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 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.

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

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 also possible to push the tendon from distal to proximal.

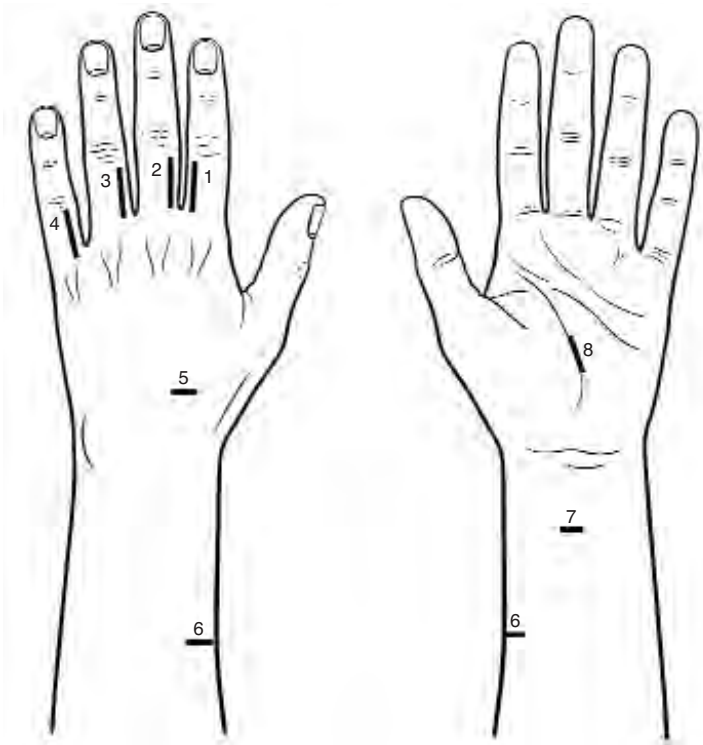

FIGURE 6-6 Incisions for EF4T. **a.** Dorsal aspect **b.** Palmar aspect.

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 graft should have two halves of the same length.

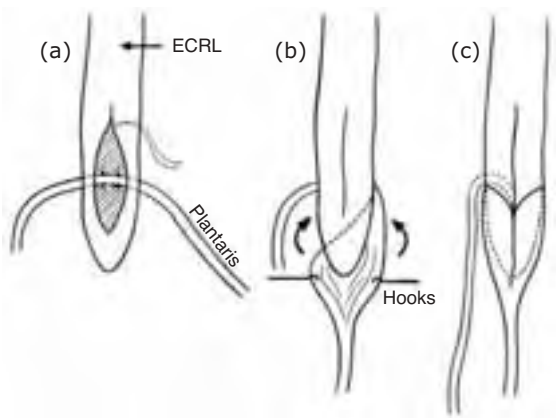

FIGURE 6-7 Brand anastomosis using plantaris tendon. **a.** 1.5 cm boat-shaped opening made in ECRL and plantaris tendon passed through the ECRL tendon at this level and sutured at its base. **b.** ECRL opening closed, plantaris stretched out flat. **c.** Plantaris tendon wrapped around the end of ECRL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

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 tendon to the graft with interrupted sutures (Fig. 6-8b). The ECRL tendon and the graft are now

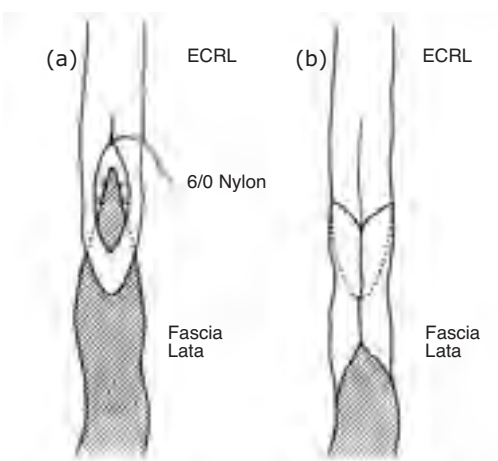

FIGURE 6-8 Brand anastomosis using fascia lata. **a.** Fascia lata passed into boat-shaped opening near the end of ECRL tendon and sutured. **b.** ECRL opening closed, fascia lata wrapped around end of ECRL and sutured in continuity with ECRL closure.

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.

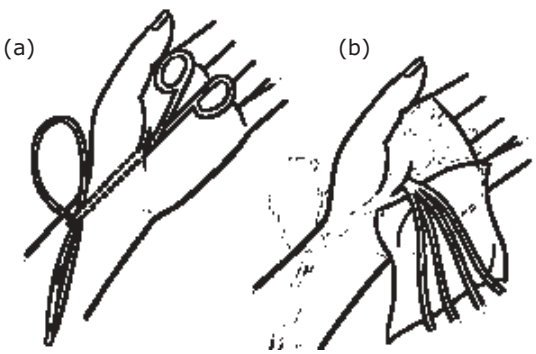

FIGURE 6-9 EF4T procedure. **a.** Passing graft into palmar incision using Anderson tunneler. **b.** Graft divided into 4 slips (from Fritschi[13], used with permission).

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

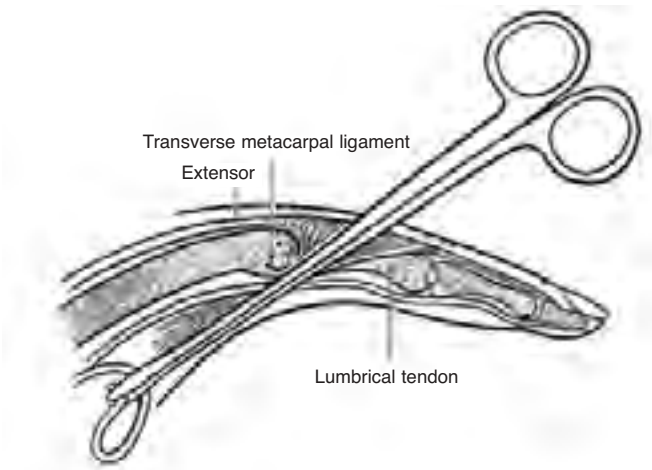

FIGURE 6-11 EF4T procedure, showing passage of graft palmar to the transverse metacarpal ligament.

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.

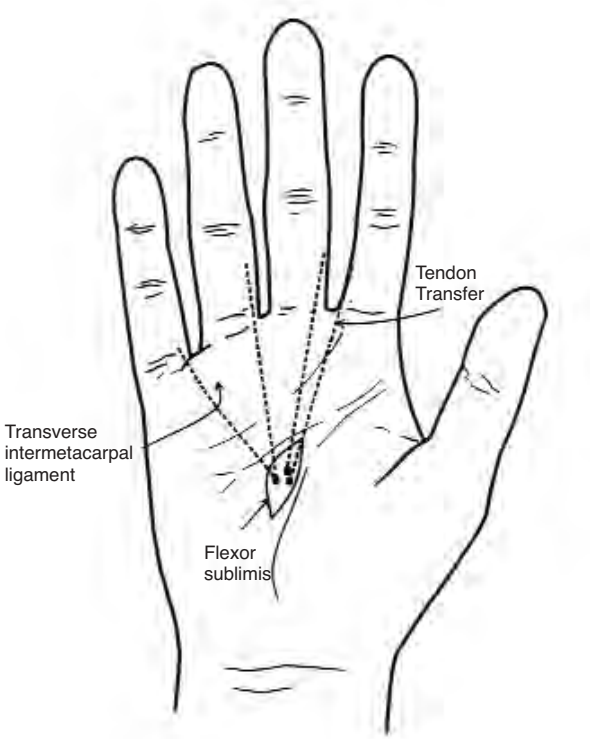

FIGURE 6-15 Route of sublimis transfer to lateral bands.

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 nonabsorbable 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.

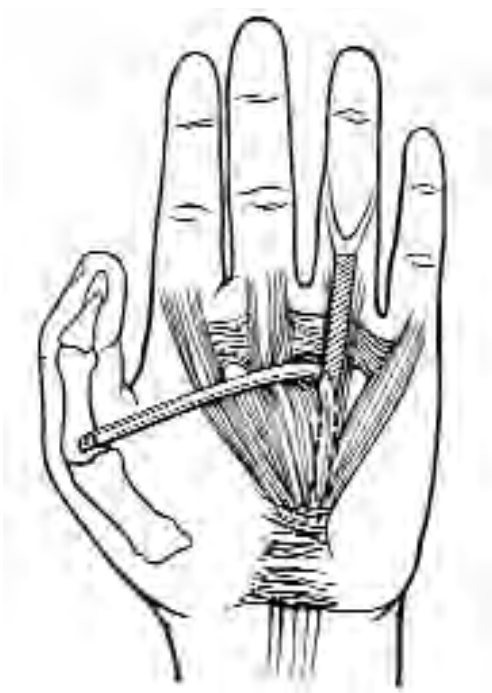

FIGURE 6-19 Flexor digitorum superficialis to adductor pollicus transfer (from Omer[25], used with permission).

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.

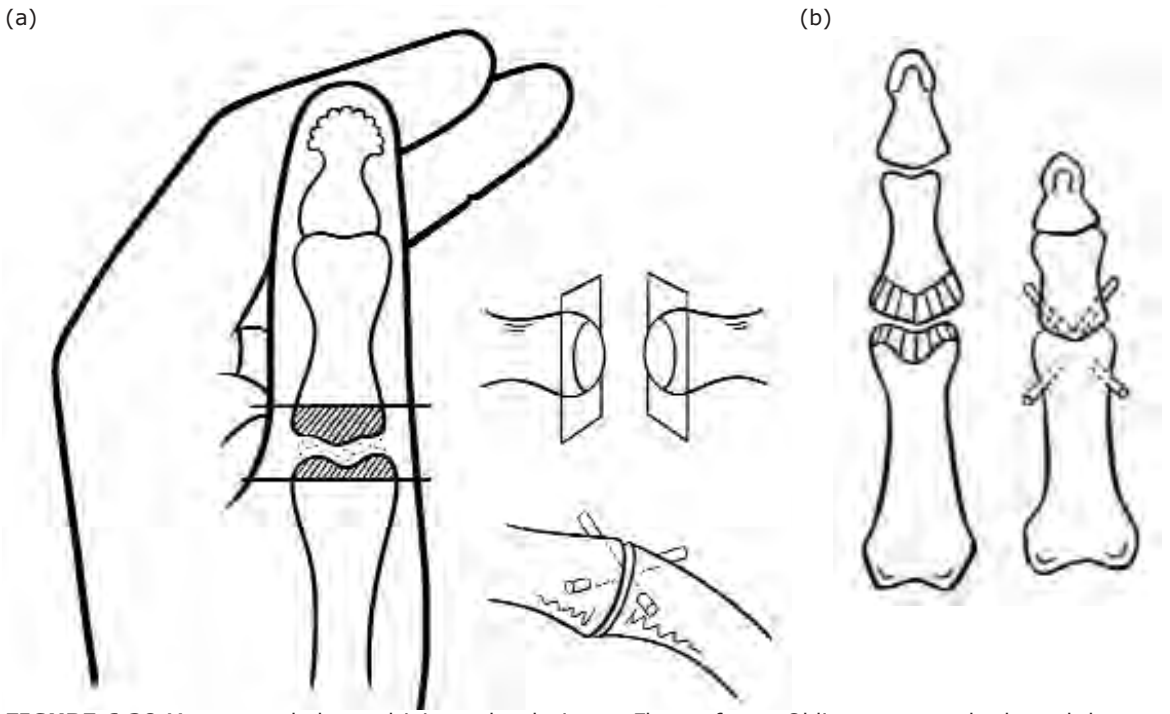

FIGURE 6.20 Metacarpophalangeal joint arthrodesis. **a.** Flat surfaces. Oblique cuts made through bone. Angle of cut determines amount of joint flexion. Fixation with cross K-wires. **b.** Chevron arthrodesis.

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

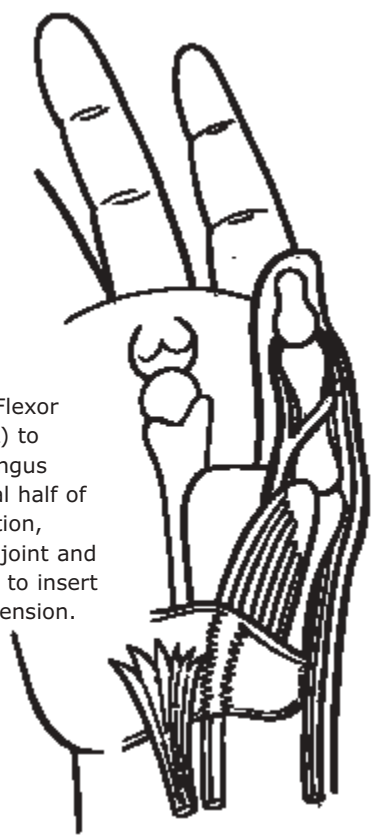

FIGURE 6.21 Half Flexor Pollicus Longus (FPL) to Extensor Pollicus Longus (EPL) transfer. Radial half of FPL divided at insertion, brought out at MCP joint and then across phalanx to insert into EPL at neutral tension.

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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Ulnar Nerve Paralysis in the thumb

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7

Median Nerve Palsy

• R. SCHWARZ

INTRODUCTION

The simian hand is defined by the presence of a thumb, which is able to oppose against the other digits in a "pinch grip." Two basic types of functional pinch are described the key pinch and the pulp-to-pulp pinch (Fig. 7-1). In the key pinch the pulp of the thumb is opposed to the side of the index finger. This action requires strong adduction of the index finger by the first dorsal interosseous and adductor pollicis, which is only possible if the ulnar nerve is functional . This type of pinch is used in holding a key, lifting heavy objects such as books etc.. The pulp-to-pulp pinch is stressed by Brand[5] as being the most important function of the thumb. This action is used for picking up small objects, buttoning etc. It requires slight rotation of the index finger to face the thumb. This movement is carried out by the first palmar interosseous. Fritschi[14] has emphasized the three-finger pulp-to-pulp pinch, which involves the pulp of the thumb opposing to the pulp of the index and long fingers. This position is used for picking up small objects, holding a pen and eating with the hand. It requires slight adduction/abduction of the long and index fingers against each other. Antia[3] also describes the short thrust pinch in which the thumb interphalangeal joint is hyperextended, providing both increased stability and greater strength in pinch.

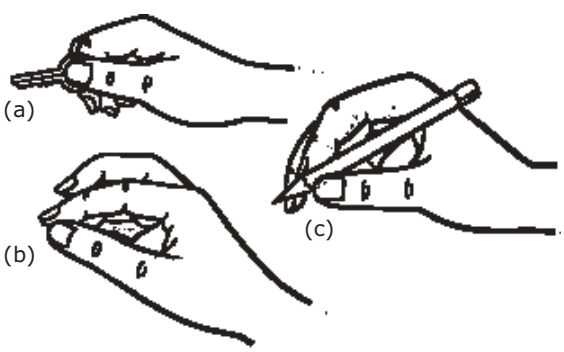

FIGURE 7-1 Three types of pinch (from Fritschi[14], used with permission.) **a.** Key Pinch, **b.** Two finger pulp-to-pulp pinch, **c.** Three finger pinch.

Mechanism of Pinch

Thumb opposition occurs mainly through movements at the carpometacarpal (CMC) joint. Opposition of the thumb is a compound movement involving simultaneous abduction and flexion at the CMC joint. The movement can best be described as that of movement around a cone, although it superficially appears to be a rotation movement (Fig. 7-2). The thumb pulp when beside the palm lies at about 45° supination and when fully opposed has moved to about 40° of pronation. This pronation is probably a secondary passive movement brought about by a combination of intrinsic muscle pull and joint ligamentous stability.[9]

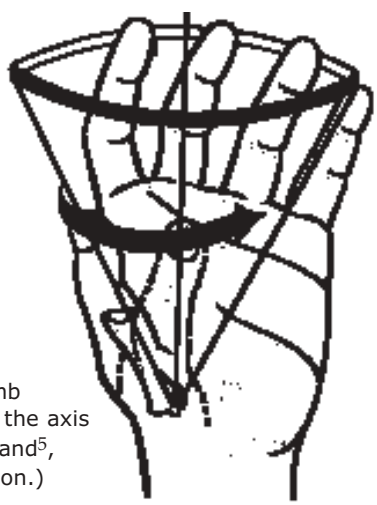

FIGURE 7-2 Thumb movement around the axis of a cone (from Brand[5], used with permission.)

Thumb opposition requires the action of several muscles. Abductor pollicis brevis and the opponens carry out the abduction component along with the flexor pollicis brevis superficial head. Abductor pollicis longus effects retroposition of the metacarpal and has little role in thumb opposition. The flexion component is carried out by the flexors pollicis brevis (FPB) and longus (FPL). Simultaneously the lumbrical, interossei and long flexors of the index and middle fingers are activated along with the adductor pollicis to complete the pinch. In pure median nerve palsy, only the abductor brevis and opponens muscle will be non-functional in most cases, as in 73% of patients FPB has at least partial innervation from the ulnar nerve.[24] Zancolli and Cozzi[26] state that the superficial head of FPB has dual ulnar/ median nerve supply in 30 percent of hands while the deep head is supplied by the ulnar nerve exclusively in 19 percent and has dual supply in 79 percent of hands. This explains why pure median nerve palsy will often maintain functional opposition.

Deficit in Low Median Nerve Palsy and Combined Ulnar/Median Palsy

The variability of innervation described above explains why many patients with pure median nerve loss maintain opposition function. Patients with isolated median nerve injury without recovery will often not require opponens reconstruction.[11,13] However with combined ulnar/median nerve palsy, as is usually seen in leprosy, the FPB as well as adductor pollicis and the intrinsics of the index fingers will be paralysed. This leads to retroposition and supination of the thumb by the unopposed extrinsic muscles of the thumb. In combined ulnar and median nerve palsy the intrinsic muscles to the fingers are also paralyzed, causing instability of the fingers, loss of adduction of the index finger and loss of primary MCP flexion (Chapter 6). In the context of thumb function combined ulnar/ median paralysis may make the squeeze pinch the only pinch mechanism possible, that is contact of the side of the thumb to the side of the hand or index finger. At best an ineffective key pinch will be possible. This severe disability requires a different approach than a pure median nerve palsy. These patients will all require restoration of opposition with effective pronation of the thumb tip to allow pulp-to-pulp pinch.

