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Restoration of Function in a Mitten Hand

• G. MALAVIYA
B. RICHARDS

INTRODUCTION

A mitten is a glove to keep the hand warm. All the fingers are in one compartment and the thumb remains as a separate digit. Some persons affected by leprosy with a combined ulnar and median nerve palsy, have little ability or awareness to protect their digits from wounds and work strain causing soft tissue and bone infections that over several years may lead to the loss of digit length. They present with a shortened thumb, maybe down to the metacarpophalangeal (MCP) joint level and similar loss of the digits to the MCP joints. This is the so called "mitten hand" (Fig. 10-1 a-c). The process of ulceration with resultant deep infection that may lead to this digit attrition are inexorable and somewhat inevitable in those who have little concept of health education and do not understand why their fingers are becoming injured and infected. There is also often the absolute need to continue to use the injured hand for personal survival in the labour market. Our inability to restore sensation means that the individual who fails to comprehend the health education message of safety measures in work and cooking will only go on to destroy any surgical procedure performed to restore digit length and function.

Thus there is an imperative for the surgeon or health care worker to notice this 'self destructive behavior' at the early stage of digit loss and to invest the time to help the patient understand the aetiology of the problem and find alternative work, if possible, and advise on lifestyle changes. The surgeon should also spend time on preventative health education.

Many persons affected by leprosy have had sensory impairment with marked deformity for many years. Often these persons having few years left to their lives, have adjusted and

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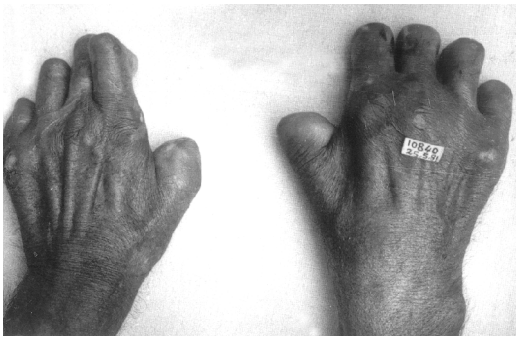

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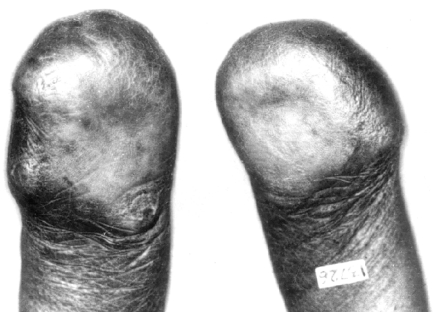

FIGURE 10-1 a-c Mitten hand.

are not very keen to have surgery. As long as some opposition of thumb and fingers is present, they can adapt to the basic functions of grasp, pinch and hook grip. They are often satisfied with being able to perform their activities of daily living and are able to care for themselves independently. Sometimes they do feel their incapabilities and request surgical intervention for improvement of hand function.

PREOPERATIVE EVALUATION OF HAND

Before contemplating any surgery, careful evaluation of both hands is essential. The greatest functional need is some form of pinch grip or pincer action for which at least two digits are necessary, hopefully in opposition to each other, i.e. a thumb and one finger. The mitten hand will have had multiple episodes of web and tendon sheath infection and will have dry calloused skin, both rendering the hand stiff. Assess remaining digit length, and mobility of the MCP and carpo-metacarpal (CMC) joints as any salvaged function requires mobility. Digits on the ulnar border of the hand may be more mobile due to the anatomical mobility of the 4th and 5th CMC joints for opposition. This makes excision of the 2nd and or 3rd metacarpals a good option to open a web space between any remaining thumb length and a mobile ulnar ray. There may also be fixed flexion deformities of any remaining finger PIP joints in which an arthrodesis in a position of function may be useful (index 30, middle 40, ring 50 and little 60 degrees of flexion). Thorough evaluation of the needs, psychology and attitude, of the person is also important.

A period of counseling regarding what surgery can achieve and the possible need for modified appliances is necessary to prevent future disappointments. Since these persons have long standing impairments the recovery of sensory functions is unlikely. However, protected use of the corrected hand may allow years of use of the hand. The hands can be classified into the following groups depending upon clinical and radiological findings:

Group 1: These persons have a minimum of 1.5 cm. long finger stumps with intact metacarpals. The thumb stump is also at least 1.5 cms. long (Fig. 10-1a, 10-2a, 10-3a).

Group 2: The thumb is predominantly affected. The finger stumps are greater than 1.5 cm. in length with intact metacarpals but the thumb stump is less than 1.5 cm (Fig. 10-2b, 10-3b).

Group 2a: The thumb metacarpal is intact.

Group 2b: Thumb metacarpal shows some absorption.

