6

Ulnar Nerve Palsy

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INTRODUCTION

This chapter discusses the various techniques that can be used to correct the hand with paralysis of the ulnar-innervated muscles. For a relevant understanding of the anatomy of the hand and the pathokinesiology of the 'intrinsic minus' hand the reader may also want to refer to Chapter 5. First, the functional impairments of the hand will be briefly discussed. The author then will discuss the procedures to correct the hand which can be divided in what are commonly called static (passive) and dynamic (active) procedures or tendon transfers.

The mixed nerve trunk most often damaged by leprosy in the upper extremity is the ulnar nerve. Less often the median nerve is involved, usually in combination with the ulnar nerve. The radial nerve is rarely involved. With paralysis of the intrinsic muscles, the hand adopts the typical posture of clawing, initially maybe only the ring and little fingers (Fig. 6-1), eventually often all fingers (Fig. 6-2). Latent or 'hidden' clawing is usually present in the index and middle fingers in a recent ulnar palsy.

FIGURE 6-1 Ulnar nerve paralysis with overt clawing confined to the ring and little fingers.

FIGURE 6-2 Ulnar nerve palsy with clawing of all four fingers.

The clawing of the fingers can be very stigmatizing in leprosy endemic areas, and is especially obvious when greeting in almost any culture. It becomes also evident when eating in cultures that use their fingers.

The important loss of sensation in ulnar nerve palsy is in the ulnar border of the hand. This may not seem important but most of our activities at home and at work are with the hand on surfaces like a desk, carpentry bench, working on a car motor or with tools in the garden. These activities all require the fine feedback of the little finger exploring first the areas where the hand is going to act. The loss of sensation therefore greatly increases the dis-ability of the already paralyzed hand.

PATHOPHYSIOLOGY OF DISABILITIES IN THE INTRINSIC MINUS HAND

With ulnar nerve palsy all interosseous muscles are paralyzed and therefore the primary flexors

of the metacarpophalangeal (MCP) joints are absent. This leads to the hyperextension deformity of the MCP's when the extensor digitorum communis tries to extend the finger to open the hand. Since the extensor digitorum is tethered by the sagittal bands, there is hyperextension of the MCP (Fig. 6-3), and the distal part of the extensor loses excursion over the distal joints and therefore the flexion posture of the proximal interphalangeal joint (PIP) and distal interphalangeal joint (DIP) occurs. [12,14,16,20,23]

Figure 6-3 Ulnar-median palsy with metacarpophalangeal hyperextension.

The intrinsic minus hand loses power in grip but has also a decrease in control of the fine coordinated movements necessary in delicate work. With ulnar nerve palsy the hand loses 40-70% of power.[15,19,33] The ulnar nerve provides most of the strong motor power to the hand through the flexor digitorum profundus, hypothenar muscles, all interossei and the adductor- and flexor pollicis muscles.

By not being able to spread the fingers the hand loses span of grasp. Surgery is indicated when there is disability in grasp, grip, pinch, greeting, eating, flat hand, human contact and when the deformities caused by the intrinsic paralysis lead to stigma and handicap. [26,28-30]

If the median nerve is still intact, the lumbricals to index and long fingers, together with the tissue restraint of the volar structures of the MCP joint, can maintain extension for some time, with normal appearance, but there is very minimal primary MCP flexion strength. It is for these reasons that tendon transfers should always be done to all four fingers, even if the paralysis is only ulnar.[4,13]

The distal palmar arch is lost or reversed in ulnar nerve palsy mainly due to loss of hypothenar muscle function. This does not allow for cupping of the hand and keeping of water or other substances. For a secure grasp it is also essential to have a transverse distal metacarpal arch.[22,24,25]

The fine finger coordination and sequence of joint movements or synergism is lost with paralysis of the intrinsic muscles.[20,28] The normal hand initiates flexion at the MCP joints, followed by flexion at the proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints. In the ulnar palsied hand this sequence is reversed (Figs. 6-2, 6-4b). This represents loss of a great part of normal hand function.

The intrinsic minus or claw position, predisposes to high pressure points on the finger tips and the metacarpal heads area. (Fig. 6-4a and 6-4b) Flexion contractures predispose to fissures when fingers are stretched. With loss of protective sensation, this can lead to wounds and infection. Therefore, by correcting the claw hand, wounds can be prevented. Almost all reconstructive operations done on leprosy patients have a preventive aspect.

FIGURE 6-4a Normal grasp with pressure equally distributed over surface of the palm.

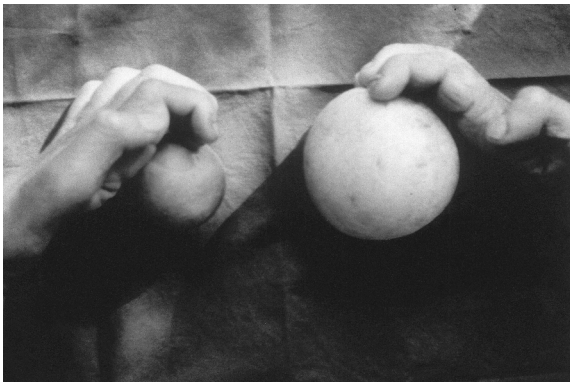

FIGURE 6-4b Grasp in ulnar palsy with pressure concentrated over fingertips and MCP joints.

It is important to emphasize the importance of the flexor digitorum profundus of the 5th and 4th fingers in grasp, as in closing the fist and also the importance of the strong flexor carpi ulnaris stabilizing the wrist in ulnar deviation in all power functions. These muscles are also innervated by the ulnar nerve in the forearm and are often totally or partially paralyzed.

The patient needs to be informed in detail about what surgery will most likely achieve. Only then can and should he or she make the decision to have surgery. It is also mandatory that a plan for the whole person should be made, not only for the hands. Patients also have to demonstrate that they have learned to care for hands that have loss of protective sensation. It is tragic to sometimes see a hand beautifully reconstructed by tendon transfers, rapidly being destroyed by the new forces because the patient has not incorporated care of the anaesthetic hand. We also need to assess if the patient can understand what the tendon transfer will do and if he or she will cooperate fully i.e. is motivated.

It is important to stress the absolute need for physiotherapy and/or occupational therapy in the pre-and postoperative period.[2,13] Contractures need to be corrected, and the muscle to be transferred must be isolated and later re-educated in its new function. As a general rule, if contractures of PIP and/or DIP joints are severe, even after full correction it will be necessary to splint these fingers also in the post operative period to prevent recurrence.

Once the decision to operate has been made, the next step is to decide on the surgical technique to be used.

SURGICAL PROCEDURES

The surgical techniques can be classified as Static and Dynamic procedures. The dynamic techniques can further be classified according to the muscle used, the insertion of the transferred tendon and/or the route the transfer takes.

