A Long term journey : Managing Complication & SURGICAL REHABILITATION OF UPPER LIMB IN TETRAPLEGIA

PC Ho, WL Tse, Marc Yang

Hand & Microsurgery Team

Department of Orthopaedics & Traumatology
Prince of Wales Hospital

SURGICAL REHABILITATION OF UPPER LIMB IN TETRAPLEGIA

- Need for upper limb rehabilitation
- Early active management
- Patient assessment
- Surgical plan & execution
- Outcome of treatment
- Future trend

WHY is there the need ?

- Majority are young adult (Ditunno 1994)
  - between 16-30 59%
  - Male 82%
- Initial Survival 94%
- Normal life expectancy 88%

The Concern

- Most survivors are of C6 segmental level (EA Zancolli 75%, D Lamb 67%)
- 75% wish to have upper limb function restored (Hanson & Franklin 1976 , Snoek 2001)

THE NATURAL DESIRE FOR HAND FUNCTION

- Self care
- Work
- Leisure
- Sex
- Independence
- Self-confidence & esteem
- Humanity……

THE PROBLEMS

- Lack of single hand grip
- Lack of strong grasp
- Lack of rapidity
- Lack of dexterity
- ……

DW LAMB (1987)

“ There can be few more catastrophic injuries for a young person at the height of physical powers than an injury of the cervical spine with complete cord damage”

How much can we offer to help these poor patients ?

