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The Orthopaedic Department.

TENDON TRANSFERENCE FOR ULNAR AND COMBINED ULNAR-MEDIAN NERVE PARALYSIS

By

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The combined ulnar and median nerve paralysis usually results in the so-called *clawhand* (Fig. 1).

The etiology of this deformity includes various diseases of the nervous system as poliomyelitis, syringomyelia, Charcot-Marie-Tooth disease and in Eastern and African countries first and foremost *leprosy*. Also traumatic lesions play a role—overlooked or unsuccessful treated cases or cases in which surgical repair has been impossible due to the extension of the nerve-damage, lesions of the brachial plexus etc.

The purpose of this paper is to present the—mainly—primary results of various forms of tendon transference made on 31 clawhands in 28 consecutive cases of leprosy operated at the Scandinavian Teaching Hospital in Seoul, Korea.

ANATOMY AND FUNCTION

To understand the mechanism of the development of the clawhand and its treatment it is necessary briefly to mention some anatomical facts and functional considerations.

Fig. 2 shows how the lumbrical and volar interosseous muscles are placed *volar* to the axis of the metacarpophalangeal joint and inserted in the extensor expansion in such a way, that their action will be exerted *dorsal* to the axis of the interphalangeal joints.

Besides ab- and adduction of the fingers the intrinsic muscles are the prime flexors

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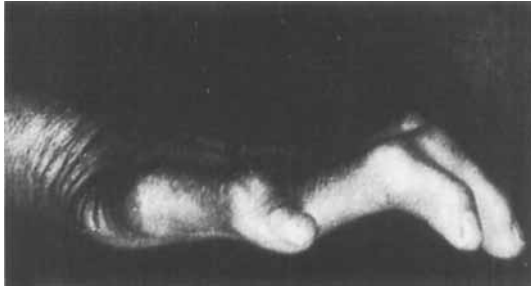


Fig. 1.
Clawhand due to leprosy.

of the metacarpophalangeal joints and—synergistically with the long fingerextensors—extensors of the interphalangeal joints.

If the metacarpophalangeal joints are stabilized in a position of 180 degrees or less, the long extensors or the intrinsics *alone* are able to extend the distal two phalanges (*Fowler's* concept of fingerextension). Normally this stabilization is produced by the intrinsics. In median-ulnar-nerve paralysis this function is lost and an attempt to open the hand fully will result in a more or less pronounced hyperextension of the metacarpophalangeal joints. Because of this hyperextension the long extensors of the fingers are unable to exert their power on the distal two phalanges. Deprived also of the extensor-function of the intrinsics the interphalangeal joints will remain in semiflexed position.

In grasping, the flexion of the fingers starts in the interphalangeal joints and only when these are flexed, is the flexion of the metacarpophalangeal joints carried out—resulting in a poor prehension.

The median-ulnar nerve paralysis does not always result in a claw-hand-deformity. In the cases in which the capsule of the metacarpophalangeal joint is tight or the interosseous muscles contracted, preventing hyperextension of this joint, the deformity will not occur. This is quite in accordance with *Fowler's* concept.

The *surgical correction* of the clawhand is mainly based on two different principles:

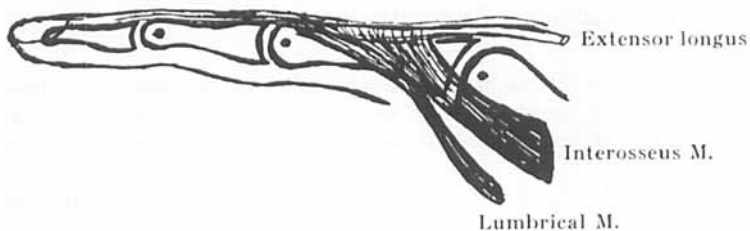


Fig. 2.

Schematic drawing of the relation of the intrinsics to the axis of the finger joints.

I. An attempt to restore the function of the intrinsic muscles by tendon transference.

II. Prevention of hyperextension of the metacarpophalangeal joints by stabilizing these in 180 degrees or less.

The logical treatment must be one which aims to restore the lost muscle function. Stabilization of the metacarpophalangeal joints may reproduce the finger extension, but not the action of the intrinsic muscles, the only muscles which directly flex these joints.

