

# Principles of tendon transfers

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# Principles

- Indications
- Prerequisites
- Technique
- Strategy of repair
- Alternatives



# Indications

## 1 - Nerve lesion

Traumatic nerve injury

- Nerve trunk
- Brachial plexus
- Spinal cord (tetraplegia)

- unrepaired, unrepairable
- repaired but failed



# Indications

## 2-Muscle or tendon lesion

- Posttraumatic rupture  
distal radial fracture (EPL)



# Indications

## 2-Muscle or tendon lesion

- Muscle defect  
complex arm/forearm trauma



# Indications

## 2-Muscle or tendon lesion

- Posttraumatic ischemia  
Volkman's contracture



## Indications

### 2-Muscle or tendon lesion

- Rheumatologic disease
- tendon rupture



## Indications

### 3 - Central lesion

- Neurologic disease
- Cerebral palsy
- Head injury
- Stroke...



## Indications

### 4 - Neuro-muscular disease

- Charcot-Marie-Tooth
- Myopathy...



## Indications

### 5 – Congenital malformations

- Arthrogryposis
- Thumb hypoplasia...



## Prerequisites



## Prerequisites

1. Local
  - skin coverage
  - skin flap







## Prerequisites

1. Local
  - skin coverage
  - supple joints
  - arthrolysis





## Prerequisites

1. Local
  - skin coverage
  - supple joints
  - stable joints
  - stabilization


## Prerequisites

1. Local
  - skin coverage
  - supple joints
  - stable joints
  - discriminative sensation (relative)




## Prerequisites

2. General
  - Patient's cooperation
    - IQ (relative)
    - behaviour problems
    - realistic expectations
    - motivation
  - Age
    - elderly
    - very young ?



## Prerequisites

3. Postoperative regimen
  - Physiotherapy
    - daily basis
    - trained physiotherapist
  - Medical and familial environment



## Timing of surgery



## Timing of surgery varies according to pathology

Posttraumatic nerve injury  
no clinical / EMG progression

- Unreparable:  
Brachial plexus : 6-9 months  
Tetraplegia : 9-12 months
- Repaired but failed:  
1 year post repair



## Timing of surgery varies according to pathology

Neurologic disease

Non progressive



## Technique



## Technical principles

Choice of motor

Direction of transfer

Tension of transfer

Distal insertion



## Technical principles

Choice of motor

MRC scale

- Grade 0 : no response
- Grade 1 : palpable contraction
- Grade 2 : active movement with gravity
- Grade 3 : movement against gravity
- Grade 4 : movement against resistance
- Grade 5 : normal



## Technical principles

### Choice of motor

- BMRC 4 and +
  - Full movement against resistance
  - No muscle fatigue
  - Some muscles are difficult to assess



Testing of Brachioradialis



## Technique

### Choice of motor

- BMRC 4 and +
- Similar length
  - Avoid grafts



ex: ECRL to fingers: graft



## Technique

### Choice of motor

- BMRC 4 and +
- Similar length
- No potential deficit at donor site



Donor : FCR



Donor : FPB

-MPj arthrodesis

-or distal re-attachment



## Technique

### Choice of motor

- BMRC 4 and +
- Similar length
- No potential deficit at donor site
- Agonist of the movement to be restored

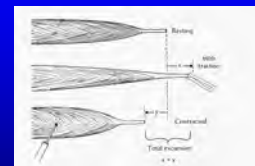
ex: finger flexor to wrist extensor



## Technique

### Choice of motor

- Similar excursion
  - Wrist tendons: 33mm
  - Finger extensors: 50mm
  - Finger flexors: 70 mm



Smith, 1987

example : BR(25) to FDP(70) = no



## Technique

### Choice of motor

- Similar excursion
- Similar power

Power  $\approx$  muscle cross-sectional area

\*Physiologic Cross Section (PCS)

= muscle volume / mean fiber length

\*Tension fraction

= PCS / sum of PCS



## Tension fraction

Supinator*	7.1	EDC (middle finger)	1.9
FCU	6.7	OP*	1.9
PI*	5.5	Fourth Di	1.7
ECU	4.5	EDC (ring finger)	1.7
ECRB	4.2	ADQ	1.4
FCR	4.1	EPL	1.3
ECRL	3.5	FPB	1.3
FDP (middle finger)	3.4	First Pi	1.3
FDS (middle finger)	3.4	Second Pi	1.2
First Di	3.2	PL	1.2
APL	3.1	APB	1.1
AP	3.0	EDC (index finger)	1.0
FDP (ring finger)	3.0	EDQ	1.0
PQ*	3.0	EIP	1.0
FDP (little finger)	2.8	Third Pi	1.0
FDP (index finger)	2.7	EDC (little finger)	0.9
FPL	2.7	FDS (little finger)	0.9
Second Di	2.5	EPB	0.8
BR	2.4	FDQ	0.4
Third Di	2.0	Lumbrical (index finger)	0.2
FDS (index finger)	2.0	Lumbrical (middle finger)	0.2
FDS (ring finger)	2.0	Lumbrical (ring finger)	0.1
ODQ*	2.0	Lumbrical (little finger)	0.1



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Ex : BR to FPL  
PL to wrist extensors



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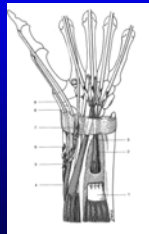
Ex : BR to FPL  
PL to wrist extensors



## Technique

### Direction of transfer

- Direct route (straight line of pull)
  - Proximal dissection of muscle body
  - Wide subcutaneous tunnel
  - Through interosseous membrane ?



