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Review Article

Understanding of Tendon Transfer in Radial Nerve Palsy in Leprosy

Imran Sajid

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Involvement of Radial Nerve in leprosy is not very common. Only 0.2% of Radial Nerve deformities is observed. There are various procedure to correct the wrist function. We have analyzed various motor units to correct the wrist function as per the patient requirement.

In leprosy the involvement of Radial nerve is very less even though if it happens it gives the major deformity and functional inability. There are various anatomical and surgical facts which effects the results of reconstruction of radial nerve paralysis cases.

Radial nerve injury whether acute or chronic has a major debilitating effect on the hand functionality. Loss of power grip associated with loss of wrist extension is a major cause of worry for the patient. With radial nerve being an exclusive motor nerve, tendon transfers to restore function in radial nerve palsy are among the best and most predictable transfers in the upper limb. Riordan (1983) noted that "there is usually only one chance to obtain good restoration of function in such paralyzed hand"; it becomes imperative to have a detailed understanding and knowledge of radial nerve anatomy and definite indications for surgery. Before going further a simplified definition of tendon transfer will be - The detachment of a functioning muscle-tendon unit from its insertion and reattachment to another tendon or bone to replace the function of a paralyzed muscle or injured tendon.

Indications :

1) Restore function to a muscle paralyzed as a result of injury of the peripheral nerves, brachial plexus or spinal cord.
2) To restore function after closed tendon ruptures or open injuries to the tendons or muscles.
3) Restore balance to a hand deformed from neurological conditions.

It is important that the distinction between complete radial nerve palsy (excluding the triceps) and posterior interosseous nerve palsy is made preoperatively. The radial nerve innervates the brachioradialis (BR) and extensor carpi radialis longus (ECRL) before it divides into its two terminal branches, the posterior interosseous (motor) and superficial (sensory) branches. Clinically, it is rather difficult, if not

[1] Imran Sajid, Dept of Orthopedics, Hamdard Institute of Medical Sciences, New Delhi.
Correspondence to: Imran Sajid **Email:** imransajid60@gmail.com

impossible, to determine the integrity of the ECRB in the presence of an intact ECRL, and the presence of the ECRB is variable in posterior interosseous nerve palsy. Spinner (1972) noted that the ECRB receives its innervation in most limbs (58%) from the superficial radial nerve, rather than from the posterior interosseous nerve.

As it emerges from the supinator about 8 cm distal to the elbow joint, the posterior interosseous nerve splays out into multiple branches, which Spinner (1972) has likened to the cauda equina. Abrams and associates (Abrams et al 1997) produced the best reference on the innervation order and location of motor branches of the radial nerve (Table 1). Although they found innervation order to be variable, knowledge of the general patterns and variations is important for the surgeon in following recovery from radial nerve injuries.

Innervation Order of Muscles: Radial Nerve

BR
ECRL
SUPINATOR
ECRB
EDC
ECU
EDM
APL
EPL
EPB
EIP

RADIAL NERVE PALSY

low radial nerve palsy: high radial nerve palsy:

LOW RADIAL NERVE PALS		HIGH RADIAL NERVE PALS	
1- With a low radial nerve injury, there will be loss of EDC, EPL, APL;		1- Loss of EDC, EPL, APL, BR, ECRL / ECRB	
2- In low nerve palsy, wrist extension is maintained.		2- Loss of Wrist extensors	
3- Anatomical Deficits		3- Anatomical Deficits	
Motor	**Sensory**	**Motor**	**Sensory**
Accessory Forarm flexion	Radial 2/3 dorsal sensations	Finger Extension	Dorsoradial forarm/ hand
Accessory forarm supination		Thumb Extension/abduction	
Wrist Extension			
Digital extension 1,2,3,4,5			
Radial Abduction of thumb			
Functional Requirements		**Functional Requirements**	
Wrist extension		Digital Extension 1,2,3,4,5	
Digital Extension 1,2,3,4,5		Radial abduction of thumb	
Radial abduction of thumb			
Synergistic Muscles Available		**Synergistic Muscles Available**	
Wrist flexors		Wrist flexors	
Pronator teres		Pronator teres	

With upper limb getting most commonly injured at the level of arm or below, wrist and finger drop is the most common form of presentation of radial nerve palsy. For this reason, transfer to restore function of hand is described here.