GOAL OF MANAGEMENT OF UPPER LIMB

1. Prevention of complication

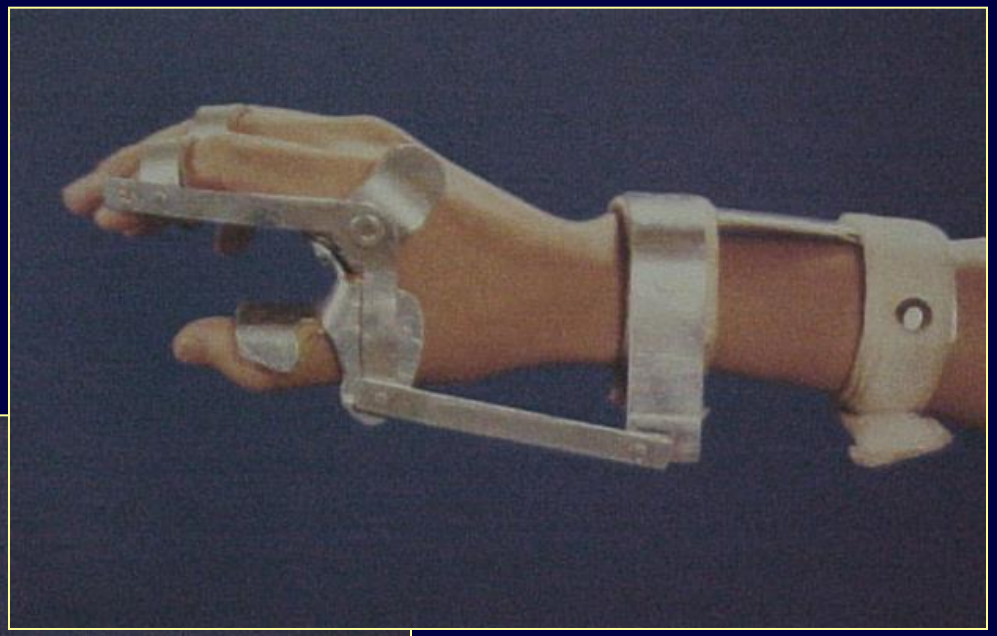
2. Correction of deformity

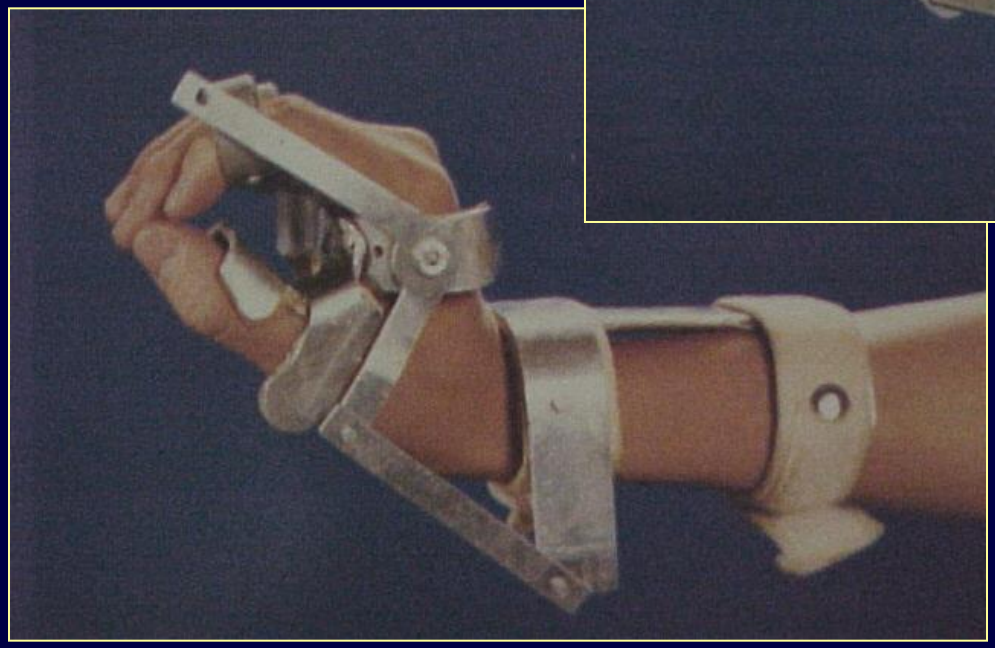
3. Improvement of function

TREATMENT MODALITIES TO IMPROVE FUNCTION

1. Orthrosis & Adaptive Devices
2. Surgical Reconstruction
3. Neuroprosthesis
4. Combination of Procedures

ORTHROSIS & ADAPTAIVE DEVICES

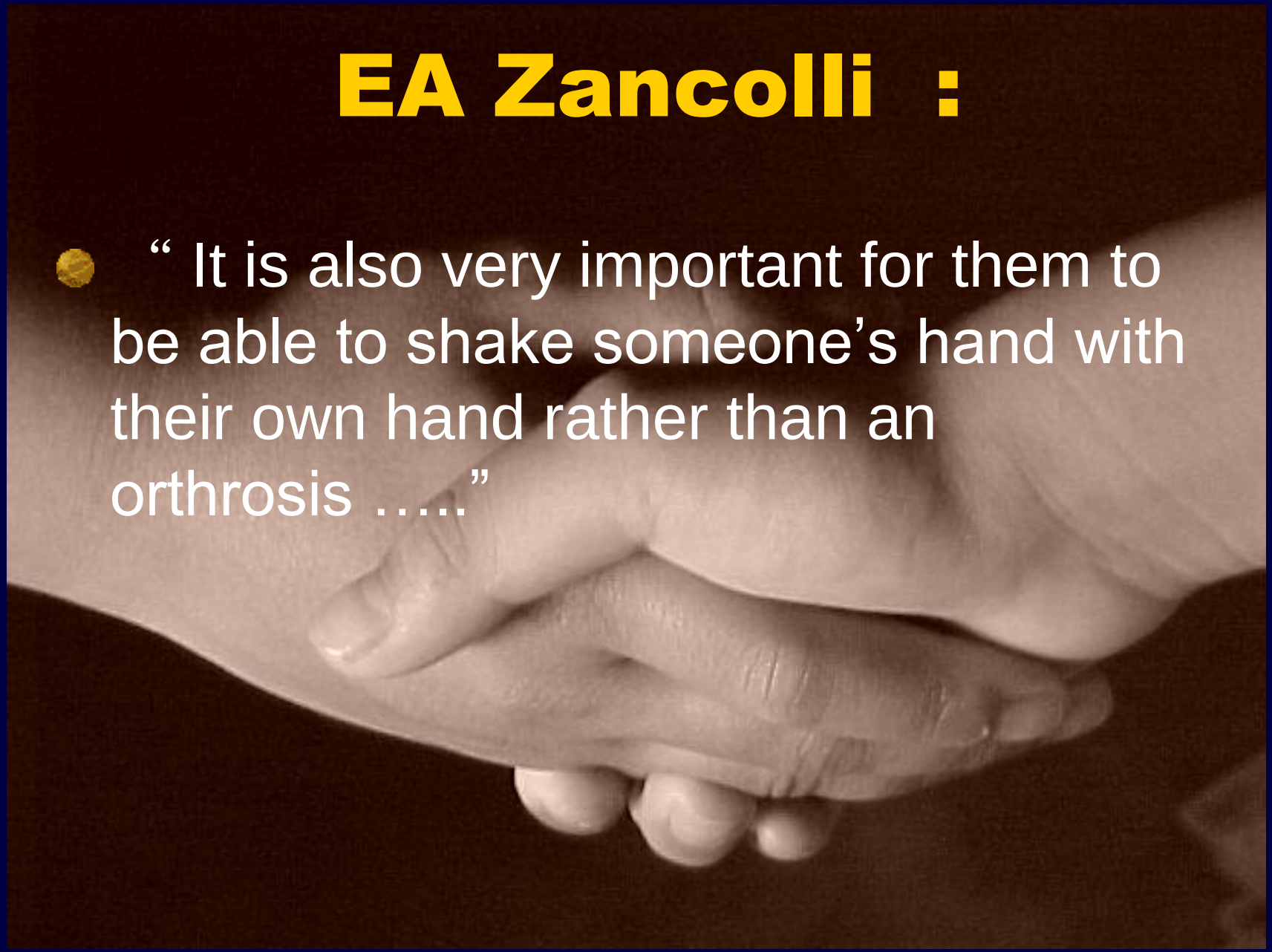




Wrist Driven
Flexor-hinge Splint

EA Zancolli :

- “ It is also very important for them to be able to shake someone’s hand with their own hand rather than an orthrosis …..”



DIFFICULTIES IN SURGICAL RECONSTRUCTION

- Multiple problems
- Less predictable recovery
- Poorer general physique
- Low moral
- Dependency on remaining function

FURTHER MORE ...

- Bilaterality
- Limited motor resources
- More difficult surgery ?
