FROM THE ORTHOPEDIC CLINIC, GOTHENBURG, SWEDEN
HEAD: ERIK SEVERIN, M.D.

REPAIR OF FAILING OPPOSITION OF THE THUMB

By

LENNART SÖDERBERG

INTRODUCTION

The thumb's ability to oppose the fingers of the hand is a complicated function made possible by the advantage taken of the united mobility of several joints and the composite action of several muscles. The opposition is chiefly the result of two types of movements: angulatory motion and rotary motion. If we watch our own thumbs performing opposition we will see that the top of the thumb describes a circular arc of about 120°, i.e. the sum of the angulatory motion. The thumb then rotates at the same time about 90°, this we can ascertain through observation of the plane of the thumb nail. These combined movements take place in the radioscaphoid, intercarpal, carpometacarpal and metacarpophalangeal joints. In the metacarpophalangeal joint the thumb itself carries out two further types of motion; during the first half of the movement in opposition there occurs solely in this joint a radial adduction and during its second half, a flexion movement. The muscles which carry out the opposition are, above all, the opponens and abductor poll. brev., both innervated by the median nerve; these are also assisted by the adductor poll. and the abductor poll. long. innervated by branches from the ulnar nerve and the radial nerve, respectively. Furthermore, in the radial adduction and rotation of the proximal phalanx the flexor poll. brev. plays its part; this is innervated by both the median nerve and a branch from the ulnar nerve. As already pointed out, however, the opponens and the abductor poll. brev., innervated by the median, above all produce the motion; without their aid no opposition can normally arise.

Inability or imperfect ability to oppose the thumb entails a considerable reduction in the functional fitness of the hand. The weakening of the grip between thumb-indexfinger and -middle finger, the most valuable accomplishment of the hand, should first be mentioned.

Further the ability to grip objects firmly in the more or less clenched hand is diminished. When the hand is clenched the functionally fit thumb lies across the second and third finger and thus makes an additional contribution to the strength in the flexors of both these fingers. It is not only the power of the musculature performing the opposition motion which helps towards this. The most important point is that the flexors of the thumb can be effectively employed to contribute to a firm hand-grip only if its ability to oppose is retained. Finally, the thumb functions, too, when the hand is clenched, as a stabiliser for the wrist; if the thumb cannot leave the radial side of index finger by means of opposition motion the wrist loses part of its stability.

Loss of opposition most commonly results from loss of nerve function to the muscles of the thenar. It is especially prevalent in poliomyelitis and trauma of the median nerve or its branch.

Methods of Restoring Opposition.

The problem of restoring failing opposition of the thumb conditioned by neurogenic factors, has been attacked in several different ways.

If the inability depends on a fresh trauma of the median nerve, primary suturing must first of all be carried out. Likewise attempts should be made at secondary suturing of the nerve in older cases, where there is reason to suppose that such an operation can restore the interrupted nerve transmission. It is important to wait a sufficiently long period of time after the operation, dependent on the level at which the nerve injury is situated, before a possible bad result is judged as certain. If the nerve lesion is placed, for example, just above the wrist joint, a usual localisation in suicide attempts by slashing, the surgeon should wait up to two years after the nerve suturing before a final prognosis is made. If, after this period, opposition motion has not returned, a reconstruction operation should be carried out. In nerve lesions in the palm of the hand conditions are more favourable. The nerves often recover exceptionally well here, owing to two factors. One is that here the nerves are not longer mixed but belong either to the purely motor or the purely sensory type. The second factor is that the nerve system's power of recovery itself increases the more one approches the periphery. After suturing the nerve at the base of the thenar, *Bunnel* has reported that an average period of one year is required ta restore opposition.

Nevertheless, if the nerve transmission to the thenar muculature

turns to be beyond repair, whether the lost function is the result of trauma or poliomyelitis, there are two fundamentally different procedures to choose between, i.e. an *arthrodesis operation* or a *tenoplasty for opposition.*

Naturally, the aim is to obtain mobile opposition of the thumb. If, however, the conditions necessary for this are not present it is of

Fig. 1.
Roentgenogram of hand with bone graft between metacarpals I and II.

value nevertheless if the thumb is suitably placed in opposition, even though it may be fixed. This of course presupposes that the other four fingers have some activity. *Fixed opposition* is secured through arthrodesis of the thumb's carpometacarpal joint or by a flat bone graft fitted into slots in metacarpals I and II.

If it is possible to perform a tenoplasty for opposition the following conditions are generally regarded as underlying a successful result: The muscle of the forearm choosen for the plasty must have complete function and preferably be used on its own for its new purpose. The joints where the movements are performed ought to have full passive mobility. Finally, no other function of the hand should be seriously affected through the operation. Therefore a muscle should be employed whose diversion from its normal function does not import that a loss of or considerable reduction in the latter is the result.

