7

Median Nerve Palsy

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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.

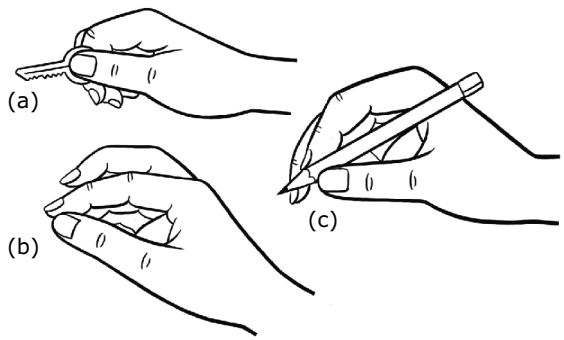

FIGURE 7-1 Three types of pinch (from Fritschi[14], used with permission.) **a.** Key Pinch, **b.** Two finger pulp-to-pulp pinch, **c.** Three finger pinch.

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]

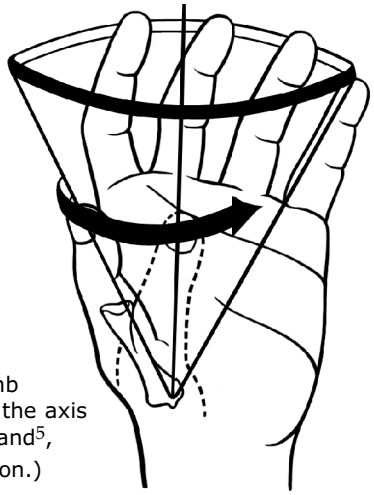

FIGURE 7-2 Thumb movement around the axis of a cone (from Brand[5], used with permission.)

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

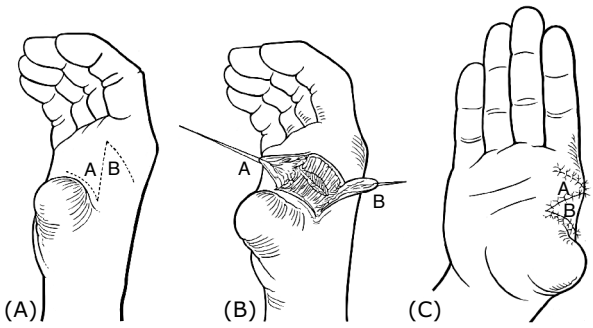

FIGURE 7-3 Simple Z-plasty (from Kleinman and Strickland[16], used with permission).

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).

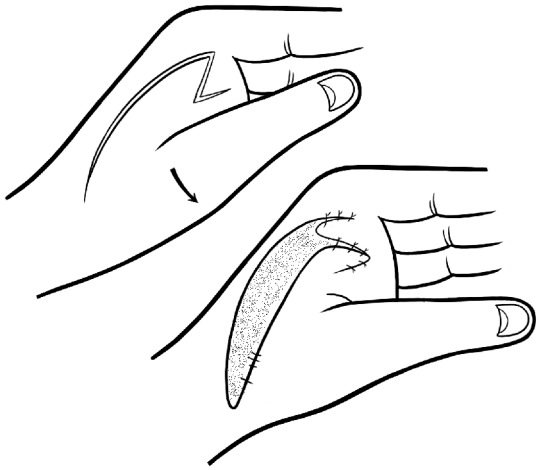

FIGURE 7-4 First webspace webplasty with full-thickness skin grafting (from Fritschi[14], used with permission).

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 sur-

FIGURE 7-5 Incisions for FDS opponensplasty.

face. 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:

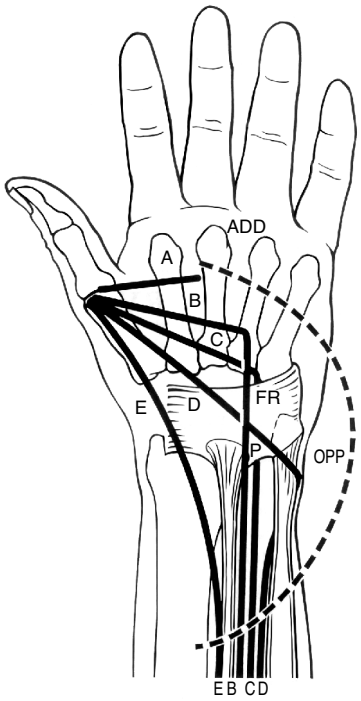

FIGURE 7-6 Potential routes of FDS opponensplasty. The arc of possibility is indicated by broken semicircle marked ADD (uction), ABD (uction) and OPP (osition). The most frequently used types of transfer are: **a.** Adductor replacement. Pulley is metacarpal two or three. **b.** Thompson route. Pulley 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

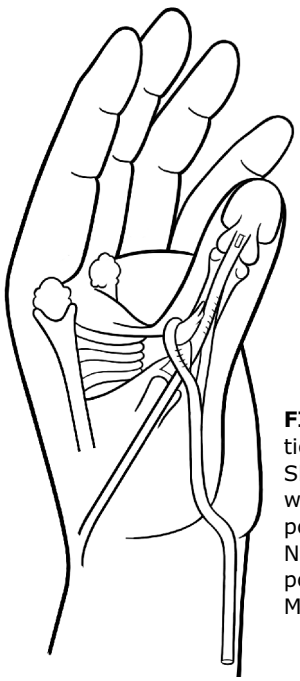

FIGURE 7-7 Double insertion of FDS opponensplasty. Shows recommended route with insertion into adductor pollicis insertion and EPL. Note how slip to adductor pollicis lies just distal to the MCP joint.