- Higher dependency
- Greater post-op care
- Loss of existing function (temporary)

PLAN OF SURGICAL RECONSTRUCTION

1. Early active treatment
2. Continuous evaluation
3. Classification of patient
4. Ultimate goal of reconstruction
5. Timing & sequence of operation
6. Rehabilitation

EARLY ACTIVE MANAGEMENT

PATIENT EVALUATION

1. SENSORY
2. MOTOR
3. FUNCTIONAL
4. PSYCHO-SOCIAL

CONTINOUS PATIENT EVALUATION

- Neurological recovery take at least 1 year
- Little relationship between level of skeletal injury & spinal cord lesion
- Lesion asymmetrical in 50% of cases (RL Waters 1993)
- Unusual pattern of sensory or motor sparing

SENSORY EVALUATION

- Erik Moberg 1978 :

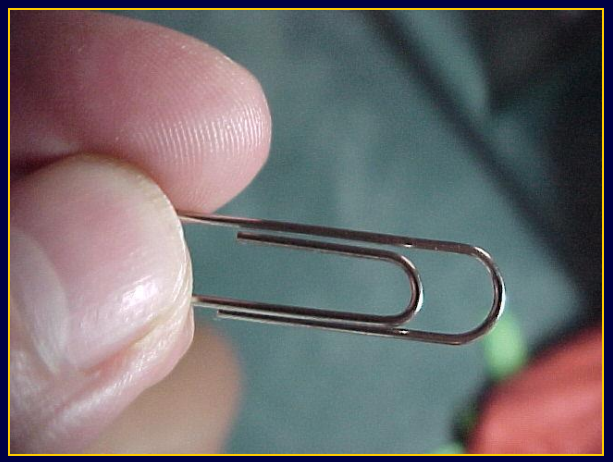
every useful motor grip is just a response to afferent impulses, coming from cutaneous sensibility, vision or the auditory system