Different methods of tenoplasty in paralyses of the opponens muscles have been reported by numerous authors.

Amongst Swedish orthopedic surgeons *Camitz* and *Silfverskiöld* have recommended the following procedure: *Camitz* inserted the palmaris longus tendon together with part of the aponeurosis palmaris on the radial side of the thumb's metacarpophalangeal joint. *Silfverskiöld* transplanted the greater part of the thumb's flexor tendon around the radial aspect of the thumb and attached this dorsally at the base of the interphalangeal joint.

Most of the other authors have employed one of the hand's remaining flexor tendons which are inserted at different places on metacarpal I or on the proximal phalanx. The course of the tendon where it runs underneath the transverse carpal ligament is preserved.

The methods of tendon transplantation mentioned certainly are valuable aids in improving the hand's function when opponens paralysis is present, but in spite of this, what should really be striven for does not arise: a true opposition motion of the thumb. This is due to the fact that the consequense of all these operative procedures is that the tendon used pulls in an incorrect direction. The thumb's contact with the finger-tips is indeed made possible by means of the adduction of the thumb across the palm combined with a more or less incomplete rotation, but this is not true opposition between the fingers.

Bunnell says: "The thumb to be in true opposition must not only be opposite to the fingers and far forward from them, but it must also be by rotation diametrically opposite them–that is, with the pulp of the thumb facing that of the fingers and with the thumbnail parallel to the palp of volar surface of the fingers. Also, in the motion of flexion and extension, the thumb and the opposing digit should move in exactiv opposite directions to each other.

Merely placing the thumb into apposition–that is, in contact with the fingers–or drawing it into the palm, is not opposition, nor is it when the thumb fails to rotate and its nail is still at a right angle to the palm."

In order to be able to speak about true opposition, therefore *the thumb must be able to move away from and forward over the palm at the same time as it rotates.* These conditions are fulfilled completely when two essential principles are taken into consideration, stated by *Bunnell* as follows:

I.The tendon employed must pass from its insertion on the thumb towards the pisiform bone so that it pulls the thumb in the right direction.

II. The tendon's points of insertion on th thumb must be on the dorso-ulnar side of the proximal phalanx just distally to the metacarpophalangeal joints. Through this the rotary component is restored.

The importance of the tendon's pulling in the right direction is very well illustrated by a case which was operated on here for paralysis of the m. opponens, brought about through a cut on the wrist. The case is not included in the series reported below. Owing to the scar tissue present at the wrist joint, the tendon (tend. sublimis dig. IV) was not taken towards the pisiform bone but was directly led subcutaneously from the canalis carp. transvers. to its point of insertion. The present status is that the tendon lies, with the thumb in position of abduction, on the ulnar side of, and distally of, the base of the head of metacarpal I. When the patient tries to carry out an opposition motion of the thumb, a quite correct opposition movement occurs at first, but is abruptly broken off by the "dislocation" of the tendon above the same section of bone in a radial direction. The tendon no longer pulls now in the correct direction and the continued opposition motion fails. If the examiner, however, retains the tendon in its original position, using one finger, an almost correctly performed opposition motion is carried through up to the finger-tip of dig. IV. It is planned to re-operate on this patient in order to construct a correct pulley.

There are of course several choises available in the matter of selecting the tendon and pulley; each hand is a problem in itself and the operation must therefore be adjusted to each one. The most important point is that a fully functioning muscle should be used, otherwise the result is very often a disappointment.

In all cases in the author's series the musc. sublimis to dig. IV was used as a motor and its tendon was pulled round the tend. flex. carpi ulnaris which was thus used as pulley. The tendon was inserted on the dorsal surface of the thumb's first phalanx on the radial or ulnar side of the tendon of extension. A more detailed account of the operative technique is given later in the article.

MATERIAL

The series, which include all cases operated on since 1947, is made up of 16 hands; 8 male and 7 female from 11–46 years of age. Thus in one case both hands were operated on. A closer account of the age distribution would probably be without interest in operations on this type of case. In 12 cases the etiology was poliomyelitis. The approximate time which passed in the poliomyelitis cases between the acute stage of illness and the actual operation will appear from the following table. (Table 1).

