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Case Report

Chinese forearm flap technique in thumb injury: a case report

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ABSTRACT

Hand injuries which involve substantial skin loss require immediate soft tissue cover to achieve early wound closure and to minimize wound infection and scarring. In 1978, Dr. Yang Guofan and Dr. Chen Baoqui described a flap from the forearm based on the radial artery or Chinese Forearm Flap. A 30-year-old male was admitted to the emergency room because of crush injury. From physical examination we found crush injuries of left hand followed with open wound between 1st and 2nd finger at dorsal and palmar side with muscle, tendon, and bone exposed, with open dislocation left 1st carpometacarpal joint, open fracture dislocation left 1st metacarpophalank joint, open fracture Left Base 2nd, 4th metacarpal, open dislocation 3rd base metacarpal, open fracture left trapezoid, open left trapezium. Soft tissue injuries of the hand which require flap cover pose a problem mainly because of the apparent lack of availability of local tissue. Wound healing problems can result in an impaired functional outcome. For complication, initially, sensory disturbances can be found in 17-75% but decrease during the next months. This radial forearm flap method of post-traumatic thumb reconstruction nowadays doesn't require expert microsurgical knowledge, which is indispensable in case of replantation or revascularization of the amputated thumb. Correct planning and elevation presupposed the flap success rates average at least 90% with no relevant limitations in strength, motion and hemodynamics in the forearm or hand and non-disturbing sensory and cosmetic outcome at the donor site.

Keywords: Forearm flap, Hand injury, Skin graft, Thumb reconstruction

INTRODUCTION

Hand injuries which involve substantial skin loss require immediate soft tissue cover to achieve early wound closure and to minimize wound infection and scarring. Skin grafts have only limited use in such cases because "graft-take" is dependent on the vascularity of the recipient bed. Skin grafting techniques remain suitable for superficial defects, but more extensive damage involving deeper structures frequently requires flap cover. Exposure of tendon or bone and the relative avascularity which often accompanies hand trauma may warrant a soft tissue covering which can provide its blood supply.

The choice of soft tissue reconstruction is not confined to the immediate problem of wound closure. Even in the acute stage of treatment consideration should be given to the quality of this soft tissue covering, bearing in mind the possibilities of subsequent reconstruction. Until now, only relatively small defects have been covered by local flaps whereas larger defects have required the use of distant flaps.

In 1978, Dr. Yang Guofan and Dr. Chen Baoqui described a flap from the forearm based on the radial artery or Chinese Forearm Flap. The initial pioneering work performed in China led to the development of a free flap technique which proved to be versatile and reliable in widely differing clinical situations.[1-3] Initially this free

flap was used to reconstruct contra-lateral and injuries, but subsequently, it was shown that the same flap could be pedicled distally on the radial artery, venae comitantes, and cephalic vein and used as an island flap to cover the ipsilateral hand. Stock et al, reported two successful cases in the German literature using this island flap technique and Biemer and Stock reported an extension of the method to incorporate a segment of bone as an osteocutaneous flap in a case of reconstruction of the thumb.[4,5] The forearm appears to offer a suitable and convenient donor site for a local island flap which can be pedicled distally and transposed to reconstruct soft tissue defects in the hand. The vascular basis of this flap is described, and its use in the management of soft tissue injuries of the hand is shown in three different clinical situations.

CASE REPORT

Figure 1: Clinical picture of the injury at emergency room.

A 30-year-old male was admitted to the emergency room because of crush injury. The patient had motorcycle accidents. When his motorcycle hit the side of a truck then fell with his left hand bumped to the asphalt. The patient came to Emergency Department 3 hours after an accident. From physical examination we found crush injuries of left hand followed with open wound between 1st and 2nd finger at dorsal and palmar side with muscle, tendon, and bone exposed, with open dislocation left 1st carpometacarpal joint, open fracture dislocation left 1st metacarpophalank joint, open fracture Left Base 2nd, 4th metacarpal, open dislocation 3rd base metacarpal, open fracture left trapezoid, open left trapezium. The capillary refill time was poor only at the thumb. The other is still normal limit. From active movement, we found all the finger was limited in motion because of pain (Figure 1) (Figure 2) (Figure 3) (Figure 4).

