



IFSSH Scientific Committee on Tendon Transfers

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Opposition Tendon Transfers

Part II: Commonly Performed Tendon Transfers

Part I of this article discussed the anatomy and physiology of thumb opposition. Part II will discuss tendon transfers to restore this important thumb function. Rather than discuss every opposition tendon transfer since many are only of historical interest, we will discuss those transfers that are currently being performed in the chronological order they were reported in the medical literature. Significant technical aspects of each procedure will also be discussed.

1. Abductor Digiti Quinti (ADQ) - Huber/Nicolaysen Transfer (1921 and 1922)

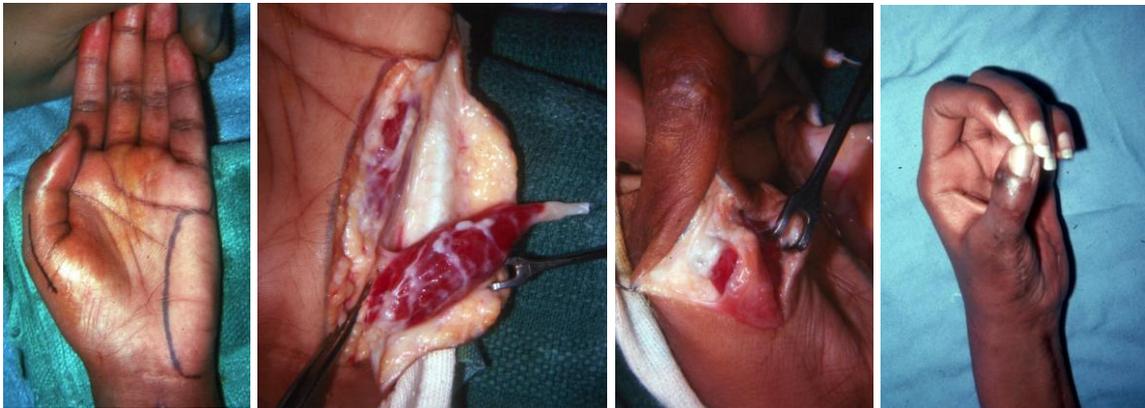
Huber in 1921 and Nicolaysen in 1922 independently proposed transfer of the abductor digiti quinti (ADQ), an ulnar nerve innervated intrinsic muscle in the hypothenar area of the palm, to restore thumb opposition.^{1,2} In term of longevity, it is the longest performed opposition tendon transfer. The primary indication for the procedure is congenital absence of the thenar muscles because in addition to restoring opposition, it adds bulk to the thenar eminence, thereby improving the aesthetic appearance of the hand.³ It is also useful for some irreparable post-traumatic injuries when other tendons are not available for transfer. (Fig. 1)



Figure 1: Paralysis of thenar muscles following median nerve laceration several years earlier with total loss of opposition

The operative approach exposes the entire length of the ADQ via an incision along the radial border of the hypothenar eminence that is curved distally and ulnarly into the distal palmar crease and then further distally along the ulnar side of the palm to the base of the little finger. The proximal end of the incision is also curved ulnarly into the wrist flexion crease. (Fig. 2) An incision on the ulnar border of the hand at the junction of the glabrous and dorsal skin, curving radially at the wrist crease is a reasonable alternative. The insertions of the ADQ into the ulnar base of the proximal phalanx and into the ulnar lateral band of the extensor mechanism are released, and the muscle is mobilized from the underlying flexor digiti quinti (FDQ) muscle. The neurovascular bundle that enters the ADQ on its dorsal surface just distal to the pisiform is identified and protected. (Fig. 3) A second incision is then made on the radial side of the thumb MP joint and is connected to the first incision by a subcutaneous tunnel of ample width to accommodate passage of the ADQ muscle. (Fig. 4) The ADQ muscle is rotated 180° on its longitudinal axis, akin to turning a page in a book, with the result that the original ulnar portion of the muscle is proximal and the original deep portion is superficial. If necessary, the origin of the ADQ is partially released from the pisiform in order to

mobilize the muscle sufficiently to reach the thumb. The muscle origin can be completely released but its attachment to the FCU must be preserved in order to protect the neurovascular bundle from any undue tension being placed on it. The distal end of the ADQ is sutured into the conjoined tendon of the APB and FPB on the radial side of the thumb MP joint. (Fig. 5)



