IFSSH Scientific Committee on Tendon Transfers

Chair: **Martin A. Posner (USA)**

Committee: **John Capo (USA)**
Ufuk Nalbantoglu (Turkey)
Lyudmil Simeonov (Bulgaria)
Hong-Kee Yoon (Korea)

Report submitted June 2014

Opposition Tendon Transfers

Part I: Anatomy and History

Thumb opposition is maximal when the pulp of the distal segment of the thumb is directly opposite the pulp of the distal segment of the middle finger regardless of the distance between the two digits, whether grasping a marble or a baseball. (Fig. 1)

It is the most important component of thumb function and is a combination of three distinct motions: abduction, flexion and pronation. Abduction occurs primarily at the trapeziometacarpal (TM) joint. The contribution of the metacarpophalangeal (MP) joint, a condyloid joint, is less because unlike the MP joints of fingers that have a wide arc of abduction/adduction, the arc of MP motion in thumbs is more limited. The interphalangeal (IP) joint, a ginglymus or hinge joint, contributes nothing to abduction. The flexion component of opposition involves all three joints. Flexion at the TM joint positions the head of the thumb metacarpal in the same sagittal plane as the head of the middle finger metacarpal, flexion at the MP joint facilitates grasping objects of different sizes, and flexion at the IP joint is related to the type of pinch. For pulp-to-pulp pinch the IP joint is extended or is in slight flexion, and for tip-to-tip pinch it is in greater flexion. Pronation, the third component of opposition, occurs around a longitudinal axis through the center of the TM joint that has a concavoconvex anatomical configuration and is commonly referred to as a saddle joint. Based on this configuration, a saddle joint should permit motions in only two planes, flexion/extension and abduction/adduction; motions that a cowboys in the U.S. is able to do when seated in a saddle commonly referred to as a "western saddle". (Fig. 2) He can bend forward and back, and shift side to side, but he is unable to turn around because of the height of the rear part of the saddle, the cantle and the prominent horn in the front. In order to turn in the saddle the cowboy must lift himself from his seated position by pushing down with his boots against the stirrups. It is much easier for a rider to turn in what is referred to as an "English saddle" that has a much lower cantle in the rear and no horn in the front; the seat is not as deep as that in a western saddle. (Fig. 3)

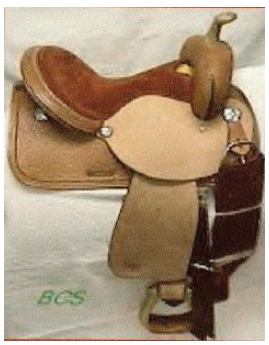
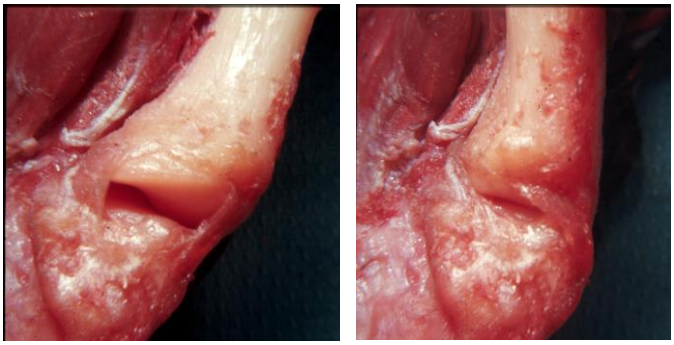


Figure 2 (left): The "western saddle". Figure 3 (right): the "English saddle"

The TM joint more closely resembles an English saddle than a western saddle because its articular surfaces are normally shallow. (Fig. 4A-B)

It is the combination of shallow articular surfaces and the laxity of the ligaments of the joint that permit pronation. (Fig. 5A-B)