I. Restoration of the Function of the Intrinsic Muscles.

a) *Use of flexor sublimis as motor.* Originally the method was worked out by *S. Bunnell*: The sublimis-tendons are cut at their insertion on the base of the second phalanx, split in two strands and transferred palmar to the transverse metacarpal ligament to the extensor-aponeurosis on both sides of each finger. The intrinsic muscles' function as flexor of the metacarpophalangeal and extensor of the interphalangeal joints is usually well restored by this procedure, while the abduction and adduction of the finger does not seem to improve considerably (*Brand*, 1958). Later the method was modified somewhat (*Bunnell*, *Littler*, *Goldner*, *Brand* and others). In stead of transferring all the sublimis-tendons, one or two are used and only inserted in one side of the aponeurosis of each finger.

b) *Use of finger extensors:* (*S. Fowler*, quoted by *D. C. Riordan*) Extensor indicis proprius and extensor digiti quinti are split in two strands. These are passed through the interosseous spaces and inserted in the extensor aponeurosis. It has been claimed that the result of this operation is merely caused by a tenodesis stabilizing the first phalanx. However, there is no doubt that an active muscle-function is obtained—provided no tendon adhesion occurs (*Duparc*).

c) *Use of a wrist-extensor:* This method is described by *J. W. Littler* (1949) and in more detail by *P. W. Brand* (1958, 1961).

Prolongation of extensor carpi radialis longus or brevis with a free graft and transference through the interosseous spaces or round the radial side of the forearm through the carpal canal to the extensor aponeurosis.

II. Prevention of Hyperextension of the Metacarpophalangeal Joints.

Procedures of this type are based on the above-mentioned concept of *Fowler*.

a) *Bone-block*. A slab from the back of the knuckle is slid distalward as a bone block (arthrorhisis) (L. D. Howard, quoted by S. Bunnell).

b) *Tenodesis* (D. C. Riordan): A strand from the tendon of extensor carpi radialis longus and one from extensor carpi ulnaris, still attached to the base of the second and fifth metacarpal bone respectively, are split—each of them—in two, passed distalward through the interosseous spaces and sutured under tension to the extensor-aponeurosis.

c) *Capsuloplasty*—shortening of the volar capsule of the metacarpophalangeal joint (F. A. Zancolli, 1957). A simple surgical procedure in which a sort of “duplication” of the volar side of the capsule is made. Both Zancolli and P. Buorrel *et al.* (1961) and J. Gosset (1962) report satisfactory results using this method.

SURGICAL TECHNIC

The surgical procedures used in our material are:

1. One—split—sublimis tendon passed through the lumbrical canals. 13 cases.
2. Same procedure as above, but with the use of *two* tendons. 4 cases.
3. Transference of extensor carpi radialis brevis (prolonged with a free graft) through the interosseous spaces. 3 cases.
4. Same procedure as 3., but with transference of the extensor tendon and graft round the forearm and through the carpal canal. 11 cases.

The technic used in group 1 and 2 has already been mentioned. As a rule we have detached the 4th sublimis tendon unless special circumstances made the use of another tendon more convenient—as for instance a completely stiff or a partially amputated finger.

The tendon is sutured under moderate tension, the wrist kept in neutral position, the metacarpophalangeal joints flexed 70–80 degrees; the strand to the “donor-finger” is intentionally made a little more slack.

As the *transference* of a *wrist extensor* to the *volar side* of the forearm (Brand, 1961) is less known and as it seems to be a very useful procedure, the technic will be described in more detail:

The tendon of the extensor carpi radialis longus or brevis is cut through a small incision 3–4 cm proximal to its insertion—in the cases reported here, we used the radialis brevis, but later on we changed to extensor longus as we gained the impression that this resulted in lesser weakening of the dorsal flexion of the wrist. The tendon is withdrawn through another incision placed radially on the dorsal side of the fore-