STATIC PROCEDURES

These procedures basically provide a static block preventing MCP hyperextension. In this position the sagittal bands move distally and the extensor digitorum has enough excursion to extend the PIP and DIP joints. These procedures do not provide an active MCP joint flexor. The normal synergistic closure mechanism is not restored, but some of the mechanics and position of the hand are restored as well as the appearance. These procedures are normally not used in leprosy, unless there is a triple or high median paralysis and there are not enough muscles available for transfer. Static procedures are used mostly in quadriplegia or brachial plexus paralysis. Some surgeons have a preference for static procedures and report good results. Static surgical procedures do not require much re-education and avoid complications that may happen with a dynamic procedure e.g. an intrinsic plus or swan neck deformity.

Many procedures have been described. All follow the same principle of limiting MCP

extension.

Parkes graft tenodesis[22]

A fascia lata tendon graft is sutured into the distal edge of the transverse ligament of the carpal tunnel, then divided into four slips and tunneled through the lumbrical canals and inserted into the lateral band of each finger. Tension is regulated so that the MCP joints are in 15 to 20 degrees of flexion with the wrist in neutral. With wrist action some control can be gained over the degree of tension in the tenodesis.

Zancolli's volar MCP capsulodesis

In this operation the volar plate of the finger MCP's is sectioned transversally or in a longitudinal flap and then re-sutured, overlapping in such a way that the MCP is held in 20° of flexion.[1,17,21] This surgical technique does not restore normal hand kinetics, but allows the EDC to open the hand for grasp. The main problem encountered is that the capsule stretches with time. Tenodesis are easier to perform if one prefers a static procedure. Technically the volar MCP capsulodesis is not easy. It requires good surgical experience.

Pulley advancement (Bunnell – Palande)

In combination with volar capsulodesis or alone, advancement of the proximal edge of the A1 pulley creates a semi-active flexion of the MCP.[1,3,8,9,17,21] Through a volar approach, the A1 pulley is cut longitudinally at each side, close to the insertion of the pulley into bone, for a distance of 1-1.5 cm (Fig. 6-5), until the flexors bowstring on contraction. If not enough pulley is liberated, the moment arm of the flexor is not enough to flex the MCP. For this reason the pulley advancement works best in combination with volar capsulodesis. Some surgeons report good results with this operation.

There are many other static procedures

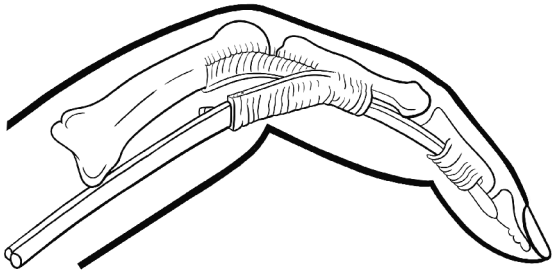

FIGURE 6-5 Pulley advancement procedure. The A1 pulley has been cut close to the bone on each side.

using tendon graft as tenodesis to block the MCP joints in some degree of flexion.[28-30] An interesting technique is Srinivasan's extensor diversion graft.[31] Four fascia lata strips are tunneled through the interosseous spaces from the dorsum of the hand, volar to the transverse intermetacarpal ligament and again to the dorsum of the proximal finger. The tendon graft is sutured to the extensor tendon on the dorsum of the hand and to the lateral bands in the finger. Tension is such, that the MCP's are held in 20° of flexion. There is a small dynamic component in this tenodesis that initiates MCP flexion. A more dynamic tenodesis described by Warren (personal communication) is to attach a graft to the lateral bands and fix the proximal end to the palmaris longus or flexor carpi radialis insertion with the MCP joints at 20 degrees with the wrist in the neutral position. This transfer will give some MCP flexion on wrist extension.

In general, static surgical procedures for correction of the intrinsic minus hand are poor substitutes for normal intrinsic action. For these reasons I recommend a dynamic transfer whenever possible.

DYNAMIC PROCEDURES

Wrist Motors

Brand extensor to flexor four tailed (EF4T)

The motor or muscle used is the extensor carpi radialis longus (ECRL).[2,4] Since this tendon is

too short to reach the fingers, a graft is needed. Brand proposed the use of the plantaris tendon but it is often absent. For this reason we use fascia lata graft routinely which gives similar results.[13] There are special tendon strippers for plantaris and for fascia lata that can be used to minimize the incisions. An open tensor fascia lata graft can also be taken if the stripper is not available, although it is easy to use ladder-like small incisions and long Metzenbaum scissors to harvest the graft. The distal insertion of the transferred tendon is into the lateral bands of the extensor mechanism of the fingers.

Technique

Incisions: The recipient area should be prepared first as this will minimize the exposure time of the transferred tendon if the insertion sites are exposed at the end of the procedure.

Incisions 1-4 are made on the dorsilateral border of the proximal phalanx on each finger (Fig. 6-6). Care is taken to preserve the dorsal vein. The incision is on the radial side of little, ring and long finger and on the index it is done on the ulnar side. This facilitates the three finger (chuck) pinch with the thumb. This is the most commonly used form of pinch and is very important for people who eat with their hands. Note that the Chinese often prefer the index insertion on the radial side to facilitate holding chopsticks. The extensor mechanism is exposed, especially the lateral bands and the central tendon. The thin synovial film that covers the extensor mechanism is removed in the area where the transfer will be sutured, otherwise the synovial film might prevent firm adhesions of the transferred tendon.

Incision 5 - A 2-3 cm transverse incision is made on the dorsiradial aspect of the wrist. Feel for the insertion of ECRL and make the incision just over this. Protect the radial cutaneous nerve branches. Dissect the tendon of the extensor carpi radialis longus free (make sure it is not the brevis or extensor pollicus longus!) and transect the tendon near its insertion, grasping the proximal end with a hemostat.

Pulling on the tendon you can feel the movement in the mid forearm (on the radial side) and make incision N° 6 which is transverse and 2 cm long 10 cm proximal to the radial styloid. Free the extensor carpi radialis longus tendon from the brevis and with a blunt instrument pull the distal part of the tendon out through the incision. Sometimes there are tendon strips crossing from ECRL to ECRB and the tendon cannot be extracted. Pulling to hard on the ECRL tendon can damage or disrupt the musculotendinous junction. It is best to make a longitudinal incision near the wrist and free the tendons. Sometimes it is

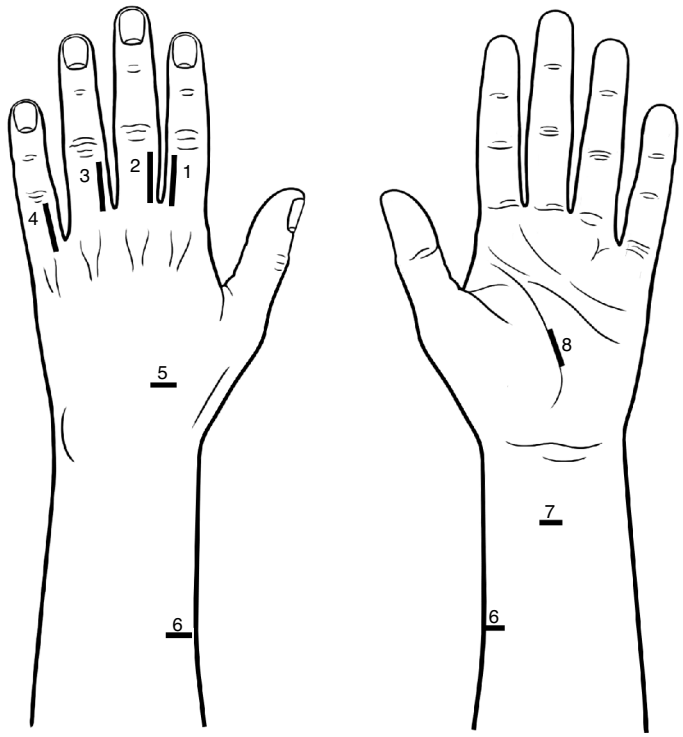

FIGURE 6-6 Incisions for EF4T. **a.** Dorsal aspect **b.** Palmar aspect.

also possible to push the tendon from distal to proximal.