In one case out of the remaining 4 cases the opposition insufficiency was of traumatic origin. This caused an injury to the median nerve at the wrist which was sutured primarily at the local hospital but still resulted in opponens paralysis. Our tenoplasty was performed on the opponens muscle 2 years after the accident. The second case was a

TABLE I

Time between early stage of illness and operation	No. of cases
13 mths	2
20 mths	1
2–3 years	4
>5 years	5

man aged 21 suffering from a progressive neural atrophy of the muscle (Charcot-Marie) which began when he was 10 years old. The third case was a chronic alcoholist who had drunk benzine 16 months beforet the operation. The results were pareses on the arms and legs together with paralysis of the opponens. The fourth and final case was a girl aged 17, who had an increasing atrophy of the thenar on her right hand. At the time of the surgical intervention the thumb was completely paralysed. In this case the etiology could not be discovered.

I have set down the periods of time between the early illness of the patients and the time of the operation with a definitiv purpose in mind. Particularly in poliomyelitis cases the possibility exists that, if the tenoplasty is performed at an early stage of the disease, the end result can be bettered owing to the circumstances that the injured nerve transmission again begins to function after the operation, and that the thenar musculature is thus able to perform the opposition motion once more, without the aid of the tenoplasty. With regard to the two cases operated on as early as 13 months after falling ill it must, therefore, be pointed out that paralysis was present at operation in spite of adequate treatment during the intervening period. On re-examination carried out 2½ years after operation in both cases the thenar musculature was still atrophied and incapable to functioning.

RESULTS

This re-examination was made in May 1951. 15 patients were personally examined by the author. Two were not able to come but by following records from earlier check-ups it is considered nevertheless that the results can be reliably assessed.

The period which elapsed between operation and follow-up was in one case, 3 months, in two, 6 months, and in the others, more than a year. The observation period of 3 months may perhaps seem short but it has been very well proved that the result can be reliable assessed after this time, as far as operations of just this particular type are

concerned. If any possible change occurs later then it is in such a case one for the better.

In 9 cases the result was *excellent*. The requirements stated for a true opposition motion were completely satisfied in all these cases. In one case (the benzine poisoned man with a history of 16 months illness) the thenar musculature was obviously restored and could presumably carry out opposition even without the help of the transplanted tendon. But complete functioning of the tenoplasty could also be confined by palpating the sublimis tendon which stretched on movement. This justifies the inclusion of the case in this group.

Three cases were judged as *good*. Considerable improvement was secured–angulating and rotation of the thumb–but yet not to such an extent that, with the thumb at extension in the interphalangeal joints, contact with the finger-tips of dig. IV and V could be obtained. But nevertheless good contact with the finger-tips of dig. II + III was reached. When the motor used had possessed full function the somewhat incomplete opposition motion seems to be due to the fact that the stretching of muscle and tendon at operation was not made correctly; the tendon was adjusted at too great a length.

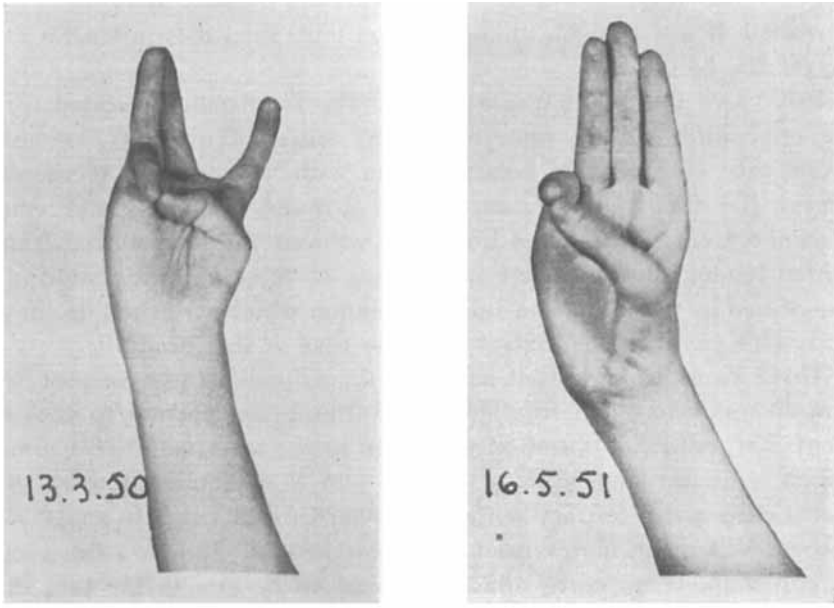
Finally, in 4 cases the result was *bad*. The angulatory and rotary motion of the thumb were very incomplete or failing. In these cases, all poliomyelitis cases, the reason for this seems to be that the functional capacity of the muscle used was obviously too kindly judged before the operation; the surgeon, however, was willing to make an attempt in the hope of improving the status of the hand. At examination all these cases proved to retain more or less pronounced pareses of the fingers flexors dig. II–V. It is now intended to perform arthrodesis operations by bone grafting on these patients.

