Paralytic hand

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Principles

Radial nerve palsy
Median nerve palsy
Ulnar nerve palsy
Etiology

• Trauma (wound - gun shot - crush)
• Infection
• Degenerative (tunnel carpal syndrome - syringomyelegia - amyotrophic lateral sclerosis)
• Leprosy
Hand muscle groups

Synergistic muscle groups:
- Wrist extensors + fingers flexors + finger adductors
- Wrist flexors + finger extensors + finger abductors

First choice: transfer of synergistic muscle
Quantitative Evaluation of muscles

- **Tension capability**: the Percentage of the combined tension of all muscles under the elbow

- **Distance (excursion)**: the average fiber length in physiologic rest
Muscle strength

**MRC system:**

- **Grade 0** *Zero*: no contraction
- **Grade 1** *Trace*: palpable contraction
- **Grade 2** *Poor*: move joint but not against gravity
- **Grade 3** *Fair*: move joint against gravity
- **Grade 4** *Good*: moves against gravity and resistance
- **Grade 5** *Normal*: normal strength
Changes after paralysis

**Passive structures:** tendon sheaths - ligaments - paratenon - areolar tissue skin.

- Tissues undergo structural changes to adapt to the new length and to restore the resting tension.
- Hand unbalance
Changes after transfer

**Muscle strength:**

Loss of one grade

- **The cause:**
  - It's not loss of tension
  - It's because changes of elastic properties of passive soft tissue.

- **Prevention:**
  - No fascia or immobile tissues cut in the same wound
  - Use of tendon-tunneling forceps
  - Rehabilitation
Changes after transfer

Muscle excursion:
To lengthen a muscle:
- attach the transferred muscle at a tension just above normal resting tension
- casting in a position to relax the tension
Mechanical balance

- Moment (torque) = muscle tension * lever arm
  - Weak muscle may produce high moment with a long lever

- Excursion = moment arm (cm) * angle degree (radian)
Mechanical balance
Planning for tendon transfer

• Work and Attitude of the Patient:
  - Best results:
    • The patient is self-employed
    • Has no one to blame
    • Wants to return to his work
  - Poorest results:
    • The patient blame someone
    • Financial rewards
    • Poor self imaging
  - young or elderly
  - Hand worker or retired
  - Acceptance of the operation
Technical considerations

- A muscle suitable for transfer = dark pink or red
- A muscle not suitable = pale pink / smaller than normal / less excursion
- The straighter the muscle, the more efficient its action
- If an acute angle is necessary, a pulley must be created
- Protect neurovascular bundle
Technical considerations

- Synergic muscles are the best for transfer.

- Transferred tendon must be passed subcutaneously (with exceptions)

- If a transferred tendon must pass through carpal tunnel, it must be deep to all tendons and sheaths.

- Equalize tension on the slips at time of attachment
Technical considerations

- Avoid longitudinal incisions along the path of transfer, protect from adhesions
- Use of tendon tunneler
Technical considerations

• Take care not to cause dynamic imbalance after transfer.
• Supple and mobile joints.
• Splint after operation:
  - position the transferred tendon in relaxation.
  - the functional position of the hand:
    • wrist dorsal flexion
    • MP joint 90°
    • PIP&DIP extended
Trick movements after paralysis

The good patient finds a way around his disability

Problems:
- Tissues become stretched
- The trick may persist after tendon transfer
Trick movements after paralysis

Lateral squeez pinch
- Low ulnar median palsy
- Both (FPL+EPL)
  - Adduction
  - (IP+MP) joints flexion
  - CM joint extension
Trick movements after paralysis

Lateral squeeze pinch cont.

- Late deformity:
  - Flexion contracture (IP joint)
  - Shortening of the web
- Prevention: C splint for the thumb
- Management:
  - EPL from between ulna and radius to its stump
    - Early rehabilitation
    - Best for elderly
  - Abductor opponens
    - Difficult for rehabilitation
Timing of transfer

• Requirement in waiting period:
  - Satisfactory range of passive joint motion
  - Proper splinting - ligamentous release
    (protect from stiffness and joint contracture)
  - Correcting bone malalignment.
  - Restore sensibility
Timing of transfer

- Irreparable nerve loss:
  - As soon as possible + tissue homeostasis

  Tissue homeostasis:
  - Normal skin mobility
  - Joint mobility
  - Hand volume
  - Skin temperature
Timing of transfer