SURGICAL TREATMENT OF MEDIAN NERVE PALSY

Management of Contractures

First web space contractures are occasionally associated with median nerve palsy, especially in association with ulnar nerve palsy. This may be due to associated trauma and scarring, or more commonly due to the chronically retropositioned thumb. Pre-operatively the web space must be fully opened with stretching exercises and any IP or MCP joint contractures corrected with therapy. Practically it is difficult to open a severely contracted webspace with therapy alone. If the patient presents early these should be prevented with first web space splints and exercises. If there is an established first web space contracture which fails to respond to therapy it must be corrected prior to or preferably simultaneous with the opponensplasty. Web space contracture is easy to detect clinically. Passive abduction/opposition will demonstrate limitation with tightness of the dorsal skin of the first web space. Carpometacarpal joint contracture is more difficult to detect. In this situation abduction is possible but opposition is restricted. The conditions may be present simultaneously.

With a moderate web contracture a simple large Z-plasty will usually suffice with the dorsal flap based distally and the palmar flap based proximally (Fig. 7-3). Dorsal fascia is

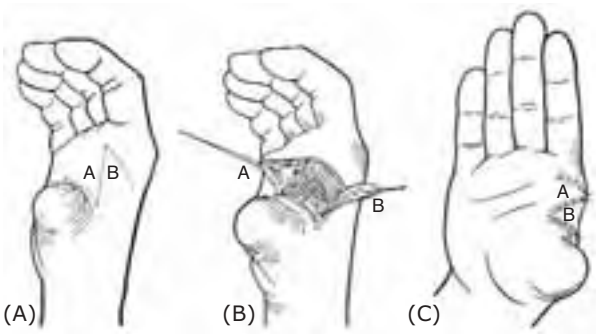

FIGURE 7-3 Simple Z-plasty (from Kleinman and Strickland[16], used with permission).

divided completely down to the level of the CMC joint and any restraining bands felt for and divided. In case of combined median/ulnar palsy the adductor pollicis is often contracted and the transverse head at least should be divided. A single large Z-plasty will give a better release than multiple Z-plasties as the contracture extends to the base of the metacarpal. This procedure also gives the advantage of deepening the web space, which can be of benefit if the thumb is short. It can be done concomitantly with an opponensplasty. It may be combined with full-thickness skin grafting on the dorsum to complete the release. An alternative is to release the contracture through a dorsal incision and apply a full-thickness graft (Fig. 7-4). An incision is made through skin and fat from the radial side of the index MCP joint, curving dorsally and ending over the first CMC joint. The skin is then undermined towards the thumb, and the dorsal fascia, thus exposed, is divided along its full length such that the skin flap will cover the fascial defect. Any restraining bands are felt for and divided. A full-thickness skin graft, usually from the groin, is then harvested to size and sutured in place with a bulky dressing tied over it. This procedure should be done prior to the opponensplasty and as soon as the graft is healed the opponensplasty should be carried out before the graft has a chance to contract. Alternatively it can be done at the same time as the opponensplasty.

For more severe contractures a dorsal flap webplasty may be required (Chapter 10).

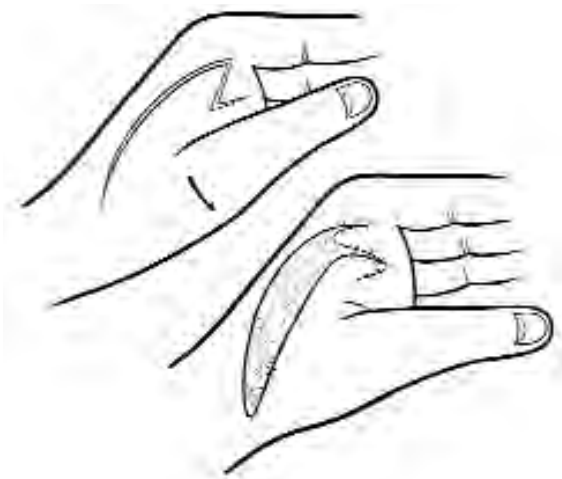

FIGURE 7-4 First webspace webplasty with full-thickness skin grafting (from Fritschi[14], used with permission).

Opponensplasty Techniques

General principles of tendon transfer apply (Chapter 1). Four standard methods will be described followed by two other methods for special situations. It is advisable for a surgeon to become proficient in the performance and problems of only two or three of these techniques rather than attempt all available transfers. For combined ulnar/median palsy the flexor digitorum superficialis (FDS) transfer is the most commonly used transfer. Some recommend a two tendon transfer, using extensor indicis proprius (EIP) for abduction and FDS or extensor carpi radialis brevis (ECRB) for short flexor replacement.[5] For isolated median nerve palsy, especially a high palsy, the EIP transfer is ideal. Others should be used only in special situations as described below.

Standard Opponensplasties

1. Superficialis transfer.
2. Extensor indicis proprius transfer.

3. Palmaris longus transfer (Camitz procedure).
4. Extensor pollicis longus re-routing.

Other Opponensplasties

1. Flexor pollicis longus transfer.
2. Abductor pollicis longus re-routing.
3. Abductor Digiti Minimi Transfer.

1. Superficialis Transfer

The ring finger superficialis tendon is usually chosen. It is less important in pinch function than the long FDS and being more ulnar gives a slightly less acute angle at the pulley. The long sublimus is an acceptable alternative. The index FDS is too important in pinch function to be sacrificed and that of the little finger is too weak to be used and is sometimes absent. The function of flexor digitorum profundus must be checked and should be at least 4/5 on the MRC scale. The strength of the ring sublimus is usually maintained even in the presence of a high ulnar nerve palsy due to cross-over of fasciculi in the main muscle belly.

Traditionally the FDS was harvested through a lateral incision at the level of the proximal interphalangeal (PIP) joint. This was to maximize the length of the tendon. However this was found to lead to a number of checkrein or swan-neck deformities. North and Littler[20] felt that division of the FDS near its insertion may cause trauma to the PIP joint capsule. It may also destroy the distal vinculae and disrupt the blood supply to the FDP. They recommended division of the FDS through an opening between the A1 and A2 pulleys, proximal to its bifurcation. Anderson et al[2] compared harvesting FDS through either a mid-lateral or a palmar incision. Extension lag at the distal interphalangeal (DIP) joint (swan-neck deformity) developed in 44% of cases with the mid-lateral incision compared with 8% with the palmar approach. Likewise, check-rein deformity developed in 8% of cases having had the lateral approach compared with 0 percent in those having had the palmar approach. He suggested that the higher incidence of complications was due to adhesions to the lateral bands, which are exposed during this procedure. In our experience harvesting over 400 FDS tendons via an opening between the A1 and A2 pulleys, few have developed significant checkrein deformity. It would seem that given the evidence of increased complications with the lateral approach and the fact that adequate length can be obtained through a distal palmar approach, that it would be prudent to cut the tendon through the latter incision.

As stated above most patients with median nerve palsy secondary to leprosy also have an ulnar nerve palsy. While some authors have stated that finger intrinsic and opponens operations should be done separately, in our experience and that of Mehta et al[18], combining opponens replacement with a "Lasso" procedure shortens the rehabilitative process without compromise in results. We obtained a good or excellent result in 93% of those undergoing opponens replacement regardless of whether they had a simultaneous "Lasso" procedure or not. Therefore if the surgeon is well experienced and the patient is intelligent and a candidate for each procedure, then both can be performed in the same operation.

Technique: An axillary block is usually used. A small transverse incision is made just proximal to the ring MCP crease and a small transverse opening made between the A1 and A2 pulleys. The FDS tendon is then divided as far distally as possible. Four more incisions are then made (Fig. 7-5). An 8 mm incision is made 1 cm. distal and radial to the pisiform, and deepened until the loose large fat lobules of Guyon's canal are seen protruding up from the small firm fat globules typical of the palm. A1 cm incision just palmar to the mid-point of the thumb MCP joint is made on the lateral surface.

FIGURE 7-5 Incisions for FDS opponensplasty.

A third, 1.5 cm curved incision, is made over the insertion of the adductor pollicis, and the fourth, an L-shaped incision, is made over the dorsum of the I-P joint.

A 1.5 cm transverse incision is then made about 3 cm proximal to the distal wrist crease. The ring finger FDS is the identified and then brought out of this incision. There are frequently vinculae between the FDS and flexor digitorum profundus (FDP), which may need to be divided from both incisions. If necessary another incision can be made mid-palm. A small curved tendon tunneller is then passed from the pisiform incision to the forearm incision, passing deep to the piso-hamate ligament and emerging in the same plane as the ulnar nerve and artery. The tendon is then withdrawn into the palm and checked for easy gliding. It is then passed deep subcutaneously into the thumb MCP incision and again checked for free gliding. A wide passage is not created, as this will increase the likelihood of adhesions.

Alternative Routes: It has been shown that the route of the tendon transfer can be altered to best suit the patient's needs[10] (Fig. 7-6). Placing the pulley more distally in the palm produces more thumb flexion and may be appropriate in patients with combined ulnar/ median nerve palsy. Similarly, placing the pulley more proximally will produce more abduction at the expense of flexion and opposition. Placing the pulley near the pisiform will produce maximal abduction/opposition. Alternate routes are described as follows:

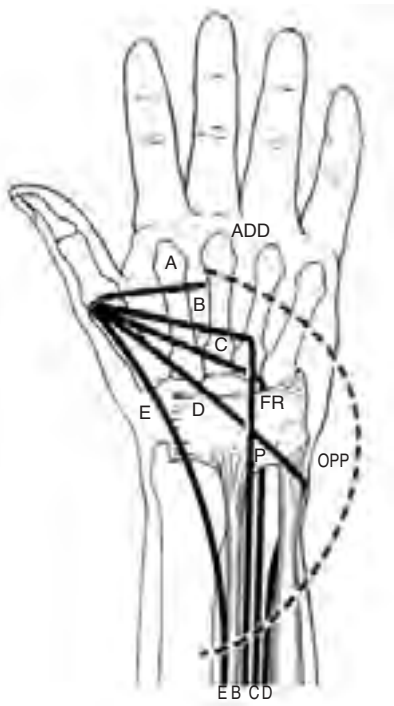

FIGURE 7-6 Potential routes of FDS opponensplasty. The arc of possibility is indicated by broken semicircle marked ADD (uction), ABD (uction) and OPP (osition). The most frequently used types of transfer are: **a.** Adductor replacement. Pulley is metacarpal two or three. **b.** Thompson route. Pulley is palmar fascia. True opponens action. **c.** Guyon's canal. Pulley is palmaris brevis/ palmar fascia. **d.** Pulley is at pisiform (on FCU). **e.** Camitz route. Weak abductor without pulley. Full adduction is type A, opposition is type B, C and D, and type E is full abduction. (from Warren[25], used with permission.)

Campbell-Thompson Route

The FDS is withdrawn via a 3 cm incision just radial to the hypothenar eminence. The ulnar border of the palmar aponeurosis is exposed and the FDS tendon withdrawn just distal to the flexor retinaculum and then tunnelled across to the thumb MCP with the insertion as described below. This will give greater MCP flexion but not full abduction and may need combined abductor pollicis longus re-routing. (See below)

Bunnell's Flexor Carpi Ulnaris (FCU) Pulley

A 4 cm incision is made just medial to the FCU insertion. Half the FCU is cut across 4 cm from its insertion and then the tendon is split distally to leave a distally based strip. This is then sutured back to the FCU insertion at the pisiform to create a fixed pulley. Some have found that this pulley tends to drift medially.[14]

Transverse Carpal Ligament (TCL)

An incision is made over the TCL and a window made at the desired level, more proximally for greater abduction and distally for greater flexion. The FDS tendon is brought out in the forearm and passed through the TCL window and then across to the thumb.

Insertion: In a pure medial nerve palsy, thumb MCP flexion is preserved and so pure abduction-opposition only is sought. This can be obtained simply by encircling the insertion of abductor pollicis brevis and suturing the tendon to itself. To set the tension, the thumb should be put into full opposition with the wrist in neutral position. The tendon should be pulled 1 cm past zero tension, and sutured with three to four sutures in this position with the wrist flexed to relieve tension.

Insertion into bone has been described by Bunnell [6], but there is no advantage to this and it does add to both time and potential morbidity.

In combined ulnar / median nerve palsy it is desirable to stabilize the thumb MCP joint as well. This can be accomplished by a double insertion technique as described by Brand.[5] In this procedure, the transferred tendon at the MCP incision is divided into two slips up to 5 cm proximally (Fig. 7-7). One slip is passed just distal to the MCP joint over the dorsal aspect and is then looped around the adductor insertion adjacent to bone. It is important to keep this slip distal to the MCP to prevent a Z-thumb deformity (Fig. 7-7). The other slip is routed palmar to the MCP joint to insert with a triple weave on the Extensor pollicis longus (EPL). This serves as a MCP flexor as well as IP extensor to correct the deformity arising from the FPB paralysis. With a dual insertion only the insertion with the shortest moment arm or under the highest tension is activated.[5] As such the tensions are adjusted to make the adductor insertion functional and the EPL insertion functions largely to prevent any Z-thumb deformity rather than to create active IP extension. The transfer functions very well in this dual role. To set the tension the adductor slip is sutured with 1 cm tension with the thumb in full opposition

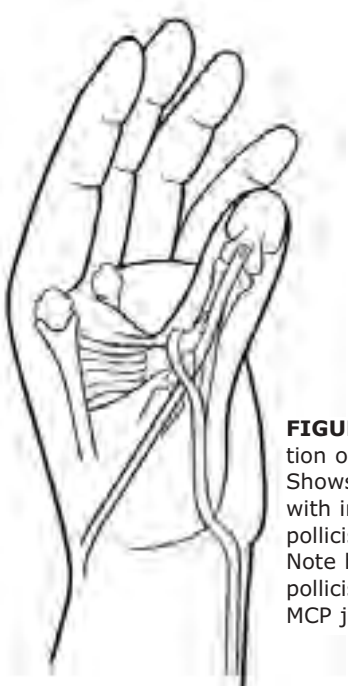

FIGURE 7-7 Double insertion of FDS opponensplasty. Shows recommended route with insertion into adductor pollicis insertion and EPL. Note how slip to adductor pollicis lies just distal to the MCP joint.

as described for the ABP insertion technique. The IP slip is sutured at neutral tension.

If a fixed I-P joint flexion deformity is present, an I-P fusion should be carried out.

The hand is placed in POP with the wrist flexed 15-20° and the thumb in full opposition-abduction. This is kept in place for three weeks after which careful therapy is commenced.

2. Extensor Indicis Proprius (EIP) Opponensplasty

This is very useful in high median paralysis where FDS tendons are not available, and is very popular for pure low median palsy as well as it does not create a secondary deformity on the donor finger and does not weaken grip.[7] (ed. note (WB): It also can create a defect on the donor finger. In leprosy I have rarely seen consistent good results of an EIP transfer). In combined ulnar-median palsy Brand recommends combining it with an FDS to adductor pollicis transfer to provide adduction/pronation in ulnar/median palsy (chapter 6).[5]

Technique: A 2 cm incision is made over the index MCP joint and the EIP cut away from its attachment to the extensor expansion. A contiguous slip of extensor hood is not required.[10] It is withdrawn through a 4 cm dorsal forearm incision starting 2 cm proximal to the wrist crease and muscle attachments freed (Fig. 7-8). It is quite deep here and may be entirely muscular, and if adhesions to index communis tendon are present it may have to be withdrawn via an incision at the proximal metacarpal level. Small incisions are then made just medial to the pisiform and over the dorsoradial aspect of the thumb MCP joint. The tendon is tunnelled around the ulnar border of the wrist, superficial to FCU to the pisiform incision, and thence across the palm to the thumb. In pure median palsy it is attached to the FPB insertion with the thumb in full opposition and the wrist in 30° flexion. In combined ulnar/median

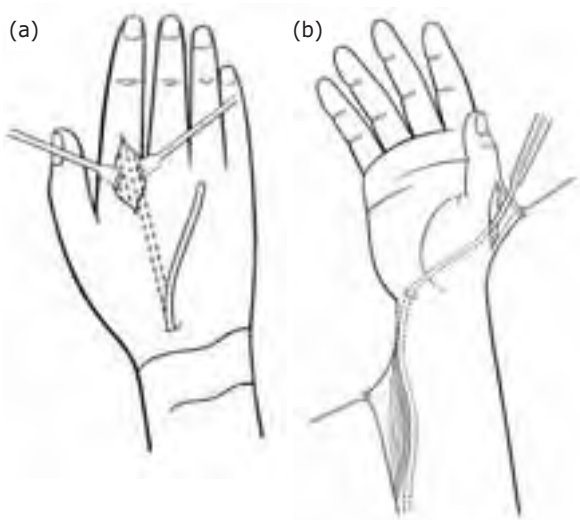

FIGURE 7-8 Extensor Indicis Proprius (EIP) transfer. **a.** Tendon is divided and delivered into a dorso-ulnar incision. **b.** Tendon is passed around ulnar side of wrist to an incision medial to the pisiform and then by a subcutaneous tunnel to the MCP joint.

palsy a split insertion to adductor pollicis and EPL can be used as described above. Riordan attaches the tendon in sequence to abductor pollicis bravis (APB) insertion, the MCP capsule and the extensor pollicis longus tendon over the proximal phalanx.[23] Alternatively, the tendon can be routed through the interosseous membrane, although some feel that the risk of adhesions is greater and the amount of opposition obtained may be decreased. Mehta et al[17] add a radial half FPL to EPL transfer to stabilize the MCP joint. Post-operatively a POP is applied with the thumb in full opposition and the wrist in 40° flexion for 3 weeks. Rehabilitation can be difficult with some patients and the patient should focus on opposition to middle and ring fingers.

Anderson et al[1,2] reported the use of this transfer in 13 high and 38 low median nerve palsies. Excellent or good results were reported in 89% of patients. They then compared their results with those of superficialis transfer and concluded that EIP transfer is indicated only in

those patients with supple hands. This is probably explained by the fact that FDS of the ring finger has a tension fraction (strength) double that of the EIP muscle, and is thus better able to overcome the resistance in stiff hands.

3. Palmaris Longus Opponensplasty

This relatively simple procedure is best suited to those patients with severe carpal tunnel syndrome and isolated median nerve palsy as it can be done simultaneous with a tunnel release with little excess morbidity. With a tension fraction of 1.0 it is not powerful enough by itself in combined ulnar- median palsy. It should be combined with FDS transfer for adduction/pronation as described for EIP transfer. As described by Camitz[9] it produces principally abduction, but by a simple modification it can also produce opposition (see below). The presence of palmaris longus (PL) muscle can be checked by cupping the tips of the fingers with the wrist flexed.