Understanding Early Tendon Transfer

The concept of early transfers is to provide a temporary "internal splint" and not as definitive treatment of the radial nerve palsy. Burkhalter (1974) believed that the greatest functional loss in a patient with radial nerve injury is weakness of power grip. Consequently, he advocated an early PT to ECRB transfer to eliminate the need for an external splint and, at the same time, to restore a significant amount of power grip to the patient's hand. The indications as per Burkhalter (1974) for early tendon transfer are that the transfer (1) works as a substitute during regeneration of the nerve to eliminate the need for splinting, (2) works as a helper after reinnervation by adding the power of a normal muscle to the reinnervated muscles, and (3) acts as a substitute in cases in which the results of nerve repair are statistically poor (e.g., injuries in elderly patients, chronic injuries, crush injuries). The important principles that need to be understood before undergoing PT to ECRB transfer are that the transfer (1) should not significantly decrease the remaining function in the hand, (2) should not create a deformity if significant return occurs after nerve repair, and (3) should be a phasic transfer or one capable of phase conversion. Burkhalter (1974) believed that the PT to ECRB transfer fulfills all of these indications and principles, and he suggested that the operation be done at the time of radial nerve repair or as soon as possible thereafter.

Internal Splint (Burkhalter)

Eg : PT ECRB

Principles of Tendon Transfer

The application of certain fundamental principles is essential for successful transfer of muscle tendon units. These important concepts were established by such masters as Mayer (1916) and were re-emphasized by Littler (1977), Boyes (1964), Curtis (1974), White (1960) and Brand (1975).

1) **Synergy**: It may be easier to retain muscle function with a synergistic transfer (Wrist flexors are synergistic with finger extensors). It also allows functional increase in excursion. Littler (1977) was a major advocate of the use of synergistic muscles for transfer whenever possible.
2) **Expendable Donor:** Removal of a tendon for transfer must not result in unacceptable loss of function; there must be sufficient muscle remaining to substitute for the donor muscle.
3) **Adequate Strength:**

a. The donor will lose 1 point on MRC scale with transfer
b. Donor should be a 4 or 5 on the MRC scale
c. Work of the muscle = strength = proportional to cross-Sectional diameter
d. Strongest muscles for transfer are bracho-radialis and FCU

The tendon chosen as a donor for transfer must be sufficiently strong to perform its new function in its altered position. Brand and Thompson (1975) did elaborate anatomic dissections and bio-mechanical studies in an effort to apply more scientific principles to tendon transfers. Perhaps even more important than the theoretical strength of a given motor is its actual strength at the time of tendon transfer; generally, a muscle should not be used for transfer. Unless it can be graded as being at least good (Steindler (1919) recommended 85% of normal).

4) **Contractures Must Be Treated First**

Joint should be supple

5) **One Tendon One Function**

Effectiveness of a transfer is reduced when it is expected to do more than one function [example extend and adduct]. At the very least, if a single tendon is transferred into two separate tendons, the excursion of the two should be the same (Brand 1974).

6) **Amplitude [or Excursion] of Motion** - try to match the donor and recipient;

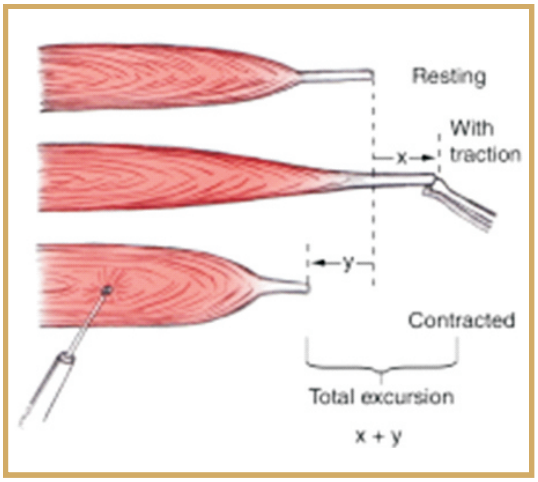
aka = fiber length = distance the muscle can shorten from its maximal length

3.3 cm - wrist flexors and extensors and thumb extensors

5.0 cm - finger extensors and EPL

7.0 cm - finger flexors

Amplitude, or potential excursion, is proportional to fiber length. In the image below, X equals the excursion length with traction minus the resting length; Y equals the resting length minus the length at full contraction; and amplitude is equal to X plus Y. Usually both measurements are equal.



The total excursion of a muscle equals

The excursion with contraction and traction; these lengths usually equal each other. X = excursion length with traction – resting length;

Y = resting length – length at full contraction.