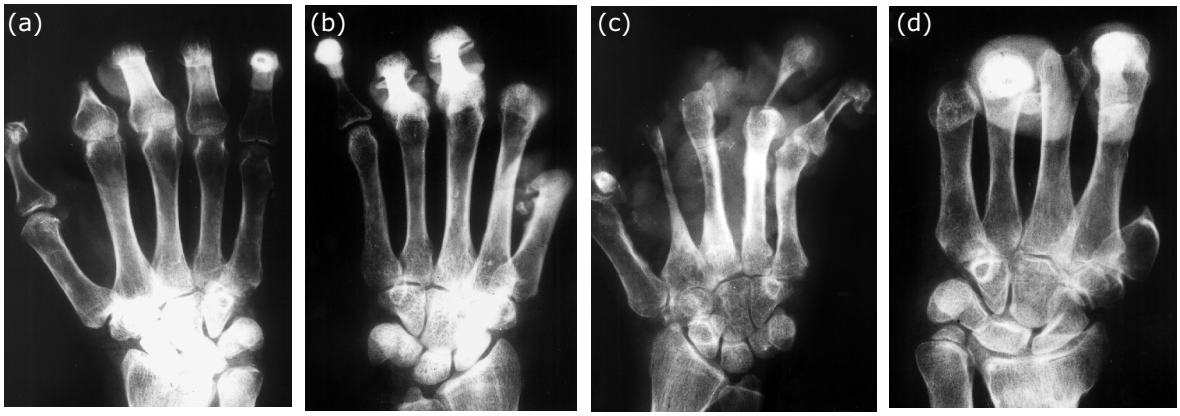

FIGURE 10-2 a-d Radiologic classification of Mitten hands.
a) Group 1 b) Group 2 c) Group 3 d) Group 4

Group 3: The fingers predominantly affected. The thumb stump is at least 1.5 cm long but the finger stumps are less than 1.5 cm in length (Fig. 10-1b, 10-2c, 10-3c).

Group 3a: The finger metacarpals are intact.

Group 3b: The finger metacarpals show some absorption.

Group 4: The true mitten hand in which there are no finger or thumb stump.[5] (Fig. 10-1c, 10-2d, 10-3d)

Group 4a: There are no finger or thumb stumps but the metacarpals are intact.

Group 4b: There are no finger or thumb stumps and the metacarpals show some absorption.

The surgery is planned depending upon the condition of both hands and the available options which should be discussed with the person in detail. The affected person must participate in the decision making process.

PREOPERATIVE PHYSIOTHERAPY

The skin of the hand is made soft and supple by soaking and oiling. The fissures and callosities are taken care of and any small ulcers in the hands should be healed before the operation. Septic foci and foot ulcers should also be clean.

The nails need to be trimmed but any residual nail spicules should not be uprooted because these can be of help in residual pinching mechanisms.

OPERATIVE PROCEDURES

The most important component to restore in a mitten hand is thumb function because more than fifty percent of daily activities are performed with the thumb.[16] An opposable thumb is an essential asset for hand function and therefore takes priority over fingers when restorative surgery is performed on such hands.

What is ideal in such situations is to restore the length of finger and thumb stumps to 2 - 2.5 cms with an adequate first web space so that prehensile capability is restored. The individual can then hold a spoon with modified handles and a glass of water.

Restoration of thumb metacarpal mobility and widening of first web space

If the thumb metacarpal and part of the proximal phalanx remains satisfactory, thumb function can be achieved by procedures designed to deepen the first web space to create a wider thumb index interval. These procedures are called phalangization. They use techniques which deepen the inter-digital cleft so that the first metacarpal and remaining proximal phalanx are relatively lengthened.[1,5,6,10] These procedures therefore are suitable for group 1 cases where some length is available. The mobility of the thumb may be restricted because of an adduction contracture which may require release.

Z-plasty

If the web skin is supple and healthy a simple "Z" plasty or a 4 flap "Z" plasty[2,26] is a good option (Fig. 10-4a and 10-4b). Thick skin flaps are dissected to ensure adequate vascularity. The covering fascia of muscles is divided or excised, and the mobility of the thumb tested. If the muscles are fibrotic they can also be resected. The wound is closed in a single layer with bulky dressings. The sutures are removed on the fifteenth day and a web spacer splint is used for another 3 to 6 months to overcome the tendency for recurrence. The gain in depth varies from 1.5 to 2 cms depending upon the extent of myofascial excision and provides a stump length to grasp large objects.