Incision N° 7: This is made in the distal third on the volar forearm, opening the aponeurosis. With the tunneller coming from incisions 7 to 6 under the fascia, grasp the end of the ECRL and exteriorize it in the volar incision.

The graft is now anastomosed to the graft according to Brand's technique. The plantaris or tensor fascia lata are most commonly used. If the plantaris longus is used, the motor tendon is incised longitudinally for about 1 cm and through 2/3 of its thickness (Fig. 6-7). The site is near the end of the tendon or more proximal so that the anastomosis does not enter the carpal tunnel, although it has not created problems if it does.[6] With a scalpel, the tendon is then pierced from side to side in the middle of the opening created and the plantaris graft passed through at 90° to the ECRL. With fine monofilament sutures the graft is sutured to the deep fibers in the longitudinal incision. The

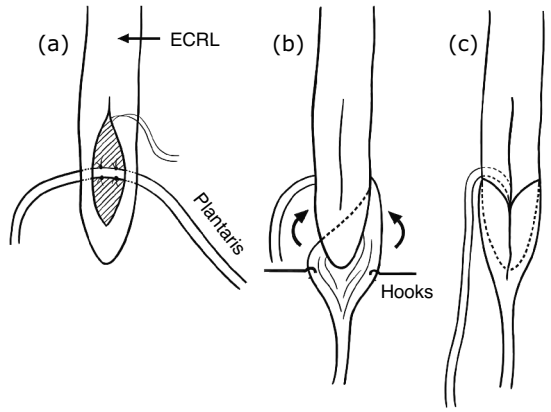

FIGURE 6-7 Brand anastomosis using plantaris tendon. **a.** 1.5 cm boat-shaped opening made in ECRL and plantaris tendon passed through the ECRL tendon at this level and sutured at its base. **b.** ECRL opening closed, plantaris stretched out flat. **c.** Plantaris tendon wrapped around the end of ECRL tendon and sutured.

graft should have two halves of the same length.

The incision in the ECRL is now closed with 5/0 or 6/0 monofilament nylon and the suture left in the field. The suture should be invaginating, so that knots and sutures are buried. One of the plantaris tendons is spread out by pulling the tendon transversally with hooks or stay sutures. The plantaris and palmaris have this quality of being able to stretch out like a film. The end of the ECRL is trimmed to size with a long oblique cut. Next the stretched plantaris is wrapped around the ECRL stump. Again 3 or 4 sutures fix the ECRL stump to the plantaris. The same fine nylon suture used to close the incision in the ECRL is now used to close the graft around the motor tendon going well beyond the end of the ECRL.

If fascia lata is used, the distal end of the graft is cut in a pointed fashion and introduced into the ECRL tendon through a hole made at the distal end of the longitudinal incision. The graft is sutured deep to the fibers of the ECRL with 3-4 fine stitches (Fig. 6-8a). The longitudinal incision is closed as described above. The ECRL is trimmed obliquely and the fascia lata is wrapped around the tendon stump and sutured into a tube, after fixing the motor ten-

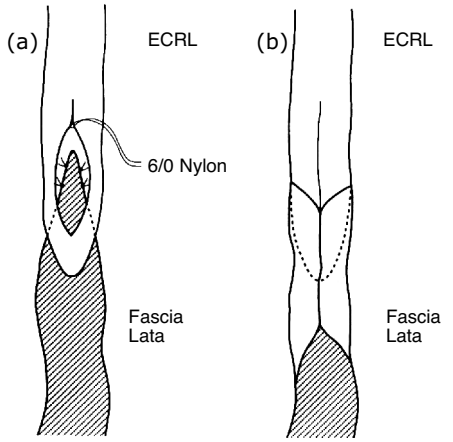

FIGURE 6-8 Brand anastomosis using fascia lata. **a.** Fascia lata passed into boat-shaped opening near the end of ECRL tendon and sutured. **b.** ECRL opening closed, fascia lata wrapped around end of ECRL and sutured in continuity with ECRL closure.

don to the graft with interrupted sutures (Fig. 6-8b). The ECRL tendon and the graft are now united to each other by 6-8 sutures and the wrap around reinforces this even more. This gives a very strong anastomosis. The graft is then tunnelled deep to all structures to incision N° 8, a 2cm incision in the proximal palm in line with the thenar crease. The tendon graft anastomosis should not enter the carpal tunnel.[6] The anastomosis should therefore be placed proximally enough on the ECRL tendon and the graft long enough to reach the dorsum of the fingers. Care is taken that the superficial vascular palmar arch is not compromised. It is best to come out with the tendon distal to the vascular arch. The graft is now divided in 4 slips (strands or tails) (Fig. 6-9). Each slip is now tunneled from the palm to the dorsal incisions on the fingers (Fig. 6-10). Care is taken to pass *volar* to the transverse intermetacarpal ligament to ensure MCP joint flexion (Fig. 6-11). Passing the tunneller from the dorsal incision to the palm, the ligament can be easily felt moving the tunneller tip volar to dorsal, back and forth. Holding the finger with the MCP in flexion will facilitate this maneuver. Possible errors are also to tunnel subcutaneously or bridge part of the palmar aponeurosis. The tunneller has to come out exactly in the middle of the incision. It is important to probe around when tunnelling to find a route with minimal resistance. All incisions, except those for the fingers, are now closed.

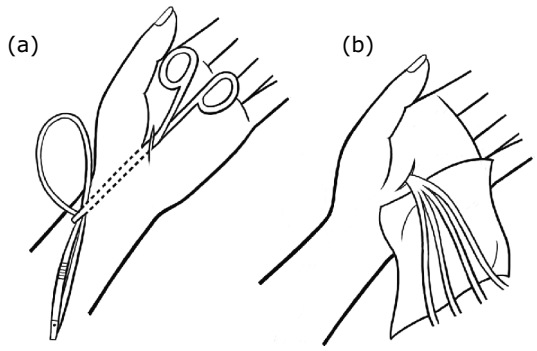

FIGURE 6-9 EF4T procedure. **a.** Passing graft into palmar incision using Anderson tunneler. **b.** Graft divided into 4 slips (from Fritschi[13], used with permission).