- **Repaired nerve:**
  - Wait until no muscle recovery is possible
  - Recovery of sensibility of the limb
- **Prognosis of muscle recovery:**
  - **Good:**
    - nerve repair is accurate without tension
    - In the same limb segment as the affected muscle
  - **Fair:** in the limb segment proximal to the muscle
  - **Poor:** in two segments proximal to the muscle
- **Early transfer:** must not leave imbalance in donor site.
Timing of transfer

• Repaired nerve cont.
  - The time of waiting for recovery
    • 3 years in brachial plexus paralysis
    • 2 years in peripheral nerve in the arm
    • 18 months in the forearm - wrist lesions
Timing of transfer

- Degenerative lesions:
  - Probability of expansion
    Pay attention = weakness in the transferred muscle
  
  In leprosy: neurolysis may protect from aggravation
Radial nerve palsy
Radial nerve

- Posterior cord (Brachial plexus)
- C5→C8 (most from C7)
- In the arm:
  - Between the medial and long heads of triceps
  - Direct contact with humerus: 10 cm proximal to lateral epicondyle
  - Branches:
    - Triceps (unlikely to paralyze in humerus fractures)
    - Brachioradialis
    - ECRL
    - Often to brachialis (musculocutaneous n.)
Radial nerve

- Bifurcation: at the level of lateral epicondyle (4cm above and below it)
  - Two branches:
    - Superficial (sensor)
      - Goes under brachioradialis
      - Sense: Dorsum of the write and hand (lateral part)
      - Motor: ECRB (56%)
    - Deep (posterior interosseous n.)
      - Goes between two heads of supinator
      - Motor: EDC - EDM - ECU - APL - EPL - EPB - EIP
      - Motor: ECRB (36%)
      - terminal sensor branches
Radial nerve palsy

**Etiology:**

- **Penetrating injuries** (lower arm - upper forearm)
- **Fracture of the humerus:**
  - 2-15%
  - Comminuted fractures in the middle third
  - Holstein-Lewis: spiral oblique fracture of distal humerus
Radial nerve palsy

Wrist drop
Radial nerve palsy

- Neuropraxia, axonotmesis → high recovery rate (intact myelin sheaths)
  
- Neurotmesis → nerve repair/graft → 77% return of some muscle function.
Radial nerve palsy

Principles of treatment:
- Closed fractures / closed injuries:
  - Observation → if no recovery (3-4 months) → neurorrhaphy neurolysis
  - After humerus reduction → early exploration
- Open fractures → exploration + repair
- Delayed palsies → observation
Radial nerve palsy

A dynamic splint with an extension assist for the wrist MP joints of the fingers and abduction or extension assist for the thumb.
# Radial nerve palsy

## Table 55.1. Transfers for Radial Nerve Palsy

<table>
<thead>
<tr>
<th>Transfer</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Standard” transfer</td>
<td>Requires little retraining</td>
<td>Unable to extend fingers and wrist simultaneously</td>
</tr>
<tr>
<td></td>
<td>Predictable</td>
<td>Dominance of radial forces across the wrist</td>
</tr>
<tr>
<td>FCR transfer</td>
<td>Maintains FCU as an ulnar wrist flexor—important in heavy laborer</td>
<td>Unable to fully extend fingers &amp; wrist simultaneously</td>
</tr>
<tr>
<td>Modified Boyes transfer</td>
<td>Able to extend wrist and fingers simultaneously; independent control of</td>
<td>Potential flexion or extension deformities of the donor finger</td>
</tr>
<tr>
<td></td>
<td>index and thumb from other fingers for pinch</td>
<td>PIP joints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transfer not synergistic with potential for difficult rehabilitation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potential for adhesions at interosseous membrane</td>
</tr>
</tbody>
</table>

ECRB, extensor carpi radialis brevis; PT, pronator teres; EDC, extensor digitorum communis; FCU, flexor carpi ulnaris; PL, palmaris longus; EPL, extensor pollicis longus; FCR, flexor carpi radialis; APL, abductor pollicis longus; EPB, extensor pollicis brevis; EIP, extensor indicis proprius; FDS III, flexor digitorum superficialis to the long finger; FDS IV, flexor digitorum superficialis to the ring finger.
Radial nerve palsy - Standard
Radial nerve palsy – FCR transfer
Radial nerve palsy – FCR transfer

- Extensor digitorum communis
- Flexor carpi radialis
- Third dorsal wrist compartment
- Extensor pollicis longus
- Extensor pollicis longus tendon
- Palmaris longus
Radial nerve palsy