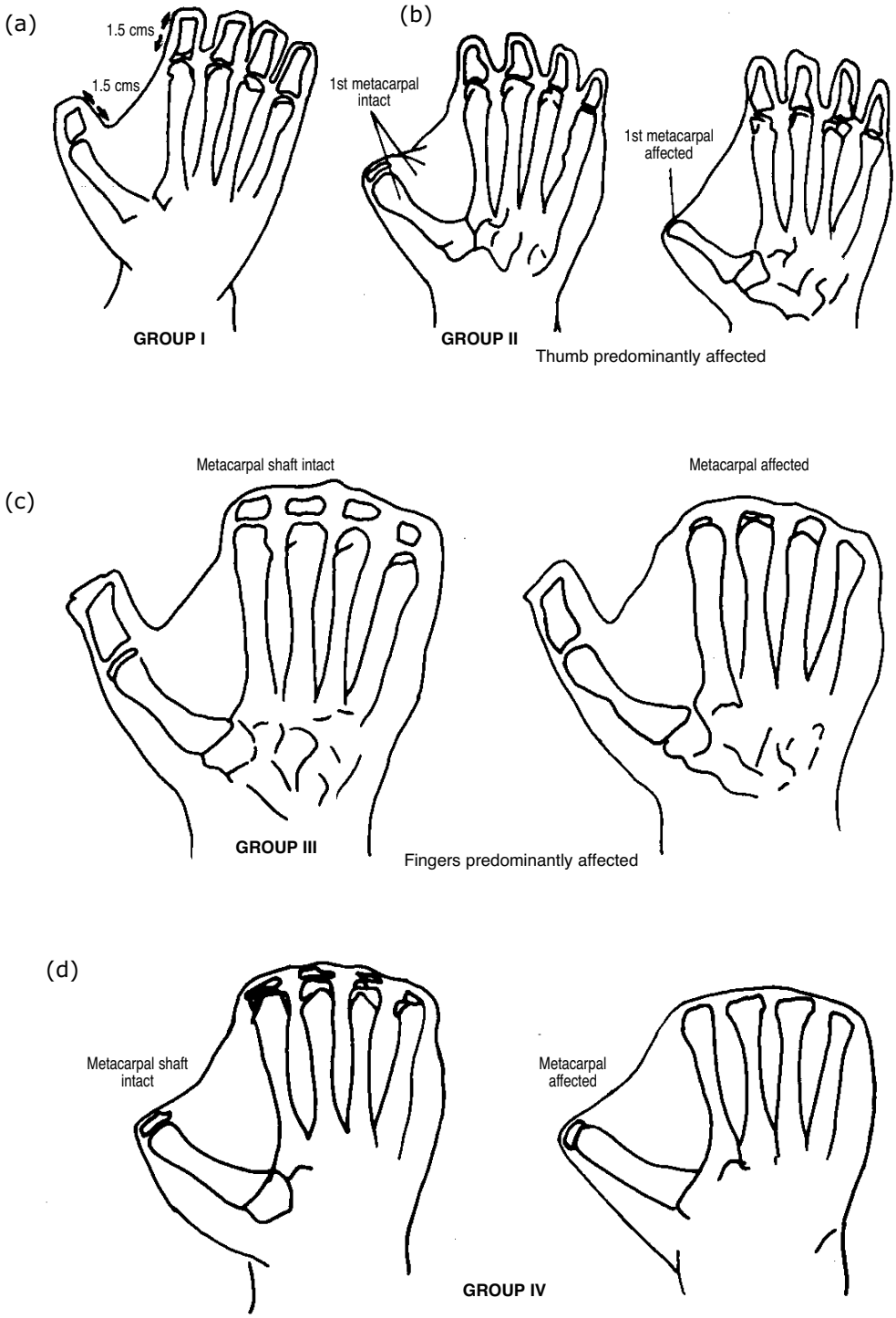

FIGURE 10-3 a-d Classification of Mitten hands.

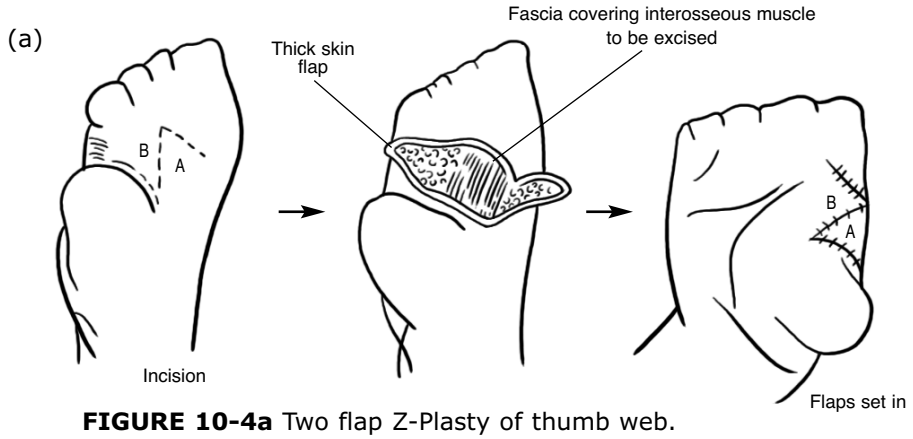

FIGURE 10-4a Two flap Z-Plasty of thumb web.

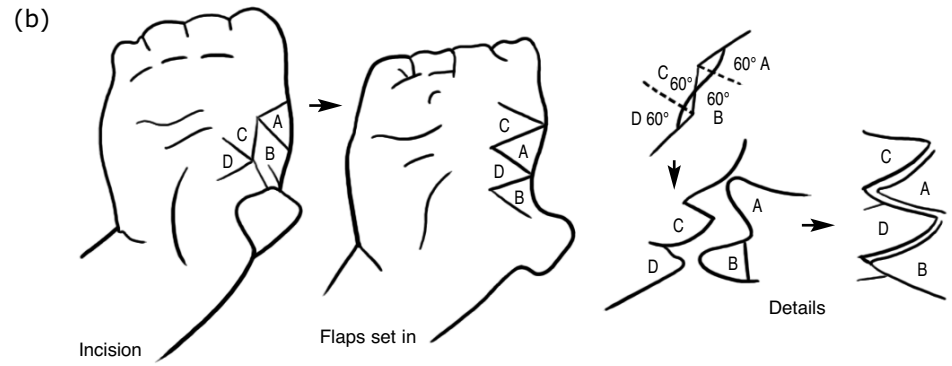

FIGURE 10-4b Four flap Z-Plasty of thumb web.

