done to assess skeletal affection and duplex was done for localization of the vascular pedicle and to assess the continuity of palmar arches. Informed consent was taken from all patients.

All patients were randomized according to the sequence of their hospital admission into two equal groups:-

1) Group A (Chinese flap group) for whom distally based radial forearm flap was used for coverage of hand soft tissue defects.
2) Group B (Perforator flap group) for whom distally based radial adipofascial perforator based flap was used.

Preoperative Planning

An Allen's test was done in the chinese flap group to secure perfusion of the palmar arch by the ulnar artery alone. With the patient in supine position and the arm on an arm table, the course of the radial artery is marked on the forearm and a template of the defect is created. The template is then centered over the course of the artery. The radial styloid process and the pivot point for the perforator flap group was marked 3cm proximal to radial styloid process.

Preoperative photography and injection of I.V antibiotics for all patients. Patients were fully anesthetized and pneumatic tourniquet was applied to provide bloodless field. Surgical debridement of the wound in cases with trauma or deep burn. Four cases suffered from injured tendons which was repaired primarily.

Dissection

Chinese flap group (Figure 1)

After closure of the tourniquet, the skin is incised and the radial artery is visualized distally. Dissection begins over the ulnar aspect of the flap moving radially in the subfascial plane. The fascia may be sutured to the overlying skin to reduce shear forces on the flap. While raising the flap, it is critical to preserve the paratenon of the flexor carpi radialis (FCR) tendon, as this area is at a high risk for loss of the donor site skin graft. Dissection is continued between the muscle and the septum towards the radius. Care should be taken to preserve the septocutaneous perforators to the skin paddle. After the septum is reached, the dissection proceeds from radial to ulnar, beginning subfascially over the brachioradialis muscle until the septum is reached from the radial side. With the muscle retracted radially, the radial artery and the concomitant veins are exposed within the septum.

The superficial branch of the radial nerve is found laterally to the septum and should be separated. The septum with its contents is then traced in a proximal to distal direction. Once the proximal tip of the flap is reached, the artery is separated from the surrounding tissue. To ensure sufficient perfusion of the flap and the hand, the vessel is proximally clamped after release of the tourniquet. The pedicle is then divided. The flap is rotated and sutured into the defect either through a subcutaneous tunnel or an open connection between the donor site and the defect. We usually prefer to open the skin bridge between the pivot point and the defect because the course of the vascular pedicle can be controlled more effectively to avoid

Fig.1

Figure 1. (A). A 30 year old male with posttraumatic injury to 1st web space. **(B).** Intra-operative pictures showing raising of the Chinese flap. **(C).** Insetting of the flap with covering the donor site with STSG. **(D).** Postoperative pictures showing good functional and cosmetic results.

compression. The donor site was closed by split thickness graft in all cases.

Perforator flap group (Figure 2)

Curved skin incision where the line marking radial artery is centralized within the skin incisions. Subdermal skin dissection was done where flimsy of subcutaneous fat was left within the skin flap. Skin flaps were dissected in both sides of the incision for a distance more than the width of the defect needed to be covered for a maximum width 10cm. Skin flaps were retracted by sutures. Elevation of the adipofascial layer then done., again, the distance between the pivot point and the distal limit of elevation should be equal to that between the pivot point and the distal limit of the defect. Elevation of the flap was started from the ulnar side, then from the radial side and left attached in the middle along the course of the radial artery by the perforators. Cephalic vein was ligated in 2 cases and spared in 8 cases. Superficial radial nerve was preserved in all cases.

Separation of the flap by dissection of radial artery perforators from proximal to distal till reaching the pivot point. Removal of the tourniquet then done. The vascularity of the flap was assessed. Haemostasis of the donor site was done using coagulation diathermy. The setting of the flap on the site of the defect was done by turning it over to the defect after incision of the skin bridge between the pivot point of the flap and the defect. Primary closure of the donor site was done with vaccum drain. The surface of the flap was covered by split thickness skin graft either immediately in 6 cases or one week later in 4 cases.

Postoperative: A posterior splint was applied for all patients to avoid wrist motion. 1st dressing was done after 5 days during which skin graft take and healing of donor site of the forearm were assessed. Operative time and length of hospital stay were assessed for all patients. The occurrence of complications was carefully observed as flap necrosis, graft loss, bleeding, infection and donor site morbidity. Patient satisfaction was assessed as regard to the function of reconstructed sites and cosmoses of reconstructed and donor sites.