## Technique

### Direction of transfer

- Avoid pulleys
  - But they are sometimes necessary



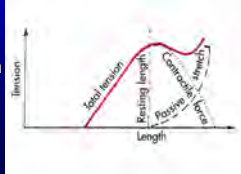
## Technique

### Tension of transfer

One of the critical factors

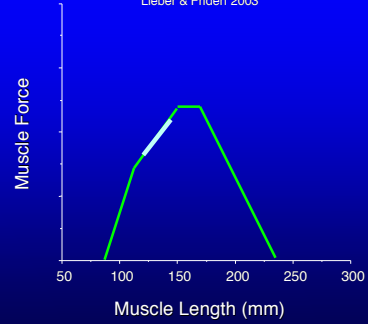
### Tension-length curve (Blix curve):

as one increases passive stretch  
contractile forces decrease



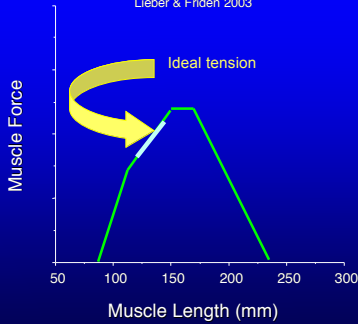
## Posterior Deltoid-to-Triceps Tendon Transfer

Lieber & Friden 2003



## Posterior Deltoid-to-Triceps Tendon Transfer

Lieber & Friden 2003



## Technique

### Tension of transfer

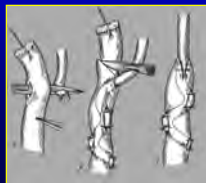
- No objective per-op measurement
- Temporary suture: physiological tension  
(evaluated with the tenodesis effect)
- Slightly superior to physiological tension

⇒ personal experience

## Technique

### Distal insertion

- To tendon  
Resistant but non adherent and non-ischemic  
→weaving Pulvertaft  
→fine nonabsorbable sutures
- To bone  
Bone anchor



## Strategy of repair

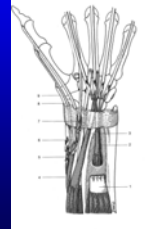
## Strategy of repair

1- One transfer for one function



## Example radial palsy

- One transfer for wrist extension
- One transfer for finger extension
- One transfer for thumb extension



## Example thumb abduction

Insérer film



## Strategy of repair

2- Several options according to the patient's needs

- ex: Radial palsy
- Heavy manual worker: leave FCU in place
  - Otherwise : use FCU for transfer



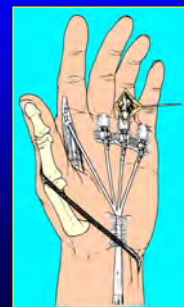
## Strategy of repair

3- Depends of extent of paralysis  
Normally 39 muscles to activate the hand and wrist

→ Simple paralyse (1 nerve trunk)  
Repair all functions



## Strategy of repair



Ex: distal ulnar palsy





## Strategy of repair

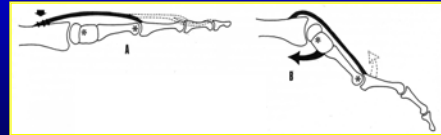
3- Depends of extent of paralysis  
Normally 39 muscles to activate the hand and wrist

→Complex paralyse  
Example tetraplegia: 1 muscle available  
Restore the most important function + additional procedures



## Strategy of repair

4- The tenodesis effect  
Automatic movement of one joint activated by another joint



## Strategy of repair

Wrist flexion (through gravity)  
= automatic finger extension  
Wrist extension  
= automatic pinch  
=potentialize finger flexion



Think twice before fusing the wrist



## Strategy of repair

5- Additional procedures  
Joint fusions (thumb)  
Tenodeses

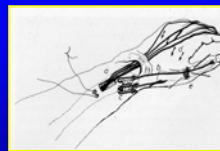


## Alternatives

Tenodesis  
Arthrodesis  
Nerve transfer, neurotization  
Free muscle transfer



## Tenodesis




Passive (Zancolli)




## Tenodesis

Active (Zancollli)



## Tenodesis

Gilbert




## Alternatives

Arthrodesis




## Alternatives

Nerve transfer, neurotization



## Alternatives

*Ex: transfer of AIN to motor branch of ulnar nerve (Wang & Zu 1997)*



## Alternatives

Free muscle transfer



## Conclusion

1 - Tendon transfers are effective procedures  
provided one follows a few basic principles

2 - No standard procedure:  
each case is different



## Conclusion

3 - Good knowledge of muscle anatomy  
and biomechanics

4 - Experience

5 - Imagination !