From left to right: Figure 2: Operative incision; Figure 3: ADQ elevated from FDQ preserving neurovascular bundle (probe); Figure 4: Attachment of tendon of ADQ into insertion of APB whose muscle is pale due to chronic denervation; Figure 5: Post-operative opposition restored

2. Palmaris Longus (PL) – Camitz Transfer (1929)

Described by Camitz in 1929, transfer of the PL has been recommended for elderly patients with longstanding Carpal Tunnel Syndrome who have complete thenar intrinsic muscle atrophy.⁴ Usually, surgical decompression of the median nerve is all that is required in these patients to relieve their sensory complaints, particularly dysesthesias. However, in some cases when the loss of opposition is disabling, an opposition tendon transfer should be considered. Obviously, using the PL requires that its presence and approximately 20% of individuals do not have the tendon and are not aware of this since it provides no important hand function.⁵ A Camitz transfer is an uncomplicated procedure and involves little more than extending distally the incision used to decompress the carpal tunnel. The PL is in effect lengthened with a strip of palmar fascia to which it is inserted, the pre-tendinous band to the middle finger that is then divided as distal as possible and sutured into the insertion site of the APB. (Fig. 6-7) Since the direction of force of the PL is to the radial side of the mid-line of the wrist, it neither flexes nor pronates the thumb. The transfer provides only abduction and the operation has appropriately been described as an “abductorplasty” rather than an opposition transfer.⁵ (Fig. 8) If pronation is required, and for effective opposition it usually is, a different transfer such as the flexor digitorum superficialis opposition transfer that will be discussed in #4 should be used.



From left to right: Figures 6 and 7: PL “lengthened” with a pre-tendinous band that is then tunneled under skin and attached to site of insertion of APB; Figure 8: Pre-operative and post-operative photos

3. Flexor Digitorum Superficialis (FDS) – Bunnell Transfer (1938)

Bunnell recognized the important role of the APB in thumb opposition and its line of force toward the pisiform bone.⁶ In order to replicate that force direction, he used a flexor digitorum superficialis (FDS) tendon, usually the FDS to the ring finger, that he routed through a pulley constructed in the flexor carpi ulnaris (FCU) tendon near its insertion into the pisiform. He then passed the FDS tendon subcutaneously across the palm to the thumb. At surgery, the FDS tendon is divided through a small window in the flexor tendon sheath between the A-1 and A-2 pulleys that leaves a distal stump of tendon that is approximately 1.5 cm in length. Cutting the FDS in this fashion is preferable to detaching the tendon at its insertion into the middle phalanx that can also result in a hyperextension or swan-neck deformity of the PIP joint in individuals with supple joints. The latter problem does not occur because the short distal tendon stump functions as a tenodesis of the PIP joint. A slight loss of 10-15° of PIP extension is not a functional impairment but a greater loss could be. It is therefore important to passively extend the PIP joint post-operatively to insure that there is not a more severe tenodesis effect from the distal tendon stump. Dividing the FDS proximal to the PIP joint also avoids damaging the vincula that when disrupted results in some bleeding within the sheath that can lead to scarring and a flexion contracture of the PIP joint. The possibility of scarring developing within the sheath resulting in a significant loss of motions of the donor finger, or any finger, is avoided by encouraging post-operative active exercises for the fingers and passive extension of the PIP joints, especially the PIP joint of the donor finger.⁷

The pulley in the FCU is constructed using the distal 4-5 cm of the tendon that is split longitudinally. The radial half of the split tendon is then cut proximally and passed through a slit in the intact distal portion of the FCU forming a tendon loop or pulley. The FDS tendon that was withdrawn through the incision in the wrist and distal forearm is passed around the FCU and then through the loop. (Fig. 9) This is an important sequence to follow because if the FDS tendon is simply passed around the FCU and not through any pulley, it can slide proximally along the FCU and away from

the pisiform, and if the FDS tendon is passed only through the pulley and not around the FCU, as described in many texts, it can also pull away from the pisiform but in a radial direction. Rerouting the FDS around the intact portion of the FCU ensures that it remains on the ulnar side of the wrist and cannot shift radially, and passing it through the tendon loop insures that the direction of pull will be toward the pisiform and in line with the normal force of an APB.