TACTILE GNOSIS

essential for learning motor skill

SENSORY EVALUATION

- Weber 2-points discrimination test
  - 2PD ≤10mm ⇒ tactile gnosis +ve

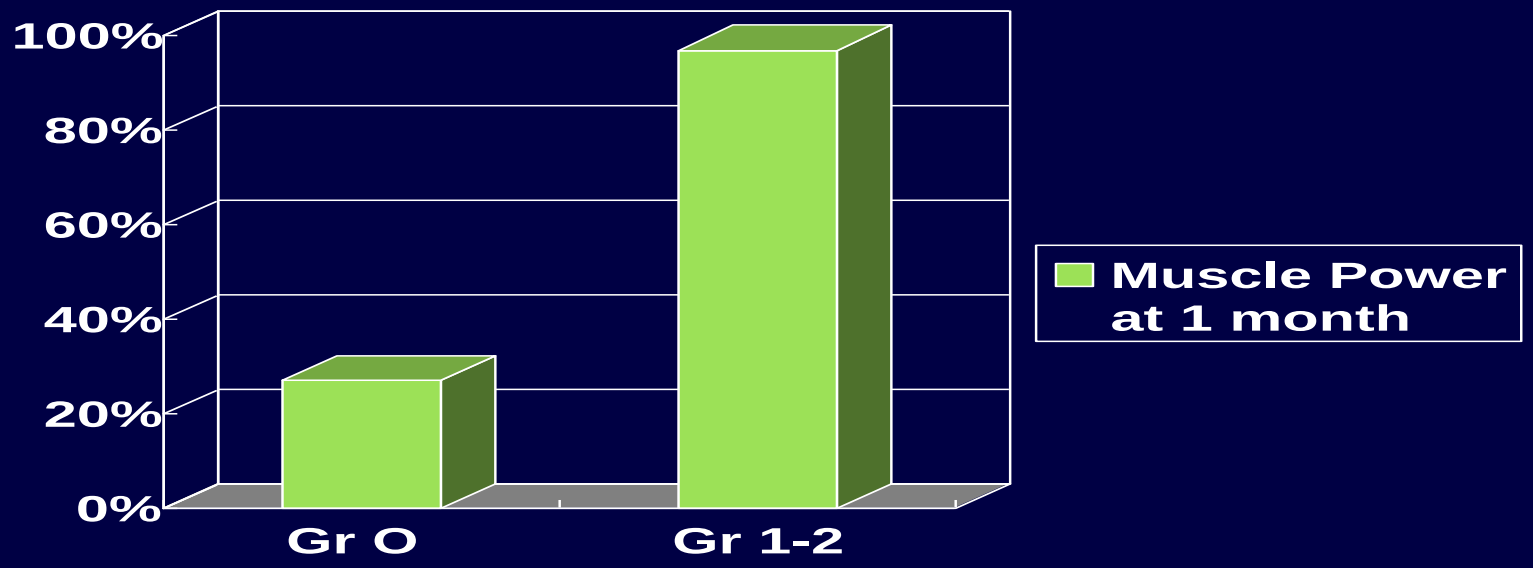


- Vision alone ⇒ reconstruction limited to one hand

Motor Recovery Pattern

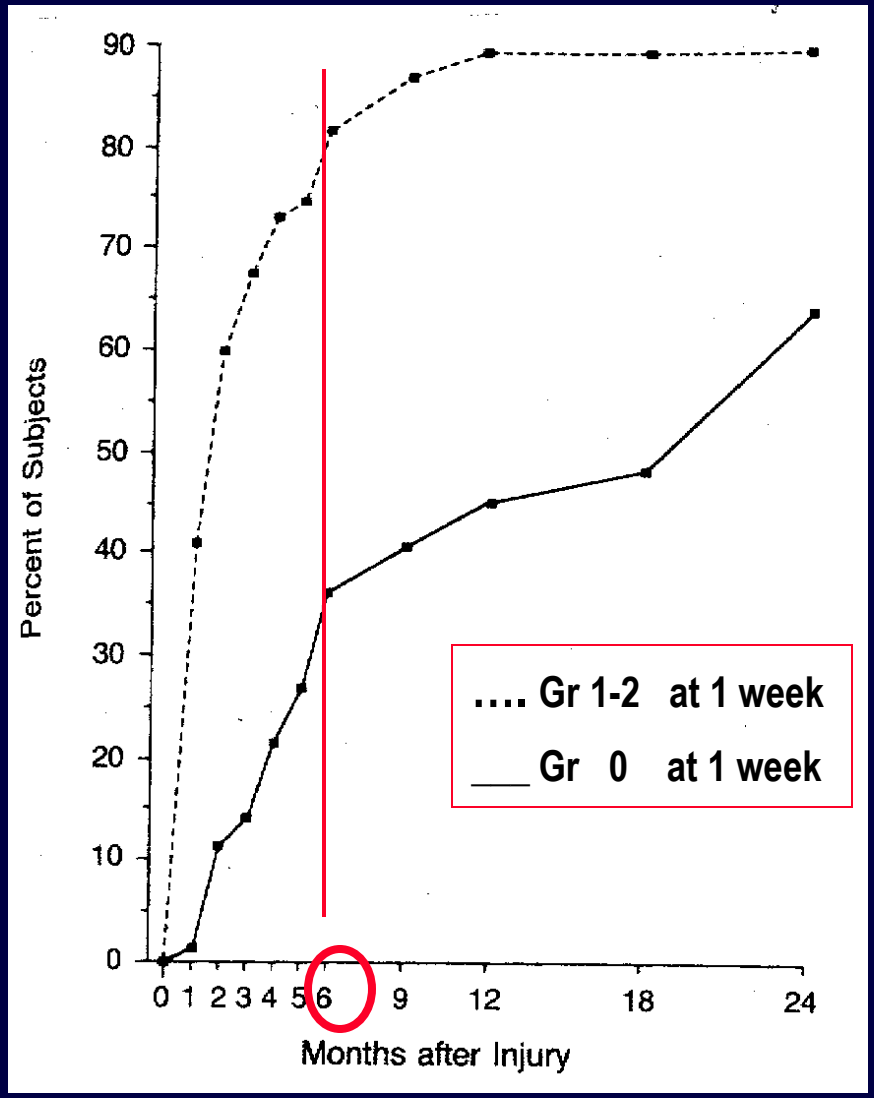
RL Waters et al **Arch Phys Med Rehabil 1993 (n=61)**