Figure 2: Radiological picture of the injury at emergency room.

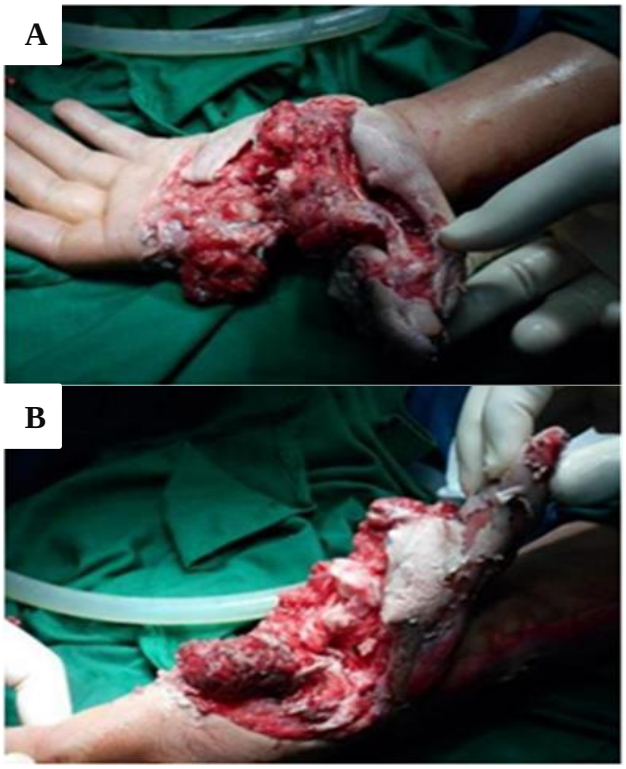

Figure 3: Clinical picture of the injury at durante operation.

The primary surgery was a damage control procedure with debridement, repair tendon and wiring at 1st carpometacarpal, 2nd, 3rd, and 4th metacarpal. And also support with backslab immobilization. After observation, the thumb was becoming darken and necrotic. We wait until four weeks after 1st surgery to see the demarcation. The necrotic demarcation is at 1cm above carpometacarpal region (Figure 5).

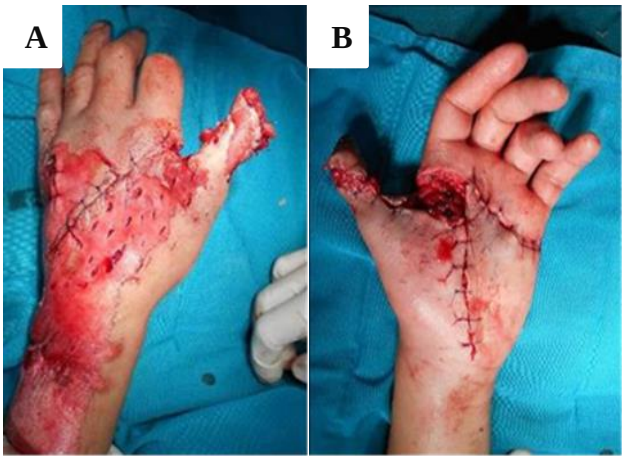

Figure 4: Clinical picture of the injury at after operation.

Figure 5: Clinical picture 1 month after 1st operation.

The 2nd surgery was the reconstruction of thumb with Chinese forearm flap procedure. The injuries included incomplete left thumb amputation from proximal phalanx level to distal with the avulsion-amputation mechanism.

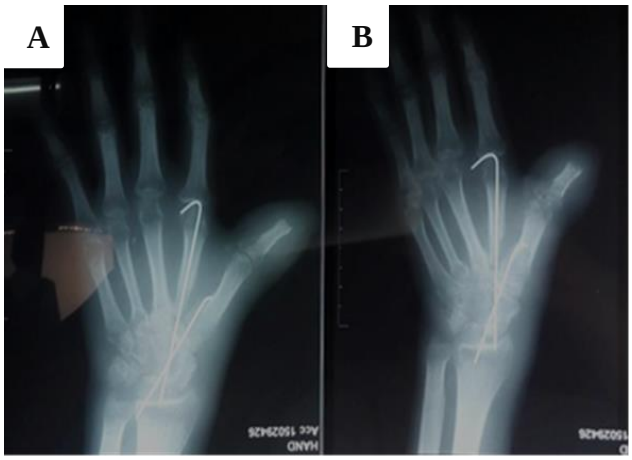

Figure 6: Radiological picture after 2nd operation.