There are several techniques used for attaching the FDS to the thumb. Probably the most common site for insertion is the APB tendon. A dual-insertion into the APB tendon and into the thumb extensor mechanism is sometimes used when there is an extension deficit in addition to the loss of opposition. Bunnell recommended that the FDS tendon be inserted into the ulnar side of the base of the proximal phalanx as a means to achieve not only maximum abduction but also maximum pronation. (Fig. 10 - 11)



From left to right: Figure 9: The FDS tendon is first passed around the ulnar border of the FCU tendon and then through the pulley constructed using one-half of that tendon; Figure 10: Insertion of the FDS into the ulnar base of the proximal phalanx provides maximum pronation; Figure 11: Post-operative opposition of the left thumb equaled that of thumb in uninjured hand.

The senior author and Dick Smith, who were in practice together in New York at the Hospital for Joint Diseases, frequently discussed the optimum attachment of the FDS tendon to achieve maximum thumb opposition. The senior author preferred the ulnar side of the base of the proximal phalanx. Dick preferred the APB tendon and in his classic textbook, “Tendon Transfers of the Hand and Forearm”, he discussed the tendon insertion in terms of the “tangent” it formed with the thumb.⁸ He stated that if the transfer passed dorsal to the MP joint to be inserted on the ulnar side of the proximal phalanx it would not improve pronation. The senior author’s preference for inserting the tendon into the ulnar side of the proximal phalanx is not intended to produce a force that curves around the thumb. By positioning the tangent closer to the dorsum of the MP joint than is the location of the APB tendon, he believes the force is more likely to achieve better thumb rotation (pronation). This disagreement between the senior author and Dick was something they both enjoyed and they often joked about it. Dick also made it an “inside joke” because whenever they were together and Dick was giving a lecture on an entirely different subject, he would usually mention the insertion he preferred for opposition tendon transfers. The senior author was only person in the audience who understood his playful jab.

Regardless of the method of insertion, tension on the tendon transfer is adjusted with the wrist in approximately 30° of flexion and the thumb in complete opposition to the middle finger. Gauging the correct amount of tension is obviously important. An effective method that follows the principles of the Blix curve is to grasp the distal end of the donor FDS tendon with a straight mosquito clamp, exert maximum traction on the tendon and measure that distance. The FDS tendon is then attached to the thumb under sufficient tension to equal approximately one-half of that distance. Tension of the transfer is correct when with passive wrist extension the thumb moves into complete opposition. Following suturing the tendon at a proper tension, the wrist is immobilized in approximately 30° of flexion and the thumb in full opposition for 4 weeks. At the end of 4 weeks, the splint is removed several times daily for active range of motion exercises but is worn at all other times for an additional 1- 2 weeks.

Bunnell's FDS transfer is probably the most commonly performed operation for thumb opposition following median nerve injuries. It is obviously not an option in high median nerve injuries that result in paralysis of all the FDS muscles, and in high ulnar nerve injuries that results in paralysis of the FDP muscles to the ring and little fingers since the FDS is the only functioning flexor tendon in the ring finger and obviously must be retained. The FDS tendon to the middle finger can be substituted in such cases because the FDP to that finger is median nerve innervated.

4. Extensor Carpi Ulnaris (ECU) – Phalen-Miller Transfer (1947)

Phalen and Miller in 1947 proposed the ECU as a tendon transfer for thumb opposition.⁹ Since the ECU is not of sufficient length to reach the thumb it is "lengthened" in a manner recommended approximately 25 years earlier by Ney who cut the extensor pollicis brevis (EPB) at its musculotendinous junction, leaving intact its insertion into the dorsal base of the proximal phalanx. He then transferred the distal end of the EPB tendon into the carpal tunnel and attached it to either the PL or flexor carpi radialis.¹⁰ Ney's procedure restored some limited thumb abduction but it was not an effective opposition transfer. Phalen and Miller instead transferred the distal cut end of the EPB across the palm and attached it to the ECU that they detached from its insertion into the base of the fifth metacarpal. The tendon junction was on the ulnar side of the wrist and the direction of the transfer was in line with the APB, the most important intrinsic muscle for thumb opposition.