Dorsal Flap Webplasty

If there is a severe web contracture or if the skin of the first web is scarred a proximally based dorsal rotation flap to provide cover to the web space is called for (Fig. 10-5). Several dorsal rotation flap techniques have proven effective in deepening the first web space and mobilising and resurfacing the thumb.[6,7,9,17] Skin can be raised quite safely from up to the proximal interphalangeal joint (PIP) joint of the index and middle finger as long as the proximal base of the flap includes the deep fascia of the first web space to ensure that the dorsal metacarpal artery is in the flap. The donor site is skin grafted. In certain cases, in addition to myofascial excision, the trapeziometacarpal joint needs volar and dorsal capsulotomy to release the contractures. Post-operatively the web space may be retained by separating the first and second metacarpal with K-wires or external fixators. The wound is closed in a single layer with bulky dressings. The sutures are removed on the fifteenth day. The pins are removed after 4-6 weeks. A web spacer splint is then used for another 3 to 6 months to overcome the tendency for recurrence. If the skin on the dorsum of hand is scarred a cross arm flap or a groin flap can also be used. In cases where the thumb stump length is about 1 - 2 cm, excision of the second metacarpal will give enough skin to

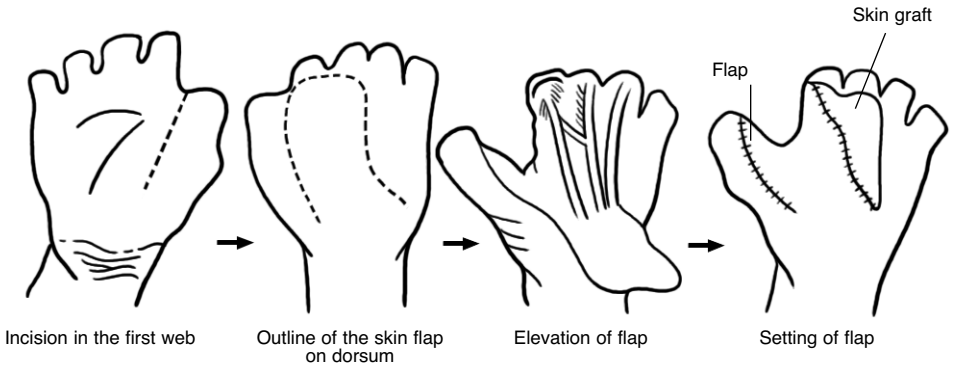

FIGURE 10-5 Dorsal rotation flap to cover web space of thumb after it has been released.

deepen the first web space and restore the thumb length by 1.5 to 3 cms so that it can be opposed to the finger metacarpal part of the palm.[21,22] Excision of the second metacarpal (and sometimes part of the third metacarpal) permits direct closure of the wound without skin grafting.[23]

Lengthening of thumb stump

Several options are available to increase the length of thumb stump in group 2 and group 4 hands. Since the bones are osteoporotic, any bone transfer will need a relatively longer period of immobilisation with rigid internal fixation to provide strength until consolidation occurs.

Metacarpal transfer (pollicization)

Transfer of the second metacarpal on to the first metacarpal stump[13,25] is performed when there is no thumb stump or the thumb metacarpal shows evidence of absorption. Pollicisation of the index or middle finger is a one stage procedure and provides a thumb with a mobile distal joint without creating significant deficit in an already deficient hand. If there are at least three remaining digits with a PIP joint and the thumb is lost down to the MCP level then one of the digits (the most radial is best) can be transferred as a pedicled digit to lengthen the thumb. This is a pollicisation and requires careful dissection of the pedicle, ensuring an independent vascular supply without sacrificing the vascular supply to the adjacent ulnar digit. This may be difficult to dissect because of previous web space sepsis. Usually the transferred digit will be aneasthetic but is still an excellent method if available to the surgeon. The first web space is enhanced by excising the second metacarpal, part of which can be mobilised on its vascular pedicle to be attached to the thumb metacarpal, thereby increasing its length.

An incision is made in the palm in the area of thumb web. It is extended proximally along the length of the first metacarpal up to its base and distally up to the base of index finger in the proximal digital crease. The flaps are raised and the radial indicis artery is identified. The neurovascular bundle in the index-middle finger cleft is dissected to the bifurcation of the common digital artery. The digital artery to the radial side of the middle finger is ligated 1.5 cms distal to the site of bifurcation of the common digital vessel and divided. The ulnar neurovascular bundle to the index finger along with the flexor and extensor tendons are protected and the deep transverse intermetacarpal ligament is divided. The interossei are separated from the second metacarpal shaft by blunt dissection. The index metacarpal is

cleaned close to its base and divided subperiosteally. The index finger stump along with the metacarpal, now attached only with the tendons and neurovascular bundle, is moved towards the thumb and transposed to the cleaned freshened edges of the thumb metacarpal. While transposing, the length of the shaft of the metacarpal is adjusted by further resecting it so that the bone is fully covered with the skin flaps. The osteo-syntheses is preferably done by carving a peg and a socket in the proximal and distal bone stumps and supporting it further through oblique K-wires. Post-operative immobilisation has to be 3 months duration to ensure complete bone healing (Fig. 10-6).