Technique: A longitudinal incision is made just ulnar to the PL extending from 2 cm proximal to the wrist crease to the proximal palmar crease in line with the index finger. The palmaris is then dissected along with 1 cm of palmar fascia in continuity with the tendon. A tunnel is then created to an incision over the insertion of abductor pollicis brevis (APB). The tendon with its attached fascia is then passed to the thumb incision and the fascia looped around the insertion of APB and sutured at 1 cm tension with the wrist neutral and the thumb in maximum opposition. Foucher et al[13] recommended insertion to the extenson pollicis brevis tendon or the dorsal capsule of the MCP joint to produce opposition and abduction although he found that this caused a slight reduction in MCP joint mobility in some patients. Alternatively the tendon can be passed up Guyon's canal and then across the palm, across the palmar incision to the thumb, which will also produce greater opposition.

The hand is placed in a plaster for three weeks with the thumb in full opposition and the wrist slightly flexed after which therapy is started. This is a relatively weak muscle with a tension fraction of 1.2 and should only be used in supple hands. Excellent results have been reported in series of patients with carpal tunnel syndrome. These results may not apply to other causes of median palsy. Therapy is relatively simple for most patients.

4. Extensor Pollicis Longus Re-Routing

The extensor pollicis longus functions a both a thumb extensor and adductor. As such it works against thumb opposition and can be the cause of long-term failure of opponensplasty, especially with a weak motor such as EIP.[22] This procedure effectively transforms the EPL from an extensor/adductor to an extensor/abductor. While excellent results have been reported with this procedure in patients with various etiologies[19,22,] in our experience the therapy can be difficult. There is a definite learning curve to this procedure for the whole hand team, and should only be done in a patient of reasonable intelligence and motivation. This transfer is especially helpful in those patients with a deficit of donor tendons.

Technique: The extensor pollicis longus (EPL) is divided through a 2 cm incision just proximal to the MCP joint (Fig. 7-9). It is then brought out from a 3 cm incision 5 cm proximal to the wrist crease, where the tendon is quite deep. A 1 cm defect is then created in the interosseous membrane, after which the tendon is passed through the interosseous membrane (IOM) to a 2 cm incision on the radial side of the flexor carpi ulnaris, keeping radial to the ulnar artery and nerve. Unrestricted gliding through the IOM should be checked. It is then passed subcutaneously along the line of the metacarpal (palmar-dorsal junction) back to the original

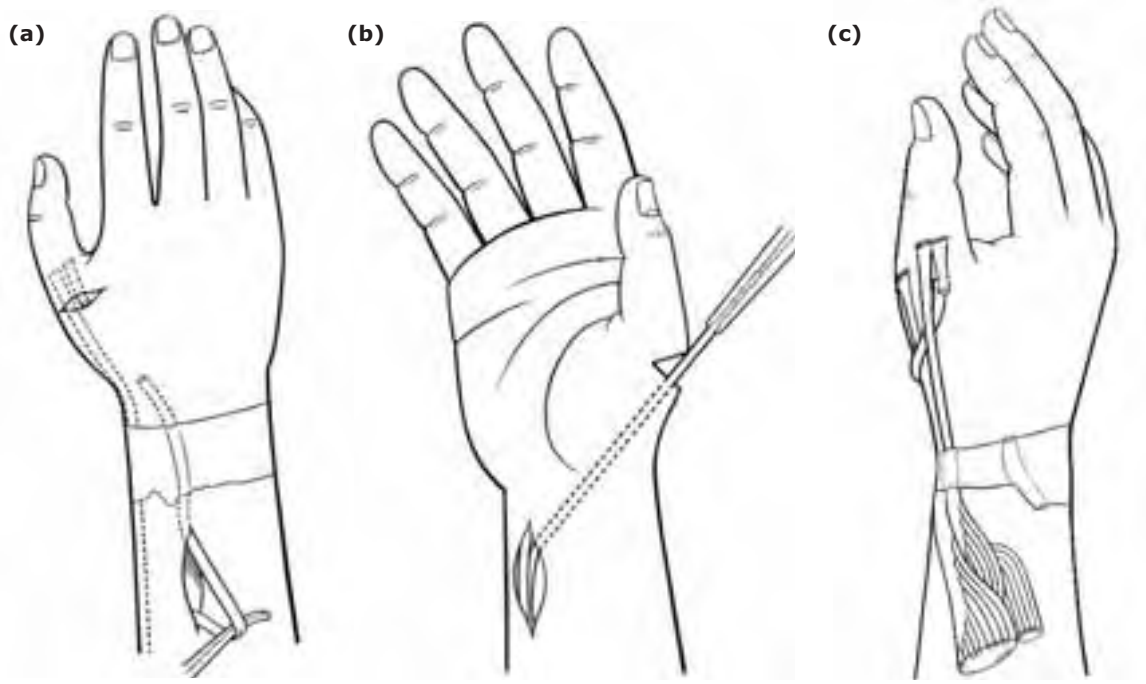

FIGURE 7-9 Extensor Pollicis Longus (EPL) re-routing. **a.**The tendon has been divided proximal to the MCP joint, and is being brought out on the dorsum of the wrist before being passed through the interosseous membrane. **b.** It is brought through just radial to the FCU and then tunneled in a subcutaneous plane along the junction of palmar and dorsal skin to the original MCP joint incision. **c.** It is passed under the extensor pollicis brevis and sutured to itself with 1 cm overlap.

incision, routing it deep to extensor pollicis brevis. This prevents future palmar subluxation. It is then sutured back to the stump of EPL with a 1 cm overlap, which will adjust the tension. Riley and Burkhalter[22] pass the tendon around the ulnar border of the wrist and add an arthrodesis of the MCP joint. I also believe that it is necessary to stabilize the thumb in cases of combined ulnar/median palsy and usually add a half FPL to EPL transfer (see Part 2 below) in place of MCP arthrodesis with good results.

A short arm thumb spica is then applied with the thumb in full opposition and the wrist flexed at 30°. The plaster is removed at 4 weeks and therapy commenced. The patient should attempt thumb opposition with the I-P joint extended, activating the transfer. Extension and opposition are not necessarily contradictory movements. The EPL should continue to function as an extensor after this procedure. A dynamic opposition splint is helpful at this time. Good or excellent results were reported by Mennen et al[19] in 31/35 patients. Clinical results are shown in Fig. 7-10.

FIGURE 7-10 EPL re-routing post-operatively. Note excellent abduction obtained.

Other Opponensplasties

1. Flexor Pollicis Longus Transfer

This transfer is indicated in those patients with a combined ulnar/median palsy with a fixed flexion contracture of the IP joint. In this situation the IP joint must be fused. As such moving the FPL insertion to the FPB insertion does not diminish thumb function nor decrease strength, as the moment arm on the MCP joint for the FPL tendon sheath and the FPB insertion are almost identical. It is especially useful in those patients with a severely affected hand such as a triple nerve palsy where there is a deficit of tendons available for transfer. Routing through the carpal tunnel as described by Davis[11] produces limited pronation of the thumb but routing via Guyon's canal will give satisfactory opposition as well as short flexor action. This transforms a thumb extrinsic muscle that was contributing to the deformity into one that improves function, similar in concept to the EPL re-routing described above. This procedure also has the obvious benefit of creating no donor deficit, although the risk of weakening thumb flexion power must be recognized.

Technique: The insertion of FPL into the distal phalanx is exposed through a volar V-incision and then divided. The FPL tendon is withdrawn into the wound as much as possible to enable division of vinculae. A more proximal incision at the level of the A1 pulley is sometimes required to divide the rest of these. A longitudinal incision is then made over the dorsum of the IP joint and an arthrodesis carried out as described in chapter 9. I use K-wires for fixation. Through a 3 cm incision starting 3 cm from the wrist crease the FPL is identified and withdrawn. A 1 cm incision is then made 1 cm distal and radial to the pisiform, and deep dissection done until the large fat globules of Guyon's canal are seen. The tendon is then passed to this incision, and then passed through a small subcutaneous tunnel to an incision on the dorso-radial aspect of the MCP joint. It is then looped around the FPB tendon and sutured with 1 cm tension with the wrist neutral and the thumb fully opposed. As there is a wide excursion of the FPL setting the tension is relatively easy. It is important not to insert the transfer onto the abductor pollicis brevis insertion, as this would give principally thumb abduction with insufficient power in flexion. The routing through the ulnar side of the wrist produces the necessary opposition and insertion into the FPB insertion will give the MCP flexion action that is necessary for a powerful pinch grip.

2. Re-Routing Abductor Pollicis Longus

This does not produce true opposition but rather turns the abductor pollicis longus (APL) from a thumb supinator/extensor into an abductor. I have not found it to produce a great deal of abduction and is better combined with another procedure. This procedure can be useful in those patients with functional flexor pollicis brevis needing only more thumb abduction for grasping large objects. It is also indicated in some patients with extensive deficits in whom donor tendons are limited and donor deficits may be very detrimental to overall hand function.

Technique: The APL is divided 1 cm proximal to its insertion into the base of the metacarpal and brought out 6 cm proximal to the first incision. It is then passed to a small incision 3 cm proximal to the wrist crease over the palmaris longus (PL) tendon, looped around the PL tendon, passed to the first incision and sutured to the APL stump with 1 cm overlap. This is immobilized for 3-4 weeks before therapy is commenced.

3. Abductor Digiti Minimi Transfer

This is a good procedure for isolated median nerve palsy. It is a technically demanding pro-

cedure, and the reader is referred to a textbook of hand surgery for a description.

Potential Pitfalls of Opponens Surgery

1. Use of Extensor Pollicis Longus in Pinch

In long-standing ulnar/median paralysis the patient often has learned to use the extensor pollicis longus as an adductor to effect a lateral squeeze to hold objects between the side of his thumb and index finger. This can become a problem after the surgery if he uses this trick movement to grasp objects. This trick movement produces thumb supination and will overpower an attempt at thumb opposition by the transferred tendon. The patient may use the transfer well in therapy, but may habitually use the EPL lateral squeeze to pinch objects due to habit and simplicity. It is important that the patient is observed during regular activities of daily living to see whether he is using the transfer in pinch grip or whether he is using his EPL. If not detected in time the transfer may be lost due to neglect.

Brand proposes four ways of dealing with this problem.[5] Firstly, one should do the opponensplasty soon, before the patient has time to develop this trick movement. Obviously this depends upon the patient presenting in a timely fashion. Secondly, the patient requires thorough re-education with therapy carried out at the workbench as well as through exercises. Thirdly, in more established cases, the surgeon should consider re-routing the EPL at the same time as the opponensplasty. With this technique the EPL is freed from its retinaculum and transposed over the course of the abductor pollicis longus and anchored here with a pulley made from fascia. The incision extends from the MCP joint to 4 cm above the radial styloid. Two or three small incisions on this line are adequate. This procedure can also be used when the problem is detected following an opponensplasty. Finally, in very established cases, the EPL can be used as the opponens motor by re-routing it through the interosseous membrane as described above.

2. Crank handle action

This problem can occur following an opponensplasty when complete pronation of the thumb is not obtained at surgery. This complication occurs when the metacarpophalangeal joint is flexed and the interphalangeal joint is extended, such as following an interphalangeal joint arthrodesis for a severe Froment's sign or an opponensplasty with insertion on the EPL tendon. With incomplete pronation, the pulp of the index finger makes contact with the ulnar side of the thumb. When pinch is attempted, the distal part of the thumb functions as a crank handle, forcing the thumb into supination (Fig. 7-11). The moment arm of this supinating force is large, and will overpower the small moment arm of the opponens transfer as it attempts to pronate the digit. The thumb will gradually be forced into more and more supination and the opponensplasty will have failed. Brand has several suggestions to prevent this.[5] Firstly, complete pronation of the thumb must be obtained at surgery. Often a webplasty will be required to accomplish this, and possibly a carpometacarpal joint release. If

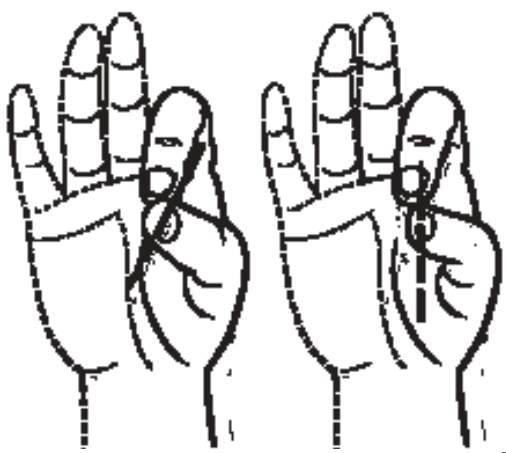

FIGURE 7-11 Crank handle action (from Brand[5], used with permission).

it is not possible to obtain full pulp-to-pulp pinch, a tip pinch should not be used and rather the patient should be trained to use a key pinch. This will not lead to a crank handle action on the thumb, but rather the index finger. This is not a significant problem and can be prevented by teaching key pinch with all fingers held together to support the index. Secondly, therapy must be aimed at pulp-to-pulp pinch and not pulp-to-side of thumb. Arthrodesis of the interphalangeal joint should be avoided if possible. In a patient with Froment's sign and a mobile interphalangeal joint there are better options such as metacarpophalangeal joint fusion. If the MCP joint is chronically flexed and causing problems again MCP arthrodesis should be considered. Finally, the EPL can be re-routed over the abductor pollicis longus as described above to eliminate its supinating moment.

HIGH MEDIAN NERVE PALSY

In this situation all muscles in the flexor compartment of the forearm are paralyzed apart from the FCU and the profundi to the little and ring fingers. Flexion of the long finger is usually satisfactory although weak. Functionally flexion of the thumb and index interphalangeal joints are absent while flexion of the wrist and ulnar three fingers is present. In leprosy the ulnar nerve is also usually affected and therefore these too are usually paralyzed, leaving no functioning flexors below the elbow. This severe deficit is fortunately quite rare in leprosy. When present it may be associated with radial nerve palsy as well. The goals of surgery are to restore thumb flexion and opposition and finger flexion. Opposition can be restored by EPL re-routing or by EIP transfer as described above if the radial nerve is intact. Thumb flexion can be restored by brachioradialis transfer to the FPL (see below). Finger flexion can be restored by tenodesis of the ring and little FDP to those of the index and middle fingers if the ulnar nerve is intact. This is accomplished by side to side suturing of all profundus tendons in the distal forearm. This will give index flexion but little strength. If strength is required the extensor carpi radialis longus (ECRL) can be transferred to the index FDP (see below). The transfer techniques described involve end-to-end anastomosis. If there is a chance of nerve recovery then end-to-side anastomosis should be performed. If the radial nerve is also involved options are severely limited, with all wrist and digit extensors also absent. In this situation brachioradialis can be used to power the finger flexors with stabilization of the wrist and thumb to provide some pinch function. In leprosy the pronator teres is often preserved, in which case pronator teres can be used to activate extensor carpi radialis brevis, with a tenodesis of the thumb to give thumb opposition/flexion on wrist extension (hinge hand procedure, see chapter 8).

Brachioradialis to Flexor Pollicis Longus Transfer[8,11]

An incision is made on the radial side of the volar forearm from the wrist crease to 8 cm distal to the elbow. The brachioradialis is then divided at its insertion. Muscle fibres are stripped off the deep fascia of the forearm to free the tendon up until well proximal to the musculo-tendinous junction. The whole distal aponeurosis must be divided, and this is then folded in on itself and approximated with a continuous fine nylon suture to decrease adhesion formation. Dissection of the muscle from its attachments proximally can increase excursion by more than 100%.[5] The dissection should be carried up to the proximal third of the forearm, releasing all attachments of tendon to investing fascia and radius. The tension is set so that the transfer will function at its maximal efficiency when the elbow is straight. With the wrist flexed 30 degrees the tension is set so that the thumb can be fully extended but will flex the thumb on wrist extension.

Excessive tension must be avoided, as otherwise the thumb will end up positioned uselessly across the palm. A Brand anastomosis is carried out between the brachioradialis and the FPL tendon, which has been divided 5 cm proximal to the wrist (Fig. 7-12). It is then immobilized in elbow, wrist and thumb flexion. As the brachioradialis is primarily an elbow flexor, the transfer will be weakened by elbow flexion. It should therefore be used in full elbow extension.

Extensor Carpi Radialis Longus to Flexor Digitorum Profundus Transfer[8,11]

The ECRL is divided at its insertion through a small transverse incision. An 8 cm incision is made on the radial side of the volar forearm from the wrist crease extending proximally. The ECRL is then brought around the radial aspect of the radius. The FDP to the index and long fingers is divided 5 cm proximal to the wrist and a Brand anastomosis is carried out to the ECRL tendon (Fig. 7-13). If this is carried out in conjunction with the brachioradialis to EPL transfer these two anastomoses should be done at different levels to decrease the risk of adhesions. Setting the tension correctly is difficult but important. The excursion of the ECRL is only about 30 mm in comparison to about 50 mm for the profundus muscles. As such excessive tension on the transfer will lead to a flexion contracture of the fingers. The same problem holds for the brachioradialis to FPL transfer. For both transfers a "dynamic tenodesis"

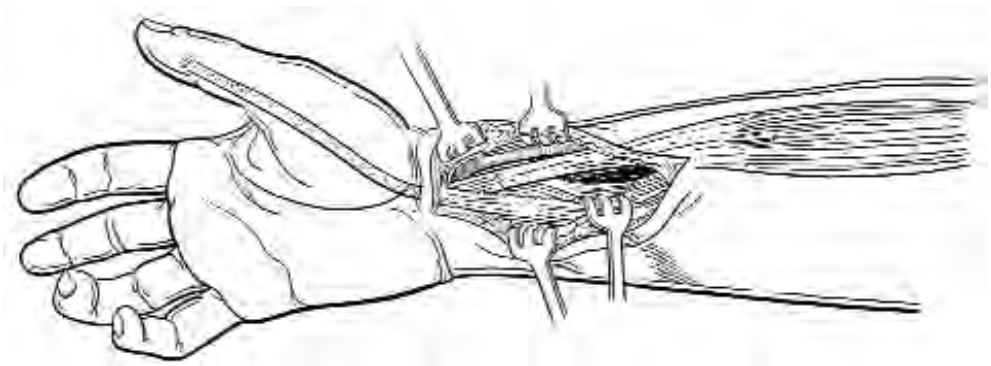

FIGURE 7-12 Brachioradialis to flexor pollicis longus transfer (from Davis and Barton,[11] used with permission).