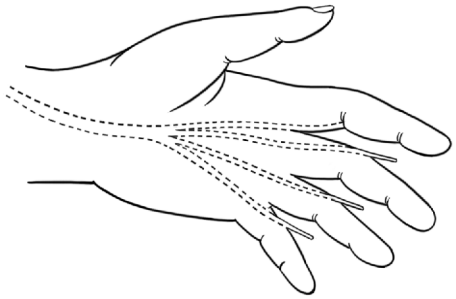

FIGURE 6-10 EF4T procedure, showing route of grafts from wrist to fingers (from Fritschi[13], used with permission).

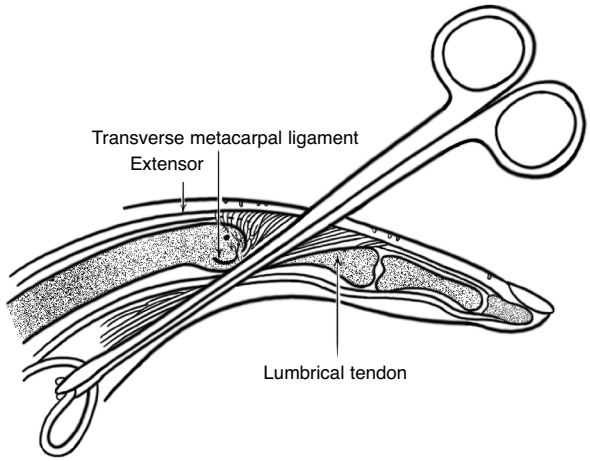

FIGURE 6-11 EF4T procedure, showing passage of graft palmar to the transverse metacarpal ligament.

Important in all tendon transfers is the tension given to the transfer. Experience has shown that by using a standard position for the hand, more consistent tension can be judged. Recommended is to position the hand with the wrist in 30° of flexion and MCP's at 80°-90° and the DIP and IP joints at 0° or neutral extension. There are special splints designed which can easily be made out of metal (Fig. 6-12) or wood, but it can easily be arranged with rolled up

green towels or a sterilized can of pop or beer. The total tendon excursion will be about 2 cm. For a stiff hand more then half the total excursion for tension should be used. In mobile hands almost no tension is adequate. Usually the index transfer is done first and then the little finger which always receives 1 cm more tension to assist in restoring the distal transverse metacarpal arch.

FIGURE 6-12 EF4T procedure/ sublimus transfer, showing hand on splint with grafts coming out of the dorsal finger incisions ready to suture to lateral bands.

By dividing the tendon graft in 5 bands, one slip can be tunnelled to the ulnar side of the little finger and sutured to the abductor digiti minimi tendon with slightly more tension. This extra step usually results in a good transverse metacarpal arch if the hand is mobile.

If the fingers are in a Boutonniere position that does not correct with physiotherapy, we have used very successfully a technique shown to me by Dr. Ernest Fritschi, referred to as dorsal fixation of the lateral band (see Chapter 9). The recipient lateral band of the tendon transfer, is freed from all underlying tissue to the middle of the mid phalanx and is folded on itself 180°. The band should cross the PIP in the middle. It is sutured to the central tendon and extensor apparatus. The tendon transfer is now sutured to the doubled up lateral band. This leaves a stiff PIP in extension initially, but physiotherapy will usually correct this.

If the DIP is fixed in extension, a tenotomy of the distal extensor tendon is done. A N° 15 knife is pushed under the skin, flat, to the DIP. It is then turned 90° with the blade towards the bone and a long oblique tenotomy of the extensor is done from the DIP proximally. Check for release of the DIP to be sure that all fibers have been cut. The DIP joint should flex to at least 45 degrees. Early mobilization of the DIP is started in the post-operative period. The tendon will heal in a stretched position. Mallet finger is seldom seen. Sometimes I have also cut the collateral ligaments at the PIP joint partially and released the volar plate as well.

The tourniquet is now released, finger incisions closed and a strong plaster splint is applied with wrist slightly in flexion, fingers straight and MCP in maximum flexion. Some use a full cast. It is essential to keep the operated hand elevated at all times for at least 72 hours.

The initial cast stays on until physiotherapy starts at about 3-4 weeks, unless there are complications. This transfer is one of the best. It adds a strong muscle to the flexor group. It is not difficult to re-educate and removing the extensor carpi radialis longus leaves very little loss of function if the radial nerve is normal. Pre- and postoperative views are seen in Fig. 6-13 a,b.

Complications of EF4T: Swan neck or "Intrinsic plus" can occasionally be seen if the tension is too strong or when the fingers are hypermobile. Unequal tension on the 4 bands can be very disabling (quadriga effect).

FIGURE 6-13 Claw hand. **a.** Pre-operatively. **b.** Following EF4T procedure with restoration of primary MCP flexion.

Palmaris longus transfer (PMT, palmaris many tailed)

Fritschi and Ranney reported on the use of the palmaris longus with a tendon graft[13,28,29,30] (fascia lata or plantaris) for intrinsics replacement of the fingers. The tendon graft anastomosis can be difficult because of the small size of the palmaris, although a Brand anastamosis should deal with this problem. It is ideal for hypermobile hands. It is not as powerful as the other motors used in the other techniques. The palmaris has a tension fraction similar to that of the lumbricals, and so can just produce primary MCP flexion in the mobile hand but with minimal strength.

Another approach to the hypermobile hand is to insert the tendon slips of FDS into the A1 pulley or as Palande has shown, into the tendons of the interossei.[22]

Extensor Extensor Many Tailed (EEMT)

Before using the volar route, Brand first described the same operation, transferring the tendon through the interosseous spaces.[2] From the palm each tendon is then tunnelled volar to the intermetacarpal ligament to the lateral bands. The main problems encountered are adhesions to the interosseous aponeurosis, reverse metacarpal arch and tenodesis effect with wrist flexion. Adhesions can be avoided by carefully probing for a defect in the fascial layers when doing the tunnelling as described above. Some surgeons still prefer to use this surgical technique, reporting good results (personal communication).

Flexor Carpi Radialis Transfer

Riordan uses the flexor carpi radialis as motor.[26,27,28] This also needs a tendon graft. He re-routes to the dorsum of the forearm, then perforates the interosseous spaces and then routes the transfer from the palm to the lateral bands for insertion. It is a strong transfer. Perforating both interossei fascia may cause adhesions. This technique uses the principal wrist stabilizer which may leave a serious weakness. This problem can be avoided by routing it on the flexor side of the wrist as a palmaris longus transfer, which will keep its role as a wrist flexor.

Finger Motors

Flexor Sublimis Transfer

The reason we use the sublimis transfer as routine in South America, is to avoid having to do the tendon anastomosis. It takes a skilled and delicate surgeon to perform the EF_4T procedure. Our aim is to include as many surgeons as possible and it is easier and faster to perform the sublimis transfer. [RS: I would suggest training surgeons to do the best procedure possible for each patient if the skill level is present.] The types of hands are also generally the strong stiff European hands and severe contractures are also common. The aboriginals have hypermobile hands similar to that seen in India or Asia.