In the absence of a suitable second metacarpal the third metacarpal can be transferred to the thumb metacarpal after excision of the second metacarpal stump so that a pincer function is restored.

"Cocked Hat" Procedure

Skeletal lengthening of thumb metacarpal can be achieved by means of a short bone graft, 1.5 - 2 cms, which is fixed to the distal bone stump of the thumb.[4] Skin to cover the graft is borrowed from medial and lateral sides of the thumb. The skin is advanced from the sides of the base of thumb to cover the graft and the raw area so created is covered with full thickness or thick partial thickness skin graft - the so-called "Cocked hat" procedure[14,15] (Fig. 10-7).

The technique involves a curved incision across the radial side of the base of the thumb which is extended both volarly and dorsally as shown. The flap so outlined is undermined to expose the underlying first metacarpal and phalangeal remnants. The flap is further dissected dorsally leaving its web space attachments so as to gain a length of about 3 to 4 cms

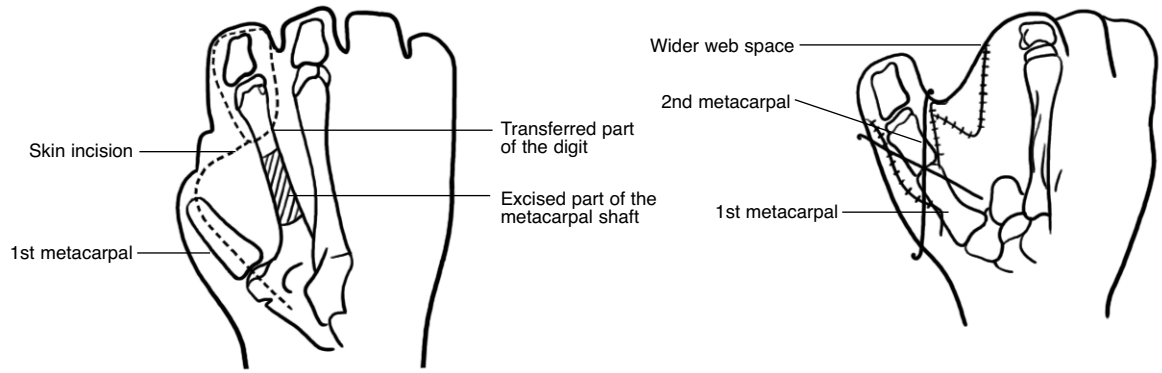

FIGURE 10-6 Pollicisation of index stump.

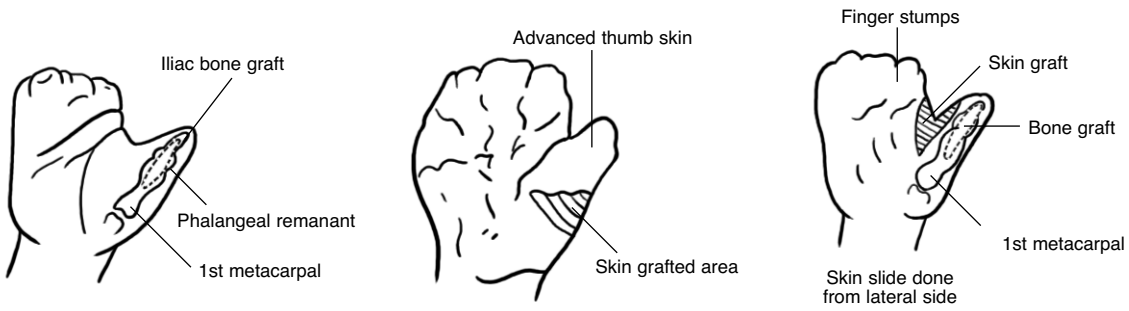

FIGURE 10-7 "Cocked hat" procedure.

depending upon the skin laxity. A 3 to 4 cms long bone graft is obtained from the iliac crest or toe (phalanx or metatarsal) and carved into a peg having 1-5 to 2 cms long stump. A cavity is made in the distal end of the thumb metacarpal to receive this peg snugly. The bone graft is then fixed to the metacarpal by compression. Oblique K-wires can be used if the stability is in doubt. The thumb skin flaps are draped over the graft and fixed to the fascia over the thenar area and the dorsum. The crescent like defect on the thumb is covered with a full thickness or thick partial thickness skin graft and tie over dressings are applied. The dressings are removed on the seventh day and a fitting plaster cast is applied for six weeks or more till the bony union is complete.