Figure 7: Clinical picture after 1 month after 3rd operation.

The patient was disqualified from thumb replantation procedure, but instead, it was proposed to him to run a secondary reconstruction by means of the radial artery flap, to which the patient agreed. The operating procedure took approximately 3.5 hours. Post-operative progress with thumb swelling, without flap necrosis, and minimal cicatrix (Figure 6).

The 3rd operation is removing the wire. The post-operative progress proved successful. The patient uses the thumb for everyday work with a minimal limitation of grasping, and patient completely satisfied with it (Figure 7) (Figure 8).

Figure 8: Clinical picture after 6 months after 3rd operation.

DISCUSSION

The radial forearm flap is a fasciocutaneous flap based on the radial artery which together with its two venae comitantes lies invested in a condensation of the deep fascia known as the lateral intermuscular septum. This septum separates the flexor and extensor compartments of the forearm and is attached to the periosteum of the radius distal to the insertion of pronator teres.

Soft tissue injuries of the hand which require flap cover pose a problem mainly because of the apparent lack of availability of local tissue. In the past, such defects have required the use of distant flaps and the development of these flaps in hand surgery has been described by Lister et al, and McGregor.[6,7] These methods require the attachment of the injured limb to another part of the body with unavoidable restriction in the mobility of the limb. Also, post-traumatic swelling can be difficult to control, particularly in the dependent positions of the abdomen and groin. A staged procedure is required, and following division of the pedicle of the flap, the skin cover to the hand loses its inherent advantage of random or axial blood supply and therefore no longer contributes to the vascularity of the injured limb.

The artery gives off certain branches which pass through the deep fascia to supply the underlying flexor muscles, and further branches which spread out on the deep fascia to form a fascial plexus via this fascial plexus the radial artery can supply the skin of the volar and radial aspect of the forearm and provide a periosteal blood supply to the distal radius.

Wound healing problems can result in impaired functional outcome. A limited wrist and finger motion and decreased muscle strength can result from graft necrosis, exposed tendons, and subsequent adherent scar formation. A careful coverage of the tendons with flexor muscles guarantees a plain wound for the split thickness graft. The paratenon should be preserved, the flap can be placed more proximally and the arm should be immobilized in extension to achieve an optimal wound healing. If muscle or bone is included in the flap, the wound healing is delayed and the risk of wound healing problems is increased. Vacuum technique can assist wound healing in complicated cases.[8] A short-time hyperalimentation should be considered in tumor patients as well. A careful preparation, together with an oblique incision to avoid dead space, especially when thick subcutaneous tissue is present, avoid hematoma and seroma formation and leads to an improved healing of the split-thickness graft. The fracture rate after an osteocutaneous ulnar or radial transplant varies between 8 and 43% but can be decreased by physiotherapy, harvesting not more than one third of the bone, performing a boat-shaped,, osteotomy, that decreases the stress concentration effect by 5%, and immobilizing the arm in extension for 6-8 weeks.[9,10]

A control radiography should be performed before and after the operation. All different kinds of objective (quantitative, qualitative, dissociated) and subjective sensory impairment were described subsequently to the

free forearm flap transfer. But in general, the patient states that he is not affected in his daily activities. Table 1 and 2 summarize complication at donor and the frequencies of disturbed sensory modalities and qualities after free forearm flap transfer (Table 1) (Table 2).[11]

Table 1: Frequencies of complications and function loss at the donor site.[12]