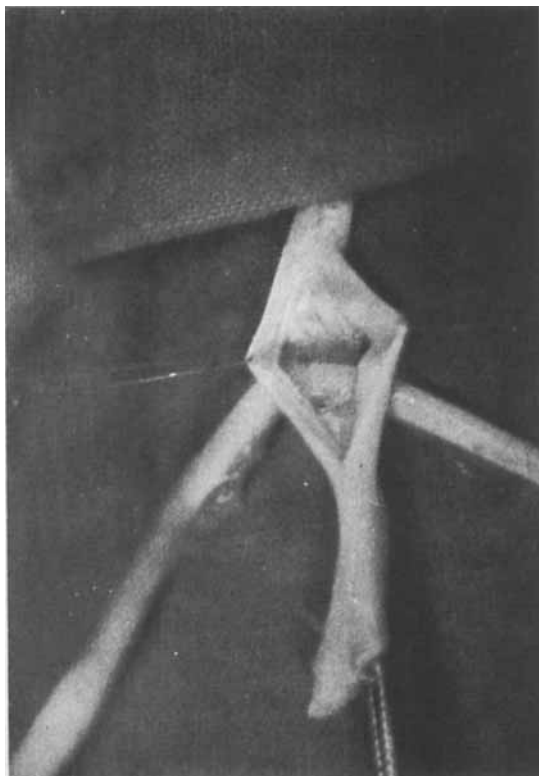


Fig. 3.

The tendon graft (m. plantaris) passed through two slits in the widened part of the extensor carpi radialis longus.

arm a little distal to the middle. A third incision is placed on the volar side of the forearm midway between the former incision and the wrist—opposite the tendons of palmaris longus and flexor carpi radialis. A tendon tunneller is pushed gently between these two tendons and beneath the brachioradialis muscle out through the incision on the dorsolateral side of the forearm. The released extensor tendon is grasped and pulled down to the volar side.

At this stage the anastomosis to the free graft is made. As the graft we used palmaris longus, a toe-extensor or the plantaris tendon.

A 1-1½ cm longitudinal incision is made a little proximal to the cut end of the extensor tendon and this is “opened” to about the double of its original width. The grafts are pulled through a small slit in the widened tendon and anchored by a few sutures on the “inside”—if the

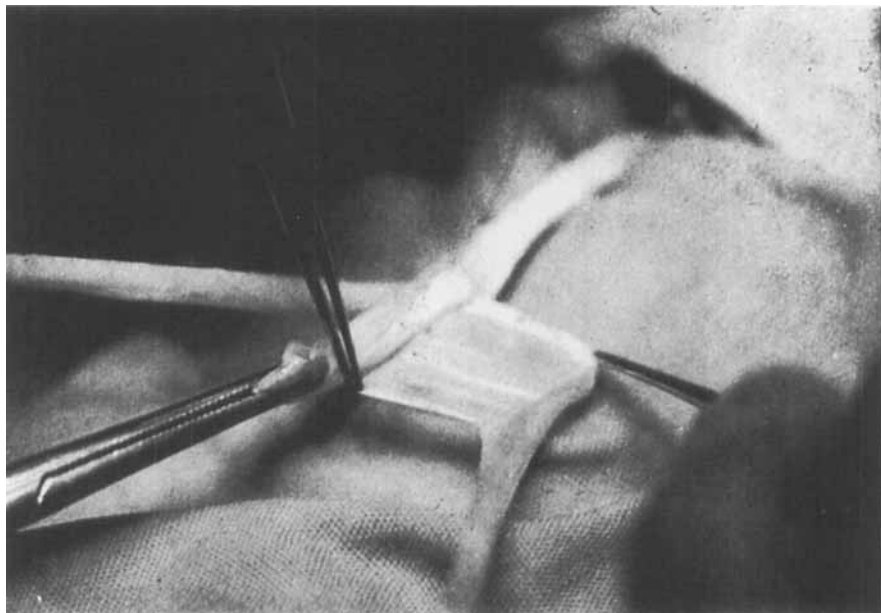
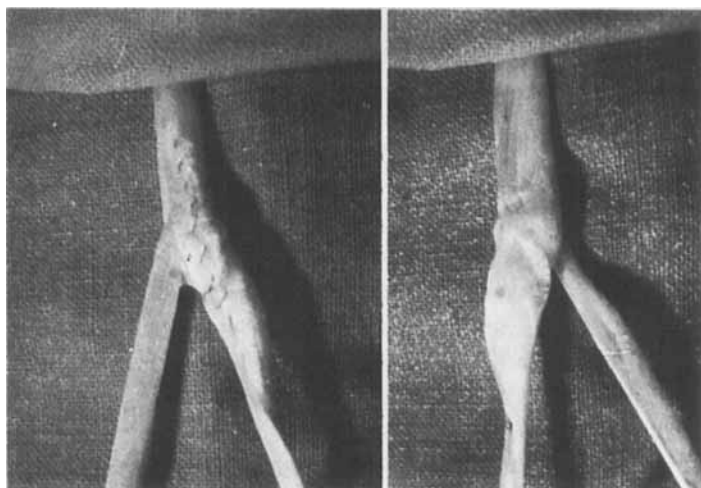