Postoperative care:
• Splint:
  - Wrist + fingers = full extension
  - Thumb = full extension + abduction
  - Elbow = 90° flexion
  - Forearm = neutral
• After 10 days → suture removal → long arm cast
• After 3 months: splint + physiotherapy
  » Wrist 45°
  » MP joints = 20° flexion
  » PIP – DIP joints free
Radial nerve palsy

Posterior interosseous palsy:
- Brachioradialis + ECRL + ECRB: intact
- Technique:
  • The same

We do not use FCU: to retain ulnar deviation force
Radial nerve palsy

Early tendon transfer: PT for ECRB

- Internal fixation (brace free)

- Indications:
  - Poor prognosis for nerve recovery
  - High radial n. laceration
  - Long nerve graft
  - Job related conditions (bracing)
Radial nerve palsy

Pitfalls & complications:

• Flexion or hyper extension contracture of PIP joint
  After FDS transfer
• rehabilitation
Median nerve palsy
Median nerve

- **Medial and lateral roots (Brachial plexus)**
- **In the arm:**
  - with brachial artery (in front of it)
  - Branches:
    - Sympathetic branches for brachialis a.
- **In the elbow:**
  - Medial to brachial artery
- **In the forearm:**
  - Between two heads of pronator teres then posterior to FDS
- **At the wrist:**
  - Behind palmaris longus
Median nerve - Anatomy

1. Branches to: pronator teres - plmaris longus - flexor carpi radialis - flesor digitorum superficialis

2. Anterior interosseous nerve:
   • Motor deep muscles (flexor digitorum profundus II_III - pronator quadratus - flexor pollicis longus)
   • Sensory: wrist - carpal joints

3. Between FDS - FDP
4. Palmar cutaneous branch
5. Carpal tunnel
6. Branch to thenar eminence
7. Branches two radial lumbricals - digital nerves
Median nerve - sensation
### Median nerve

#### Table 56.1. Muscles Innervated by the Median Nerve

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexor Carpi Radialis (FCR)</td>
<td>Wrist Flexion</td>
</tr>
<tr>
<td>Palmaris Longus (PL)</td>
<td>Wrist Flexion</td>
</tr>
<tr>
<td>Pronator Teres (PT)</td>
<td>Forearm Pronation</td>
</tr>
<tr>
<td>Pronator Quadratus (PQ)</td>
<td>Forearm Pronation</td>
</tr>
<tr>
<td>Flexor Digitorum Superficialis (FDS)</td>
<td>PIP Flexion</td>
</tr>
<tr>
<td>Flexor Digitorum Profundus (FDP)</td>
<td>PIP and DIP Flexion</td>
</tr>
<tr>
<td>Flexor Pollicis Longus (FPL)</td>
<td>IP Thumb Flexion</td>
</tr>
<tr>
<td>Abductor Pollicis Brevis (APB)</td>
<td>Thumb Palmar Abduction, Pronation</td>
</tr>
<tr>
<td>Opponens Pollicis (OP)</td>
<td>Thumb Pronation</td>
</tr>
<tr>
<td>Flexor Pollicis Brevis (FPB)</td>
<td>Thumb MP Flexion</td>
</tr>
</tbody>
</table>
Median nerve palsy - Examination

• Pronator teres:
  effects more with elbow extended
  ↓
  we examine pronation in flexion and supination
Median nerve palsy - Examination

- FDS: flexion of PIP joint, we hold the remained finger in extension
- FDP: flexion of DIP joint
Median nerve palsy - Examination

• FPL: flexion of IP joint
Median nerve palsy - Examination

- Thumb opposition:
  - Palmar abduction of the thumb
  - Flexion of the MP joint
  - Pronation of the thumb
  - Radial deviation of the proximal phalanx
  - Motion of the thumb towards the fingers

  The APB is the most important

Extrinsic muscles: stabilize the MP-IP joints while the CM joint is free
Median nerve palsy - Examination

**Normal hand**
Thumb is perpendicular to plane of palm

**Median nerve lesions**
Thumb is externally rotated into plane of palm. Thenar eminence is wasted.
Median nerve palsy - opposition

Trick movement: the pinch is at the base of the thumb.