Opposition is a function of the intrinsic muscles in the thenar eminence that comprise the abductor pollicis brevis (APB), the flexor pollicis brevis (FPB) and the opponens pollicis (OP). The adductor pollicis (AP) is also an intrinsic thumb muscle but it is not a "thenar muscle" because it is not in the thenar eminence. Its function, as its name indicates, is to adduct the thumb. Of the thenar intrinsic muscles, the APB is the most important for opposition; it abducts, flexes and rotates the metacarpal, abducts and flexes the proximal phalanx, and extends the IP joint. The direction of its force is toward the pisiform. Therefore, tendon transfers to restore opposition try to replicate the direction of the force of the APB. The FPB is not as important as the APB for opposition. In many patients the FPB has a dual innervation from both the median and ulnar nerves that is fortunate in those that sustain median nerve lacerations. Although these individuals lose the pronation component of opposition because the APB is paralyzed, they usually retain sufficient thumb abduction through the radial head of the FPB that remains innervated by the ulnar nerve, that they do not require opposition tendon transfers. The OP in spite of its name is the least important intrinsic muscle for opposition because it inserts solely on the first metacarpal and has no effect distal to the MP joint. Emanuel Kaplan who was an outstanding anatomist and first Chief of the Division of Hand Surgery at NYU Hospital for Joint Diseases, always referred to a tendon transfer for paralysis of the thenar muscles as an "opposition tendon transfer"

rather than an “opponensplasty”. His explanation was simply, “Why name an operation for the least important thenar muscle?”

The extrinsic abductor pollicis longus (APL), in spite of its name, contributes little to thumb opposition. Its primary function is to extend the thumb via its insertion into the base of the first metacarpal. Its contribution to thumb abduction is minimal and only when one of its tendon slips inserts volar to the TM joint. Rather than abducting the thumb, the APL extends the first metacarpal that is important for maintaining the longitudinal arch of the thumb. Without that arch, secondary hyperextension of the MP joint frequently develops and the IP joint flexes, resulting in a zigzag deformity. This is commonly seen in individuals, usually middle-aged females, with TM arthritis when the metacarpal base has subluxed radially due to attenuation of the ligaments, particularly the volar oblique ligament. The insertion of the APL also becomes attenuated and its normal extension force on the base of the thumb metacarpal is significantly weakened. The result is a flexed metacarpal that frequently leads to a hyperextended MP joint to compensate for the loss of extension at the TM joint. (Fig. 6) Since the APL is not an abductor but an extensor of the thumb metacarpal it is a misnamed muscle. A more appropriate name would be the “extensor metacarpus primus”, the extensor of the first metacarpal.

Opposition is not actually grasp but is a preparatory position to grasp, whether it is power grasp or precision grasp. Thumb opposition and grasp are separate stages. Opposition does not require a strong muscle/tendon transfer. Any tendon capable of moving a passively mobile thumb has sufficient force to be an effective opposition tendon transfer. Only when the force of grasp is impaired is a strong tendon transfer required. Power grasp, that includes key pinch, is rarely significantly compromised in a low median nerve injury because the adductor pollicis (AP) innervated by the ulnar nerve, and the flexor pollicis longus (FPL) innervated by the median nerve in the forearm are not impaired.

Prior to any opposition tendon transfer, passive mobility of the thumb should be complete or almost complete, and passive abduction is more important than passive rotation. An adduction contracture of the first web space should be corrected and unless the contracture is rigid, non-operative therapy should be used that may involve the use of static and dynamic splints. It is important that when using an abduction force on the thumb, the force is applied to the ulnar side of the metacarpal head and not to the ulnar side of the proximal segment that could result in ulnar instability of the MP joint. When non-operative measures are unsuccessful, surgery is necessary to release the adduction contracture that almost always includes sectioning the fibrotic intrinsic muscles in the first web space, the first dorsal interosseous and adductor pollicis. In some cases, a skin contracture must also be corrected as well as a capsular contracture of the TM joint.