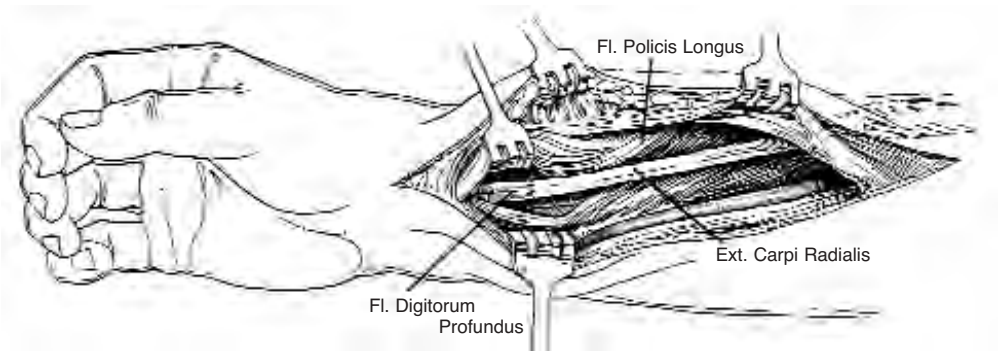

FIGURE 7-13 Extensor carpi radialis longus transfer to flexor digitorum profundi of long and index fingers (from Davis and Barton,[11] used with permission).

approach is used, using wrist motion to enhance the function of the transfer.[8] Full wrist volar flexion will allow full finger extension while full wrist extension will allow full finger closure. To check for correct tension, 30 degrees of wrist flexion should give full finger extension, while 30 degrees of wrist flexion should produce passive finger closure so that the transfer can then use its power with the fingers closed. Arthrodesis of the DIP joints can enhance the function of this transfer. The arm is immobilized in 30 degrees of wrist flexion with MCP joints flexed at 80 degrees and the interphalangeal joints straight.

CARPOMETACARPAL JOINT DISORDERS

The thumb carpometacarpal (CMC) joint consists of two saddle shaped surfaces of trapezium and metacarpal bones with the axes of the two near perpendicular to each other. There is little bony stability, and stability depends on a strong volar plate with ligaments on the other sides. The dorsal ligament is reinforced by the abductor pollicis longus. There is normally minimal laxity. Adduction/ abduction occur along the length of the trapezial "saddle" while flexion/ extension occurs across the saddle. The small amount of true rotation at the CMC joint is due to incongruency of the radial and ulnar aspects of the trapezial joint surface. The CMC joint is where opposition of the thumb occurs, and it is therefore integral to the function of the thumb.

Contracture of the Carpometacarpal Joint

The most common disorder seen in the trapezio-metacarpal joint is contracture of the intermetacarpal ligaments. This is usually associated with longstanding ulnar-median nerve palsy where prolonged retroposition of the thumb causes progressive ligament shortening, which in turn causes restriction of passive opposition. There is often associated web contracture and/or dorsal skin deficiency.

Treatment

Prolonged therapy by web space stretching and CMC mobilization by forced opposition may be necessary. In established CMC joint contracture conservative measures will often not suffice. If full opposition is not obtained then surgical release is indicated. A webplasty is usually also required and the CMC release may be able to be accomplished through this incision. Otherwise a separate incision is necessary.

Technique: A 3 cm incision is made just medial to the extensor pollicis longus tendon. The joint capsule is opened in a longitudinal direction until full opposition is obtained. A fat graft may be placed to prevent recurrence. A K-wire may be required to maintain position. The thumb is placed in a spica for three weeks in full opposition after which full motion is allowed but night splinting is continued for three months. This may be combined with an opponensplasty.

Carpometacarpal Dislocation

This condition is often unrecognized, but is reported in 20% of ulnar-median nerve palsy hands.[4] If looked for it is easy to diagnose. The thumb is forcibly retroflexed using the metacarpal as a fulcrum and the joint can be seen to dislocate in a radial direction. Beine[4] felt that it is more common after MCP fusion or opponensplasty, but I have not noted this. With loss of adductor pollicis and the first dorsal interosseous, the extensor pollicis longus assumes the adductor role with the fulcrum at the tip of the thumb, causing radial stress at the

CMC joint. The flexor pollicis longus also causes radiovolar stress at the CMC joint when the thumb is retropositioned. The abductor pollicis longus as well causes radial stress as it attempts abduction of the thumb. All these stresses lead to attenuation of the intermetacarpal ligament and radiovolar subluxation. In most cases this creates no functional deficit. In about a third of patients it can prevent full opposition by locking of the CMC joint, and in these cases surgical intervention is warranted.[4]

1) Joint Arthrodesis

Intracapsular arthrodesis such a performed in tetraplegia patients is technically difficult. A high non-union rate is reported in non-tetraplegic patients[14], perhaps due to the increased hand power with resultant increased stress on the joint. Fritschi describes an intermetacarpal bone block.[14] However it is likely that an arthrodesis would cause a greater disability than the CMC dislocation and it is not recommended.

FIGURE 7-14 Reconstruction of thumb CMC joint using half flexor carpi radialis (FCR).

2) Capsular Reconstruction

In this procedure, described by Eaton[12], the tendon of the flexor carpi radialis (FCR) is used to reinforce the weakened dorsal ligament and will only minimally restrict normal CMC movement.

Technique: An 'L' shaped incision is used with one limb along the thumb metacarpal and the other extending along the distal wrist crease (Fig. 7-14). The superficial radial artery and the branches of the dorsal sensory branch of the radial nerve must be preserved. The thenar muscles are elevated and the capsule excised. A subchondral (i.e. 5 mm distal to the metacarpal joint surface) channel is created in the metacarpal perpendicular to the thumbnail using a drill or gouge. The FCR tendon is exposed through a small transverse incision 8 cm proximal to the wrist crease and the radial half mobilized proximally using one or two distal incisions until the radial strip is left attached only to the trapezium. This strip is then passed through the channel in the metacarpal base to emerge on the dorsal surface. This is facilitated with a wire or nylon suture. It is then sutured to the dorsal periosteum with the joint reduced and the thumb opposed under neutral tension. It is then passed under the insertion of the abductor pollicis longus on the metacarpal and sutured to reinforce the dorsal aspect of the joint. It is then passed under the insertion of the FCR and back onto the radial aspect of the joint capsule where it is again sutured to strengthen this aspect of the joint. It must not be sutured so tight as to restrict movement of the joint. The thenar muscles are reattached. Eaton uses a K-

wire to fix the MCP joint in 20° flexion.[12] The thumb is immobilized in opposition for four weeks after which gradual mobilization is commenced. Opponensplasty can be carried out within three months of surgery.

SUMMARY

The balanced reconstruction of the thumb requires a good understanding of thumb anatomy and function to obtain good results. Each hand presents with its own unique impairments. These impairments and the patient's desires and expectations must all be taken into account while preparing a treatment program, which is unique for each patient. While the surgeon should not use a uniform procedure for all patients, he/she should use procedures that are familiar to both him/herself and the therapists on the team. With appropriate planning and good pre- and post-operative therapy results should be excellent for opponens reconstruction. In high median paralysis, transfers to provide extrinsic replacement will produce a functional hand satisfactory to the patient. The sensory deficit, while a significant disability, will not be a major obstacle in the use of the hand in a motivated and trained patient.

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8

Radial Nerve Palsy

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INTRODUCTION

Radial nerve palsy is a serious functional impairment, causing loss of wrist, finger and thumb extension. The loss of wrist extension causes wrist instability and forces the fingers to flex at a mechanical disadvantage due to the finger flexors commencing action in a shortened position. This greatly reduces the strength in power grip. The loss of finger and thumb extension deprives the hand of the ability to grasp large objects. In leprosy, radial nerve palsy is often associated with median and/or ulnar palsy, which greatly compounds the impairment and limits the number of tendons available for transfer. The usual combination seen is a high radial palsy, a high ulnar palsy and a low median palsy. Many combinations of transfers have been developed for the treatment of radial nerve palsy.[2,3,8,9,18,21,26,31] The actions that need to be restored are wrist extension, finger extension, and thumb extension-abduction. In triple nerve palsy thumb abduction and primary finger metacarpophalangeal flexion must be restored. The standard transfers that will be described in this chapter are shown in Table 8-2. While the standard transfers are very successful when performed correctly, Riordan correctly points out that "there is usually only one chance to obtain good restoration of function in such a paralyzed hand."[28] If the first procedure is not performed well, with excellent follow-up care, the chance of making a good functional hand is small.

The surgeon must have a good understanding of the three-dimensional anatomy of the forearm and should review this prior to surgery. The principles of tendon transfer surgery as outlined in Chapter 1 must be followed carefully.

TABLE 8-1: List of abbreviations used in this chapter.

ECRB	Extensor carpi radialis brevis
ECRL	Extensor carpi radialis longus
ECU	Extensor carpi ulnaris
EDM	Extensor digiti minimi
EPL	Extensor pollicis longus
FCR	Flexor carpi radialis
FCU	Flexor carpi ulnaris
FDS	Flexor digitorum superficialis
PL	Palmaris longus
PT	Pronator teres

TABLE 8-2: Tendon transfer program for triple nerve palsy.

First Stage	
	PT to ECRB yoked to re-routed ERCL
	FCR to EDC (and possible EPL)
	PL to re-routed EPL
Second Stage	
	FDS (long) to lateral bands
	FDS (ring) opponensplasty

The issues involving nerve repair, in case of trauma, will not be addressed here. The reader is referred to Green's discussion of this if desired.[15] While some advocate early transfer as a splint to prevent contracture. I would suggest that the therapy team should be able to prevent such problems during the time of potential nerve recovery.[7,22]

Pre-Operative Treatment

It is essential that the therapy team obtains and maintains joint mobility prior to tendon transfer and also to 'stretch' the long flexors out to full length. Thumb webspace contracture, if present, must also be corrected. Splinting is required, both to prevent contractures and to provide the mechanical advantage that wrist extension gives. Burkhalter notes that a simple cockup wrist splint can increase grip strength by three to five times.[23] More complex splints can be designed that provide dynamic extension of the thumb and fingers using outriggers with rubber bands that allow full flexion.[12] However these are very conspicuous and would probably only be used by those who will need to continue doing fine manual work prior to definitive surgery. Brand recommends that if only a cockup wrist splint is used then at night a splint that keeps the fingers also in extension should be used to prevent long flexor contractures.[4]

RECONSTRUCTION OF WRIST EXTENSION

There have been many modifications of the basic Pronator Teres (PT) to Extensor Carpi Radialis Brevis (ECRB) transfer since Jones first described the procedure in 1916.[18] A few authors have advocated wrist arthrodesis.[11,18] However the advantages of active wrist extension are so strong and the results of an active tendon transfer are generally so good that there is little reason to do a wrist arthrodesis as a primary procedure unless there are inadequate muscle-tendon units available for transfer. Brand has extensively studied the moment arms for the muscle tendon groups of the hand and has devised a procedure which is a modification of Jones' original procedure.[4] We recommend this procedure as the most sound and most likely to function without complications.

Pronator Teres to Extensor Carpi Radialis Brevis Transfer

The ECRB has a strong moment arm for wrist extension but it also has a moment arm for radial deviation. Therefore a simple PT to ECRB transfer may lead to the development of radial deviation of the wrist, which wastes the PT movement in a non-useful direction of movement. FCU (if present) can resist this but this will weaken wrist extension. Three of fourteen patients undergoing PT to ECRB surgery in our series developed radial deviation adversely affecting function[21], and 5 of 40 patients in Chotigavanich's series developed radial deviation.[9] Some have also advocated yoking ECRB to ECRL.[18] ECRL has a greater moment arm for radial deviation then wrist extension, thereby further aggravating the problem. Brand has shown well, when two tendons are yoked together, the one with the smaller moment arm will be preferentially activated by the transfer (Fig. 8-1).[4] As ECRL has a shorter moment arm than ECRB for radial abduction, it will be the prime wrist mover, thereby pulling the hand into radial deviation following surgery. Brand tried yoking ECRB to ECU, but found that ECU had a small moment arm for wrist extension, and none when the wrist was pronated. He recommends yoking ECRB to ECRL, detaching ECRL from its insertion in the base of the second metacarpal and reinserting it into the base of the fourth metacarpal.[4] This insertion has the same moment arm for extension as the ECRB , and will therefore give balanced extension. Tubiana describes a similar procedure using the same rationale.[31] This transfer is the key to success of a rehabilitation program for someone with combined nerve palsies. Good wrist extension is necessary for effective finger flexion and will optimize the function of tendon grafts for intrinsic and opponens transfers. Interestingly, the muscle fibre excursion for the PT (25 mm) is only half that of the wrist extensors (59 mm). The fact that many patients undergoing PT

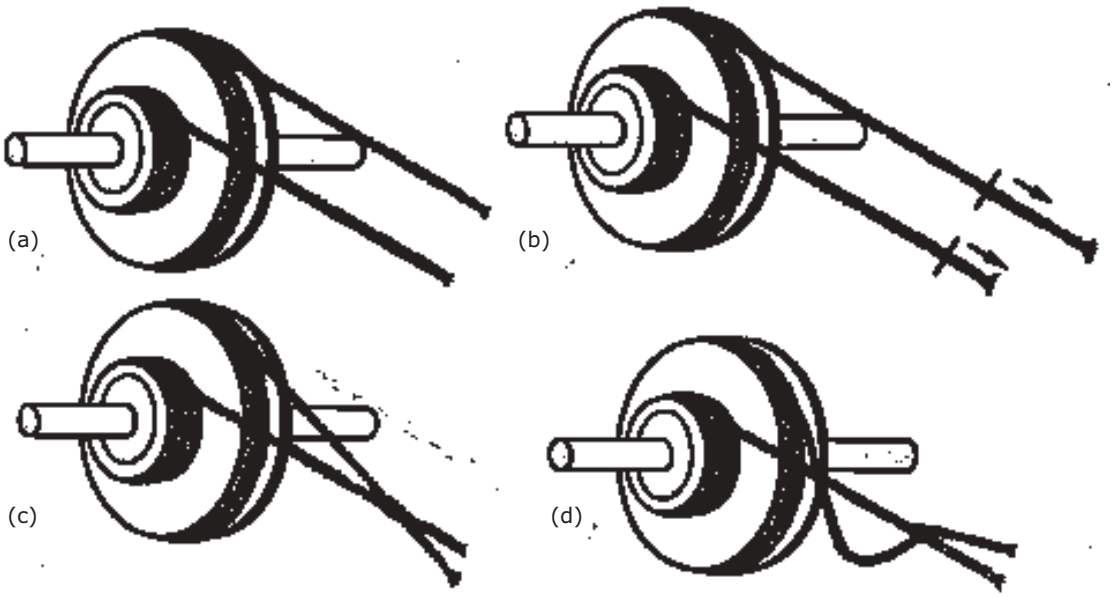

FIGURE 8-1 **a.** Two pulley wheels fixed to a common axle. **b.** For a given amount of rotation, the larger rope releases a longer length of rope (tendon) **c.** Both ropes are fixed together, similar to a double tendon insertion. **d.** Pulling on common rope (tendon) causes the rope on the wheel with the larger moment arm to become slack. Only the smaller wheel is functional (from Brand[4], used with permission).

transfers for wrist extension eventually achieve a full range of motion implies that the excursion of the pronator muscle actually increases following surgery.[29] Brand suggests that sarcomeres are added or removed in response to a change in the tension of a muscle at rest, but that this process is slow.[5]

Technique: The PT to ECRB transfer is usually combined with the FCR- to-EDC (Flexor Carpi Radialis to Extensor Digitorum Communis) transfer. Only the incisions for the wrist extension part of the procedure will be described here (Fig.8-2). An 8-10 cm curved incision (1) is made over the convex part of the middle of the radial border of the forearm to expose the insertion of the PT and the tendons of ECRB and ECRL. At this level the ECRB tendon is usually surrounded by muscle but the tendon is easily found inside.

The insertion of PT is identified by following the muscle down to its fanlike insertion onto the radius. The end is grasped and cut off the radius, taking care to include a 1-2 cm strip of periosteum with it to use for the anastamo-

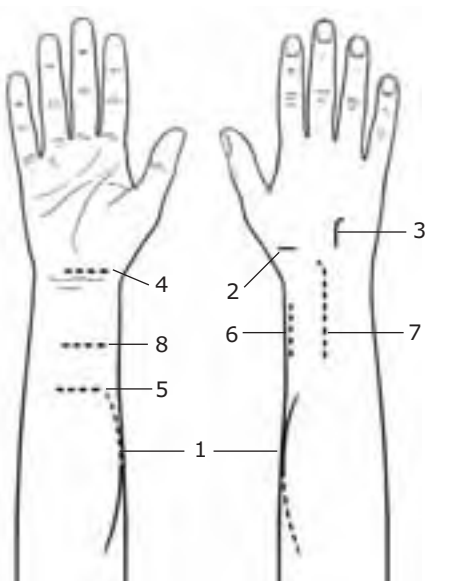

FIGURE 8-2 Incisions for PT to ECRB transfer (dark lines) and FCR to EDC transfer/ PL to EPL transfer (light lines). **a.** Volar aspect **b.** Dorsal aspect. Incisions are numbered as in text.

sis. It is easy to miss some of the upper attachments of PT to the radius. The PT is then brought around, superficial to the brachioradialis, to avoid adhesions to the radius (Fig. 8-3a). The wrist is put in a 45° extension splint. A small transverse incision (2) is then made over the insertion of ECRL, making sure it is not the extensor pollicus longus. The ECRL is detached and brought out through the proximal incision and then passed down superficial to deep fascia to a small incision (3) over the base of the fourth metacarpal (Fig. 8-3b). Attachments of the ECRL to radius are freed to allow it to lie on the ulnar side of the ECRB. Here a distally based flap of periosteum is elevated and the end of the ECRL is fixed to periosteum with braided nylon suture. If finger and thumb extension transfers are being done in the same operation they are completed at this point.