As an alternative procedure an osteotomy of the thumb metacarpal can be performed and a piece of bone graft, 1 - 1.5 cm inserted in between and retained with K-wires. Distraction lengthening of the thumb metacarpal is possible but is not preferred because of risks involved due to osteoporosis of the bones of the hand and sensory impairment.[12] There is a risk of excessive rotation of screws of the distractor by the persons due to anaesthesia, which can threaten the vascularity of the thumb stump. It is also time consuming.

Osteoplastic reconstructions of thumb using bone grafts from the iliac crests have been tried to increase the length of the thumb metacarpal. It is less traumatic to the remaining hand structure but it does not create a mobile articular thumb. Long term results have not been very encouraging because of gradual absorption of graft, possibly due to the denervated state of the hand or the poor graft bed.[8] Bone grafts from a toe phalanx have a lower absorption rate.

Osseocutaneous Flaps

i) Radial Artery Forearm Flap.

A radial artery forearm island osseocutaneous flap includes a large longitudinal segment of radius to reconstruct the thumb.[3,11] The post-operative immobilisation of the hand and forearm unit is important to provide healing time for the radius to prevent a fracture.

ii) Distally Based Posterior Interosseous Fasciocutaneous Island Flap with Vascularized Ulnar Bone Graft (Fig. 10–8).[20]

The procedure can be performed under brachial plexus block. A tourniquet is used and this is inflated with the arm in elevation but, without compressive exanguination. This helps

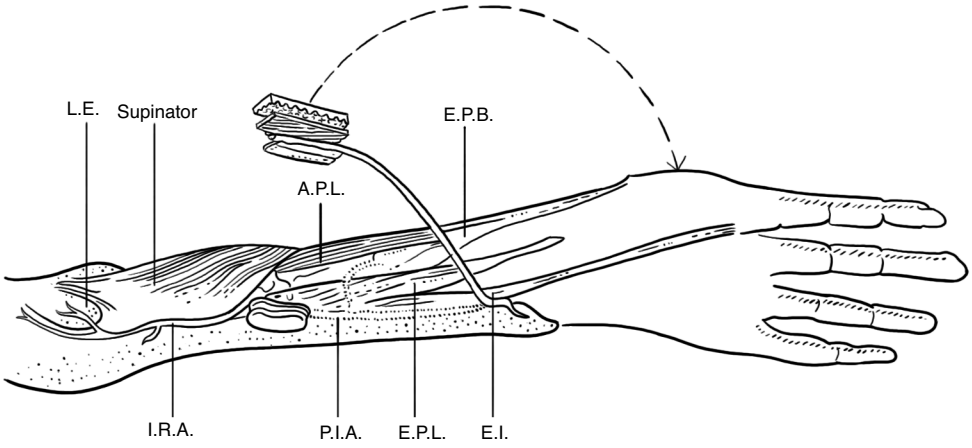

FIGURE 10-8 Distally based interosseous fasciocutaneous island flap. PIA- posterior interosseous artery, APL- abductor pollicis longus, EPL- extensor pollicis longus, EPB- extensor pollicis brevis, EI- extensor indicis. Excision of second metacarpal and part of third metacarpal.

in the identification of the vessels within the fascial septum during dissection. The surface marking axis of the posterior interosseous vessels lies along a line joining the lateral epicondyle and the ulnar styloid with the arm in full pronation. The pivot point of the vascular pedicle is the lower end of the ulna. From here, the reach of the flap and its dimensions can be planned on the forearm. A flap as large as 15 cm long and 9 cm wide can be raised. It is recommended that the procedure should commence with a distal forearm exploration between the tendons of extensor digiti minimi (EDM) and extensor carpi ulnaris (ECU) to locate and confirm that an anastomosis exists between the anterior and posterior interosseous arteries. A distal forearm incision is extended to the deep fascia and the septum between the EDM and ECU is identified. The deep fascia is incised on each side of the septum and the posterior interosseous artery identified. Working proximally the vascular pedicle and the delicate septum containing the cutaneous perforators, lying between EDM and ECU muscles, are then isolated and raised in a siege approach working from both sides of the septum in a subfascial plane. For increased safety, the epimysium of the muscles bordering the septum could be included within the deep fascia and if a sizable musculo-cutaneous perforator is encountered, that could be included within the flap pedicle with the sacrifice of only a few muscle fibres. It is important to avoid injury to the motor branches of the posterior interosseous nerve, both proximally (supplying ECU) and distally (supplying EDM), during the dissection of the vascular pedicle since the resulting muscle palsy will significantly worsen the disability. The origin of the interosseous recurrent artery is identified and a portion of this artery can be included in cases where a septocutaneous perforator for the skin in the flap is present. The outline of the skin paddle is completed by incising through the deep fascia to raise the fasciocutaneous flap. When raising a compound flap to include a segment of the ulna, the proximal deep dissection should incorporate a cuff of the EPL (proximally) or ECU (more distally) muscle belly attached to the periosteum and adjacent interosseous membrane. The dissection goes behind the artery, through a cuff of muscle to the interosseous border of the ulna. The interossous membrane is incised along the length of the bone to be harvested. A length of about 8cm of bone is stripped of a 0.5 cm swathe of periosteum. The bone segment is carefully raised with a hammer and chisel. If an oscillating saw is used, constant irrigation is necessary taking great care not to burn the bone or jeopardise its blood supply. A 1.5 cm length of bone segment at the distal end must be freed of all its muscle to act as the insertion peg into the bony remnant of the thumb after tranposition. Once the flap is completely raised, the tourniquet is released and the flap is allowed to perfuse for about ten minutes. Topical lignocaine, papaverine or verapamil are useful in overcoming spasm of the delicate vessels supplying the flap. After confirming that the perfusion of the flap is satisfactory, the flap is transferred to the previously prepared thumb or web space. This may be done by a tunneled route, but any tunnel for the passage of the flap must be generous and if there is any tendency for venous congestion in the flap after inserting it, the tunnel must be laid open and if necessary the pedicle covered by a skin graft. If it is a osseo-cutaneous transfer then the bone must now be fixed. A single Kirschner wire placed obliquely, combined with an interosseous wire fixation loop passed through drill holes made in the distal portion of the thumb remnant and proximally in the ulnar bone graft, will provide secure bone fixation (Fig. 10-8). Next the skin island is fashioned to create a neo-digit. Depending on the skin laxity, it maybe possible to close the donor defect