Fig. 4.
The tendon "veil".



a

b

Fig. 5.
The finished anastomosis.
a) From the "anterior" side.
b) From behind.

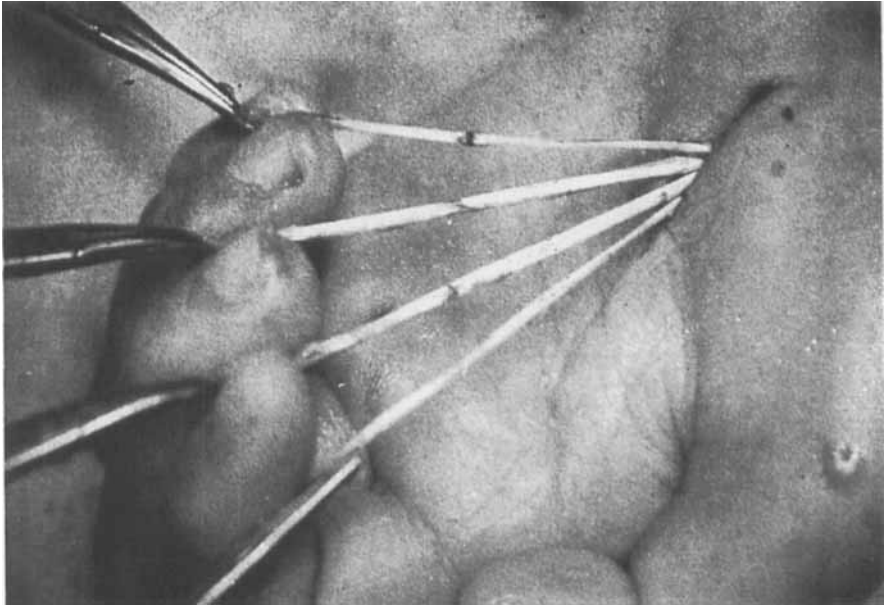


Fig. 6.

The four strands pulled through an incision right distal to the transverse capal ligament.

plantaris tendon is available, it is pulled out through another slit (Fig. 3) forming an up-side-down-U. The two edges of the "opened" tendon are sutured with running suture. The end of the tendon is cut obliquely to obtain a spindleshaped anastomosis. In order to cover the raw surface of the cut end, the proximal 2 cm of one of the grafts is transformed into a thin "veil" by a forced pull on each side of the tendon by mean of a fine surgical forceps (eye-forceps for instance). (Fig. 4). The running suture, started in the extensor tendon, is continued distally, closing the "veil" after this has been wrapped around the end of this tendon (Fig. 5).

The two grafts (or the two ends of the plantaris tendon in case this has been used) are passed distally beneath the transverse carpal ligament and through an incision corresponding to the crease between thenar and hypothenar. The grafts are split (Fig. 6) and passed palmar to the transverse intermetacarpal ligaments and inserted in the extensor-aponeurosis (Fig. 7).