Usually the long finger flexor superficialis is used as the motor and the insertion can be into the lateral bands in the same manner as described for the EF_4T, or the insertion can be into the A1 pulley as described by Zancolli or Brooks.[4,5,13,25,26,27,28,29]

Lateral Band Insertion: (Stiles - Bunnell - Brand)[8,9,32] Incisions in the fingers are the same as described in the EF_4T. The tendon of the long finger sublimis is harvested through an oblique incision on the volar aspect of the proximal phalanx. The tendon on one side is transected just proximal to the vinculae longa. If the vinculae is transected then complete hemostasis must be achieved to avoid scarring and later flexion contracture of the PIP (check rein). Fritschi recommends to cut the flexor superficialis as close as possible to its insertion.[13] The other tendon can be visualized and cut by pulling on the first tendon. The second tendon will appear underneath the flexor profundus.

The decussation of the tendon has to be divided, otherwise it slings around the flexor profundus and the flexor sublimis can not be withdrawn. This is done by flexing the wrist and MCP's and pulling on the two tendon slips with hemostats. A closed scissor is passed along the flexor superficialis until a window is felt. Pulling on the scissor hooked into the window, the union between the two slips is visualized and can be transected.

The sublimis tendon can also be harvested through a transverse incision just proximal to the flexion crease at the MCP joint. The tendon is withdrawn through the interval between A1 and A2 pulley or an interval is created. Pulling hard the sublimis tendon can usually be exteriorized and cut just proximal to the decussation and vincula.

Through a 2 cm incision at the base of the palm in line with the thenar crease, the flexor superficialis of the long finger is withdrawn, preferably distal to the superficial palmar vascular arch. The sublimis is divided into 4 equal slips (Fig. 6-14). This is not difficult because the fibers are very parallel and straight. Maintaining strong tension on the tendon, a knife can be passed from proximal to distal.

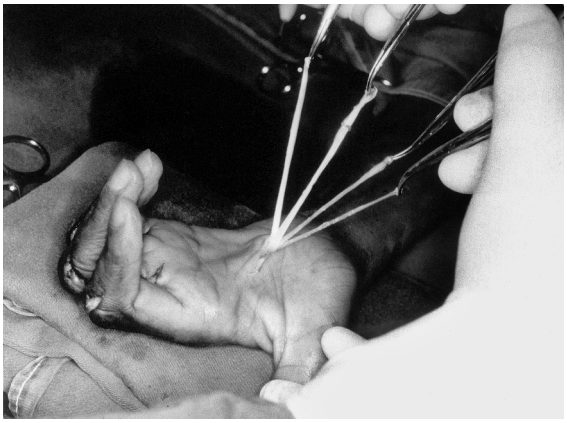

FIGURE 6-14 Sublimis transfer with sublimis tendon split into four tails in palm.

The remainder of the surgical technique is as described for the EF_4T with similar tensions (Fig. 6-15). Pre-and post-operative results are seen in Fig. 6-16 a,b.

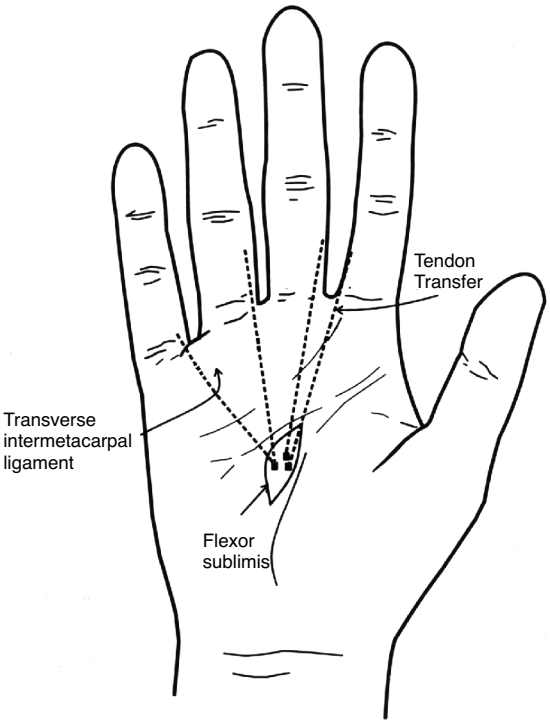

FIGURE 6-15 Route of sublimis transfer to lateral bands.

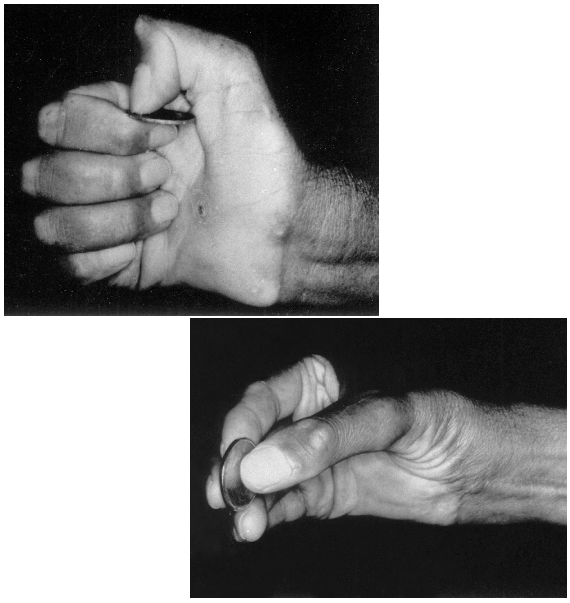

FIGURE 6-16 Ulnar/ median palsied hand. **a.** Pre-operatively. **b.** Following sublimis transfer to lateral bands and opponensplasty, with full restoration of primary MCP flexion.

Insertion into Flexor Pulley (Zancolli Lasso-Brooks)[7,13,27,28,29,33]

The area of insertion is the distal palm. A curved, transverse incision is made in the palm from the radial border to the ulnar border, about 1 cm proximal to the MCP flexion creases.

The flexor tendon sheaths are dissected free and the proximal border of the A1 pulley identified. The synovial sheaths are opened just proximal to the A1 pulley border with scalpel or pointed scissors, care taken not to injure the flexor digitorum superficialis.

The flexor superficialis of the long finger is transected distally as described above. It can easily be withdrawn through the long transverse incision. The tendon is withdrawn through a small separate incision at the base of the palm and divided into 4 slips or bands as described before. A fifth slip can be divided.

The 4 slips are tunneled close to the radial side of each flexor sheath into the transverse incision (Fig. 6-17). Each slip is then pulled through the proximal 5-7 mm of the A1 pulley (Fig. 6-18). A small gallbladder hemostat is quite helpful. Grinding the tips of a gallbladder forceps or a curved mosquito hemostat makes it easier to pierce through the pulley. With the hand flat on the table and the fingers in extension, the slips are sutured to itself under maximum tension. The little finger receives about 1 cm more tension. Some surgeons insert the tendon into the A2 pulley to increase the moment arm. The problem is that the tendon bowstrings. I have seen patients with large calluses at the volar MCP and also with problems in grasping small objects like tool handles, especially brooms. [RS: I routinely use the A2 pulley without seeing the problems noted above. It has the same moment arm as the interossei insertion.[4]]

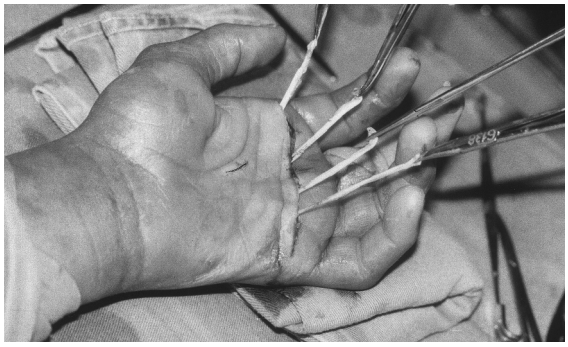

FIGURE 6-17 Zancolli "Lasso" procedure, showing sublimis tendon split into four slips and having been passed from palmar incision back to transverse palmar incision.