↓

Fixed adduction and external rotation of the thumb
Median nerve palsy

**Etiology:**
- Trauma (laceration - traction - fracture - gun shot)
- Chronic compression neuropathy
- Diabetic peripheral neuropathy
- Viral and leprematous infection
Median nerve palsy

- Neurorrhaphy of median nerve has poor prognosis (despite microsurgical techniques)
- Joint fusion:
  - Especially in FDP palsy (normal FDS)
    - Simple operation
    - does not restore mobility.
- Tendon transfer:
  - Require surgical skill - rehabilitation
  - Restore mobility
Median nerve palsy - opposition

Non surgical concepts:
- Frequent range of motion
- Opposition splint
Median nerve palsy - opposition

Surgical concepts:
• Release contractures (web space)
  - Dividing the fascia
  - Z plasty of the web
  - CM joint arthrodesis
  - Excision of the trapezium
• Correct the rotation deformity (fusion):
  - MP joint in 15° with slight internal rotation.
  - IP joint in 20°
Median nerve palsy - opposition

Surgical concepts cont.:

- **Tendon transfer:**
  - Force must pull from the direction of pisiform (parallel to APB)
  - Insertion is to the tendon of APB.
  - Choices: FDS - EIP - EDQ - ECU - PL - ADQ - FPL - ECRL
Median nerve palsy - opposition

Transfer of FDS of ring finger (Riordan)

- Rehabilitation: to bring the thumb to the ring finger
Median nerve palsy – opposition

EIP transfer
Median nerve palsy - opposition

FCU with FDS ring finger (Groves-Goldner)

• Extension of the wrist provides opposition of the thumb
Median nerve palsy - opposition

ADQ transfer
Postoperative care:

- 4 weeks of immobilization:
  - Wrist = 30° palmar flexion
  - MP joint = maximal flexion
  - PIP – DIP = 20 flexion
  - Maximal thumb abduction

- Then:
  - Physical therapy
  - Gentle resistance at 6 weeks
Median nerve palsy

- Tendon transfer for FPL palsy:
  - Choices:
    - FDS: not available in high median nerve palsy (fusion is the choice)
    - Brachioradialis

- Tendon transfer for FDP palsy:
  - FDP (side to side)
  - ECRB
  
  If FDS isn’t available → DIP joint fusion
Median nerve palsy

**Pitfalls and complications:**
- Uncorrected preoperative joint stiffness
- Surgical technique
- Rehabilitation
- Swan neck deformity after FDS use.
Ulnar nerve palsy
Ulnar nerve

- **Medial cord (Brachial plexus)**
- **C8 – T1**
- **In the arm:**
  - Medially in the flexor compartment
  - In the lower third: pierces the intermuscular septum → behind medial epicondyle
  - No branches in the arm
- **In the forearm:**
  - Between two heads of FCU then under it
- **In the wrist:**
  - Across the front of the flexor retinaculum
Ulnar nerve

- Dorsal ulnar cutaneous nerve
- Palmar cutaneous sensory branch
- Hypothenar motor branch
- Digit sensory branch
- Intrinsic muscles
Ulnar nerve

- **Motor:**
  - FCU
  - FDP (ring and little finger)
  - Interosseous muscles (dorsal - palmar)
  - Lumbricalis (III - IV)
  - Hypothenar group (ADQ - FDQ - ODQ)
  - Adductor pollicis

- **Sensor:** medial part of hand - IV, V fingers
Ulnar nerve- Sense

1- ulnar n.  2- median n.  3- radial n.
Ulnar nerve palsy

May affect the:

• Flexion and ulnar deviation of the wrist
• Flexion of ring and little fingers
• Independent flexion of MP joint of all fingers
• IP joint extension
• Abd. Add. Of all fingers
• Add. Flexion of CM joints
• Add. Flexion of thumb MP joint
Ulnar nerve palsy - FCU

**FCU** : the strongest in the forearm
- Important in : humming - use the knife - swing an ax
- High ulnar paralysis → paralysis of FCU :
  - Feel of weakness
  - No loss of function
  - No need to transfer : may be ( FCR )
Ulnar nerve palsy - FDP

FDP (ring - little fingers)

High ulnar palsy

\[ \downarrow \]
- Weakness
- Reversal of the metacarpal arch

Choices:

- Side to side suture of FDP
- ECRL transfer (rebalance the wrist)
Ulnar nerve palsy - MP joint

- MP joint extension
- No full IP extension

Claw hand
Ulnar nerve palsy- grasp

- normal grasp → flexing from proximal to distal
- Paralysis → MP extension + flexed IP joint (claw hand)
Ulnar nerve palsy – grasp
Ulnar nerve palsy - grasp
Ulnar nerve palsy – grasp

Pressure sores
Ulnar nerve palsy – grasp

To Prevent MP extension:
Tenodesis – capsulodesis - bone block
Ulnar nerve palsy - IP joints

**IP joint extension:**

- **three mechanisms**
  - Lumbricalis + interosseous (lateral band)
  - Long extensors (MP joints are flexed)
  - Lumbricalis
Ulnar nerve palsy – IP joints