Statistical analysis: Data are presented as means and standard error of the mean (SEM). The incidence of complications, patient satisfaction and other qualitative parameters were compared by using the chi-square test. Operative time, length of hospital stay means between groups and other quantitative parameters were analyzed by unpaired Student's t-test. The level of significance was set at $p < 0.05$.

RESULTS

Twenty adult patients were included in this study, 12(60%) males and 8(40%) females. Nine defects were due to trauma, ten defects were created after surgical release of post- burn contracture scar and one defect was created after deep burn debridement. 16(80%) patients were suffering from loss of skin and soft tissue of the hand with exposure of the tendons, while 4(20%) patients had skin and soft tissue defects associated with tendon injuries which were repaired primarily. 17(85%) defects were on the dorsum of the hand, while 3(15%) defects were over the 1st web space. There were no significant
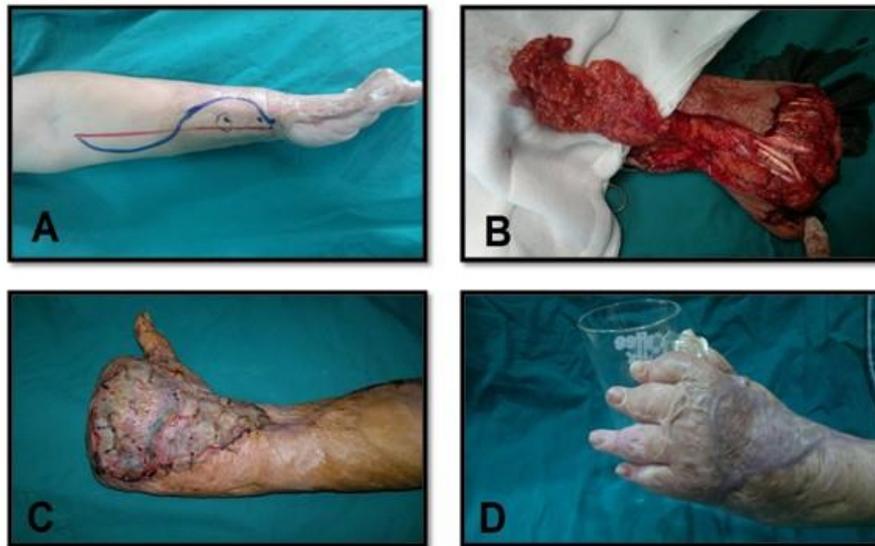
Fig.2

Figure 2.(A). A 28 year old female with postburn contracture on the dorsum of the hand with marking of the pivot point 3cm above radial styloid process. **(B).** Intra-operative pictures showing harvesting of the adipofascial flap. **(C).** Delayed grafting of the adipofascial flap after 1 week. **(E).** Postoperative pictures showing good functional and cosmetic results.

differences between both groups regarding age, sex, aetiology of the defect, the defect character and site. The defect size range was from 35-90cm^2 in the chinese flap group and was from 30-95 cm^2 in the perforator flap group, while the flap size range was from 45-95cm^2 in the chinese flap group and was from 40-100 cm^2 in the perforator flap group. There were no significant differences between both groups regarding the defect and the flap size.(Table 1)

The operative time and the length of hospital stay were decreased significantly in the chinese flap group compared to the perforator flap group (p=0.041 and p=0.013 respectively). In the chinese flap group one patient suffered from distal flap necrosis, this was probably attributed to the turnover pattern of the flap insetting at the 1st web space, one patient suffered from partial graft loss at the donor site and one patient had infection at the site of the flap. The three cases were treated conservatively. On the other hand, in the perforator flap group, one patient had mild bleeding from the flap, two patients suffered from distal flap necrosis due to venous congestion, two patients had ischemia at the edges of the donor site due to superficial dissection, one patient had infection at the donor site and two patients suffered from near total graft loss from those which were done immediately.

All cases were treated conservatively except the two cases that lost the grafts, regrafting was done after 10 days. There was significant reduction in the incidence of complications in the chinese flap group compared to the perforator flap group (p=0.025). As regards patient satisfaction, the functional satisfaction didn't differ significantly between both groups, while the cosmetic satisfaction increased in the perforator flap group compared to the chinese flap group but didn't reach the significant level (p=0.074). (Table 2)

DISCUSSION

Soft tissue reconstruction of the hand remains a challenge for the hand surgeons. Over the past decade, the traditional chinese flap was the surgeon's first choice whenever the local resources are exceeded. Still, this type of chinese flap would present two main drawbacks.[27] Since the distal radial artery perforator flap has been described, it has become a very popular loco-regional flap for hand reconstruction.[16,28] By using these flaps instead of the traditional chinese flap, one can overcome the two major disadvantages of the chinese flap: the conspicuous donor site and the sacrifice of the radial artery. [29] In this study, we aimed to compare the classical radial forearm flap with the radial adipofascial perforator based flap for reconstruction of hand soft tissue defects.