History of Opposition Tendon Transfers

The history of opposition transfers dates back to 1918 when Steindler re-routed one-half of the insertion of the FPL tendon to the radial side of the proximal phalanx.[1] The procedure was not effective since the portion of the tendon he re-routed was unable to move the thumb in a different direction from the intact portion of the tendon that flexed the IP joint. Several years later, Ney in 1921 cut the extensor pollicis brevis (EPB) at its musculotendinous junction and transferred the cut end of the tendon into the carpal tunnel where it was attached to either the palmaris longus (PL) or flexor carpi radialis (FCR).[2] Similar to Steindler's earlier procedure the transfer provided very limited thumb abduction and no pronation; it was not an effective opposition tendon transfer. Royle in 1938 recommended a procedure that was similar to Steindler's transfer but instead of transferring the radial one-half of the FPL to the radial side of the proximal phalanx of the thumb, he did the same using the FDS tendon of the ring finger that he re-routed through the FPL tendon sheath.[3] Unfortunately, it was as ineffective as Steindler's transfer. Thompson in 1942 modified Royle's operation by transferring the FDS around the ulnar border of the palmar aponeurosis that served as a pulley and then passed the tendon subcutaneously across the thenar eminence to the MP joint of the thumb.[4] He then split the distal end of the tendon and attached one end into the radial base of the proximal phalanx and the other end into the neck of the metacarpal. The procedure became known as the "Royle/Thompson procedure" named for the two surgeons who described it and for the sequence in which they published their articles. It has also been referred to as the "Thompson/Royle procedure" with Thompson's name first because he improved the procedure with his modification. The procedure is generally recommended for patients who have sustained both median and ulnar nerve injuries resulting in paralysis of all the intrinsic thumb muscles, both abductors and adductors. The procedure "splits the difference" between an opposition tendon transfer and an adductor transfer and attempts to restore both thumb functions. Unfortunately, in most cases neither function is restored to a satisfactory level. It is far preferable for the patient who has suffered a total loss of intrinsic thumb function and has significant disabilities due to the loss of both opposition and thumb adduction characterized by weak key pinch, to use separate tendon transfers for each function. The tendon transfer for the more severe functional deficit is usually performed first.

Many other techniques using a variety of donor muscles have been described for opposition tendon transfers (see below). The most successful transfers are those in which the line of force of the donor motor extends from the area of the pisiform to the insertion of the APB. This is essentially the method described by Bunnell and Burkhalter (see Part II) that restores both abduction and pronation of the thumb. Variations in the manner in which the donor tendon is attached to the thumb have been described that will be discussed with those transfers.

Chronology of Procedures reported in the literature

1918 – Steindler:[1] radial half of FPL through tendon sheath to radial side of phalanx

1921 – Ney:[2] PL or FCR attached to EPB that is transposed into carpal tunnel

1921 – Taylor:[5] Extensor digiti quinti proprius (EDQP) around ulnar border of hand to radial side of thumb metacarpal

1921 – Huber,[6] (+ Nicolaysen 1922[7]): abductor digit quinti (ADQ) in hypothenar eminence to APB

1922 – Kruckenberg:[8] radial half of FDS (middle) re-routed as described by Steindler

1924 – Lyle:[9] FCR to EPB and radial half of FPL to radial side of proximal phalanx

1926 – Howell:[10] FPL transected at wrist, rerouted around the ulna to radial side of the thumb

1929 – Camitz:[11] PL + palmar aponeurosis to radial side of thumb MP joint

1938 – Bunnell:[12] FDS (ring) through pulley in FCU to ulnar base of proximal phalanx

1938 – Royle:[3] FDS (ring) through tendon sheath to radial side of proximal phalanx

1942 – Thompson:[4] FDS (ring) rerouted ulnar border of palmar aponeurosis to the thumb

1947 – Phalen and Miller:[13] Extensor carpi ulnaris (ECU) to rerouted extensor pollicis brevis

1956 – Zancolli:[14] EPL through carpal tunnel into APB

1959 – Riordan:[15] insertion of FDS; one half into APB and the other half into EPL [17]