Bouvier manoeuvre:

3 possibilities:
– Easy extension
– Hard extension
– No extension
Ulnar nerve palsy – IP joints

**IP extension transfer:**

- **Tendon transfer to lateral bands** *(Steiles-Bunnell)*
  - MP flexion with PIP extension
  - May cause: swan neck deformity

- **Tendon transfer to flexor sheaths** *(Brooks-Zancolli)*
  - PIP extension by long extensors
Ulnar nerve palsy

Abd. Add. Of fingers:
- 8 tendons of interosseous muscles
  (dorsal-abductors & palmar-adductors)
- Most tasks are done with fingers adducted.
Finger Add. transfer:
- The purpose is to put fingers side to side
- Attached to radial side of III-IV-V fingers and ulnar side of II
- Index abductor (stable pinch)
Ulnar nerve palsy - pinch

**Normal pinch**

**With index abducted**

**With index adducted**

**Key pinch**
Ulnar nerve palsy- Choices for intrinsic transfer

FDS of ring finger + grafts ↓
Attach to extensor aponeurosis ↓
Become PIP extensors (MP flexion with PIP extension)

Complication:
- Swan-neck deformity
Habit of wrist flexion:
- An attempt to extend the IP joints
- It creates tenodesing effect on the long extensors

\[ \downarrow \]

Failed Bunnell modified transfer

\[ \downarrow \]

Riordan transfer
Ulnar nerve palsy- Choices for intrinsic transfer

**FCR**
- Transferred to the dorsum
- + 4 tendon grafts
  ↓
  Attach to radial sides of extensor apponeurosis

**Indication:**
- Sever clowing hand
- Flexion contracture of the wrist
- Flexion habit

**Riordan transfer**
Ulnar nerve palsy- Choices for intrinsic transfer

ECRB
Lengthened by tendon grafts
↓
Radial side of III-IV-V
+
ulnar side of II

Difficulty of reeducation

Brand transfer
Ulnar nerve palsy - Choices for intrinsic transfer

FCRL
To the volar side of forearm
↓
Through carpal tunnel
↓
4 tendon grafts
↓
The same attachments

Brand transfer
Ulnar nerve palsy- Choices for intrinsic transfer

**Indication:**
Weak flexors-extensors

**Fowler transfer**
Ulnar nerve palsy - Choices for intrinsic transfer

PL + EIP
↓
4 tendon grafts
↓
The same attachments

Riordan transfer
(fowler modification)
Ulnar nerve palsy – Pitfalls

Insertion to the lateral band (extensor appeneurosis)

↓

» MP flexion + PIP extension
» No MP flexion without PIP extension
» May produce swan-neck deformity

Modification:
Brooks-Jones: insertion to the flexor sheaths
MP flexion + IP extension with long extensors
Ulnar nerve palsy – Pitfalls

Zancolli (lasso operation)

FDS of each tendon to flexor sheaths

MP flexion

+ IP extended with long extensors

Complication:

• No PIP flexion
• DIP persistent flexion

↓
Ulnar nerve palsy – Pitfalls

- Flexion of PIP with DIP
- Provides more satisfactory hand
Ulnar nerve palsy- Capsulodesis

Zancolli capsulodesis:
Supple MP joints  (Bouvier = easy extension)
Make MP flexion (40° - 30° - 20° in V - IV - III)
Ulnar nerve palsy - Capsulodesis

Zancolli capsulodesis
Post operative
Ulnar nerve palsy - Tenodesis

4 tendon grafts
Inserted to extensor carpal ligament

Fowler tenodesis
Ulnar nerve palsy - Tenodesis

Riordan tenodesis

Tendon strands fro ECRB - ECU
Ulnar nerve palsy - thumb adduction
Ulnar nerve palsy - thumb adduction
Ulnar nerve palsy - thumb adduction

FDS IV

↓

Around palmar fascia

↓

Insertion to

- EPL
- APB

Brand technique
Ulnar nerve palsy - thumb adduction

BR – ECRL – ECRB
With tendon graft
↓
To adductor brevis insertion
Ulnar nerve palsy- thumb adduction

Smith technique
ECRB transfer through 2\textsuperscript{nd} space
Ulnar nerve palsy - thumb adduction

EIP transfer
References

- Chapma’s Orthopedic surgery
- Campbell’s Orthopedic surgery
• This lecture is one of a series of lectures were prepared and presented by residents in the department of orthopedics in Damascus hospital, under the supervision of Dr. Bashar Mirali.

• This site is not responsible of any mistake may exist in this lecture.

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