In all our cases, whatever method was used, the insertion was made

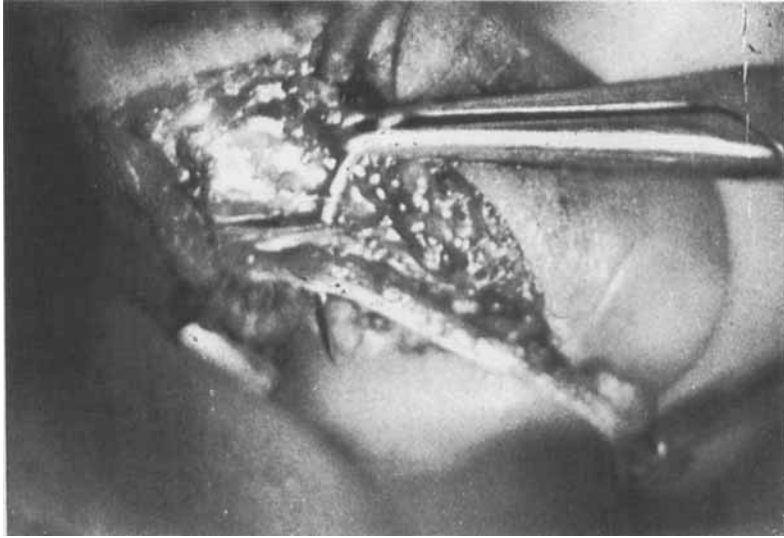


Fig. 7.

The tendon is sutured to the edge of the extensor expansion.

on the ulnar side of the index and the radial side of the other three fingers.

As far as the tension is concerned under which the tendons were sutured we used different principles, but ended up with the following: The tendons are sutured *without* tension, while the hand is kept with the wrist slightly and the metacarpophalangeal joints more flexed, so that the fingers form an angle about 90–100 degrees to the forearm.

It should be pointed out that if the anastomosed grafts are passed through the interosseous spaces instead of round the forearm, the wrist is placed in 45 degrees dorsiflexion and the metacarpophalangeal joints in 70 degrees flexion.

Postoperative immobilization in three weeks after which physical exercises are started—in the beginning with the interphalangeal joints fixed in extended position by means of some easily removable dorsal splints.

Our material consists of 31 hands in 28 patients with low ulnar or combined ulnar-median nerve palsy due to leprosy.

In 29 there was clawing of the four ulnar fingers, in 2 only the three ulnar fingers were involved.

The age of the patients varied from 11–46 years—except one, who

was 64! The average was $22\frac{1}{2}$ years. 9 were females, 19 males. The time of observation was from 1 to 10 months, average 3.8 months.

To evaluate the results we grouped the patients in four groups as follows:

1. *Excellent*: cases in which the fingers can be fully extended in both metacarpophalangeal and interphalangeal joints without or with negligible hyperextension of the metacarpophalangeal joints. Flexion is to 90 degrees in the metacarpophalangeal joints with the interphalangeal joints extended. Able to close fist fully. (We have not included systematically the examination for "hook-position" (Brand, 1961)—the ability to flex the interphalangeal joints without flexion of the metacarpophalangeal joints. An ability which is interfered with in case of "intrinsic overaction").

2. *Good*: residual extension defect (20–25 degrees) of the interphalangeal joints (a few cases in which the lumbrical function is restored within the limits of a structural extension defect are included in this group). The functional value is practically as in group 1.

3. *Fair*: the preoperative existing hyperextension of the metacarpophalangeal joints is only little improved. 30–40 degrees extension defect of the interphalangeal joints. In all cases some improvement of the grasping function.

4. *Poor*: a) unchanged. b) two or more fingers unchanged—even though the other operated fingers would belong to group 1 or 2. (This is an evaluation of technic rather than functional value.)

The results in accordance with this classification and their relation to the different surgical methods are demonstrated in Table 1.

Table 1

Result	Excel- lent	Good	Fair	Poor	Total
Method					
Transfer of sublimis	7	5	1	4	17
Wristextensor through interosseous spaces	2	1	0	0	3
Wristextensor through the carpal canal ...	5	4	2	0	11
Total	14	10	3	4	31

It should be mentioned that two of the cases belonging to group 1 were reoperations. About one month after the first operation (transference of a wrist extensor to the flexor side) it became evident that

the unsatisfactory result was due to adherences; reoperation with loosening of the adherences was done after which the function was excellent.

Analysis of the Failures.