The ECRB is then sutured side to side to the ECRL while applying equal tension on both tendons. The PT is passed through the joined ECRB/ECRL tendon as far distally as possible and sutured with braided nylon with moderate (1 cm) tension. The end is buried in the muscle and the anastamosis is covered with 6-0 monofilament nylon. The skin incisions are then closed. The wrist is immobilized in 45 degrees of extension for four weeks before mobilization is commenced (see Chapter 21 for specific therapy techniques).

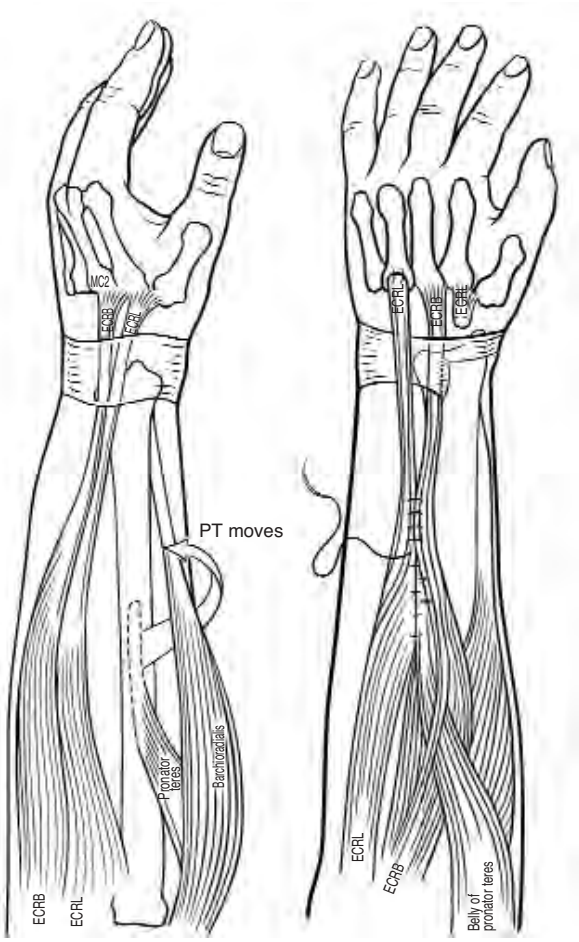

FIGURE 8-3 a. The PT is elevated with a strip of periosteum and transferred above the brachioradialis. **b.** ECRL is transferred to base of the ring metacarpal, ECRL is attached to ECRB and the PT is attached to ECRB (from Warren[33], used with permission).

RECONSTRUCTION OF FINGER/ THUMB EXTENSION

Thumb extension

Brand advocates the use of the palmaris longus (PL), when available, as the active tendon, to replace the extensor pollicis longus (EPL).[4] In the absence of the PL, the FCR is the tendon of his choice. The replacement of the abductor pollicis longus (APL) is also stressed by Brand, as it acts as an extensor of the metacarpal of the thumb, providing for a "circle" pinch. To achieve this, the preferred active muscle is the FCR. However in these instances, Brand is considering the radial paralysis alone with normally functioning intrinsic muscles.

However in cases of leprosy, we normally encounter a triple nerve paralysis, where the adductor pollicis and other intrinsic muscles of the hand are paralysed and consequently, the muscle imbalance is different. Moreover the number of active muscles available for the transfer is limited.

Finger Extension

Many active muscles have been used in the replacement of finger extensors. Jones advocated the use of the FCU[18], while Brand has used the FCR for four-finger extension.[3,4] Clezy,[11] and later Fritschi,[13] have advocated the use of the FCR for the restoration of four-finger and thumb extension. Goldner and Kelly[14] and later Boyes[2] and Chuinard,[8] have recommended the use of the FDS muscles of the ring and/or middle fingers for finger extension. However this is acceptable only if the radial nerve is the only paralysed nerve. If there is associated ulnar and median nerve palsy (triple nerve palsy), as is usually the case in leprosy, these tendons are needed for intrinsic muscle replacements.

Advantages and disadvantages of various procedures

The PL, if present, is an ideal muscle to use for thumb extension. The EPL tendon may be re-routed more radially to be attached to the PL to improve the direction of action.

The FCU as the extensor of the fingers has the advantage of being strong and well able to provide the necessary action. However, it lacks the excursion required to provide a complete range of motion. (Its ulnar side fibres are only 4 cms long). It is also too bulky and causes an unsightly bulge as it crosses over on the ulnar border of the wrist from the flexor to the extensor aspect. It is an important muscle in its own right, causing essential ulnar deviation in activities like hammering and cutting vegetables. Use of this muscle for the transfer deprives the wrist and hand of these effective actions.

The FCR has the advantage of having greater excursion than the FCU and therefore can cross more than one joint. It is also less bulky and therefore is not as unsightly on transfer. It has the disadvantage of having the scar of all tendon junctions at the region of the extensor retinaculum. This can cause problems with mobilization in the post-operative period due to adhesions.

The FDS muscles to the ring and middle fingers have the advantages of good length so that the tendon sutures lie well distal to the retinaculum reducing the risk of adhesions. The FDS has adequate excursion to allow full range and independent movement of the wrist and fingers. The relative disadvantage is that the FDS are antagonists to the movement they are required to produce making re-education more difficult.

This transfer is usually done in combination with the previously described procedure for extension of the wrist; that is, in the same sitting it will follow Pronator Teres transfer to the ECRB.

Palmaris Longus to Extensor Pollicis Longus and Flexor Carpi Radialis to Extensor Digitorum Communis Transfer

***Indication*:** Radial nerve paralysis in isolation or in combination with a high ulnar and low median paralysis.

Technique: Following the PT to ECRB transfer, a small incision (4) (Fig. 8-2) is made over the wrist crease over the visible PL tendon. The tendon is identified, isolated and withdrawn in the forearm via incision 5, about 10 cms proximally. Through a longitudinal incision (7) just proximal to Lister's tubercle over the level of the extensor retinaculum, the EPL is identified and isolated. It is divided at its musculo-tendinous junction. This tendon is withdrawn distally, just proximal to the metacarpophalangeal joint of the thumb. It is tunneled subcutaneously to lie over the tendon of the APL. The PL tendon is then tunneled subcutaneously to meet the EPL at this point, incision 6. It will lie basically in line with the first metacarpal. The two tendons are sutured here with a short interlace, under high tension, with the thumb positioned in extension in the same plane as the palm (Fig. 8-4).

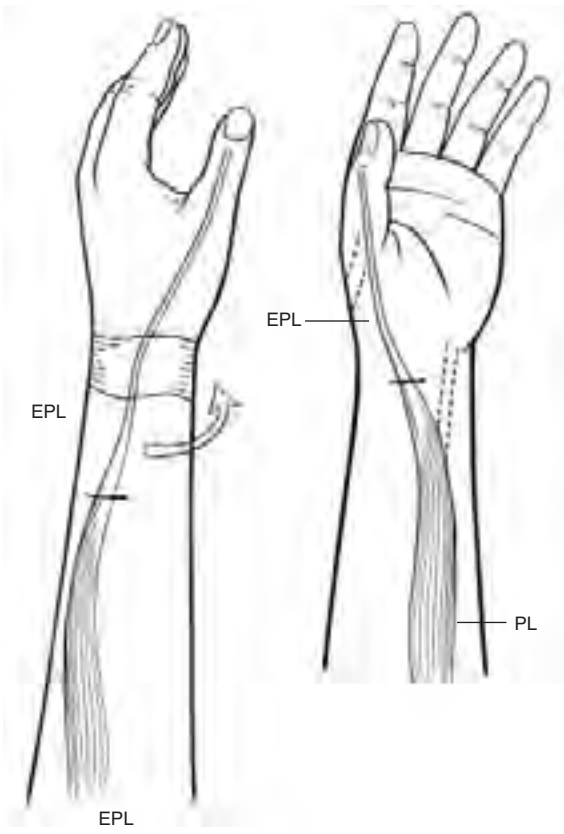

FIGURE 8-4 Route of PL to EPL transfer. Moving the EPL tendon to the radial side of the wrist will produce both abduction and extension.

Through the same incision over the wrist crease, just proximal to the insertion of the FCR, the tendon is isolated and detached from its insertion and recovered in the forearm through a transverse incision (8) about 7 cm proximally. A longitudinal incision (7) is made on the midpoint of the dorsum of the wrist and the extensor retinaculum is cut along the same line to expose the EDC. The FCR is tunneled subcutaneously into this incision, finding the path of least resistance using a blunt instrument.[4] Setting the tension correctly is difficult, especially in triple nerve palsy. With the wrist in about 45 degrees extension, and the fingers extended fully at the metacarpophalangeal joints, the FCR tendon is passed through the individual slips of the extensor digitorum as distally as possible after taking up the slack. It is sutured in such a manner as to incorporate all the tendons in the stitch (Fig. 8-5). Another method is to insert the FCR into the extensor tendons of the ring and middle fingers and then to attach the tendon of the index to that of the middle and the tendon of the little finger to that of the ring finger. Most authors do not include the EDM for fear of creating too much extension/abduction in the little finger.[1] Green suggests pulling on the EDC to assess the adequacy of little finger extension.[15] If there is an extensor lag of the little finger, the EDM is also included in the transfer.

The transfer should then be tested passively. Wrist flexion should produce MCP joint extension but not hyperextension. With the wrist extended it should be possible to achieve full

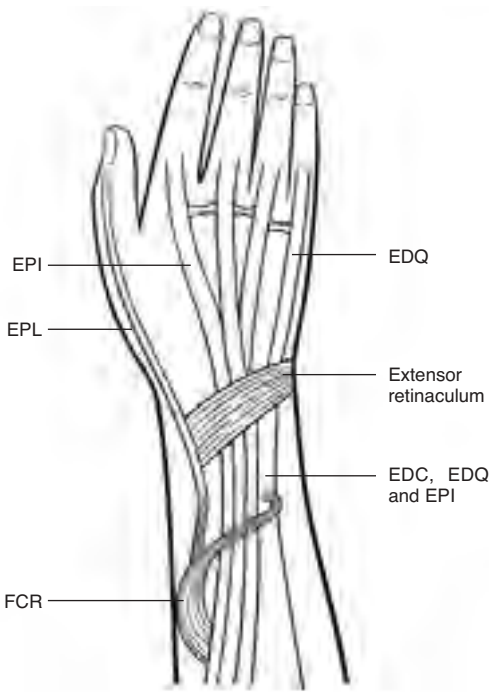

FIGURE 8-5 FCR to EDC transfer. A single weave is carried out obliquely, and the unsatisfied end is buried in one of the extensor tendons. A similar join is carried out for an FDS transfer but comes either through he interosseous membrane around the ulnar border.

finger flexion. The tourniquet is now released, haemostasis achieved and the wounds closed.

In case the PL is absent, Brand advises the use of one of the FDS tendons for extension of the thumb.[3] This however can be done only if the paralysis is confined to the radial nerve, as the FDS tendons will be needed for intrinsic replacement procedures in a triple nerve palsy. Fritschi,[14] and McEvitt and Schwarz[21] however, advocate the use of the FCR divided in two slips, one for thumb extension and the other for four-finger extension even when the palmaris longus is present. The EPL can be taken out of the dorsal retinaculum as shown in Fig. 8-5 to give more abduction. They advise leaving the palmaris longus in situ as a flexor of the wrist.

Multiple Flexor Digitorum Superficialis to Extensor Pollicis Longus and Extensor Digitorum Communis Transfer

Indication: Isolated radial nerve paralysis

***Technique*:** The FDS of the ring finger and/or middle finger are detached from their insertions through incisions in the respective fingers and recovered in the mid forearm. Here they are tunneled through a window in the interosseous membrane passing on either side of the flexor tendon mass. The tendons are received in the dorsum and then tunneled subcutaneously to the dorsum of the wrist. The extensor retinaculum is opened. The EDC tendons and the EPL are identified. The middle finger superficialis is attached to the EDC and that of the ring finger is attached to the EPL. The postoperative immobilization regime is the same as that described for the FCR and PL transfers (see below), although specific therapy techniques will obviously differ.

When the PL is available for the thumb, the FDS of the middle finger alone can be used for the four fingers.

Post-operatively: Place the arm in a full plaster from the fingertips to the upper arm, with the forearm fully pronated and the elbow at 90°. The wrist is kept at 45° of extension with the fingers kept fully extended. The plaster is bivalved at three weeks and cut off below the elbow. Gentle range of motion and transfer activation exercises are commenced. By seven weeks post-op a full unrestricted range of motion should be achieved (see Chapter 21). Physiotherapy should be continued until adequate wrist extension is achieved. Schreuders et al demonstrated continued improvement in active range of movement following a PT to ECRB transfer up to one year following the surgery.[24] This is probably because therapy not only trains the patient to effectively use the transfer, but also trains the muscle to increase its excursion as noted above. It appears to take some time for a muscle to increase its excursion.

Wrist Arthrodesis: Arthrodesis of the wrist should be reserved as a last option, as loss of movement of the wrist adversely affects the functioning of the hand. Even with a triple palsy with a high median nerve involvement, a more functional hand can be obtained with the 'hinge hand' operation (see below) than with an arthrodesis. Weiss et al[33] report that efficiency of hand function decreases by only about 20% following wrist fusion, but it should be noted that these were patients with normal neurologic status. Patients with multiple nerve paralysis would be expected to have a greater negative impact on hand function from wrist arthrodesis.

Indications:

1. Wrist instability, subluxation or neuropathic degeneration.
2. Failed PT to ECRB transfer without hope of successful revision.
3. Triple nerve palsy with high median involvement (relative).

There are now several methods of internal fixation available, which can be used if the equipment is obtainable. Arbeitsgemeinschaft Osteosynthesefragen (AO) techniques of plating have reported non-union rates of 0-2%.[17,33] The following method requires only K-wire fixation, is easy to perform and has a very high success rate.[13] If tendon transfers are planned in the same hand, the arthrodesis should be carried out before the transfer to avoid disuse and further adhesions of the transfer. The ideal position of wrist fusion has not been determined. In one study common activities of daily living were found to use an arc between 10 degrees of flexion and 35 degrees of extension.[6] Most authors recommend a position of about 10 degrees of extension.[16] Pryce[25] reported that power grip was greatest in slight extension and ulnar deviation, and Kraft and Detels[19] found that grip strength was similar from 0-30 degrees of extension but was weakened in flexion. It would seem that a position of between 0 and 10 degrees would be ideal.

Technique: A lazy S incision is made from the base of the third metacarpal to a point 7 cm proximal to the tip of the radial styloid in the center point of the dorsal forearm. The skin is mobilized at the level of the deep fascia, preserving as many of the veins as possible. The deep fascia and retinaculum are then raised as an ulnar- based flap along the full length of the incision. This can be difficult to keep as one piece, especially over the distal radius. The extensor tendons are now exposed. The extensor digitorum tendons are retracted ulnarwards and the extensor pollicus longus tendon radially. The periosteum is then stripped off of the radius. A strip of bone graft is harvested from the distal end of radius by cutting a groove 5 cm long, 5 mm deep and 6 mm wide, tapering distally. An oscillating or circular saw is best for this, although I (RS) usually use osteotomes. The joint spaces of the radioscaphoid, radiolunate, capitolunate joints are opened and the articular cartilage of each joint surface is removed with bone nibblers, saw or a gouge. Some also include the third CMC joint.

With the wrist held in 30° extension, the groove in the radius is extended through the lunate and scaphoid using a gouge or fine nibblers. This groove is then continued directly into the head of the capitate, gouging a hole with a gouge or a drill with the wrist in flexion (Fig. 8-6). This extends up into the base of the third metacarpal and must be wide enough to fit the bone graft. The distal end of the bone graft is then gently hammered into the hole, after which the wrist is slowly extended until the graft fits back into the groove. Cross K-wires are used to stabilize the wrist. Any remaining cancellous bone is used as bone graft. The periosteum is then sutured over the graft and the fascial flap sutured over the tendons and skin closed.

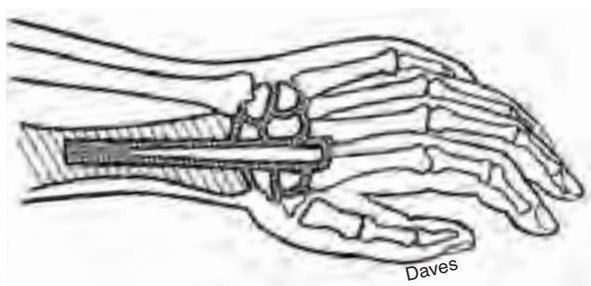

FIGURE 8-6 Wrist arthrodesis. The bone graft is harvested from the distal dorsal radius and placed in the carpus and inserted into the base of the third metacarpal after creation of a groove through the lunate, scaphoid and capitate.

A plaster extending from the PIP joints to above the elbow is placed for 10 weeks total. A check X-ray must be taken prior to plaster removal. The plaster can be trimmed to allow finger movement at four weeks. If not buried the K-wires should be removed at one month.

The finger and thumb extension procedures can be carried out when there are 3 weeks remaining until plaster removal.

Complications: Infections and skin edge necrosis are unusual. The most common, and serious, complication is delayed or non-union. The rate of non-union has been reported at 5-18% using techniques not utilizing plates.[10,16] AO plate methods of fusion however have reported non-fusion rates of 0-2%.[16] Adhesions of extensor tendons can occur. Carpal tunnel syndrome has been reported in 4-10% of arthrodeses using the AO plate fixation.[16]

COMBINED NERVE PALSIES

As mentioned, in leprosy radial nerve palsy is usually seen in combination with median and/or ulnar palsies. Combined nerve palsies may be seen in other peripheral neuropathies as well. A complete hand assessment is mandatory to determine which muscles are still available for transfer. In the presence of a low median/high ulnar palsy, the most usual presentation, the usual plan is a two or three stage reconstruction to carry out the procedures outlined in Table 8-2. In the first stage the wrist and finger/thumb extension replacement procedures are performed. There is concern that removing the PL would leave the wrist without a dedicated flexor. Zachary has demonstrated that the PL alone is not adequate to provide wrist flexion in a hand with a simple radial nerve palsy.[34] While it appears to be adequate in a triple nerve palsy hand, removing it will leave the wrist without an independent flexor. For this reason we usually use FCR to activate extension in both fingers and thumb. However the finger flexors will also stabilize the wrist in flexion. Therefore if independent thumb extension is needed the PL could be used in this situation. In the second stage a sublimus transfer (FDS to lateral bands, see Chapter 6) is carried out for intrinsic replacement, and an opponens replacement is performed using flexor digitorum superficialis (Chapter 7). It is important to avoid making the sublimus replacement so tight that the finger extensor transfer is unable to extend the metacarpophalangeal joints.[1] It is best to do a Bunnell type transfer to the lateral bands as opposed to the flexor pulleys, as with the latter the finger extensors have to extend the interphalangeal joints on their own. Arthrodesis of the thumb metacarpophalangeal joint or a half flexor pollicus longus transfer would be appropriate for stabilizing the thumb (Chapter 6).