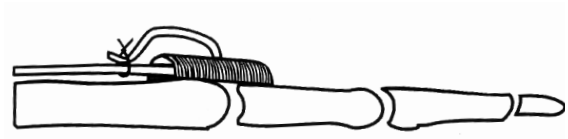

FIGURE 6-18 Zancolli "lasso" procedure, showing transferred sublimis slip looped around the A1 pulley and sutured to itself.

A 5th slip can be created and inserted into the ulnar side of the MCP of the little finger to increase the transverse arch.[32]

Complications: Check rein (scarring at PIP level) presents as a PIP fexure contracture, and is dealt with in chapters 7 and 22. MCP flexion contracture can rarely be seen if sutures of the tendon slips are done with fingers in flexion. Intrinsic plus, superficialis minus or profundus plus deformity at the donor or other fingers are fairly common. These are all swan-neck-like deformities but are the result of too much power in the transfer, taking the superficialis away or of the FDP creating a flexion deformity at the DIP, respectively (see chapters 7, 9 and 22).

Extensor Proprius Transfer

Fowler uses as motor the extensor indicis proprius and extensor digiti quinti minimi, each divided into two slips and the same as Riordan, perforates the interosseous membranes.[13,28,29,30] I have used this technique in my initial years of leprosy work. The results were consistently poor. Adhesions and difficulty in re-education were the main problems.

Intrinsic Reactivation Technique

Palande, in this technique, uses the extensor carpi radialis longus as motor, with fascia lata graft. The insertion is into the adjacent interosseous tendons in the interdigital space. It reactivates the primary flexors of the MCP joints leaving extension for the extrinsic extensors. The results seen by these techniques in Palande's patients are really excellent, but it is an operation for the well experienced hand surgeon.

The Contracted Claw Hand

If the contracture of the PIP is less than 45°, and physiotherapy is of no help, tendon transfers can still be done for claw hand deformity. Function increases greatly. Surgical methods releasing skin and ligaments can also be used successfully. When the contracture is near 90° soft tissue release may be attempted and arthrodesis of the PIP gives a functional hand (chapter 9). As Dr. Paul Brand so often said "an arthrodesed hand loses a lot of its humanness" and there is seldom a patient happy with an arthrodesis. Especially in interpersonal contact a rigid finger feels very unnatural.

The long standing paralysis of the intrinsics in the hand can lead to fixed contractures with MCP's in extension and PIP and DIP's in full flexion. Function of the hand is severely reduced and the patient basically uses the hands as paddles. Physiotherapy should always be attempted for 2 or 3 months. It is surprising how often contractures improve.

The surgical solution is to arthrodese the PIP and DIP in extension. This leaves the finger at half its length because of the amount of bone to be resected. Non union and mal union are common (see chapter 9).

One patient showed me another way. By hacking off the 4 fingers of both hands with a machete at the PIP level, he forced me to tidy up his surgery. He was a bricklayer and later had improved function of the hands with only proximal phalanges. Observing other patients I noticed that when finger injuries reach the PIP level, often no more injuries occurred. The length is the same as the arthrodesed finger. The only thing missing is the fingernail which is important to some patients, especially females. The proximal phalanx is well padded and the long flexors act now as MCP flexors, improving function greatly as compared to the rigid claw position. I now prefer the PIP level amputation.

Summary- intrinsic loss

We have used the Brand EF_4T transfer with insertion into the A1 pulley in hands that needed a strong transfer, but were hypermobile. There is often discussion as to which technique is better: the A1 pulley or the extensor insertion. We believe each has its place. In hypermobile hands the insertion in the A1 pulley pro-

vides an active MCP flexor and restores the normal sequence in closing the hand used in grasp without acting on the extensor mechanism. The danger of producing a swan neck is less. But the extending of the fingers has to be done by the extensor digitorum communis, which in turn will act against the transfer. This may need extra attention in re-education. It is easy to recognize a "Zancolli" hand, because the fingers are seldom fully extended when adopting the intrinsic position. Functionally this is not important, but it may be cosmetically.

The insertion of the transfer into the lateral bands restores most of the intrinsic function and is reserved for stronger, stiff hands, or with residual contractures.

With the EF_4T and the two FDS transfers we have been able to solve most problems with the intrinsic minus hand. The palmaris longus transfer for hypermobile hands is also reasonable.

FLEXOR DIGITORUM AND FLEXOR CARPI ULNARIS WEAKNESS

When the FDP of the long finger is weak, all 4 flexor digitorum profundus tendons can be sutured together in the distal forearm in the natural finger cascade position. However Brand did not consider this a major problem and only recommended surgery if the FDS to the little finger was weak or absent.[4] If the long finger FDP is strong, the index FDP does not need to be included. Use a strong non-absorbable suture like 3/0 nylon and free the tendons of synovium at the transfixing suture site. In this situation it would be advisable to use a wrist motor procedure such as the EF_4T as opposed to an FDS transfer.

Rarely a patient may complain of significant effect of the loss of wrist ulnar deviation (due to loss of FCU) on his ability to function well. In this case the FCR tendon could be transferred to the FCU insertion, and use brachioradialis to attach to the FCR stump, as Brand suggests.[4] This is seldom a problem.

ULNAR NERVE PARALYSIS IN THE THUMB

In ulnar nerve paralysis the adductor pollicis, the first dorsal interosseous and often flexor pollicis brevis (FPB) are paralyzed. Loss of adductor pollicis causes marked weakening of key pinch. Loss of FPB causes interphalangeal (IP) hyperflexion (Froment's sign) or metacarpophalangeal hyperextension (Z-thumb), depending on the individual hand. Prolonged uncorrected ulnar/median palsy is not infrequently associated with trapezio-metacarpal subluxation.