directly. Direct closure of flaps up to 6 cm wide is safe. However, it would be wise to skin graft the donor defect if the attempted primary closure appears too tight and could produce a

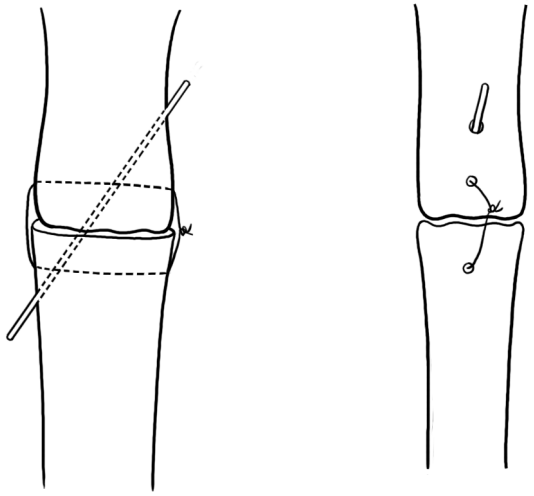

FIGURE 10-9 Bone fixation method. Two transverse holes (1.0-1.2 mm) are drilled and wire inserted and twisted together, K-wire inserted.

tourniquet effect to the limb.

Post-operative care includes elevation with vascular compromise observations for 2 days in a protective POP backslab and then protected for a further 4 weeks allowing gently active movement of the neo-digit. Remove the K-wire after 6 weeks.

Lengthening of finger stumps

When digital remnants are present it may be possible to phalangise mobile metacarpal segments to accomplish crude pinch and grasp functions. It can therefore be attempted in suitable cases of group 1 and 2 where 1.5 to 2 cm long finger stumps are left. Digitalisation of phalangeal remnants by deepening the interdigital clefts with a "Z"-plasty or "W-"plasty, creating dorsal and volar flaps up to the metacarpal neck levels, can appreciably increase the length of finger stumps (Figure 10-10).

Distraction lengthening of metacarpals, though a theoretical possibility, is not advised because of existing osteoporosis and anaesthesia. However, it can be considered in experienced hands. The ulnar metacarpal (little finger) can be lengthened using this procedure to provide a larger span for the hand.

In some cases excision of 4th metacarpal can be done to create a cleft between the 3rd and 5th metacarpals so that an ulnar post is created to which thumb can be opposed (Fig. 10-11).[24] In other cases where a full and mobile first metacarpal exists with minimal lengths in adjacent metacarpals, an ulnar post can be reconstructed using osteoplastic procedures. A suitable combination of the above procedures can accomplish the desired goals of restoring crude prehensile functions. [ed. Note: The real functional gain from this procedure would appear

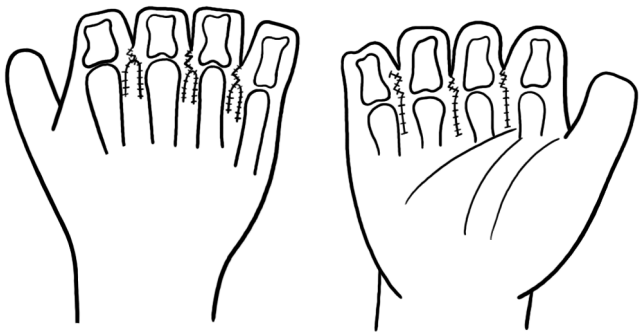

FIGURE 10-10 Incisions for phalangisation of digits.