It should be noted that not all patients with a triple nerve palsy will be candidates for all procedures. In our study 18 of 21 patients undergoing reconstructive surgery for radial nerve palsy secondary to leprosy reactions had involvement of all three nerves.[21] Of these 18, only eight had intrinsic reconstruction and ten had opponens reconstruction. Reasons for this were partial nerve palsy, refusal of further surgery, or unsuitability for further reconstruction. Some patients presented with severe contractures or shortened digits and were not considered candidates for reconstruction of all functions.

In combined low median and high radial nerve palsy with an intact ulnar nerve, an FCR to EDC transfer should be carried out. The FCU will maintain wrist flexion. The PL should then be used with a re-routed EPL to provide thumb extension and abduction. This procedure may provide enough abduction that the patient may not desire to proceed with an opponensplasty. Combined high median and radial nerve palsy with intact ulnar nerve is virtually never seen in leprosy. If it does present, Omer recommends wrist arthrodesis, or PT to ECRB transfer if available, for wrist extension with the FCU transferred to EDC and EPL for finger/thumb extension.[22,23] A tenodesis of FDP tendons of the index and middle finger to FDP of ring and little fingers is carried out to give active finger flexion of all fingers. The thumb is stabilized by thumb MCP arthrodesis,

tenodesis of FPL across the IP joint and tenodesis of the APL tendon to the radius.

If the median nerve is intact with a combined radial/ulnar palsy then a Bunnell type sublimus transfer is carried out as second stage procedure. Again, arthrodesis of the thumb metacarpophalangeal joint or a half flexor pollicus longus transfer would be appropriate for stabilizing the thumb.

The hinge hand procedure

It is not uncommon to be requested to reactivate a hand in which there are very few muscles functioning. The patient desires appearance, social acceptability and as much function as possible. There are many options aimed at providing the maximum possible function and appearance. Transfers for tetraplegic patients are described elsewhere.[16] However there is a relatively simple procedure that often gives a satisfactory result in the severely motor deficient hand.

If there is only one muscle of reasonable strength that can be used in isolation, it can be used to activate wrist extension to provide a "hinge hand". The hand at rest should be in a normal posture and when the wrist is extended the fingers close for grasp. Patients do not have a lot of strength but there is usually enough stability to hold large light objects especially if they have a stem for easy holding. If this muscle can be used to provide a good wrist extension it is possible by tenodesis of the flexors to provide a hand that grasps, albeit weakly.

A normal strength ECRB or ECRL is usually adequate although the wrist extension may be stabilised by yoking one tendon to the 4th metacarpal base to give pure wrist extension. No other active transfer will be needed. If there is no active wrist extensor it is necessary to transfer some other muscle, yoked to give better wrist extension stability. Suitable muscles need to be relatively strong and they include brachioradialis, pronator teres, flexor carpi radialis and FDS.

It is desirable to tenodese any extensor tendons at the same time as the active transfer is inserted. This allows a uniform tension to be achieved across all extensors. The technique described is similar to that of Zancolli.[35] The flexor tendons are tenodesed 3 months or longer before the extensors are dealt with so that they can be put in more tightly than would be possible if extensors were done first. A tenodesis of thumb opposition can also be performed, usually at the time of the flexor tenodesis. This will alter the ability to grasp objects of wide diameter but will improve the ability to hold something like a drinking glass with a narrow stem as the rim of the glass will be supported all around. Alternately, the abductor and long flexor of the thumb can be tenodesed.

Technique-flexors: Initially the flexor side is operated on. The FDS tendons are located about 2-3 cm above the wrist on the radial side of the forearm, and sutured together, side by side, when the fingers are straight. For attachment to the radius, use a small 2-3 mm diameter drill or burr and drill a series of 3 small holes, the distal two being 0.5 cm apart and the third one some 1 cm proximal. The bridge of bone between these two distal holes is removed so a cavity down to the marrow is displayed (Fig. 8-7). The flexor tendons are identified and pulled tight with the fingers extended, and wrist straight or up to 10 degrees flexion.

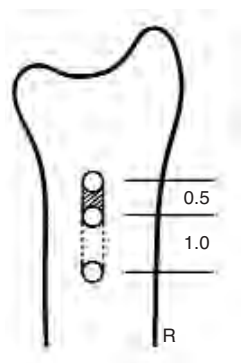

FIGURE 8-7 Tenodesis technique. Three holes are drilled in the distal radius. Then the bone between the distal two holes is nibbled to create a larger single hole. A sub-cortical tunnel is then created between these two holes through which a single tendon will then be passed.

They are sutured together at the site of the distal hole. The long finger tendon is then cut and passed into the distal hole and out through the proximal hole. A strong Silk or braided nylon is used to pass this tendon into the distal cavity and out through the proximal hole so the tendon can be sutured back to itself, (Fig. 8-8). This means that only 3-4 weeks immobilisation is required for enough healing to start physiotherapy. If the tendon is inserted in bone via a Bunnell suture so that the tendon just ends in the bone a much longer immobilisation is required. This tenodesis ought to result in the fingers being flexed at the MCP and PIP joints when the wrist is extended (Fig. 8-9). The degree of flexion will depend on the position of the wrist when the tendon length is cut before suturing.

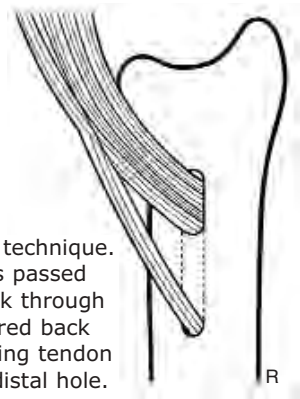

FIGURE 8-8 Tenodesis technique. A single flexor tendon is passed from the distal hole back through the proximal to be sutured back to itself and the remaining tendon ends are buried in the distal hole.

FIGURE 8-9 Hinge hand procedure. Extension of wrist produces flexion of the fingers (from Warren[33], used with permission).

The long extensor of the thumb can be attached similarly but it is often better to divide EPL and attach it to the insertion of FCR so that the thumb automatically pulls out straight and into abduction when the wrist extends. This should be done at the same time as the flexor tendon tenodesis. McDowell and House recommend stabilizing the thumb by carpometacarpal joint fusion, combined with a half flexor pollicus longus to extensor pollicus longus transfer to stabilize the interphalangeal joint.[20] After this procedure the arm is plastered with the wrist flexed, the fingers straight and the thumb fully opposed and abducted.

Technique-extensor: The methodology for transferring the basic active motor (PT or if absent brachioradialis) into ECRB is as described above.

For the finger extensors it is necessary to open the forearm for about 5 cm proximal to the wrist with an incision that allows dissection onto the ulna bone about 2-3 cm proximal to the wrist joint, where the tendons will be attached. The attachment technique is the same as for the FDS (Fig. 8-10). The tension for this suture is fixed at neutral when the fingers are straight and wrist extended about 10-15 degrees. This should allow the fingers to straighten when the wrist is allowed to drop towards flexion (Fig. 8-11), but to flex at the MCP and IP joints when the wrist is extended.

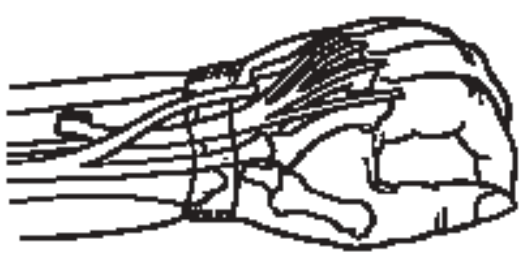

FIGURE 8-10 Hinge hand procedure. Attachment of finger extensors to ulna (from Warren[33], used with permission).

FIGURE 8-11 Hinge hand procedure. Flexion of wrist produces finger extension and thumb extension and abduction (from Warren[33], used with permission).

The exact tension that can be applied will depend on what the tension is in the flexor tendons. This can easily be tested on the table before final suturing and closure.

The arm is plastered with wrist fully extended and the fingers straight as is done for the pronator teres splint. If the thumb has also been operated on it will require to be held in abduction and opposition. The plaster ought to be above elbow especially if ECRB or BR is the used motor.

Physiotherapy is relatively easy. The cast is left on for 4 weeks and then the transferred wrist extensor is re-educated. The fingers will automatically activate so that when the wrist extends the fingers flex, and when the wrist flexes the fingers extend and the thumb is abducted and extended.

SUMMARY

While radial nerve palsy, and especially combined nerve palsies, are a serious disability, surgery for these conditions is usually very rewarding. Careful attention to technique is essential to achieve correct balance, and skilled therapy is necessary to achieve a good result.

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9

Management of Miscellaneous Conditions in the Paralysed Hand

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H. DA ROSA PEREIRA

INTRODUCTION

Hand surgery in nerve injury aims to restore function and cosmesis. Undoubtedly, tendon transfers and nerve decompression are the most common and needed operations in a surgical program aiming to physically rehabilitate neuropathic hands. However, surgeons dealing with leprosy patients will be faced with a variety of conditions: from a preserved hand with just mobile clawed ulnar fingers to a grossly deformed and destroyed hand (Fig. 9-1). The first condition is easily resolved with a simple tendon transfer. The latter could lead surgeons to a feeling of frustration and hopelessness in the sense that nothing can be done for such conditions. The aim of this chapter is to present some suggestions for selected techniques devised to correct and/or ameliorate some of these deformities not covered elsewhere in the textbook.

The leading philosophy is that, in many instances, something can be done to improve the function of a badly deformed hand. Sometimes, a minor arthrodesis may result in a dramatic improvement in the daily life activities of a patient. However, it is most important before the operation, to carefully examine the hand, select an adequate intervention and fully discuss with the patient the possible results and operate only if the patient understands and agrees with the procedure.

FIGURE 9-1 A grossly deformed hand. Unattended acute reactions may lead to severe deformations in the hand due to myositis, arthritis, joint contractures and scarring of skin wounds after necrotizing erythema nodosum.

The cosmetic appearance of the hand should not be neglected. Some surgeons consider these aspects as non-priority. However, one should remember that this decision should be given to the patient and not to the surgeon. It is intriguing to realize that some patients with longstanding ulnar paralysis are, by far, more concerned with wasting of the first web than with clawed fingers. They can often overcome the functional disadvantage with a variety of tricks but hardly can conceal a depressed web other than keeping the hand in the pocket. This attitude may lead to socially embarrassing situations.

Contractures

Collateral ligaments, volar plate and joint capsules are structures to provide a stable link that allows efficient transmission of muscular force across the joints. These structures are maintained in their optimal flexibility and length by a normal joint. Muscle weakness or palsy interferes greatly with this intricate mechanism and the final result can be soft tissues and joint contractures. Longstanding muscle palsy is com-

mon in leprosy and thus joint contractures are also frequent if preventive measures are not timely. The sensory loss may lead to wounds that may become infected, compromising deep structures and resulting in tendon, bone and joint involvement. There may be loss of insertion of the tendons, bone sequestra and joint destruction.

The end result may be shortened fingers with contracted joints that interfere with normal function of the hand. A careful analysis of each hand may lead to the indication of surgical techniques that can improve the function. It is important to note that these cases are of long-standing contractures and not recent conditions as we commonly see after trauma. For this reason, possibilities for surgical correction are very limited. In many cases the surgical techniques are restricted to release skin contractures and arthrodesis in order to simply improve the position of the finger and thereby improve hand function.

FIGURE 9-2 The contracted distal phalan made grasping of objects difficult. A DIP arthrodesis has improved function of the hand.

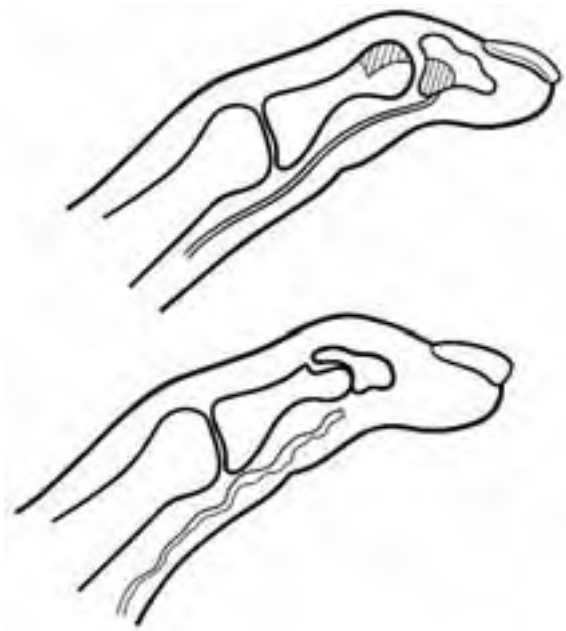

FIGURE 9-3 DIP arthrodesis with reshaping of the distal bone, which increased the surface contact between the remaining distal phalanx and the medial phalanx.

Distal interphalangeal joint contractures

To the clawed fingers contractures of the distal interphalangeal joint (DIP) may cause additional difficulty for pinch and grasp. Arthrodesis of the DIP joint can improve the overall function of the hand (Fig. 9-2). Frequently in leprosy the amount of bone at the distal phalanx is not enough to allow adequate fusion. Therefore it is useful to shape the bone ends to increase the bony surface (Fig. 9-3).

Operative technique: After a wrist or finger anesthetic block, incise deeply and longitudinally in the dorsal aspect of the distal finger including the terminal slip of the extensor tendon. Preserve as much as possible the dorsal venous drainage. Expose the capsule and collateral ligaments and release these structures carefully with a #15 blade.

Fully expose both the articular facets and remove the cartilaginous tissue with a thin osteotome and shape the proximal end of the distal phalanx and the distal portion of the middle phalanx in order to obtain an angle of 15° to 20°. Carefully remove debris between the facets and firmly fix both phalanxes with two Kirschner wires keeping the bones compressed as the wires are inserted (Fig. 9-4).

Proceed with hemostasis and close the

wound with separate sutures of nylon 6/0. Immobilize with a plaster cast, which should be removed after 4 weeks.

Proximal interphalangeal joint contractures

Contractures of the PIP joint are the most common in hands of patients affected by leprosy. Contractures following recent paralysis should be treated with adequate physical therapy and/or surgical release of ligaments and volar plate by conventional techniques.[19] It is also advisable to consider the use of distractors, which has the advantage of allowing progressive and slow lengthening of soft tissues and collateral vessels.[14] However, this section will describe only treatment for longstanding contractures in which most of the conventional techniques are not successful. The surgical technique is similar as that for DIP arthrodesis (Fig. 9-5a,b). Besides these standard techniques, others can be advocated depending on the experience of the surgeon.[1,12,16] How-ever, its is important to stress that, due to the accompanying severe contracture of skin, the amount of bone to be removed to allow good positioning may severely shorten the finger. In order to avoid this problem it is advisable prior to arthrodesis to release soft tissue contrac-tures. A good technique for this purpose is the one proposed by Fritschi described below (Fig. 9-6, 9-7 and 9-8).

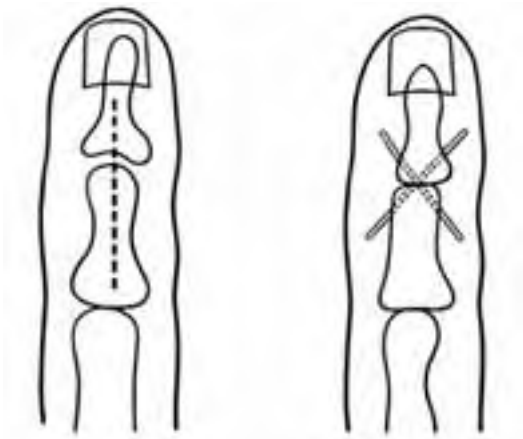

FIGURE 9-4 DIP arthrodesis. If the distal phalanx has enough bone, a conventional two K-wire arthrodesis can be done. Bone parts should be kept under compression while inserting the wires.

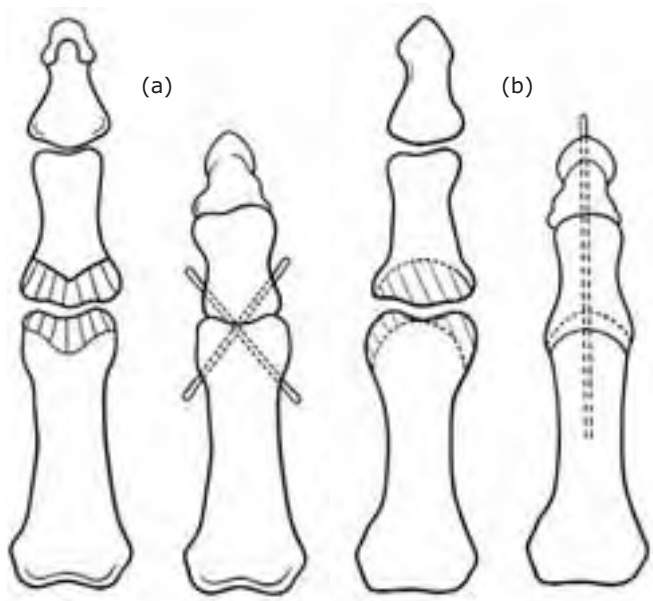

FIGURE 9-5a,b PIP arthrodesis. (A) Chevron-type technique. (B) Cup and cone type arthrodesis allows adequate bone-to-bone contact and, most of all, makes the final adjustment of the phalanx position before the fixation with K-wire easier.

Operative technique

With a marking pencil outline a "Y" in each side of the joint which legs should join at the volar aspect of the joint. Incise along the drawing and make sure to keep the knife superficial – do not incise deeply, that is, beyond the dermis.

With fine scissors, undermine distally and proximally to the volar incision in order to draw areolar tissue to your surgical wound to cover the flexor tendon sheet, which will be exposed along with the progressive release of the joint and skin contracture.

Through the "V" portion of the "Y" incision, release the collateral ligament on both sides and the volar synovial pouch if it is obliterated.