Restoration of Key Pinch

Approximately 25 percent of thumb adduction strength is provided by the extensor pollicis longus (EPL) and flexor pollicis longus (FPL) and as such most patients do not request intervention to strengthen key pinch. However, a patient with particular work requirements with an ulnar palsy in the dominant hand may request increased thumb adduction strength. The infrequency of this procedure being performed may be partly due to the surgeon failing to either examine the hand at work or to actually measure pinch strength, as Brand has pointed out[6], and the defect may go unrecognized. Adductor pollicis (AP) is a powerful muscle with a tension fraction (TF) of 3.0, with FPB providing an additional 1.3. For comparison the FPL has a tension fraction of only 2.7. For those who do require strengthening of key pinch, either extensor carpi radialis brevis (TF 4.2) or flexor digitorum superficialis (m) (TF 3.4) can be used. Extensor indicis proprius has been used[7] but with a tension fraction of only 1.0 this seems rather weak to be very effectual, although Palande also confirms its usefulness

(personal communication). Brand suggests using two tendon grafts to the thumb in ulnar/median nerve palsy, using FDS to the adductor and extensor indicis proprius for opposition.[3] Boyes[1] has used the brachioradialis extended with a graft, taking this through the third metacarpal space, but this can be difficult to re-educate.

Extensor Carpi Radialis Longus to Adductor Transfer-Technique (Omer)

This technique was originally described by Smith[7] and modified by Omer.[6] The extensor carpi radialis brevis (ECRB) tendon is divided at its insertion and extended with a free tendon graft using a Brand anastomosis. The graft is then tunnelled through the third inter-metacarpal space to the palm. It is then brought volar to the AP and dorsal to the flexor tendons and neurovascular bundle to be attached to the abductor pollicis brevis insertion. The tension is adjusted so that the thumb is just palmar to the index finger when the wrist is straight. Immobilization is continued for three to four weeks after which therapy is commenced. Wrist flexion allows thumb abduction, and when the wrist is extended the thumb is adducted against the palm. The key pinch strength is doubled on average by this operation.[7] This operation has the disadvantages of using ECRB, the principle wrist extensor, and an angle at the pulley of 90°. Smith stopped using this transfer subsequent to his publication (personal communication).

Flexor Digitorum Superficialis to Adductor Pollicis Transfer- Technique

Littler first described this procedure.[19] The disadvantage of this procedure is the loss of one flexor digitorum superficialis (FDS), especially if another is going to be used for intrinsic replacement for the fingers. This will further weaken power grip. The FDS is divided through a distal palmar incision just proximal to its decussation. It is brought out in the palm and then tunnelled across the palm volar to the adductor pollicis (AP) to be attached to the AP insertion (Fig. 6-19). The palmar fascia where it has been split serves as the pulley. Tension again is set so that the thumb lies close to the index finger with the wrist in neutral. Plaster is applied with the wrist in 30° of flexion with the thumb adducted, and the hand kept immobilized for three to four weeks. Brand prefers attachment to abductor pollicus brevis insertion or to extensor pollicus longus halfway along the proximal phalanx in patients with median/ulnar palsy. This will give both adduction/flexion and also improve thumb pronation.[3] A separate tendon such as extensor indicis proprius is then used for thumb opposition. Hamlin and Littler[4] reported a pinch power of 70 percent of the opposite hand following this procedure.

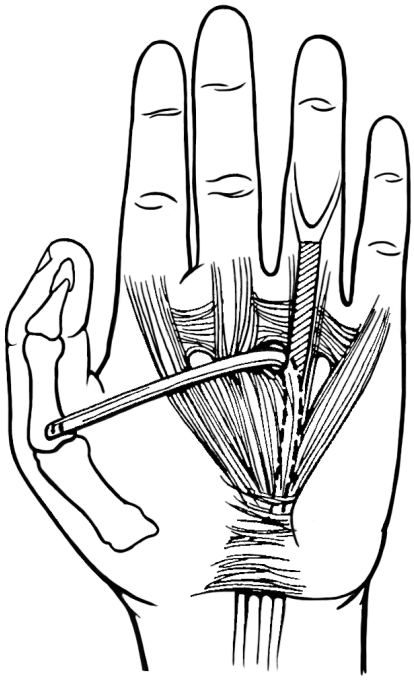

FIGURE 6-19 Flexor digitorum superficialis to adductor pollicus transfer (from Omer[25], used with permission).

Restoration of Primary thumb MCP Flexion

Patients with isolated ulnar nerve palsy usually have adequate primary MCP flexion and do not require further surgery. With combined ulnar- median paralysis primary MCP flexion is lost, which may produce variable amounts of I-P hyper-flexion as well as MCP hyper-extension. This in turn may produce an unstable pinch as the grip surface is the tip rather than the pulp. Often the double-insertion FDS (Brand) opponensplasty as described in chapter 7 adequately stabilizes the thumb to prevent IP hyper-flexion. If not, there are five ways this problem can be corrected.

Metacarpophalangeal joint arthrodesis.

Half flexor pollicus longus to extensor pollicus longus transfer.

Additional slip from 'Lasso' to AP insertion.

Interphalangeal joint arthrodesis.

Flexor- adductor replacement.

The best technique depends on the patient, the thumb and the hand (see below). For a Z-thumb deformity, the most reliable technique is metacarpal-phalangeal joint arthrodesis. For isolated interphalangeal joint hyperflexion, half FPL to EPL transfer gives the best result.

1) Metacarpophalangeal Arthrodesis

Similar to the fingers, when the metacarpophalangeal joint of the thumb is stabilized the interphalangeal joint is able to extend. As well, fixing the metacarpophalangeal joint in slight flexion will allow the distal joint to flex independently, avoiding the hyperflexion produced when the proximal joint is hyperextended. The metacarpophalangeal joint functionally has a limited range of movement, from 0-20° in the flexion-extension plane. The loss of this movement does not result in any functional impairment, and arthrodesis will restore control of the distal joint. For this reason for a patient with a mobile interphalangeal joint the MCP joint should be arthrodesed, and the distal joint should only be arthrodesed when there is a fixed flexion deformity present. This is the procedure of choice for a fixed deformity of the MCP joint such as a fixed hyperextension.

Technique

There are many ways to fuse a digital joint. The following technique I have found quite satisfactory. A 4 cm dorsal incision is made over the dorsum of the MCP joint, displacing the extensor tendon and then proceeding to cut down to bone. The fibres of the extensor brevis are divided and the joint capsule is opened. The collateral ligaments are divided to allow dislocation of the joint. The joint surfaces are cut with either a saw or bone cutters so that when opposed the joint will be in 15° of flexion and 5° of abduction (Fig. 6-20a). A Chevron cut (Fig. 6-20b) will give a larger surface area and more stable fixation. Two crossed K-wires are then advanced into the proximal phalanx to exit the skin. The two bone surfaces are then opposed with the thumb in 15° of pronation and the K-wires drilled into the metacarpal. The thumb is immobilized in a short thumb spica for 8 weeks and then active motion of the thumb is permitted. The K-wires are removed at 8 weeks or when bone healing is seen on X-ray.

2) Half Flexor Pollicus Longus to extensor pollicus longus transfer.

This procedure, described by Malaviya[20] stabilizes the interphalangeal joint by making the flexor pollicus longus both a flexor and extensor of the joint, but a pure flexor of the MCP joint. This prevents extension of the MCP joint during thumb flexion and corrects the interphalangeal hyperflexion resulting from this. It is the procedure of choice in a patient with a mobile IP joint with Froment's sign.