- Lower Limb
  - Gr 0/5 at 4/52 ⇒ No recovery in 90%
- Upper Limb
  - Predict recovery to ≥ Gr 3/5 at 1 year



Rate of Motor Recovery

JF Ditunno et al **Arch Phys Med Rehabil 1992 (n=150)**



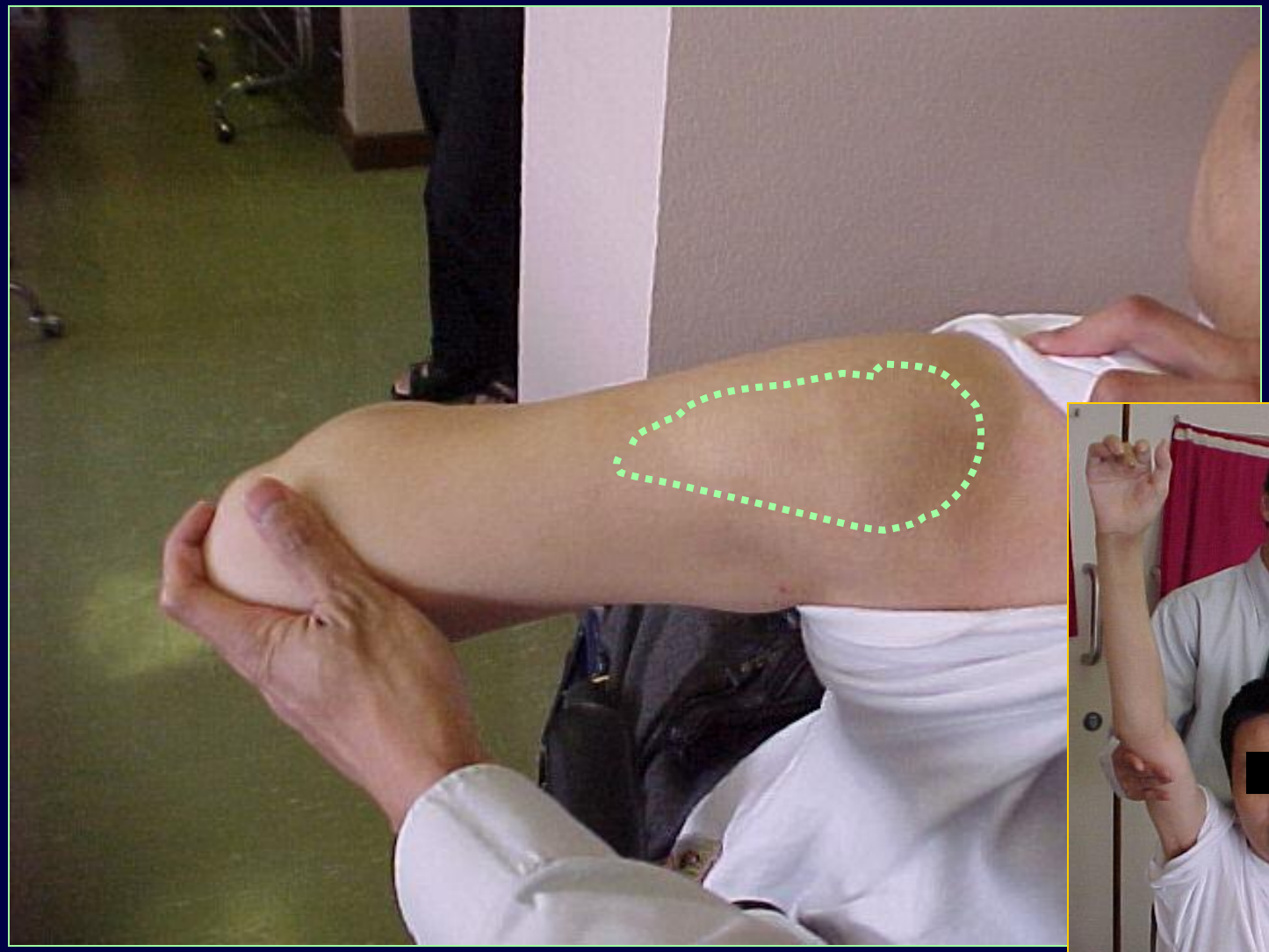
MOTOR EVALUATION

- 3 muscles of central interest :

    1. Deltoid (posterior 1/3)
    2. Brachioradialis
    3. ECRB/ECRL

** Need Gr 4/5 for transfer purpose

Posterior 1/3 Deltoid



Brachioradialis

ECRL / ECRB

Utmost Important to ensure ECRB of Sufficient Strength to avoid Disaster !!

FUNCTIONAL EVALUATION

- Objective hand function test & ADL assessment
  - Jebsen test, Sollerman test
  - Canadian Occupational Performance Measure
    (Mulcahey JHS 2003)
  - Grasp & Release Test
  - Functional Independence Measures (FIM)
- Video recording

PSYCHO-SOCIAL EVALUATION

- psychological adjustment
- motivation
- cooperation
- expectation
- socio-economic status