7 cases—3 fair and 4 poor—must be regarded as failures. In four of these the operations were unsatisfactory from a technical point of view—they were combined with other operative procedures which moreover resulted in difficulties as regards the postoperative re-education. One case was infected, and for some unknown reason one did not receive any postoperative physical therapy. The seventh case was a rather uncooperative man who probably never should have been operated.

DISCUSSION

To secure a good result for the operation a meticulous preoperative muscle test is required—as in all kinds of tendon transference. The condition of the extensor expansion should be paid special attention. If an examination reveals that the degree of passive extension of the fingers exceeds the so-called assisted extension (active extension of the interphalangeal joints during external stabilisation of the metacarpophalangeal joints at 180 degrees or less—cf. *Fowler's* concept)—it indicates a defect in the extensor expansion. This must be repaired prior to any tendon transference or else the result will be disappointing.

To restore the function of the important first dorsal interosseous muscle the tendon to the index finger ought to be inserted on the radial and not as here on the ulnar side of the finger. However, it has been found (*Brand, Bourrel et al.*) that a single insertion on the radial side of the indexfinger may result in a tendency to radial deviation of this finger, whereas the index and third finger tend to stabilize each other in the pinch, when the tendons have been inserted on the ulnar and radial side of the two fingers.

The *tension* under which the tendons are sutured is of course of extreme importance. This problem has already been dealt with above. To secure "proper" tension *Brand* uses a metal splint on which the hand and fingers are placed (we found a small bowl of stainless steel—placed upside down—very convenient; Fig. 8). Even though this precaution is taken, it is our experience that there is a tendency to pull the last sutured strands more tightly than the first ones, resulting in an im-

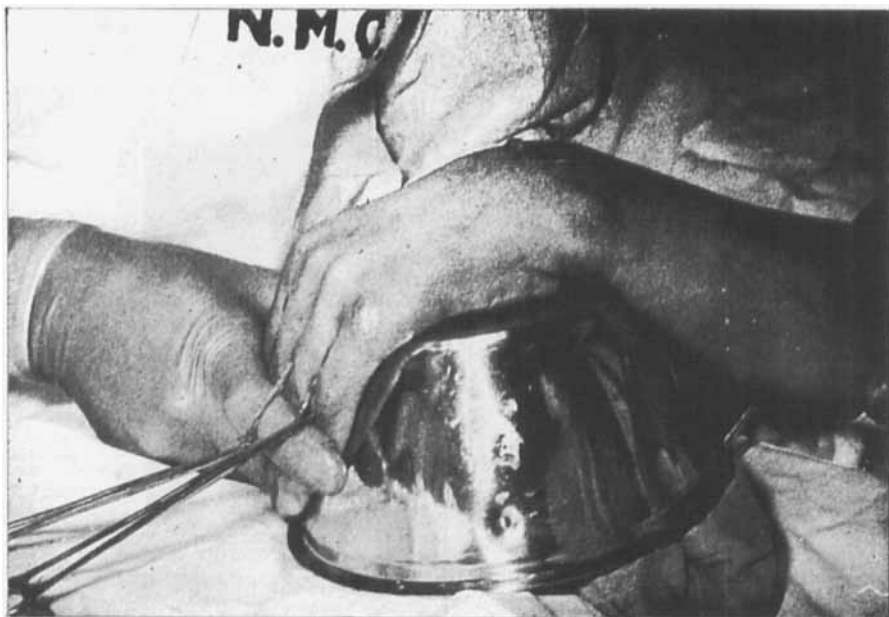


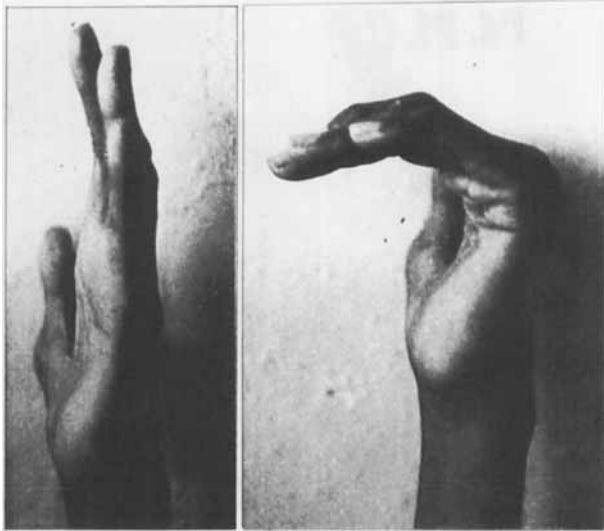
Fig. 8.