In 3 out of all the cases a flexion contracture had occurred in the first interphalangeal joints of the fourth finger but not rising above 30° at the most. The mobility and strength of the finger were otherwise good.

RECOMMENDED METHOD OF TENOPLASTY IN PARALYSIS OF THE OPPONENS

Guided by the experience obtained in observing and re-examining this series I should like to suggest the employment of the following procedure in operative treatment of opponens paralysis:

Only a muscle with perfect function should be used as motor. If you transplant m. sublimis dig. IV, you must first convince yourself that the profundus musculature to the same finger is strong. No dis-



A. B.

Fig. 2.
Photographs of hand with paralysis of opponens taken before and after the operation. Notice the clearly visible course of the transplanted tendon over the thenar region!

advantage worthy of mentioning exists when the functioning of the sublimis is directed from the finger, provided that the functioning of the profundus is satisfactory.

Operative technique:

The intervention is made under general narcosis (alternatively plexus-brachialis anaesthesia) and in a bloodless field.

A longitudinal incision is made on the volar surface of the forearm. The flexor sublimis muscle to dig. IV is then identified. An incision is made on one side of dig IV on a level with the first interphalangeal joint. The sublimis tendon is divided barely 1 cm. proximally to the first interphalangeal joint and the distal end is sutured over the joint with the finger in position of extension. The sublimis tendon is brought forward in the operative field above the wrist. From the region of the pisiform bone a tunnel is made subcutaneously up to the base af the thumb's first phalanx where an incision is made on the dorso-radial side and a cavity is drilled in the bone for the tendon's insertion. Then the sublimis tendon is transposed under and around the tend. flex. carpi ulnaris, which thus serves as pulley, and is drawn

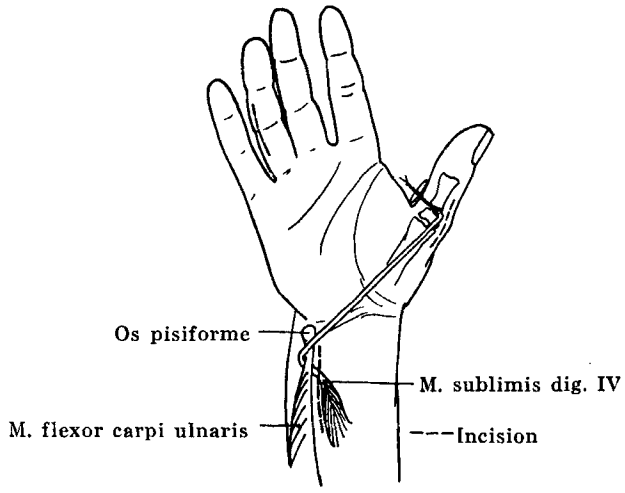


Fig. 3.
Diagram demonstrating the tenoplasty.

through the tunnel to the first phalanx of the thumb, where it is put into the bone cavity and is made firm with pullout-wire.

Kivilaakso (1949) described in this paper an operation which he names *Langenskiöld*'s method. In this the tendon of flexor digitorum sublimis to the ring finger is passed through an incision in the transverse carpal ligament and then subcutaneously across the thenar eminence to be inserted in the periosteum of the dorso-ulnar side of the end of the first metacarpal. The series comprised 18 cases; the end-result was good in 12, satisfactory in 4 and poor in 2.

The following details of the operation deserve particular attention. The tenodesis at the interphalangeal joint of the 4th finger is intended to prevent the later arisal of a hyper-extension position. The surgeon must be careful that the tendon slip used for the tenodesis is not made longer than stated above, for in such a case the risk of a later flexion position is incurred instead, owing to the tendency of the tendon tissue towards contraction (this happened in 3 cases). It is very important, as in all operations of this nature, that the transplanted tendon is correctly adjusted in length, in other words, that the stretching of muscle and tendon is most suited to the function which it is desired to obtain. In the actual case it is best to adjust the length of the tendon so that the thumb secures an angulatory position of about 90°. At the same time care must be taken that the wrist is maintained in position of function when the tendon is fixed with the thumb in this angulatory position. If the wrist is held instead, for example, volary flexed during

this the tendon will be too short. Then difficulty may arise later in trying to bring out the thumb parallel with the palm of the hand when the wrist is in postion of function. At the end of the operation, when the fingers and wrist joint are held in the latter position the top of the thumb ought to point between the finger-tips of dig. II and dig. III.