1962 – Henderson:[16] ECU, ECRL, ECRB or BR prolonged with a graft or to EPB

1967 – Makin:[17] translocation of intact FPL through an osteotomy in the proximal phalanx

1968 – Tubiana and Valentin:[18] EPL around FCR superficial to carpal tunnel into APB

1969 – Schneider:[19] described transfer of EDQP proposed by Taylor in 1921

1973 – Magnus:[20] FPL around FCU to APB, tenodesis of FPL at interphalangeal joint

1973 – Burkhalter:[21] Extensor indicis proprius (EIP) around ulnar border of hand to APB

The following commonly performed opposition transfers will be discussed in part II of this article:

1. Abductor Digiti Quinti (ADQ) - Huber/Nicolaysen Transfer
2. Palmaris Longus (PL) - Camitz Transfer
3. Flexor Digitorum Superficialis (FDS) – Bunnell Transfer
4. Extensor Carpi Ulnaris (ECU) – Phalen-Miller Transfer
5. Extensor Indicis Proprius (EIP) Transfer – Burkhalter Transfer

References

1. Steindler A. Orthopaedic operations on the hand. JAMA 1918;71:1288.
2. Ney KW. A tendon transplant for intrinsic hand muscle paralysis. Surg Gynecol Obstet 1921;33:342-348.
3. Royle ND. An operation for paralysis of the intrinsic muscles of the thumb. JAMA 1938;111:612-613.
4. Thompson TC. A modified operation for opponens paralysis. J Bone Joint Surg 1942;24:632-40.
5. Taylor RT. Reconstruction of the hand. Surg Gynecol Obstet 1921;32:237-248
6. Huber E. Hilfsoperation bet median uhlahmung. Dtsch Arch Klin Med 1921;136:271.
7. Nicolaysen J. Transplantation des m. abductor dig V. die fenlander oppositions fehigkeit des daumens. Dtsch Z Chir 1922;168:133.
8. Krukenberg H. Uber ersatz des M. opponens pollicis. Z Orthop Clin 1922;42:178
9. Lyle HHM. Results of an operation for thenar paralysis of the thumb (extensor-flexor-flexorplasty) Ann Surg 1924;79:933.
10. Howell BW. A new operation for opponens paralysis of the thumb. Lancet 1926;16:131.
11. Camitz H. Surgical treatment of paralysis of opponens muscle of thumbs. Acta Chir Scand 1929;65:77-81.
12. Bunnell S. Opposition of the thumb. J Bone Joint Surg 1938;20:269-84.
13. Phalen GS, Miller RC. The transfer of wrist extensor muscles to restore or

reinforce flexion of power of the fingers and opposition the thumb. J Bone Joint Surg 1947;29:993-997.

14. Zancolli E. Cirugia de la mano. Musculos intrinsecos. Prensa Med Argentina 1956;43:1299.

15. Riordan DC. Surgery of the paralytic hand. In. Instructional course lectures, the American Academy of Orthopaedic Surgeons St. Louis: Mosby;1959,16:79-90.

16. Henderson ED. Transfer of wrist extensors and brachioradialis to restore opposition of the thumb. J Bone Joint Surg 1962;44:513-522.

17. Makin M. Translocation of the flexor pollicis longus tendon to restore opposition. J Bone Joint Surg Br 1967;49:458-61.

18. Tubiana R, Valentin p. Opposition of the thumb. Surg Clin North Am 1968;48:967.

19. Schneider LH. Opponensplasty using the extensor digiti minimi. J Bone Joint Surg 1969;51:1297-1302.

20. Mangus DJ. Flexor pollicis longus tendon transfer for restoration of thumb opposition. Plast Reconstr Surg 1973;52:155-159.

21. Burkhalter W, Christensen RC, Brown P. Extensor indicis proprius opponensplasty. J Bone Joint Surg Am 1973;55:725-732.