The hand placed in the correct position for insertion of the tendon grafts.

paired function of these. Therefore, the tension should be checked carefully by pulling the motor-tendon while observing the finger motion. If the strands are sutured from the ulnar to the radial side, a slight—overlooked—difference in tension will be less harmful because it will mainly concern the fifth finger.

A disadvantage of the original Bunnell-procedure is the tendency to develop the opposite deformity of the clawhand—the “pill-roller-hand”, an intrinsic-plus deformity. The cause is that a strong muscle is removed from the flexor side of the proximal interphalangeal joint and transferred to the extensor side of the same joint sometimes resulting in a hyperextension of this joint. The deformity, which can be rather disabling, does not develop in noticeable degree until 1–2 years have passed and may for this reason be overlooked. It is especially in fingers with very mobile joints that this deformity occurs.

As pointed out by *Bunnell* a flexion-contracture of the proximal interphalangeal joint can occur if a stump of the cut sublimis tendon is left behind in the tendon sheath. By attaching itself to the sheath proximal to the joint it will act as a sort of tenodesis. This complication should be avoided by detaching the tendon close to its insertion.

*Fig. 9.*

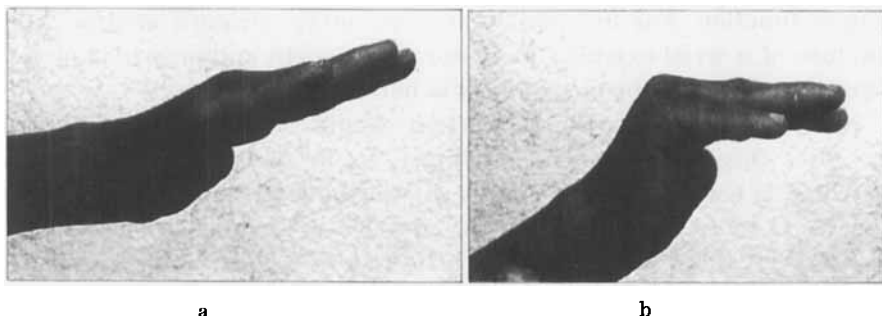
A clawhand 9 month after transference of the extensor carpi radialis brevis—prolongated by a free graft—through the interosseous spaces to the extensor expansion of the four ulnar fingers.

The objections to the method in which a wrist-extensor, prolonged by a graft split in four strands, is transferred through the interosseous spaces, are that the grafts are apt to adhere, so that the result will be merely a sort of tenodesis. Moreover, dorsiflexion of the wrist will result in a less powerful action of the transferred muscle. Another draw-back is that the postoperative re-education is somewhat more difficult in these cases compared with the Bunnell-operation. Only three of our cases belong to this group—and all of them are satisfactory with active function of the transferred muscle (Fig. 9).

In the cases in which the tendon is passed through the carpal canal a risk of crowding this may exist—so far we have not seen any signs of that. In this connection we should like to draw attention to the importance of not placing the anastomosis between the extensor tendon and the graft at such a level that it finally will be situated beneath the transverse carpal ligament.

A certain degree of weakening of the dorsiflexion of the wrist will occur by this method.

Lucien Cornet et al. (1962) report 20 cases in which the second and fourth sublimis are used to restore the intrinsics. At the same stage the third sublimis is transferred to the thumb for restoration of the opposi-

*Fig. 10.*

A clawhand 2 months after transference of the fourth sublimis tendon. Note a slight tendency to hyperextension of the proximal interphalangeal joint of the fourth finger (b).

tion. The primary results seem to be good. Nothing is mentioned about development of intrinsic plus deformity (it is not quite clear how long the observation-period has been). *Bourrel et al.* (1961) report 74 cases operated according to Bunnell's method using the sublimis tendons to the third and fifth finger. Among these patients 18 were submitted to opponens plasty—probably also using a sublimis tendon (the technic not mentioned). At the follow up "interphalangeal hyperextension" was met in 5 cases. Of the 74 cases 20 had a "pre-existing stiffness" of the fingers. In 30 cases nothing is mentioned. One patient had a radial paralysis. It must be supposed that at least the rest, 23 patients, had good mobility of the finger-joints preoperatively. It is most probable that the five cases with interphalangeal hyperextension (that is: intrinsic overaction!) may be found in this last group counting 23 patients—a rather high percentage.