Bunnell states that the tendon should be inserted on the dorsoulnar side in order to restore the rotary component of the thumb. In our operations the tendon was inserted in 10 cases on the dorso-ulnar side and in the other 6 on the dorso-radial side. No difference between the performance of the rotary movement was noticed upon comparison of the cases where the tendon was inserted on the dorso-ulnar side and the dorso-radial side. On the contrary one would imagine that the drawback of the insertion of the tendon on the dorso-ulnar side might be that the sublimis tendon then comes into contact with the thumb's tendon of extension and in this way might have en injurious effect on the functioning of the latter. But this has not proved to be so, either. Since the rotation of the thumb remains just as good whether the tendon is inserted on the dorso-ulnar side or on the dorso-radial side and since the latter procedure is rather simpler perhaps, it seems to me that this point of insertion is to be preferred.

As far as the fixation of the fingers after operation is concerned, a plaster bandage is not necessary but the fingers and wrist may be fixed in position of function by using a firm bandage. This fixation is maintained for a period of 4–5 weeks and then even the pull-out-wire is removed and physiotherapy is commenced.

SUMMARY

The author gives an account of the motion of the thumb, above all, its capacity for opposition and of what the loss of opposition means to the functioning of the hand. Different surgical methods in the treatment of paralysis of the opponens muscle are discussed.

The author then describes a method of tenoplasty which was employed at the Orthopedic Clinic at Gothenburg in 16 cases of opponens paralysis. The plasty is performed according to principles stated by *Bunnell*. The method is such that the sublimis tendon to dig. IV is transposed round the tend. flex. carpi ulnaris to act as a pulley and is dorsally inserted on the first phalanx of the thumb. The thumb remains fixed for 4–5 weeks after operation and then physiotheraphy is commenced.

The result was *excellent* in 9 cases, *good* in 3 and *bad* in 4 cases.

In these cases where complete function was not attained, either the muscle employed dit not possess full strength or the tendon was inserted with insufficient stretch.

RESUME

L'auteur étudie le mouvement du pouce qui est capable d'opposition, et le préjudice porté à la fonction de la main par la perte de celle-ci. Différentes méthodes de traitement de la paralysie de l'opposant du pouce sont discutées.

L'auteur décrit ensuite une méthode de transplantation de tendon qui a été appliquée par l'Hôspital Orthopédique de Gothembourg dans 16 cas de paralysie de l'opposant du pouce. Cette méthode consiste à transposer le tendon sublimis du dig. IV autour du tendon fléchisseur carpien ulnaire qui agit comme une poulie et est inséré dorsalement sur la première phalange du pouce. Le pouce reste fixé 4 à 5 semaines après l' opération, après quoi commence la physiothérapie.

Le résultat a été excellent dans 9 cas, bon dans 3 et mauvais dans 4 cas. Dans les cas où la fonction complète n'a pas été recouvrée, ou bien le muscle utilisé ne possédait pas son entière force ou bien le tendon avait été inséré sans être suffisamment tendu.

ZUSAMMENFASSUNG

Der Verfasser gibt eine Darstellung der Bewegung des Daumens, seiner Oppositionsfähigkeit und der Bedeutung des Verlustes der Opposition für die Funktion der Hand. Die verschiedenen Methoden der Behandlung der Lähmung des m. opponens werden besprochen.

Der Verfasser beschreibt dann eine Methode der Sehnenverplanzung, die an der orthopädischen Klinik in Gothenburg in 16 Fällen von Opponens-Lähmung angewendet wurde. Die Methode gestaltet sich derartig, dass die Sublimissehne des 4. Fingers um die Sehne des flexor carpi ulnaris, die als eine Rolle wirkt, geschlungen und dorsal an der ersten Phalanx des Daumens befestigt wird. Der Daumen wird für 4–5 Wochen nach der Operation fixiert und hiernach wird mit der physikalischen Behandlung begonnen.

Das Ergebnis war ausgezeichnet in 9 Fällen, gut in 3 Fällen und schlecht in 4 Fällen. In den Fällen, in welchen vollständige Funktion nicht erzielt wurde, besass der angewandete Muskel nicht volle Normalstärke oder aber die Sehne war unter ungenügender Spannung befestigt worden.

REFERENCES

Bunnell, S.: Surgery of the Hand.

Camitz, H.: Über die Behandlung der Oppositionslähmung. Acta Chir. Scandinav. 65:77, 1929.

Kivilaakso, R.: On the Treatment of Opposition Paralysis of the Thumb. Acta Orthop. Scandinav. 18:421, 1949.

Silfverskiöld, N.: Sehnentransplantationsmethode bei Lähmung der Oppositionsfähigkeit des Daumens. Acta Chir. Scandinav. 64:296, 1928.