Twenty adult patients with hand soft tissue defects were enrolled in this study. The patients were randomly divided into even groups. There was no significant difference between both groups as regards the demographic data, but we observed a predominance of hand injuries in young adult males, which is consistent with other studies. [6,25,30,31,32]

In our series, nine patients had post traumatic hand defects while eleven patients had post burn hand defects. Similar to our study and findings, El-Sabbagh et al. [33] studied the application of the reversed radial forearm flap for the coverage of various areas of hand injuries and found eight cases were due to mechanical trauma and seven cases were post burn.

Our study demonstrated sixteen cases with exposed tendons and only four cases with injured tendons. In similar study, Maamoun et al. [30] evaluated the role of the use of adipofascial perforator based radial forearm flaps in the coverage of hand defects in 15 cases. Five cases with exposed tendons and seven cases with exposed bones and

Table (1): Demographic data of patients

Variable	Chinese flap group n=10	Perforator flap group n=10	p Value
Age(yrs), mean± SEM	35.2±4.3	32.7±3.3	**NS**
Sex, n Male Female	 7 3	 5 5	**NS**
Aetiology, n Trauma Burn	 5 5	 4 6	**NS**
Defect character, n Exposed tendons Injuried tendons	 7 3	 9 1	**NS**
Defect site, n Dorsum of hand 1st web space	 8 2	 9 1	**NS**
Defect size(cm^2), mean± SEM	58.5±5.1	59.5±6.1	**NS**
Flap size(cm^2), mean± SEM	69±5.2	71±5.7	**NS**

Table (2): Outcome data

Variable	Chinese flap group n=10	Perforator flap group n=10	p Value
Operative time(minutes), mean± SEM	68±3.4	80±4.2	**0.041**
Length of hospital stay(days), mean± SEM	8.8±0.8	13.6±1.5	**0.013**
Complications, n(%)	3(30%)	8(80%)	**0.025**
Functional satisfaction, n(%)	7(70%)	6(60%)	**NS**
Cosmetic satisfaction, n(%)	3(30%)	7(70%)	**NS(0.074)**

tendon and one case of contracted first web space, one case of exposed metacarpophalengeal joint with its tendons and another case of exposed wrist joint with bone and tendon exposure.

We found that seventeen patients in our series had their defects on the dorsum of the hand, while the remaining three patients had 1st web space defects. In another study by Cheema et al.,[4] the most common soft tissue defects were in the area of palm and there were eight cases in his group while in three cases flap was wrapped around the thumb. Web space defects were covered with this flap in two cases. Two cases required coverage of amputation stump at transmetacarpal level and yet another required a big flap to cover the soft tissue defects at palm, dorsum and thumb. They concluded that radial forearm flaps can be used to cover most of the defects at palm, dorsum, around the thumb and the first web space.

This series witnessed no significant difference between both groups as regards the defect and the flap sizes. We observed that the flap size range was from 45-90 cm^2 in the Chinese flap group and was from 40-100cm^2 in the perforator flap group. Unlike our findings, Al-Najjar et al.[31] found the size of the transferred flaps ranged from 12-63 cm^2 and concluded that distally based radial forearm flaps can be used with small to moderate size tissue defects of the hand.

Our findings are consistent with that of Sami et al.,[6] who transferred flaps of 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. They are also consistent with the findings of Ignatiadis et al.,[32] their flap size ranged between 18-120 cm^2 and concluded that distal ulnar and radial artery fascial or adipofascial perforator flaps are extremely useful for the reconstruction of severe defects of the hand with covering ability may range from an individual finger to the entire dorsum of the hand.

The pivot point for the Chinese flap group was fixed at the radial styloid process which is consistent with many other studies. [29,31,33,34] While, the pivot point point for the perforator flap group was fixed at minimum 3cm proximal to the radial styloid process which is consistent with Chang and Hou [28] who proposed the pivot point between 2-4 cm above the radial styloid process. While, Weinzweig et al.[20] who introduced distally based radial forearm fasciosubcutaneous flap with perforators situated 5-8cm above the radial styloid process. Saint-Cyr et al.[26] demonstrated a large-caliber perforator was found to be present within 2 cm of the radial styloid in all of the 26 cadaver forearms dissected.

