APPLICATIONS OF FLAPS FOR HAND RECONSTRUCTIONS

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Wound coverage following complex hand injuries is one of the most difficult problems in management of hand injuries. Before the development of reconstructive hand surgery, amputation of the involved digits on the entire hand was recommended to preserve the function of the remaining uninjuried parts. Post-injury managment problems depend on the degree of hand trauma and the soft tissue loss. Simultaneous volar and dorsal coverage for large defects is difficult to achieve.

Hand portrays one's personality. The gestures of our hands are almost as characteristic as the voice or expression of the eyes[2]. The word "function" generally is used to indicate the prehensile capability of the hand. The measure of our success is not only the restoration of a part but whether the patient persues a useful and normal life is very important. Our concern is also an important asthetic consideration; whether the appearance of one's hand affects the patient's personality and therefore function.

Tissues selected for transfer should match in color, texture and be hairless. Consideration to the donor skin site should also be given. At the same time, a flap which is transferred from a distant site should remain viable in an acute clinical problem.

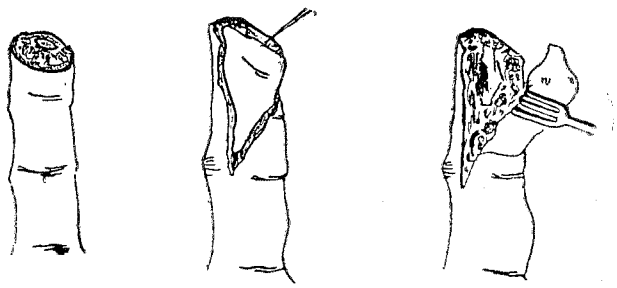
An ideal flap must be capable of being raised and transferred in a single stage which means it has to be long in relation to its breadth on a single pedicle[20]. Flap vascularity and peripheral nerve function have led to the utilization of innervated axial, myocutaneous and free flaps for the reconstruction of defects[8].

Tissue replacement is determined by :

1. site of the defect,
2. size of the defect,
3. shape,
4. reconstructive needs,
5. patient's health, and
6. other general considerations.

Flap Design

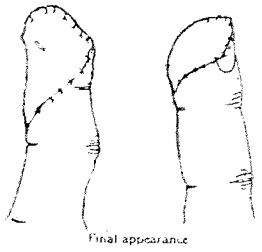
1. Most suitable to donor site.
2. Raising of flap in one stage, single pedicle with predictably adequate circulation.
3. Must be larger than the defect.
4. Sufficiently vuscular so that it can be thinned to best fit the defect without compromising blood supply and supplement the vuscular bed of the recipient site.
5. Least possible restriction of joint mobility during transposition of the flap.



(a) (b) (c)

(a) A typical oblique amputation.
(b) Outline of oblique triangular flap.
(c) Flap raised from the bone and fibrous flexor sheath.

6. Emphasize the importance of maintaining maximum range of motion of joints throughout the transfer period.



Final Appearance

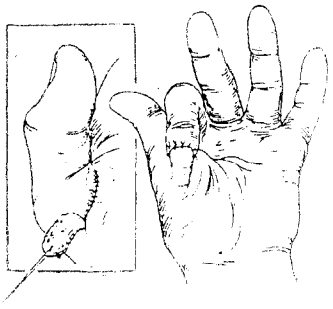
Other Considerations

In emergency situations if a flap has to be raised without preparation, it should be designed as short as possible in relation to its breadth in order to stay viable. Avoid adverse effects of tension and shearing on the circulation of the flap. A careful and meticulus preparation is essential. Observe two principles to ensure maximum flap viability[8].

1. Facial covering of the muscle should be included while raising a flap;
2. Use fluorescine an aid whenever there is a question of viability.

Local Random Pattern Flap

It is defined as a flap with a vuscular pattern which lacks bias in any particular direction and is subject to relatively strict limitations of length : breadth ratio (20). Coverage by a flap is necessary when :



Thumb flap is radially based and raised from MP joint flexion crease. Donor defect is closed primarily.

1. subcutaneous tissue is needed for recon struction,
2. exposed vital structures need mobile subcutaneous tissue,
3. blood supply in wound bed is too poor to vuscularize a skin graft,
4. disasthesia in a previous skin graft.

Repair of Defects of Digital Tips. Many techniques have been proposed for resurfacing partial amputations of finger tips.

A. Dorsal Oblique Amputation
   —primary closure
   —secondary healing
   —triangular palmar V-Y flap (Kutler)

B. Perpendicular Fingertip Amdutation
   —small triangular flaps from either side
   —one triangular flap from volar surface
   —bipedicle visor flap from the dorsum of the finger (Bunnell)
   —a dorsal flap based on terminal dorsal branches of neurovascular bundle.