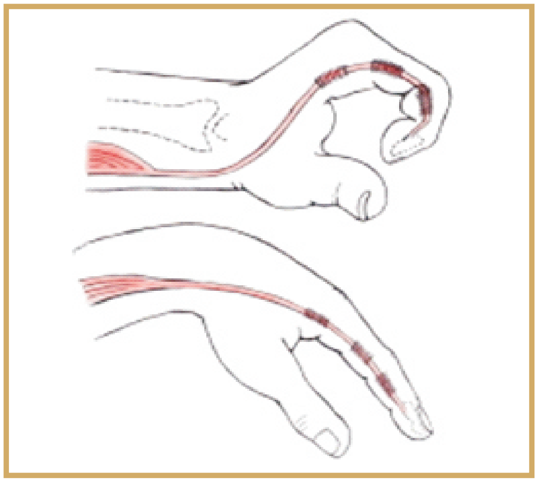
Amplitude = X + Y

Two methods can be used to increase amplitude:

i. Tenodesis effect [related to synergism]

when a tendon crosses two joints

example = FCU to EDC has insufficient excursion to / fully extend the fingers unless the wrist is flexed can increase amplitude by - 2.5 cm



Demonstrates the tenodesis effect of wrist flexion, which augments amplitude by 2.5 cm.

A muscle can be converted from monarticular to biarticular or multiarticular, effectively using the natural tenodesis effect. When a flexor carpi ulnaris (FCU) or FCR is transferred to the EDC, it is converted to a multiarticular muscle, and the effective amplitude of the tendon is increased significantly by active volar flexion of the wrist, allowing the transferred wrist flexor to extend the fingers fully.

ii. Dissect the fascial attachment surrounding the musculotendinous unit

Example = FCU to EDC transfer

7) **Straight-line of Pull**

a. to get most efficiency

b. the path of pull of the muscle must be as straight as possible to the new insertion

8) **Tissue Equilibrium**

a. aka = adequate soft-tissue coverage

b. must have non-indurated, non-scarred bed.

Steindler's classic expression "tissue equilibrium" (quoted by Boyes 1964) is a good one; it implies that soft tissue induration is gone, the wounds are mature, the joints are supple, and the scars are as soft as they are likely to become.

9) **Sensibility**

a. controversial

b. should have protective sensation

10) **Cross Minimal Joint Surfaces**

a. with transfers crossing a joint the joint must be stabilized by an antagonist or fusion.

Specific For Hand:

a) To restore thumb pinch - stabilize the carpometacarpal joint in extension and metacarpophalangeal joint in flexion.

b) To restore finger extension, the MCP joint is maintained in slight flexion.

Goals of Tendon Tranfer for Radial Nerve Palsy:

1) Wrist extension (High radial nerve palsy).

2) Restoration of finger (MCP Joint) extension.

3) Restoration of thumb extension and abduction.

Timing of Tendon Transfers:

"Sufficient time" is determined by using Seddon's (1972) figures for nerve regeneration (i.e., approximately 1 mm/day). This means that it may take 5 or 6 months before one sees return in the most proximal muscles (BR and ECRL) after nerve repair in the middle third of the arm. The remaining muscles should return in orderly progression at the same rate of 1 mm/day.

Distances (cm) from Distal End of Supinator to Point of Innervation

ECU 1.25

EDC 1.25-1.8

EDC 1.25-1.8

EDM 1.8

APL 5.6

EPB 6.5

EIP 6.8

EPL 7.5

From Spinner M: The radial nerve. In Injuries to the Major Branches of Peripheral Nerves of the Forearm, Philadelphia, WB Saunders, 1972, pp 28-65

Jones is credited with being the major innovator of radial nerve transfers, and all the articles in the post–World War I era acknowledged his fundamental contributions. The "classic" Jones transfer has been quoted and misquoted so many times, however, in articles and texts that it is worthwhile to review his original articles (Johns 1916, Johns 1921) to see exactly what he did advocate. Part of the confusion arises from the fact that Jones described at least two slightly different combinations of transfers.

Jones Transfer:

1916 (16)	
PT to ECRL and ECRB	- Wrist Extension
FCU to EDC III-V	- Finger Extension
FCR to EIP, EDC II, and EPL	- Thumb Extension

1921 (17)	
PT to ECRL and ECRB	- Wrist Extension
FCU to EDC III-V	- Finger Extension
FCR to EIP, EDC II, EPL, EPB and APL	- Thumb Extension and Abduction

Problems with Jones Transfer:

Classic Jones transfer

1. Uses FCU to restore finger extension:
   i. Removes it as ulnar stabiliser
   ii. May lead to radial deviation (esp. if posterior interosseous palsy, as ECRL functioning)

Brand's (1974) stated that FCU should not be used as a tendon transfer for two reasons:

(1) The FCU is too strong and its excursion is too short for transfer to the finger extensors, and

(2) Its function as the prime ulnar stabilizer of the wrist is too important to sacrifice.