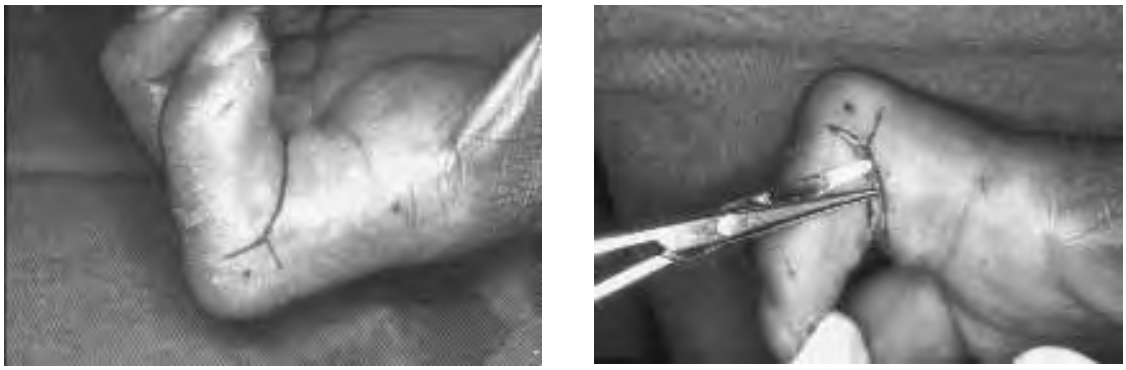

FIGURE 9-6 Fritschi's Y technique for skin and joint contracture. **a.** The "Y" is marked in the skin. The dot is intended as the fulcrum of the PIP joint. **b.** A careful superficial undermining is made both distally and proximally releasing contracted tissue and drawing areolar tissue to the open surgical wound.

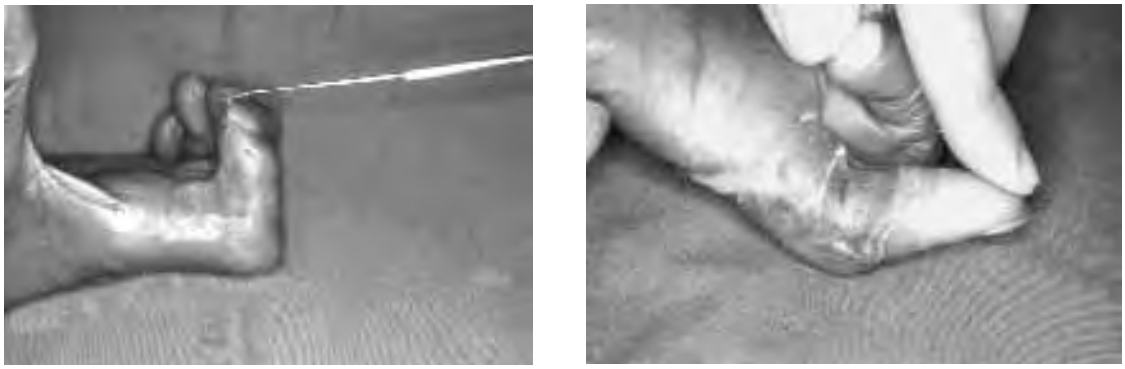

FIGURE 9-7 Fritschi's Y technique for skin and joint contracture. **a.** Pre-operative view with passive extension. **b.** Passive opening of the finger after surgery.

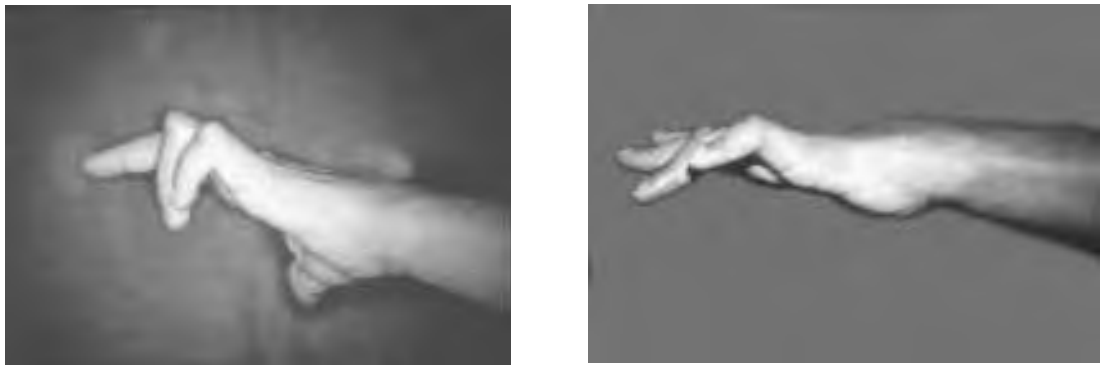

FIGURE 9-8 Fritschi's Y technique for skin and joint contracture. **a.** Pre-operative view – active extension. **b.** Postoperative view – active extension.

As the release proceeds, notice that the surgical wound becomes wider. This is actually the gain in the passive range of movement of the PIP and it also shows the amount of skin necessary to cover the gap.

Harvest the needed amount of full-thickness skin graft and apply the graft over the surgical wound at the volar aspect of the joint. Before suturing the skin graft, insert at least one Kirschner wire to effectively immobilize the joint while, in the post-operative period, the skin graft takes and retracts.

Full-thickness skin grafts are preferable to repair the surgical gap due to the smaller degree of contraction in the post-operative period and because the quality of skin is better than in split-skin grafts. For all skin grafting techniques in this chapter it is recommended to harvest the donor skin from the antecubital space. In this space it is possible to harvest a reasonably amount of good quality hairless skin yet allowing easy closure of the transverse defect. If there is need for a larger piece of skin, it must be harvested at the groin.

According to the severity of the contracture the surgical wound may prove to be inadequate for a skin graft. This happens when, after release, the joint becomes exposed and the amount of areolar tissue is not enough to provide a recipient bed for the graft. In this case a flap may be used. A cross finger flap is a satisfactory choice to cover the remaining defect (Fig. 9-9) and it is easy and safe to perform. The inconvenience is that the fingers must be kept immobilized for 2 weeks and there is need for a second operation to release the pedicle.

FIGURE 9-9 Fritschi's Y technique for skin and joint contracture. A cross-finger flap can be used to improve coverage of the surgical wound.

Metacarpophalangeal joint contractures

Flexion contracture of the MP joints is seldom seen in leprosy. However, extension contractures may occur as a result of a severe and inadequately treated "reactional" hand. This is a challenging condition to the surgeon. The dorsal skin may become shiny, immobile and fragile with poor blood supply. The capsule is contracted as well as the extensor hood, which may additionally be laterally dislocated. The joint itself may be affected e.g. exostosis and compromise of the cartilaginous facets. Extension contractures of MP joints are highly dysfunctional since they prevent adequate grasping or pinching. If possible, release of skin and joint contracture should be undertaken to allow the distal joints to perform basic tasks of daily life activities.

Operative technique

Place a transverse incision at least 3 cm proximal to the knuckle of the MP joints. It is of utmost importance to preserve dorsal veins at this stage. Undermine carefully the distal border of the incision to expose the MP joint area. If necessary, complete the incision with an extended "V" in both radial and ulnar sides (Fig. 9-10).

Expose and incise the two collateral ligaments and release the volar plate pouch with a small curved elevator. If exostoses are present, remove them with a fine nibbler.

At this stage, sufficient flexion should be obtained (50°-60°). Immobilize the affected joints with a longitudinal Kirschner wire taking care to maintain the finger properly aligned on its longitudinal axis.

Apply a full-thickness graft to repair the widened dorsal surgical wound. Immobilize

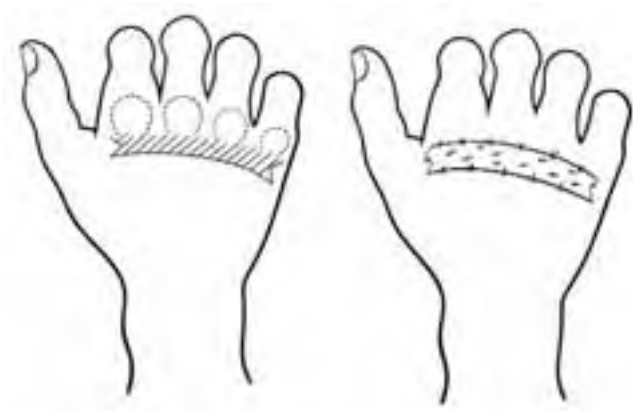

FIGURE 9-10 Technique for dorsal release. A skin graft is applied to cover the defect.

the hand with a volar plaster cast including a padded dressing in the dorsum to ensure mild compression over the skin graft.

Soft tissue contractures

Soft tissue contractures can be severely limiting to the function of the hand in leprosy. These contractures can be treated by physical therapy. For finger contractures the choice treatment includes exercises, splinting and serial cylinder casting. The latter is particularly efficient to restore adequate range of movement (ROM), but requires a carefull follow-up and complete patient compliance. However, in some long-standing contractures, surgical interven-tion is necessary.

Release of soft tissue contractures in the fingers can be treated by skin graft or pedicle flap and the various techniques have been previously discussed in this chapter. Skin contractures in others sites of the hand need a careful analysis and the surgical technique should be decided on each specific situation. Again, skin grafts are, in most cases, the preferable option after release of the contracture. Z-plasty is a goodprecious technique that should be considered whenever applicable (Fig.9-11a and b).

Intrinsic plus deformity (Swan-neck)

In this deformity there is hyper-extension of the PIP and some degree of flexion in the ter-

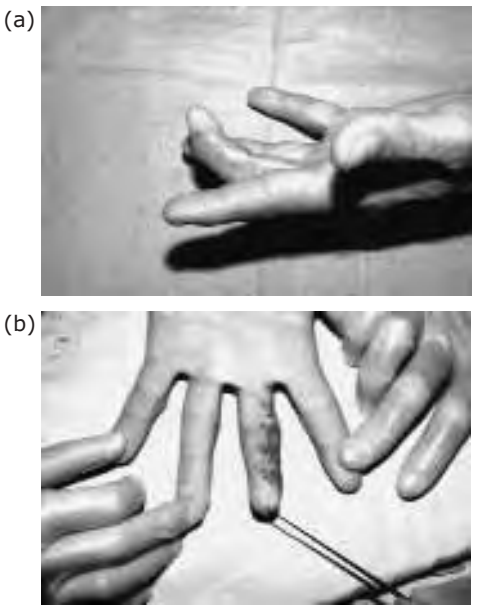

FIGURE 9-11 Z-plasty for skin contracture release. **a.** pre-operative view. **b.** a multiple Z was done along the axis of the scarred tissue.

minal joint (Fig. 9-12).[13,15] Most frequently, the One cause for intrinsic plus deformity in leprosy is contracture of the intrinsic muscles due to myositis as a result of reactions. The degree of severity depends on the time elapsed without adequate treatment and the severity of the reaction. Sometimes it is possible to see "acute" swan neck during an acute reactional state due to spasm of the intrinsic muscles (lumbrical and interosseous).[5] On the other hand, following a severe reaction without proper treatment or with delayed attention (drugs, splinting and physical therapy), the fine structures of the dorsal expansion become contracted and fibrotic, the skin contracts and the joint develops stiffness. Contracture of the oblique retinacular ligament is also a common feature of longstanding intrinsic plus deformity. Another common cause for "intrinsic plus" deformity is the removal of the flexor sublimis for tendon transfer in the hand (sublimis-minus).[2,13] A

FIGURE 9-12 Swan-neck deformity. Note the hyperextension of the PIP and flexion of the DIP joint.

third cause is following intrinsic replacement surgery in an excessively mobile hand. An alternative in these hands is to employ the Lasso technique of Zancolli[19], which corrects the clawed fingers without direct attachment of tendon slips in the extensor apparatus, thereby greatly reducing the risk of swan-neck deformity.

In mild deformities where flexion of the PIP joint can be actively achieved and there is no gross contracture, there should be no need for surgical correction. If necessary, a simple dermadesis (Fig. 9-13) may be sufficient to reverse the deformity though the correction proves to be not longstanding in my experience.

Correction of Swan-neck deformity

The traditional technique for correction of "intrinsic plus" was described by Littler.[10] He suggests excision of a triangle of the oblique fibers in the dorsal expansion at the level of the middle or proximal third of the proximal phalanx. This technique is indicated in those cases in which the flexion of the PIP is restrained (Fig. 9-14). Another possibility is an incision of the lateral band at the proximal third leaving the band attached to the distal end. The band is then rerouted volarly to the ligament of Cleland and sutured to the flexor tendon sheath. In this way, the tension on the band allows extension of the DIP and prevents hyperextension of the PIP (Fig. 9-15).

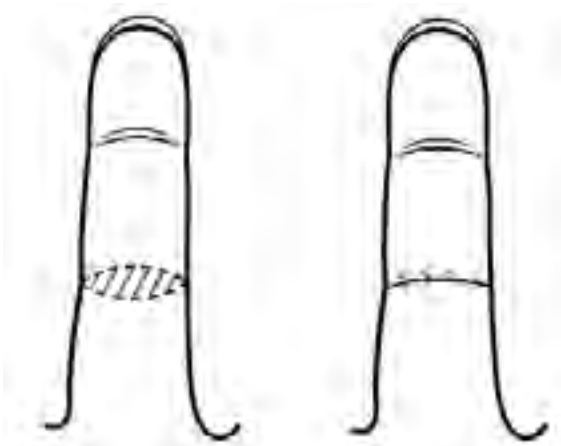

FIGURE 9-13 Dermadesis at PIP joint. An elliptic skin resection is made. The incision should be placed in order that the final suture lies in the natural PIP volar crease.

Fritschi[3,8] recommended a longitudinal incision along the expansion, which divides the oblique fibers and continues distally dividing the lateral band (Fig. 9-16). After release of the hyperextension of the PIP, the lateral band is reattached to the oblique fiber in the new position.

Tenodesis of the flexor sublimis is an alternative that may give good results.[7] A slip of the flexor sublimis is cut in the proximal end of the proximal phalanx. The slip is passed through a small opening made in the distal portion of the A2 pulley and sutured to itself (Fig. 9-17). This method prevents the hyperextension of the PIP.

In severe cases of intrinsic-plus deformity it may be necessary to release skin contracture with Z-plasty and reconstruction with flaps. The dorsal expansion should be released as well as the lateral band. Finally, the PIP is arthrodesed in slight flexion. This is almost a salvage procedure that should be fully discussed with the patient before operation.

Boutonniere deformity

The extensor apparatus of the finger is a fine

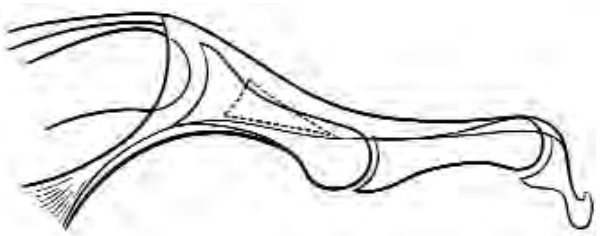

FIGURE 9-14 Littler's technique for Swan-neck correction. Using a triangular resection, the lateral band and oblique fibers of the dorsal aponeurosis are removed at the level of the middle or proximal third of the proximal phalanx.

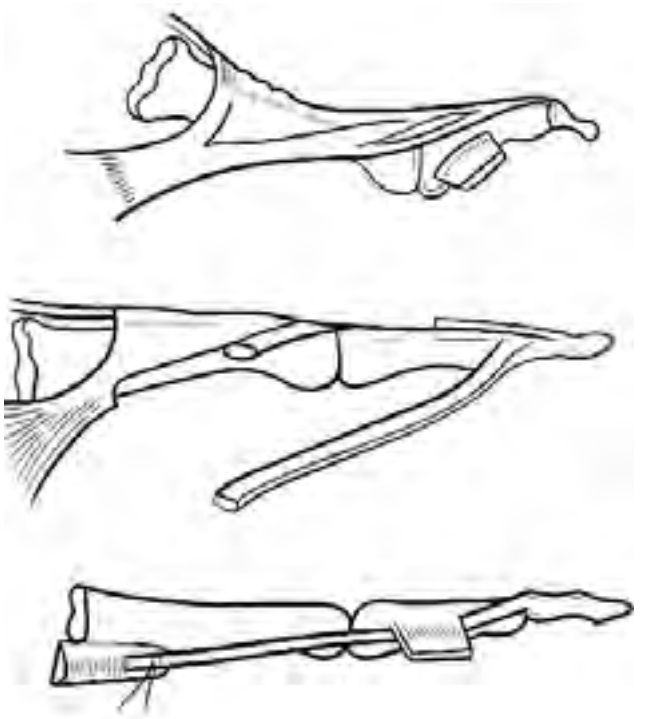

FIGURE 9-15 Swan-neck correction by rerouting of the lateral band. The lateral band is detached at the proximal end and reattached to the flexor sheath after having been threaded volarly through Cleland's ligament, which prevents its dorsal excursion. The new route of the lateral band avoids hyperextension of the PIP joint while still allowing extension of the DIP.

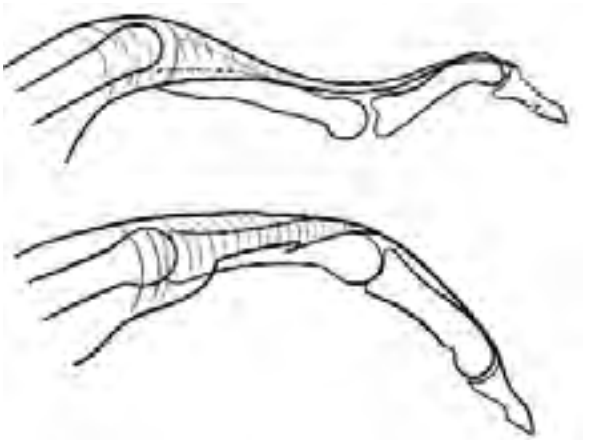

FIGURE 9-16 Swan-neck correction. Fritschi's modification of Littler's operation. The lateral band is sectioned. The PIP joint is flexed at 60º and the lateral band is re-sutured to the cut oblique fibers in the new position.