Advantages of Flap

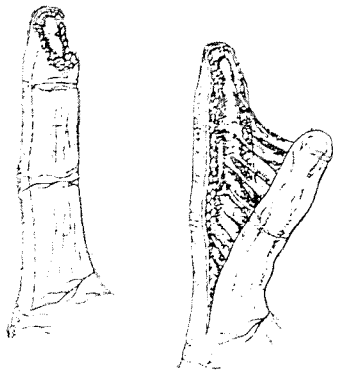
Scarring around the flap is minimal and the recovery of two point discrimination with this flap is superior to all other flaps or skin grafts.[7]

Disadvantages—or the problem is that the amount of tissue available is limited and excessive advancement compromises its blood supply or results in development of dysesthesia. It is important to divide the verticle fibrous septa in the finger pad close to the bone avoiding injury to the more anterior branches of the neurovascular system and allow tension free flap advancement.

C. *Volar Oblique Amputations.* The method of choice depends on the digit involved and the general need for preservation of sensibility.

For index and thumb; any digit in children:
—volar advancement flaps
—spiral flap of Heuston
—cross finger flap.

Volar-dorsal vascular relationship of digits.



Tecenique of volar advancement flap (Moberg)

Cross finger flaps[1,2]—are an excellent method for providing finger tip coverage when bone shortening is detrimental. Flap is raised from the dorsum of adjacent digit based on volar neurovascular bundle. The flap is turned 180° presenting its raw surface in a posterior direction.

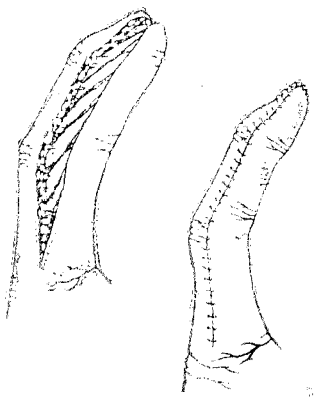
Disadvantage : 1. conspicuous donor site scar on dorsal digit;
2. cross finger flap can not be applied easily for closure of perpendicular finger amputations. A very long distally based cross finger flap is required.

D. *Upside Down Cross Finger Flap.* A modification of standard cross finger flap is the depithelialized upside down cross finger flap to cover dorsal digital defects. The donor area, and undersurface of flap are then covered with a thick split thickness skin graft which does not minimize donor site deformity but does provide local skin and subcutaneous coverage for dorsal surface of a digit which otherwise require a distant flap[2,5]. The volar based cross finger flap has been introduced for closure of thumb amputations. The advantages are that it provides a normal glabrous tissue for volar defects and the donor site is not conspicuous and also provides sufficient pad.

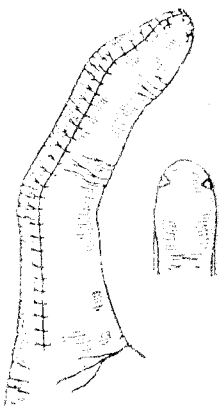
The disadvantage of this flap is that it is technically difficult and the pedicle cannot be dissected free of the digital neurovascular bundle at its base and requires a second operation.

Thenar Flaps. The best method for major distal phalangeal amputation is the thenar flap. The flap is designed high on the thenar eminence and the tissue match is perfect with sufficient subcutaneous tissue. The donor site is inconspicuous.

This flap should not be confused with palmar flaps which have the commonest complication of fixed contracture of proximal interphalangeal joints of the recipient finger and persistent tenderness of the flap donor site on the palm.



Note advancement of flexion creases.

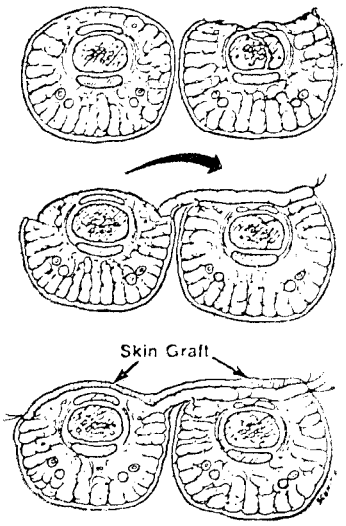


Anchoring of volar flap to dorsum

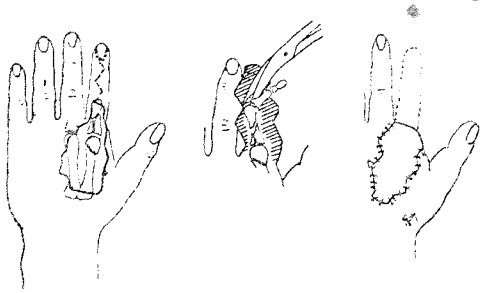
In thenar flap observe:

1. Flexion at MP joint of recipient finger.
2. Full palmar abduction of the thumb or opposition.
3. Design a proximally based pedicle high on the thenar eminence so its lateral margin is at metacarpo-phalangeal skin crease.
4. Immediate active exercises after division of the pedicle to remobilize the hand.