Complication at the donor site	
Total patients with complication	14-33%
Delayed wound healing at the donor site	Suprafascial transplant:0-6% Fasciocutaneous transplant:8-24%
Necrosis above a tendon	3-13%
Hematoma/ seroma	2-7%
Infection	13%
Radius fracture in osteocutaneous flaps	8-43%
Function loss and long-time results at the donor site	
Fasciocutaneous: intact range of wrist motion in 94,4% and free forearm rotation in 97,4% Osteocutaneous: intact range of wrist motion in 89-90% After fractures impaired range of motion in up to 50%	
Impaired muscle strength	0-16%; after fractures: 50%
Unsightly scar formation	Unstable scar 10,5% Pigmentation disturbance 58,4% Level difference 46,8% Strong plaster one over 18,7%
Mean circumference loss in fasciocutaneous flaps	1,3%
discontent	2-28%

Table 2: Frequencies of sensory impairment at the donor site after fasciocutaneous forarm flap transfer.[12]

	Type	Frequency	
		Initial	**Final**
Quantitative	Hypoesthesia, hypopathia, hypoalgesia	16-75%	0-32% 77-86, 5% of the defects covered with split-thickness grafts 8,6% of those areas are anesthetical
	Hyperesthesia, hyperalgesia, hyperpathia (neuroma)	5-14%	1-10% 8,6% of the defects covered with split-thickness grafts
Qualitative	Allesthesia	Sporadically, <3%	Only 10-12,4% of the patients have a two-point discrimination on the defects covered with split-thickness grafts
	Causalgia/ reflex sympathetic dystrophy	Sporadically, <3%	Sporadically, <3%
Dissociated	Temperature discrimination	Cold intolerance with improvement with time 0-32% (climate dependency) Single cases of heat intolerance	
Subjective	Itching	Initially manifesting subjective sensory dysfunction often signals nerve regeneration or nerve ingrowth	14-19,6%
	Dysesthesia Hypersensitiveness		10-40,6% 29,5% but in only 1,1% pronounced
	Scar pain		3-36%; 6,5% of them are distinct or strong

For complication, initially sensory disturbances can be found in 17-75% but decrease during the next months. Hypersensitiveness, paresthesias and dysesthesias can signal sensory regeneration. However, hyperesthesia and

neuralgia could signal nerve section, but decrease in the following months, too. Together with pain due to neuroma formation or causalgia, they are difficult to treat, what underlines the importance of careful preparation and good vascularization to prevent perineural scar formation and assist nerve regeneration. Richardson et al, described four neuromas in a group of 86 patients making a surgical neuroma excision necessary.[11,13] The nerve endings should be covered with muscle and not come into contact with the split-thickness skin graft. Although it is not possible to preserve the cutaneous nerves in each case, e.g., the lateral antebrachial cutaneous nerve or the superficial radial nerve, an ulnar-based flap and the limited dimension to the radial or ulnar border can improve sensory outcome.[14] It is not surprising that women are more pretentious with regard to the aesthetic outcome at the forearm.[12,15]

Hülsbergen-Krüger et al, described in their group of 267 patients after closing the defect with split-thickness graft, reduced pigmentation in 43.4%, increased pigmentation in 15%, level differences >0.1cm in 46.8%, but in only 12% >0.4cm, an unstable scar in 10.5% and an adherence of the defect in 18.7%.[16] Adequate compression, first with dressings and later with compression stockings, and the application of 2 mm metal plates can assist the wound healing.[12,16]

The most utilized technique to close the defect at the donor site is the coverage with 0.2-0.6mm split-thickness skin grafts. Lutz and colleagues described a success rate of 98% compared with 84% in full skin grafts.[17] However, if the wound is not plain, e.g. above a tendon, opposite results can be found as well. Other studies showed a complete loss of the split-thickness skin graft in 8-16%, a partial loss in 16-35% and a loss of split-thickness skin grafts in suprafascial elevated flaps in 0-4%.[7,13,15,17,18]