1 cm tension with the thumb in full opposition 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

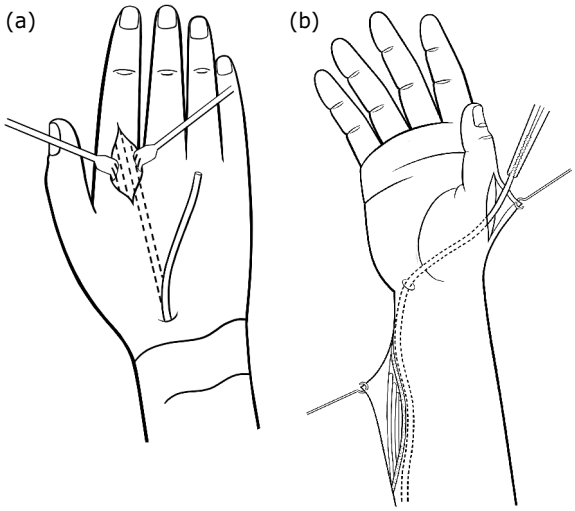

FIGURE 7-8 Extensor Indicis Proprius (EIP) transfer. **a.** Tendon is divided and delivered into a dorso-ulnar incision. **b.** Tendon is passed around ulnar side of wrist to an incision medial to the pisiform and then by a subcutaneous tunnel to the MCP joint.

in 30° flexion. In combined ulnar/median 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

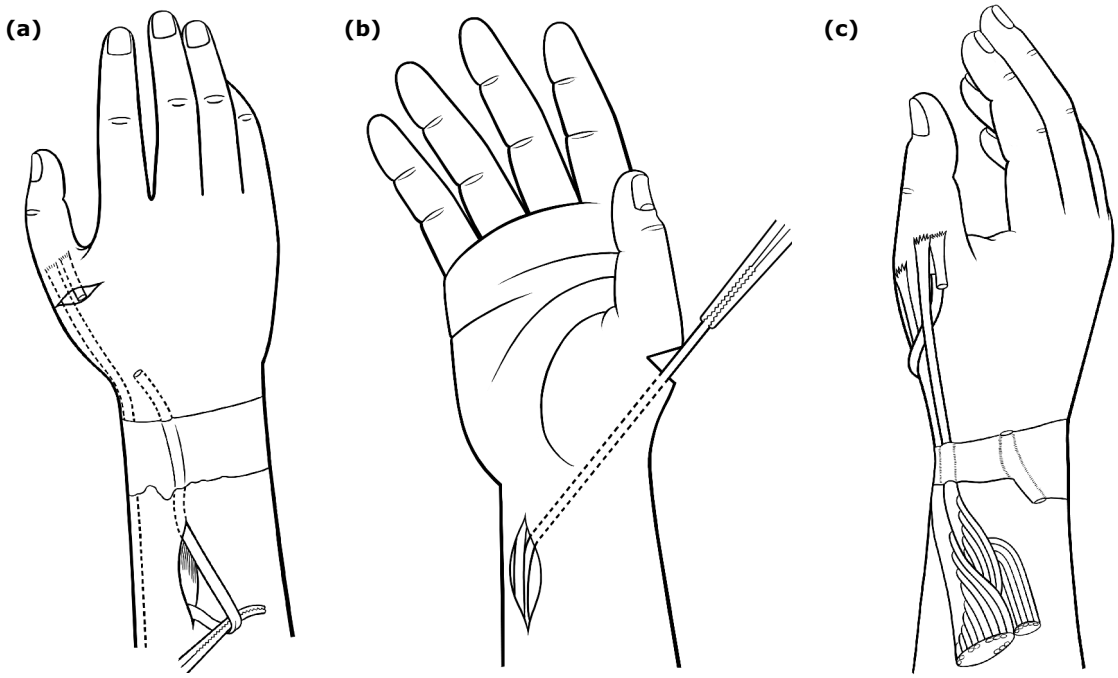

FIGURE 7-9 Extensor Pollicis Longus (EPL) re-routing. **a.**The tendon has been divided proximal to the MCP joint, and is being brought out on the dorsum of the wrist before being passed through the interosseous membrane. **b.** It is brought through just radial to the FCU and then tunneled in a subcutaneous 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.