2. uses FCR for thumb extension:
   i. thus removes both wrist flexors

Modifications:

a) Starr (1922) (FCR Transfer) (1922)

Used PL and left one of the wrist flexors intact to main flexion:

PT to ECRB
FCR to EDC lll-V
PL rerouted to EPL

b) Zachary (1946) - one strong wrist flexor should be retained to prevent wrist hyper-extension.

c) Scuderi (1949) - Promoted the concept of PL to EPL transfer. According to him function is better when the transfer is done only into one tendon (Jones was suturing the FCR into four tendons(EIP, EDC II, EPL, EPB and APL) with separate functions).

PT to ECRL
FCU to EDC ll-V
PL to EPL

d) BOYES (1960) : Used FCR instead of FCU as FCU more important wrist flexor to preserve than FCR:

1) Normal axis of wrist motion is from dorsal - radial to volar ulnar. Elimination of this balancing force may accentuate radial deviation of hand and disturb the more normal wrist flexion- extension arc.

2) Wrist flexors amplitude - 33 mm

Finger extensors amplitude - 50 mm

Therefore full active extension of the fingers with an FCU or FCR transfer can be achieved only by simultaneous volar flexion of the wrist, by the tenodesis effect of the transfer.

Because of their greater excursion (70 mm), the FDS (sublimis) tendons would be ideal motor for finger extensors.

PT	to ECRL and ECRB
FCR	to EPB and APL
FDS (middle finger)	to EDC (via interosseous memb)
FDS (ring finger)	to EPL and EIP (via interosseous memb)

It can also be used in patients with absent PL.

References

1. Abrams RA, Ziets RJ, Leber RL et al (1997). Anatomy of the radial nerve motor branches in the forarm, *J Hand Surgery(Am)*. **22**: 232-237.
2. Boyes J (1959). Tendon transfers in the hand. In Medicine of Japan. Proceedings of the 15th General assembly of the Japanese Medical Congress. **5**: 958-969.
3. Boyes J (1960). Tendon transfer for radial palsy. *Bull Hosp Jt Dis.* **21**: 97-105.
4. Boyes J (1964). Bunnels Surgery of the hand, Philadelphia. *JB Lippincot*.
5. Brand P (1974). Biomechanics of tendon transfer, *Orthop Clin North[Am]*. **5**: 205-230.
6. Brand P (1975). Tendon transfers in the forarm. In Flynn JE(ed): Hand Surgery, Baltimore, Williams and Wilkins. 189-200.
7. Brand PW, Beach RB, Thompson DE (1981). Relative tension and potential excursion of

muscles in the forarm and hand. *J Hand Surgery [Am].* **6**: 209-219.

8. Burkhalter W (1974). Early tendon transfer in upper extremity peripheral nerve injury. *Clinical Orthop Relat Res*. **104**: 68-79.
9. Curtis R (1974). Fundamental principles of tendon transfer, *Orthop Clin North[Am]*. **5**: 231- 242.
10. Jones R (1916). On suture of nerves, and alternative methods of treatment by trans-plantation of tendon, *BMJ*. **1**: 641-643.
11. Jones R (1921). Tendon transplantation in cases of musculospinal injuries not amenable to suture, *Am J Surg.* **35**: 333-335.
12. Littler J (1977). Restoration of power and stability in the partially paralysed hand. In Converse J (ed): Reconstructive Plastic Surgery, Philadelphia, WB Saunders, 3266-3280.
13. Mayer L (1916). The physiological method of tendon transplantation. *Surg Gynaecol Obstet*. **22**: 182-197.
14. Riordan D. (1983). Tendon transfers in hand surgery. *J Hand Surgery (Am).* **8**: 748-753.
15. Scuderi C (1949). Tendon transplants for irreparable radial nerve paralysis. *Surg Gynecol Obstet*. **88**: 643-651.
16. Seddon H (1972). Factors influencing indications for operation. In Seddon H (ed): Surgical disorders of the Peripheral Nerves, Baltimore, Williams and Wilkins. 240-245.
17. Spinner M (1972). The Radial N. In injuries to the major branches of the peripheral nerves of the forarm, Philidelphia, WB Saunders. 28-65.
18. Starr C (1922). Army experiences with tendon transference, *JBJS [Am].* **4**: 3-21.
19. Steindler A (1919). Operative treatment of paralytic conditions of the upper extremity. *J Orthop Surg (Hong Kong).* **1**: 608-624.
20. White W (1960). Restoration of function and Balance of the wrist and hand by tendon transfers, *Surg Clin North [Am].* **40**: 427-459.
21. Zachary R (1946). Tendon transplantation for Radial paralysis, *Br J Surg.* **23**: 358-364.

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