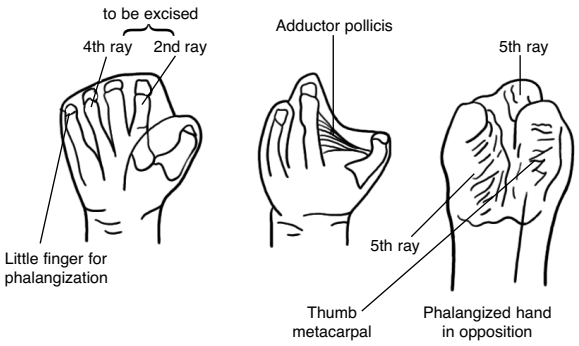

FIGURE 10-11 Phalangization of metacarpals.

to be minimal.] The results of these procedures may prove disappointing if one can not ensure a satisfactory mid-ray space, opposable strength and motion of at least one ray. The functional abilities are reassessed periodically and additional surgery can be performed if needed.

Amputation

In some cases below elbow amputation with immediate prosthetic fitting can sometimes offer a rapid return to activities of daily living but such a favorable situation is usually not possible. The amputation stump is often anaesthetic and can give rise to stump ulcers. Usually there is bilateral hand involvement so that putting on the prosthesis requires some assistance, creating a dependency on others. Attempts to provide upper extremity prosthesis may meet resistance and may not be used after discharge. Alternatively in rare cases a Krukenburg procedure (distal forearm amputation with separation of ulna and radius into two “digits”) can be done. This will provide the patient with rudimentary grasp. It is generally only indicated in bilateral amputees who are either blind or cannot get good quality prostheses.

ADAPTED APPLIANCES

To meet the ergonomic requirements of leprosy affected persons, grip aids have been developed. These grip aids not only provide insulation from heat to some extent but can also be molded into the shape of digits. Such molding enhances the contact area of the tools of daily use permitting better grip and reducing pressure on certain vulnerable sites. These sites vary from hand to hand depending upon the extent of deformities. These also support the grip so that the tools can be held more securely without applying much force.

Ideally the material used for making such grip aids should be insoluble, non-brittle, stable, non-toxic and easily available at an affordable price. Several materials have been used such as sodium alginate and epoxy resins. Of these, two products have been found suitable: "Modulan", marketed by Ciba-Geigy, and "M-Seal", (Mahindra Engineering and Chemical Products Limited, 145 Mumbai-Pune Road, Pune, India). Both Modulan and M-seal packs contain two semi-solid sticks in different colors one of which is resin and the other a hardener. Equal parts of both are mixed manually to give a uniformly colored putty which can be molded in different shapes. They harden in air in a few hours.

Preparation of grip aid

The patient is observed in his or her daily activities to notice what tools are used and how they are held. The types of tools required and their technique of usage are discussed with the patient and the tools are selected on which the grip aid is to be applied. The handles, if smooth, are scraped a little with a metallic file to roughen them so that the putty can be held firmly on the handle when it hardens. The tool is then cleaned with spirit to remove any grease on the surface. The putty is prepared in an adequate amount by mixing the portions of resin and hardener. An adequate amount is then applied on the handle so that when the tool is grasped by a full grip appropriate indentations will be left on the putty.

A little cream is applied on the hand (this helps in freeing the hand from the tool after indenting the putty) and the patient is asked to hold the tool as if he or she were actually using it. If inadequate pressure is applied the indents will be too shallow to support the grip. If too much pressure is applied the indents will be too deep and free movement of digital stumps on the tool will not be possible. Use of the tool will cause friction, producing blisters and callosities. While the person is holding the grip

aid, putty is displaced into all corners and the gaps between the digits and the tool so that the contact area is increased. After a few minutes the person is asked to take his hand off the tool carefully without disturbing the ridges so created. The sharp edges and corners are smoothened and rounded off and the tool is allowed to dry for 8 to 12 hours. The tool can then be used.

Heat resistant handles can be made twisting thick PVC insulated wires and using Modulan on the handles. Multipurpose grip aids[27] can also be made for e.g. spoon, comb, and shaving razor by slitting the nozzle end of a 10 ml plastic syringe into which the handle of various articles can be fitted. Use of a syringe makes the grip aid lighter. Microcellular rubber can also be used in making such grip aids where the palmar side of the handle has MCR and the digital side the putty.

Handling of adapted appliance and care

The person while using the tool has to adjust his grip in the indentations properly so that the tool can be properly held. The use of the aid is reassessed while the person is using it so that modifications can be done if required. The grip aids are checked periodically and remade if found damaged.

CONCLUSIONS

Elementary pinch and grasp functions are restored by reconstructing the thumb and a medial pillar on which to oppose the thumb.

The decisions as to whether to operate and the choice of operative procedure are as important as the technique when one thinks of any surgical intervention. A person may be quite well adjusted to an impairment especially if it is on the nondominant side and of long duration. Each individual needs an individualised approach because of their different needs and expectations.

Factors which must be considered include length of stumps, condition of both hands, age, occupation, the person's psychological state and the presence or absence of protective and residual sensibility. Good results can be achieved in a well motivated, active and intelligent person who has set realistic goals and understands the limitations of such procedures. A combination of surgery and adapted appliances will be more useful than either alone. Since these persons have adjusted to a particular way of life, the operations should be performed in willing, well informed and well motivated persons. Acceptance of good hand practices, protected use of hand and adequate care will keep the operated hands useful for several years to come.

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