(palmar-dorsal junction) back to the original 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,

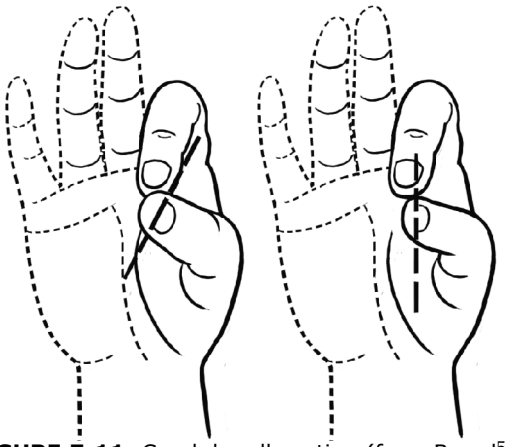

FIGURE 7-11 Crank handle action (from Brand[5], used with permission).

and possibly a carpometacarpal joint release. If 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 exces-

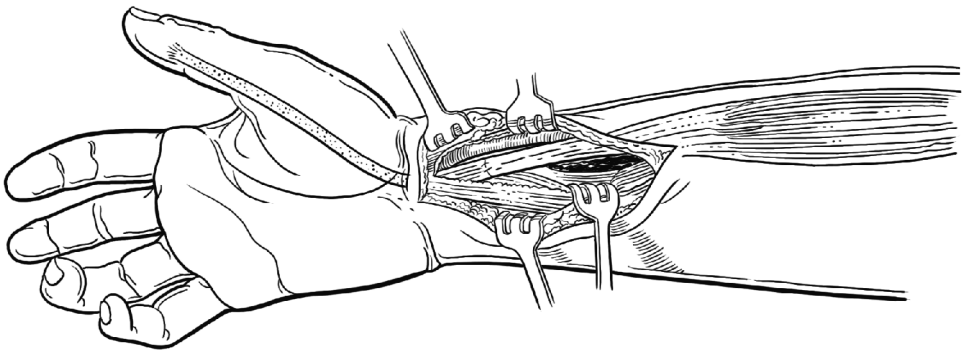

FIGURE 7-12 Brachioradialis to flexor pollicis longus transfer (from Davis and Barton,[11] used with permission).

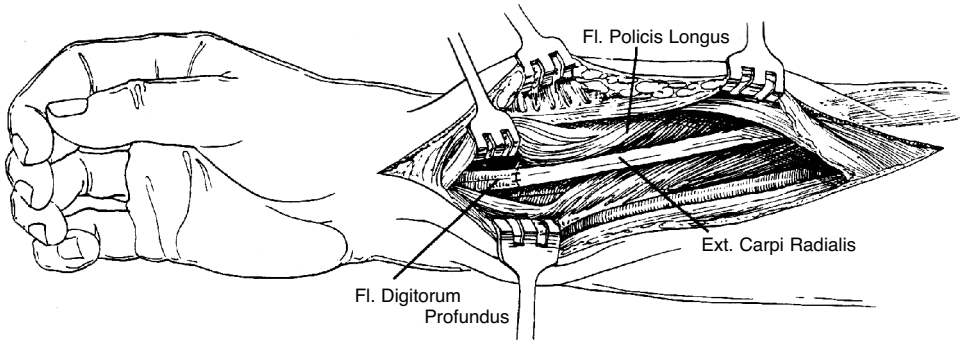

FIGURE 7-13 Extensor carpi radialis longus transfer to flexor digitorum profundi of long and index fingers (from Davis and Barton,[11] used with permission).

sive 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" 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.

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

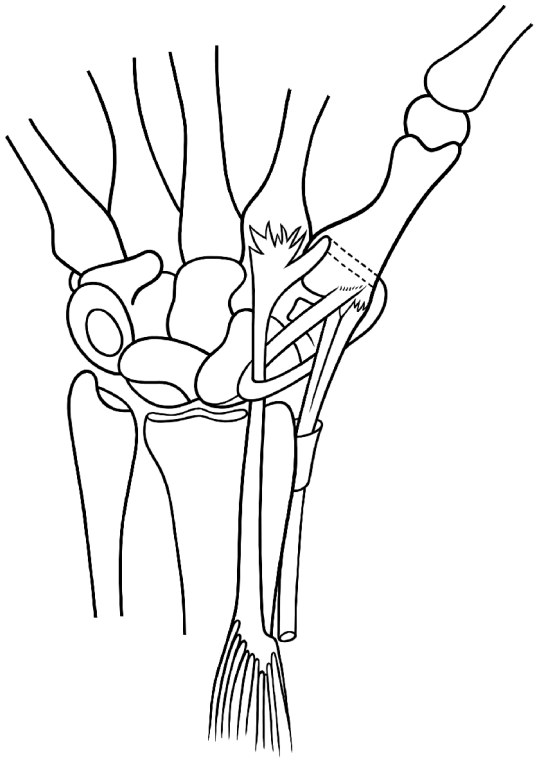

FIGURE 7-14 Reconstruction of thumb CMC joint using half flexor carpi radialis (FCR).

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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