The operation requires three incisions and the sequence of the first two incisions is unimportant. One is over the dorsoradial aspect of the distal forearm proximal to the extensor retinaculum where the EPB is transected at its musculotendinous junction, and the other is over the dorsum of the thumb MP joint. At this second incision, the EPB tendon is mobilized up to the MP joint to avoid a hyperextension deformity but not distal to the joint that can result in an opposite flexion deformity when the tendon shifts volar to its axis of motion.¹¹ The latter problem can be avoided by looping the EPB tendon around the EPL tendon. It is also important to cut the fascial connections between the EPB and EPL because failure to do so can result in hyperextension of the

interphalangeal joint. The third incision is on the ulnar side of the wrist where the ECU is cut at its insertion into the fifth metacarpal, taken out of its sheath and then attached to the EPB that had been passed subcutaneously across the palm from the dorsum of the thumb MP joint. The location of the tendon junction depends on the length of the EPB. When it has sufficient length, the junction is on the dorsoulnar side of the wrist but if its length is shorter, the junction is in the area of the pisiform. (Fig. 12) Although excursion of the transfer is limited, the ulnar border of the wrist functions as an effective pulley for opposition.

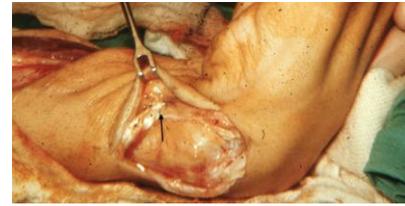


Figure 12. Attachment of ECU tendon to transposed distal end of EPB (arrow)

An important prerequisite for a Phalen-Miller opposition tendon transfer is intact function of the flexor carpi ulnaris (FCU) in order to preserve balance of the wrist post-operatively.⁹ When the FCU is weak through injury or is paralyzed secondary to a high ulnar nerve injury or neuropathy, the wrist will deviate radially post-operatively. Although a Phalen-Miller opposition transfer should not be performed with a high ulnar nerve injury or neuropathy that has resulted in severe weakness or paralysis of the FCU, it can be performed with low ulnar nerve injury or neuropathy that is combined with a median nerve injury. It can also be performed in other situations when other potential donor tendons are unavailable or required for other transfers. It is not a commonly performed transfer and is indicated only when other options are not available.

5. Extensor Indicis Proprius (EIP) Transfer – Burkhalter Transfer (1973)

In the patient with total intrinsic muscle paralysis due to combined low median and ulnar nerve injuries, the extensor indicis proprius (EIP) described by Burkhalter in 1973 is often the procedure of choice to restore thumb opposition.¹² It has several advantages that include preserving the FDS tendons to correct clawing of the fingers, no loss of grip strength since an expendable extensor tendon is used, using a tendon that has sufficient length and does not have to be lengthened, and construction of a pulley is unnecessary. The route of an EIP transfer is more direct than a FDS transfer whose path takes a more acute angle as it passes through a pulley in the FCU. By having a more direct line of pull, significantly less force is required for an EIP transfer than a FDS transfer.¹³

The EIP tendon is harvested at its insertion through a small transverse incision over the dorsum of the index MP joint. Some recommend it should be harvested with a contiguous strip of the extensor hood to insure that it is of sufficient length to reach its insertion. This is usually unnecessary and can cause a problem if the extensor hood is not properly repaired because the EDC can shift radially post-operatively and result in an extension lag.¹⁴ The EIP is usually transected just proximal to the extensor hood and its distal stump is sutured to the EDC in order to preserve a balanced extensor pull on the proximal phalanx. A small transverse incision just proximal to the pisiform permits retrieval of the EIP tendon that is then passed subcutaneously to the radial side of the

thumb MP joint where it is sutured to the APB tendon. Tensioning of the transfer and the post-operative care are the same as for a FDS transfer.

When discussing an EIP transfer for thumb opposition, mention should also be made of transfer of the other proprius tendon, the extensor digiti quinti proprius (EDQP) that was described many years earlier by Taylor in 1921 and later by Schneider in 1969.^{15,16} Both the EIP and EDQP have similar advantages in that they are both available in patients with volar wrist injuries, in patients with combined low or high median and ulnar nerve injuries, do not require lengthening with a tendon graft, and have almost no deleterious effect on post-operative hand function. The disadvantage of using an EDQP is that it is often the dominant extensor tendon to the little finger and using it as a transfer could result in a loss of extension of the little finger that has only a rudimentary extensor digitorum communis. It is primarily for that reason that the EIP is preferred to an EDQP for an opposition transfer.

Conclusions

Opposition is not grasp but a pre-position for grasp that involves abduction, flexion and pronation. The most important thenar muscle is the APB whose direction of pull is toward the pisiform, and this is the muscle that opposition tendon transfers replicate. Numerous opposition transfers have been described that differ in the donor tendon (or muscle when the ADQ is used), the route of the transfer, and method of attachment to the thumb. No one transfer is applicable for every clinical condition, and each transfer has its advantages and disadvantages.

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