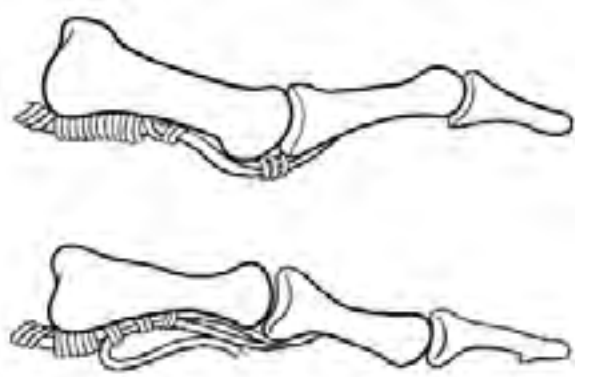

FIGURE 9-17 Tenodesis for correction of Swan-neck deformity. A slip of the flexor sublimus is cut proximally to its insertion at the base of the medial phalanx. The slip is threaded through a small opening made in the distal part of A2 pulley and sutured to itself after flexing the PIP joint. During flexion of the fingers the slip becomes loose but as the finger attempts to extend, the slip becomes tight and prevents hyperextension of the joint beyond the adjusted angle of the PIP joint.

complex of bands, slips and ligaments that contributes to a smooth and coordinated movement of extension and flexion of the finger. Damage to any of its portions may induce severe imbalance in both movements.

Disruption of the integrity of the extensor apparatus at the level of the middle joint may result in a boutonniere (button-hole) deformity. Actually division of the central slip of the extensor tendon alone is not enough for a bou-

tonniere deformity to occur. Also required is some involvement of the retinacular component of the dorsal apparatus.[3] This concept should be borne in mind to understand the pathogenesis of the deformity in leprosy.

The most common cause of boutonniere in ulnar palsy is the chronic abnormal position of the various structures of the extensor apparatus as a result of longstanding clawed fingers. The lateral bands migrate volarly resulting in contracture of the oblique retinacular ligament of Landsmeer. Sometimes this is referred to as "hooding deformity". It is important to note that clawed fingers greatly expose the often insensitive skin of the knuckles of the finger to repetitive trauma which may lead to wounds that may become infected and destroy the tendon apparatus on the dorsum of the middle joint. In other instances, the granulomatous component of a reaction can also compromise these fine structures. As a result, the boutonniere (hooding) deformity in leprosy is basically characterized by volar displacement of the lateral bands and contracture of the oblique retinacular ligament. The final picture is flexion of the PIP joint with mild extension of the DIP joint (Fig. 9-18).

To assess contracture of the oblique retinacular ligament the PIP is passively extended and then the distal phalanx is flexed. In the presence of a boutonniere deformity there will be marked resistance to flexion of the DIP. With the PIP flexed it will be easier to flex the DIP joint (Fig. 9-19). Before considering surgically correcting a recent boutonniere, the patient should be asked to actively flex the DIP while extending the PIP with the other hand.

Surgical treatment of boutonniere in leprosy depends on the severity of the case. Different from fresh or traumatic boutonniere[9] the deformity in leprosy is commonly chronic with intense residual fibrosis and disorganization of the fine extensor apparatus structures – therefore, results are often unrewarding.

Central Slip Advancement

In mild cases with rupture of the central slip an advancement of this structure can be performed.

Operative technique

After a wrist, or even a finger block, make an incision on the dorsal aspect of the middle and proximal phalanx, fully exposing the region of the PIP.

Identify and remove the fibrotic callus on the central slip over the PIP. Sometimes it is difficult to recognize the difference between the

FIGURE 9-18 Severe Boutonniere deformity.

FIGURE 9-19 Restrained flexion of the DIP joint is a characteristic of advanced Boutonniere. The test should be made before any attempt for physical therapy or surgery treatment.

tendon (central slip) and the fibrotic tissue. The former has a shine pearl aspect and the latter is light gray and transparent.

While removing the fibrotic callus, leave a cuff of tissue attachment to the base of the middle phalanx, which will help later inthe reattachment of the advanced central slip to the dorsum of the medial phalanx.

In order to advance the extensor tendon, make two lateral and parallel incisions in the central slip towards the MP joint. While incising, be careful not to harm the underlying tissues to prevent adhesion of the tendon to the bone phalanx.

Suture the lengthened central slip to the attachment in the base of the middle phalanx. If no attachment is present, fix the central slip to the periosteum of the middle phalanx. The finger should assume slightly the shape of a swan neck. Tenotomy of the distal tendon to release retinacular contracture is advocated by some authors and contraindicated by others.

A Kirschner wire may be inserted in the PIP to guarantee adequate immobilization of the joint. Immobilize the hand for 4 weeks and then start gentle physical therapy.

Dorsal Fixation of Lateral Bands

In cases with a marked relaxation of the extensor structures but still with no fixed contractures, it is possible to reconstruct the extensor apparatus.

Operative technique

Incise the skin in the dorsal aspect of the middle and proximal phalanx exposing the tendinous structures, including the displaced lateral bands.

If the central slip is loose it may be required to excise a few millimeters of the slip and reattach it distally in order to shorten the central slip.

The displaced lateral bands should be freed of attachments, including its connections with the oblique retinacular ligament. Thus, the bands are brought to their original physio-logical position and sutured to the central slip with 2 fine 6-0 nylon sutures (Fig. 9-20). If necessary, the triangular ligament should also be reconstructed.

Immobilize the PIP joint with a Kirschner wire for 4 weeks.

In severe long-standing boutonniere deformities with marked contractures and joint stiffness a PIP arthrodesis of the most con-tracted fingers can be performed using one of the standard techniques described elsewhere in this chapter.

A mild anterior displacement of the lateral bands without severe contracture of the oblique retinacular ligament is a common finding in hands with clawed finger. This displacement results in a poor extension of the distal phalanx after intrinsic replacement. It is important while correcting clawed finger by any of the flexor to extensor tendon transfer techniques to restore the lateral bands to their original position while performing the insertion of

FIGURE 9-20 Mild Boutonniere. The central callus should be removed. The freed central slip is advanced and sutured in the base of the middle phalanx.

the transfered slip into the lateral bands.

Fritschi[8] has devised a simple procedure that aims to correct this problem (Fig. 9-21a) and consists in an additional step to the Stiles-Bunnel sublimis transfer, which can apply to any of the techniques involving insertion into the lateral bands. While suturing the tendon slip in each finger, one should pass the suturing needle through the central slip and then in the free border of the lateral band and finally in the tendon transfer slip (Fig. 9-21b). When the suture is concluded the lateral band will be brought dorsally to its original position allowing adequate extension of the finger. This is a simple procedure that should be kept in mind when performing intrinsic replacement for correcting clawed fingers with a mild hooding deformity.

Extensor Tendon Guttering

Guttering is the ulnarward subluxation of the extensor tendon of the fingers (Fig. 9-22). The extensor tendons lay in the gutter between the knuckles of two adjacent fingers. This is a common finding in hands with rheumatoid arthritis. In the normal hand fingers show more lateral mobility towards the ulnar than the radial side. The index finger normally tends to be ulnarly deviated at rest. Although common in rheumatoid arthritis, guttering deformity in leprosy is seldom seen and also difficult to explain. It can occur due to spasm of the intrinsic muscles and thus there may be a connection with intrinsic-plus deformity. However, hypermobility of joints, looseness of the dorsal apparatus and flexion contracture of MP joints also seem to play an important role in the pathogenesis of this deformity.

As in rheumatoid arthritis, there are three degrees of ulnar deviation. When mild the patient can actively reduce the deformity. When more severe the deformity can only be passively reduced. Lastly, the guttering is not passively reducible.

FIGURE 9-22 "Guttering" deformity of the fingers with marked ulnar deviation.

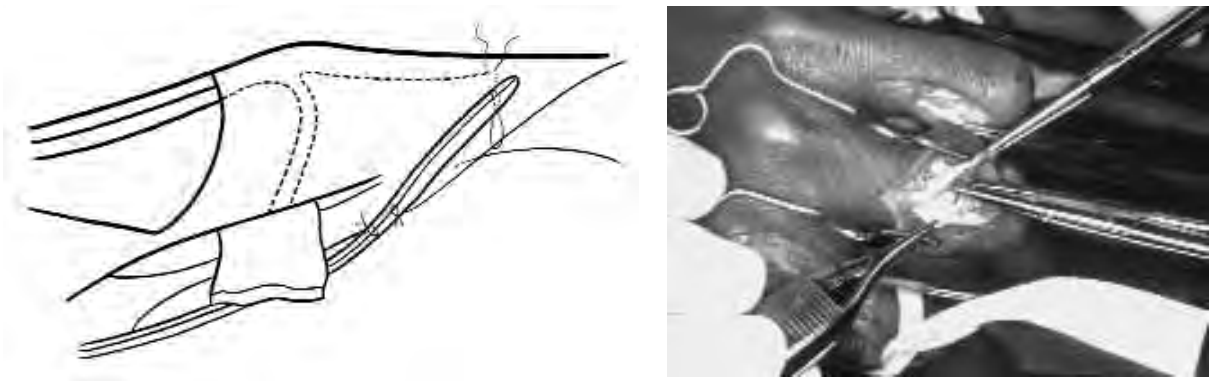

FIGURE 9-21 Lateral band dorsal fixation: Fritschi's technique. In selected cases this procedure should be carried out during a Bunnell's flexor to extensor tendon transfer for claw hand correction. **a.** Drawing of the basic procedure proposed by Fritschi. **b.** The intra-operative photograph shows the lateral band being taken by the needle that has been previously passed through the central slip of the extensor tendon (dorsal). While fixing the suture the lateral band is moved dorsally.

Guttering Repair

For mild guttering Boyes recommends a flap of the dorsal expansion aponeurosis at the ulnar side of the extensor tendon that is sutured to the same aponeurosis in the radial side.[4] This flap acts as a pulley that brings the extensor tendon back to its original position on the crest of the knuckle of the affected finger. This same procedure is advocated by Fritschi with a minor modification consisting of placing an individual longitudinal incision for each affected finger to prevent damage to the dorsal veins.[8] Milford proposes a different approach that is easy to perform and results are not disappointing for mild guttering (Fig. 9-23).[12]

Operative technique

Expose each affected extensor tendon through a single incision on the ulnar side of the MP joint of each finger and not a single transverse incision. After incision, expose the extensor tendon and the extensor hood at the knuckle. Make a short and longitudinal incision at the radial side of the extensor hood and a relaxing incision in the ulnar side of the hood. Place the extensor tendon in its normal position on the crest of the knuckle and suture the radial incision with fine separate sutures of nylon 6/0. If necessary, overlap the edges of the radial side incision to better position the central tendon. The incision on the ulnar side should not be sutured.

Suture the skin incisions and apply a mild compressive dressing. The hand should be immobilized in a plaster cast with mild extension of the metacarpophalangeal joints.

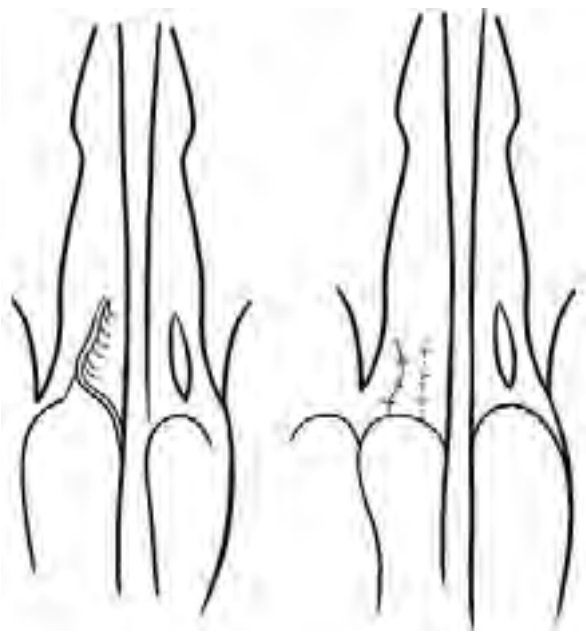

FIGURE 9-23 Technique for correction of mild guttering. (Left) An incision is made on the radial side of the hood and a small relaxing incision in the ulnar side. (Right) The relaxing incision permits repositioning of the extensor tendon. The radial side incision is then closed after its edges are overlapped.

Correction of muscular wasting in the first web

Atrophy of the first dorsal interosseous and adductor pollicis muscles is common following ulnar nerve paralysis resulting in a shallow aspect of the first web. In many countries this deformity is considered as one of the most stigmatizing signs of leprosy (Fig. 9-24).

Many techniques have been described to restore the bulky contour of the first web space to correct the cosmetic problem. Dermal grafts, silicon rubber and fat graft have been used with results ranging from good to disappointing. These techniques have their own advantages and disadvantages. Dermal grafts are problematic due to complications such as der-

FIGURE 9-24 Wasting of the first web is quite noticeable and recognized as a sign of leprosy.

mal cysts and the need for a reasonable amount of dermis to adequately fill the web space. Fat grafts are likely to lose up to one half of their original bulk. Recently, it has been suggested to use fat graft harvested by liposuction that is injected in the web pocket. There are no reported data on its results although the idea seems interesting. The use of carvable silicon rubber implants has been recommended and results are promising although the consistency of the implant is harder than the normal muscle.[6] The encapsulated silicone gel implants are more appropriate for procedures such as testicular implants.[18]

Silicone Implant Insertion

A special encapsulated silicone gel implant for the first web was designed by Dr. Adenaur M. Goes (unpublished data) from Brazil. The implant is commercially available in four sizes at an affordable price (Fig. 9-25).

Operative technique

Select the implant according to the size of the hand. Manufacturers provide a set of 4 samples for this purpose (7, 9, 11 and 13), #13 being the largest one. Implant # 9 is the most suitable for the average hand (manufacturer: SILIMED Inc.

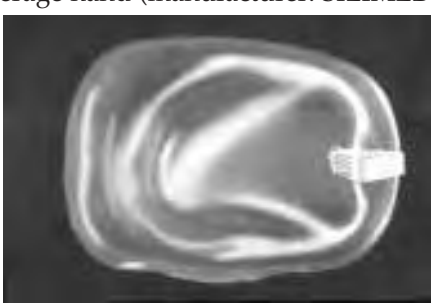

FIGURE 9-25 Encapsulated silicone gel implant.

Rua Figueiredo Rocha 374. Rio de Janeiro Brazil.

Use local anesthesia. It is advisable to infiltrate the superficial branch of the radial nerve distal to the wrist. The procedure does not require use of a tourniquet and, a bloodless field is not necessary nor desirable, since perfect hemostasis is mandatory before closing the incision.

Incise along the first web no longer than 4 cm following the interdigital line and close to the index finger (Fig 9-26).

Create a pocket through this incision by blunt dissection between the paralyzed fibers of the adductor pollicis and first dorsal interosseous muscles. The size of the pocket should be enough to receive the implant (Fig. 9-26 b). Proceed carefully while dissecting to prevent damage to vessel, particularly in the deep portion of the pocket and obtain hemostasis.

Rinse the implant and the pocket with saline. Introduce the implant deeply into the pocket. If necessary, introduce a guiding suture (nylon 3-0) from proximal to distal, pass the suture through the loop included in the implant and back to the proximal dorsal skin.

FIGURE 9-26 Silicone gel implant. A short incision is made in the first web along the line separating the dorsal and palmar skin. After careful tissue dissection between the fibres of the first dorsal interosseous and the adductor pollicis, the pocket is ready to receive the implant.

This is seldom necessary.

Close the fascia with 2 to 3 sutures of nylon 6/0 and then suture the skin with 3 or 4 separated fine nylon stitches.

Apply a bulky padded dressing or a plaster cast to immobilize the first web for 2 weeks. Allow free movement after that period.

The main advantages of the encapsulated gel implant are the muscle-like consistency and readiness of the implant. There is no need for shaping. In a 12 month follow-up in a group of 14 cases results are good and no complications have been reported.[6] Patient's satisfaction is high (Fig. 9-27 a,b and Fig. 9-28).

Conclusion

The techniques described in this chapter should serve as a complement to the other chapters on hand surgery in this book to give the reconstructive surgeon a broad range of skills to re-enable the paralyzed hand. With the dramatic reduction of prevalence of leprosy worldwide as a result of MDT implementation, the number of disabled patients appears to be reducing. Many of the procedures described in this chapter apply to patients with nerve injury who present late with established secondary deformities. In developing countries these types of patients will continue to be seen, especially among patients affected by leprosy. As such these surgical skills will be needed for years to come. Fortunately, most of the procedures discussed in this chapter are related to a very limited number of patients. Patients in need for these secondary techniques are those that could not have an early diagnosis, an adequate treatment, a careful follow-up and effective health education. Certainly we must be striving to prevent patients from developing such late severe disabilities. However when these patients present, surgeons should be prepared to cope with theses situations in order to assist patients in improving the functional condition of their hands, aiming to restore dignity and self-respect to their life. It is to this purpose that this chapter has been included, to assist even those with severely disabled hands to regain some of the independence they had lost through their hand deformity.

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FIGURE 9-28 Silicone gel implant. The left hand has not been operated. Compare with the right hand in which the implant was included.

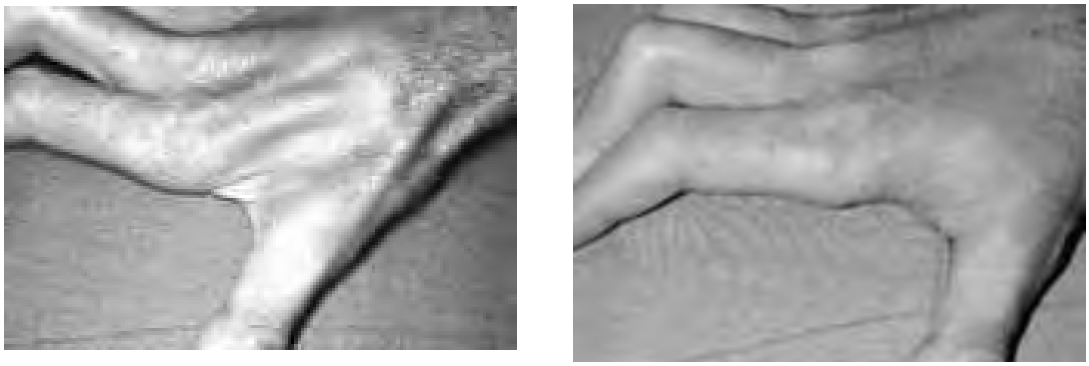

FIGURE 9.27 Silicone gel implant. **a.** preoperative view. **b.** postoperative view.

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