Age is not a contraindication to the use of thenar flaps. The main disadvantage of this flap is that it may be difficult to apply to short index finger. There is hyperpigmentation of skin graft over the thenar eminence. Defects over the dorsal surfaces usually can be closed with rotation flaps.[21] Use of a transpositional V-shaped flap from the side of the finger to cover volar skin defect has been described by Brinkman.[10] However, the author recommended the use of skin graft to cover the donor site. Green et al described the use of a transposition flap for release of volar contractures of finger at MP joint, with primary closure of the donor site.[10] Usually grafting of the secondary defect is necessary step especially in triangulated transpositions.[14] The best example of advancement flap is V-Y advancement of the flap in finger tip amputations of Moberg volar advancement flap for thumb and digits.[18]



Upside-down cross-finger flap in cross-section showing flap flipped 180° with undersurface and donor area skin grafted.



A B C

A. A dorsal racquet incision for deboning a useless finger. B. The skeleton is filleted carefully preserving the neurovascular bundles. C. The more proximal dorsal defect covered by the fillet of finger flap.

Local Axial Flaps

They are based on anatomically well-defined arterio-venous system[20] superficial to the muscular facia. Sometimes it is accompanied by a nerve. Axial pattern flap in upper extremity is volar digital neurovascular is land flap described by Littler in 1956. This flap is often raised on the ulnar aspect of the thumb or index finger for thumb reconstruction. Although full sensibility is not attained, the procedure is well recognized for thumb reconstruction.

The composite "kite" or island flap supplied by first dorsal interosseous artery and innervated by terminal branches of superficial radial nerve is also used for reconstruction of thumb. The flap is transferred from dorsum of proximal phalanx of Index to thumb.[6,15]

Fillet of Finger and use of skin flap from a floating thumb in pollicization of index[16] are also known procedures. In irreparable damage of a useful digit, the non-functional digit with adequate blood supply and viable skin must be considered to use as fillet of finger or as a composite tissue flap or an island flap.

Myocutaneous Flaps

Myocutaneous flaps generally failed popularily for reconstruction of upper limb. A dynamic myocutaneous flap has been used to reconstruct skin as well as functional opposition following resection of an AV malformation of thumb.[4] Latissimus dorsi muscle flaps are well known for reconstruction of elbow and arm etc. Littler in 1952 described transfer of composite flap contaning hypothenar muscles and overlying skin on a small proximal subcutaneous pedicle containing ulnar nerve and artery. This transfer was successful in reconstruction of thumb. For opponens transfers, the abductor digiti minimi myocutaneous flap can be used.

Distant Axial Flaps

Several well-defined axial pattern flaps have been described as shown in Figure. The staged groin flap is commonly used method for reconstruction of adult hand. A similar procedure of staged groin flap has been successfully applied to pediatric hand.[17] Groin flap is based on superficial circumflex artery. Hypogastric flap on inferior superficial epigastric artery and thoracoepigastric and deltopectoral are based on internal mammary perforating arteries. The groin flap is very predictable and can be elevated for a great length. Donor site can be primarily closed leaving behind an acceptable scar.

Disadvantage of groin flap is edema of the arm. But McGregor emphasizes a long pedicle and active hand exercises.

Certain distant axial flaps are actually random flaps on which axial pattern vessels run. Examples are lateral thoracic artery and cross arm flaps. These flaps are hairless, thin, supple and good color match for hand. The medial upper arm flap is good for repair of contralateral thumb, first web space or volar aspect of hand. A cross forearm flap may be developed[5] to provide good sensation but leave conspicuous scar and have dense hair.

Arnold described the use of omental flaps for distal foream.

Free Flaps

Free tissue transfer began in 1967 when Cobbett and Buncke reported free great toe to thumb transfers. Thumb reconstruction also requires accurate functional and asthetic considerations. All the methods generally have some deficiencies in appearence. Another method with the use of iliac crest bone graft and a free neurovascular "wrap around" flap for big toe has been described.[22] Large sensory flaps from the first web space and dorsum of foot including second toe also have been described for reconstruction of hand.[26,19,11] The patient should be young, intelligent, well-motivated and in good health. The common indication for toe transfer is amputation distal to thenar muscles and imairment in pinch and grip function. Yoshimura reported a large series of digital reconstructions with second toe transfers. Preoperative arteriograms of the donor and recipient sites are recommended due to anatomical variations. Vascularized bone grafts and nerve grafts have been used for upper extremity. In absence of appropriate venous anastomosis, a subcutaneous flap technique has been tried by S. Poletti successfully as an alternative to allow venous drainage from replanted digit.[24]

Free flaps are capable of adding to our knowledge of axial flap behaviour and the factors involved in axial flap necrosis. A typical axial flap is divided into two parts. The proximal part with arteriovenous system and distal part without it which gets transferred. The proximal

part of flap is very crucial for survival. The carefully controlled vascular environment of the free flap is capable of providing an excellent physiological experiment and a better understanding of axial flaps. The single stage operation is an attractive aspect of free flap transfers by microvascular anastomosis.

Conclusions

With a better understanding of the physiological and anatomical aspect of flap and with the improvement in surgical techniques, the reconstructive needs of the upper extremity are improving. Flaps for hand and forearm reconstruction include random pattern, axial pattern, myocutaneous and free flaps. Selection of each flap should follow a very careful evaluation of all the factors involved and each measured against the alternatives.

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