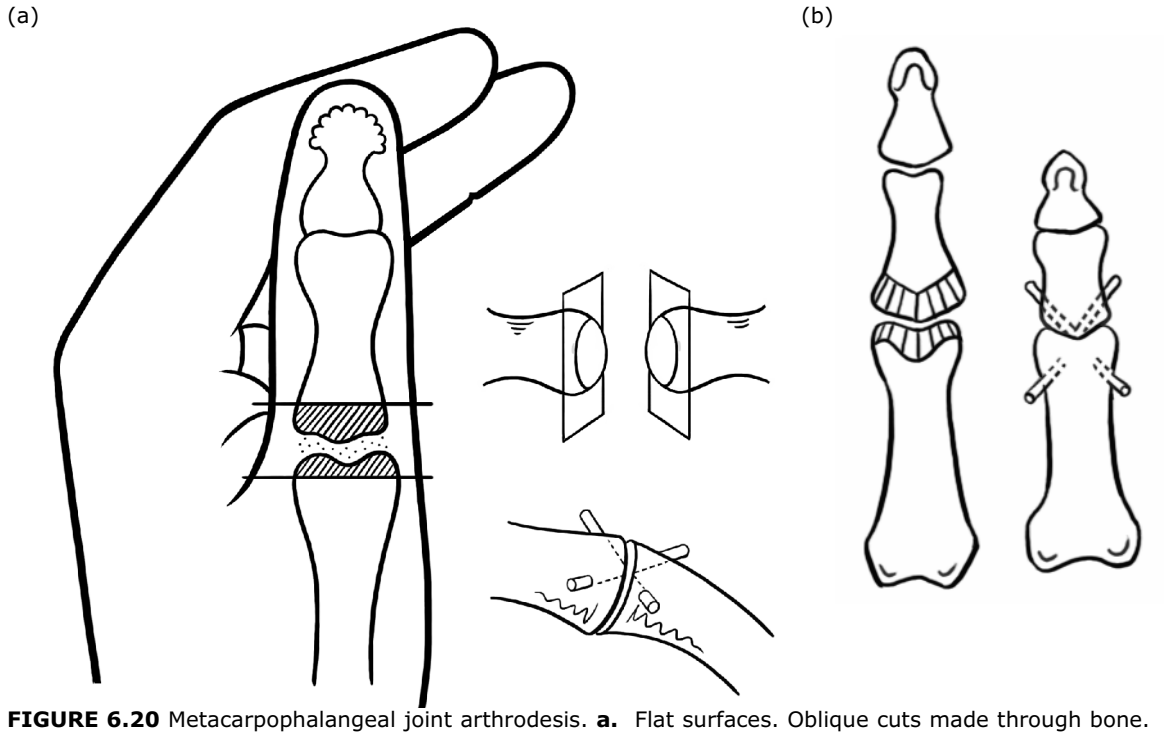

FIGURE 6.20 Metacarpophalangeal joint arthrodesis. **a.** Flat surfaces. Oblique cuts made through bone. Angle of cut determines amount of joint flexion. Fixation with cross K-wires. **b.** Chevron arthrodesis.

Technique

The flexor pollicus longus is identified though a small transverse incision along the interphalangeal joint crease and again through a second incision along the metacarpal joint crease. From the first incision the radial half of the tendon is separated and cut off its insertion. It is then separated as proximally as possible by flexing wrist and thumb and pulling on both slips. The cut slip is then identified and withdrawn from the proximal incision. It is then brought around the radial aspect of the proximal phalanx to be inserted into the extensor pollicis longus at the mid-point of the proximal phalanx (Fig. 6-21). Tension should be adjusted so that in full interphalangeal extension and 20° of metacarpophalangeal flexion the two slips of the flexor pollicus longus are at the same tension. The dorsal slip therefore becomes taut in flexion, and because the tendon is volar to the MCP joint it will then flex

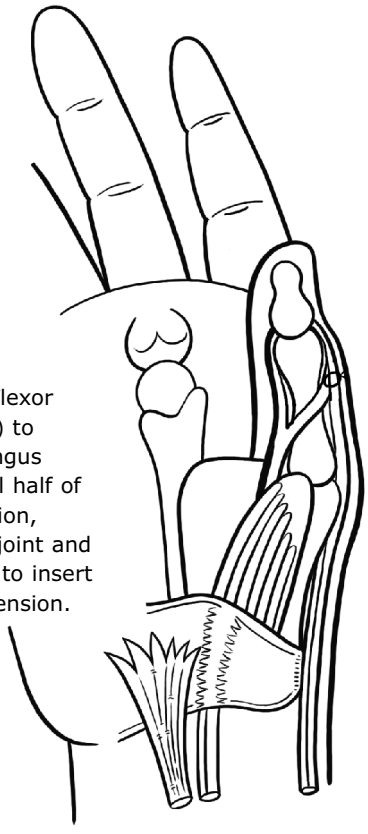

FIGURE 6.21 Half Flexor Pollicus Longus (FPL) to Extensor Pollicus Longus (EPL) transfer. Radial half of FPL divided at insertion, brought out at MCP joint and then across phalanx to insert into EPL at neutral tension.

this joint. A thumb spica including the wrist is placed with the thumb in full opposition and the wrist in 20° flexion for three weeks.

3) Additional slip from 'Lasso'

When a lasso procedure is being carried out for intrinsic loss replacement (see intrinsic replacement section of this chapter), a fifth tail can be added to the transfer to provide first MCP flexion. The radial-most slip from the superficialis tendon is brought radially over the adductor pollicis and deep to the digital vessels to insert into the abductor pollicus brevis insertion. The distal edge of the palmar fascia therefore becomes the pulley. It is sutured with the thumb in near full abduction. If this is too tight the grip span will be reduced. This will produce thumb adduction, pronation and MCP flexion. This may be expecting too much of a single transfer in some hands and detract from the intrinsic function of the transfer on the fingers.

4) Arthrodesis of Interphalangeal Joint

This procedure is only indicated in the presence of a relatively severe fixed flexion contracture of the IP joint. It is rather disabling as it does not allow the patient to adjust the thumb tip angle in pinch, yet if the MCP joint is mobile patients cope well. It is preferable to a fixed contracture in which the nail is part of the contact surface, which predisposes to ulceration. A mild flexion contracture is usually best not interfered with.

The technique is as for finger I-P fusion. The ideal position is straight or even in slight extension, although in the presence of shortened digits slight flexion may be necessary to facilitate contact.

5) Flexor-adductor replacement

The adductor replacements described above also provide primary MCP flexion and can be used as such.

SUMMARY

In general, surgery for the ulnar deficit hand in leprosy is most rewarding and if good physiotherapy is available, most patients have excellent results, the hands look better and function better and are less likely to have injuries.

Do not embark on surgical correction of claw hands without the presence of experienced hand therapists. Preparing the hands and re-educating the transferred muscle, is an essential part in the rehabilitation of any paralyzed hand.

Ideally, nerve function loss should be prevented in leprosy patients. If present, the secondary complications such as contractures should be prevented so that dynamic tendon transfer procedures can be employed to give maximum functional and cosmetic benefit to the hand. Only if hands are very badly contracted need the surgeon resort to arthrodesis and other operations to restore some functionality to the hand.

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