Patients are more content with full skin grafts than with split thickness grafts: 92% to 57%.[17] Defects up to 4x8cm in size can be closed with a V-Y transposition flap.[19] Enough skin should be disposable to avoid limitations in wrist extension, chronic lymphatic edema, sensory disturbance of the forearm or necrosis. Another alternative of closure is skin expansion that can be primary or secondary. Because of wound healing problems in about 30%, Hallock recommends for the secondary skin expansion a coverage with split-thickness skin graft, in the first instance.[20] After six weeks, it is possible to begin the expansion. A secondary shrinking and a thinning out of the subcutaneous tissue needs to be considered. The skin area of the harvested transplant should never be expanded as a shrinking at the recipient site would be the consequence. The flap preparation should begin from the region opposite to the expanded area to avoid shrinking during the operation. However, a disturbance of the microcirculation with venous congestion might still occur. Dehiscence after expansion was described in up to 40%,[14,21] but other studies showed complication rates of less than 10%.[3,12]

Important anatomical variations in regards with the free forearm flap transfer were reported and should be described briefly. The raised forearm flap area should not extend beyond the antecubital fossa and the radial or ulnar borders to avoid complications and sensory impairment. Yang et al, described a forearm flap of 35x15cm, but the dimensions of the forearm transplant are limited by the bifurcation of the forearm arteries at the level of the antecubital fossa.[1] Both, the radial and the ulnar artery participate in the blood supply of the palmar arches but show in only 27-35% equal supply to the hand and fingers.[22,23]

In 4,31%, the radial artery possesses an unusual course: a dorsal course in the distal third, a deep course beneath the pronator teres muscle and a superficial course on the brachioradialis muscle.[24-27] These variations are explained by the origination of the radial artery from the anterior interosseous artery and the superficial brachial artery, respectively. In those case a precise examination of the forearm vessels and its dominance is necessary preoperatively. Mc Cormack described in a study with 750 bodies, the origination of the radial artery from the axillary artery in 2.13%, in 5.7% a superficial brachial artery that courses medial to the biceps muscle, in single cases a superficial radial artery and in 4.43% a median artery. Besides, McCormack found an origination of the ulnar artery from the axillary artery in 0.93%.[24] A median artery originates from the brachial artery and runs through the two bellies of the pronator teres muscle. A superficial ulnar artery is found in about 2-9%.[24] It runs on the flexor muscles but beneath the palmaris longus muscle and the flexor carpi ulnaris muscle. The last muscle can be absent in these cases. Radial or ulnar artery dominance can be a hint for presence of a superficial ulnar artery or median artery, which can be used for elevation instead of the dominant artery.[12,28]

The venous drainage of the forearm is guaranteed equally by the subcutaneous veins and the venae commitantes. Consequently, the subcutaneous veins can be preserved or serve for a vein graft. A transplant based on the deep venous system shows advantages in older patients and avoids the risk provided by veins venipuncture a few days or weeks ago and facilitates the prevention of cutaneous nerve damage.[12,20]

The superficial venous system shows high variety in size, dominance and course. Numerous anastomoses exist between the superficial veins, the deep veins and the deep and superficial venous system. Boutros described that the lateral antebrachial cutaneous nerve supplies 61.8% of the potential flap area (range 48.3-71.6%), the superficial radial nerve 34.6% (range 26.8-44.1%) and the medial antebrachial cutaneous nerve 33.8% (range 30.5-38.9%).[12,29]

CONCLUSION

With complete holistic treatment, which included pre-operative planning, durante, and post-operative care. It minimized complication and later successful in treatment in anatomical, functional and cosmetic. This radial forearm flap method of post-traumatic thumb reconstruction nowadays doesn't require expert microsurgical knowledge, which is indispensable in case of replantation or revascularization of the amputated thumb. Recently it may also be implemented in emergency mode, yet like every method, it may result in the occurrence of complications. Microvascular surgery often presents the only possibility to reach satisfactory functional, and cosmetic outcomes and to achieve acceptable quality of life for reconstruction in the head and neck. Due to distinct characteristics, the forearm flap is one of the most used transplants for reconstruction in the head and neck and a widely used transplantation for other indications as well. Correct planning and elevation presupposed the flap success rates average at least 90% with no relevant limitations in strength, motion and hemodynamics in the forearm or hand and non-disturbing sensory and cosmetic outcome at the donor site.

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