So far we have not seen any cases of intrinsic plus deformity among our patients—but the time of observation is too short to state anything. However, we have noticed in a few cases of the "Bunnell-type"-operation, that the donor finger (Fig. 10) has a tendency to hyperextension in the proximal interphalangeal joint—we have anticipated this "complication" and, as mentioned, intentionally sutured the strand to the donor finger under a little less tension than the other fingers.

However, we feel that there is a definite risk for more disabling deformities in case two sublimis tendons have been detached from their insertion—maybe even a third one for opponens plasty! And—at least in hands with normal mobility of the finger joints—we would hesitate to use as many as three sublimis tendons for the reconstruction of the

finger function. For the same reason we prefer Brand's method with the use of a wrist-extensor as motor. The fourth sublimis tendon can then be used if an opponens plasty is necessary.

Some degree of intrinsic overaction should certainly be anticipated in other fingers than the donorfinger, as in the cases in which an extensor is used as motor—simply due to the fact that the transferred muscle is more powerful than the muscles it is supposed to replace.

However, there should be only little risk of a more pronounced deformity and impaired function, because the flexors of the proximal interphalangeal joint are preserved.

S U M M A R Y

The result of various forms of tendon transference for low ulnar and combined median-ulnar nerve paralysis due to leprosy is reported.

The material consists of 31 hands in 28 patients.

The different principles and surgical procedures are mentioned and Brand's technic is described in more detail.

With the disabling intrinsic plus-deformity in mind the authors will not recommend procedures—advocated by some—in which not less than three sublimis-tendons are detached from their insertion and used to restore the function of the intrinsics and the thumb. Except cases with rather stiff joints the method of choice should be one that uses a wrist-extensor, extensor radialis longus, as motor.

R E S U M E

Est rapporté le résultat de différentes formes de transferts de tendons dans la paralysie due à la lèpre du nerf ulnaire distal et des nerfs ulnaire et médian combinés.

Le matériel d'observation comporte 31 mains chez 28 malades.

Les différents principes de la procédure chirurgicale sont mentionnés et la technique de Brand est décrite plus en détail.

En pensant à l'incapacité intrinsèque s'ajoutant à la déformité, les auteurs ne veulent pas recommander des procédures — défendues par certains — par lesquelles pas moins de trois tendons superficiels sont détachés de leurs insertions et utilisés pour restaurer la fonction des muscles intrinsèques et du pouce. Excepté dans les cas où les articulations sont assez rigides, la méthode de choix doit être celle qui utilise comme moteur un extenseur du poignet, l'extenseur radial long.

ZUSAMMENFASSUNG

Über das Ergebnis von verschiedenen Formen der Sehnenüberpflanzung bei distaler Ulnaris- und kombinierter N. medianus-ulnaris Lähmung wegen Lepraerkrankung wird berichtet.

Das Material besteht aus 31 Händen von insgesamt 28 Patienten.

Die verschiedenen Behandlungsprinzipien und chirurgischen Methoden werden erwähnt und die Technik von Brand wird eingehender beschrieben.

Unter Beziehungsnahme auf die invalidisierende "intrinsic-plus Deformität" empfiehlt der Verfasser nicht ein Vorgehen, das von einigen verteidigt wird, bei dem nicht weniger als drei Sublimissehnen von ihrer Insertion gelöst und zur Wiederherstellung der Funktion der kleinen Handmuskeln und des Daumens benützt werden. Mit Ausnahme von Fällen mit ziemlich steifen Gelenken, sollte die Methode der Wahl in der Verwendung eines Handgelenksstreckers, extensor carpi radialis longus, als Kraftspender bestehen.

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