We noticed that there was a significant decrease in the operative time in the Chinese flap group compared to the perforator flap group (68±3.4 mins versus 80±4.2 mins) (p=0.041). In a similar study, Ignatiadis et al. [25] found that distal ulnar and radial artery adipofascial perforator based flaps are easy to elevate with operative times usually less than one and half hours.

We observed that the length of hospital stay decreased significantly in the Chinese flap group compared to the perforator flap group (8.8±0.8 days versus 13.6±1.5 days) (p=0.013). Contrary to our results, Maamoun et al., [30] in the study of adipofascial perforator based flaps to cover hand defects, found that the patients' hospital stay ranged between 5-15days with an average of 7.5 days. However, this could be attributed to immediate grafting of all adipofascial flaps and also due to lower complication rate (46%) in their series.

In this study, the incidence of complications decreased significantly in the Chinese flap group compared to the perforator flap group (p=0.025). The sacrifice of radial artery after a satisfactory Allen's test has not been associated with either acute or chronic hand ischemia which is consistent with many other studies. [4,6,29,34] Only one case of acute ischemia after harvest of the radial artery has been published.[35] Meland et al.[36]reported on 13 consecutive patients without vein grafting of the radial artery that showed a delay in rewarming of the hand after 1 min, but no further difference after 5 min. Brodman et al.[37]and Suominen et al.[38] stated that doppler studies showed an increase in the ulnar artery diameter and in the ulnar artery blood flow with a higher peak flow velocity as well as a higher ulnar/brachial artery peak flow velocity ratio.

In the Chinese flap group one case had distal flap necrosis due to venous congestion which is consistent with Ghadimi et al.[34] who studied the use of sensate reverse island radial forearm flap in thirteen patients with thumb degloving injuries and reported one case with venous congestion and partial flap necrosis. Our data confirmed Emerick et al.,[39] who identified only one patient out of 54 who had a partial graft loss at the donor site with delay in the wound healing.

Two patients in the perforator flap group had distal flap necrosis due to venous congestion which agreed the findings of Chang and Chen[40], who demonstrated that the large, superficial, cephalic vein has no positive role for flap survival; it can't help venous drainage by reverse flow through valves, but it does conduct venous blood from the hand to the flap, causing congestion and swelling that are hazardous to flap viability. In the perforator flap group two patients suffered from near total graft loss from those which were done immediately. In the study performed by Maamoun et al.[30] four cases out of 15 had a partial graft rejection and needed regrafting.

Our study reported no significant difference between both groups as regards the functional satisfaction. Similarly, Megerle et al.[29] found that postoperative range of motion is rather dependent on the cause and extent of the primary defect rather than the type of reconstruction.

We observed improvement in the cosmetic satisfaction of the patients in the perforator flap group compared to the Chinese flap group but didn't reach the significant level (p=0.074). Many suggestions have been published regarding this issue. Mühlbauer et al.[41] recommended restricting flap harvesting to the palmar forearm. Karimi et al.[42] suggested that the coverage of flexor tendons, together with purse string closure and local meshed skin graft would allow a direct closure of small to medium size defects while reducing the defect size (of up to 70%) and enhance the final esthetic outcome. Gupta et al.[43] concluded that the use of preoperative tissue expanders significantly reduces the morbidity rates of RFF donor site and may allow primary closure of the donor site.

In a recent study, Lee et al.[44] evaluated the long-term functional and esthetic outcomes of radial forearm flap (RFF) donor site repaired with split thickness skin graft (STSG) and found 21% of the patients (4/19) were satisfied with the cosmetic result while 32% (6/19) found it acceptable. In

another study, El-Sabbagh et al. [33] harvested the reversed radial forearm flap in 15 cases and reported that none were dissatisfied with the appearance of the donor site. Although it leaves an unsightly scar at the donor site, in our population, no patient considered this to be a serious disadvantage.

CONCLUSION

Distally based radial forearm flap remains the cornerstone for reconstruction of hand soft tissue defects with acceptable cosmetic results and low incidence of complications provided that adequate preoperative vascular assessment. The radial adipofascial perforator based flap is new innovative technique requires further anatomic studies for more accurate assessment of the forearm perforators with their angiosome distribution and regarding the matter of immediate or delayed skin graft, it is obvious that delayed grafting has superior results but further evaluation studies are recommended.

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