- family support

PSYCHOLOGY

- The MAJOR obstacle -

- Delicate mind
- Easily influenced by external inputs & belief system
- Strong faith on future technology
- Belief on Miracle

International Classification for Surgery of the Hand in Tetraplegia

Edinburgh 1978

(modified - Giens, France 1984)

CLASSIFICATION OF PATIENT

- practical classification using spared muscles & sensibility
- guide to transfer in forearm & hand, not for shoulder
- each UL may have different classification

INTERNATIONAL CLASSIFICATION

0	No muscle below elbow
1	BR
2	+ ECRL
3	+ ECRB
4	+ PT
5	+ FCR
6	+ Finger Extensors
7	+ Thumb Extensor
8	+ Partial Digital Flexors
9	Lack only Intrinsics
10	Exceptions

** SENSIBILITY O = Ocular sense

OCu = 2PD ≤10mm

ULTIMATE GOAL OF RECONSTRUCTION

- ACTIVE ELBOW EXTENSION
- SINGLE HAND GRIP
- IMPROVE BOTH HANDS IF POSSIBLE

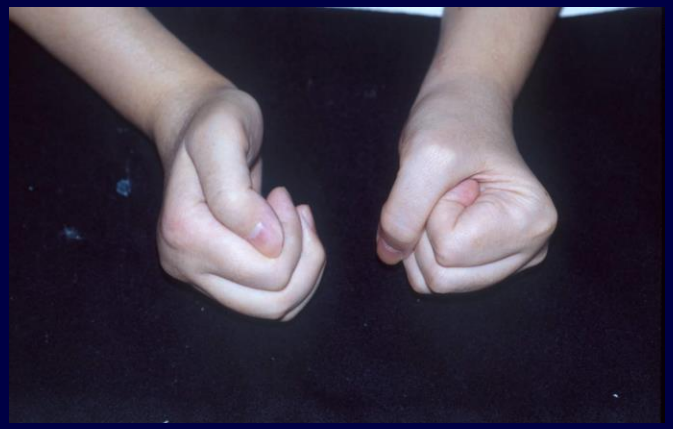
GENERAL PRINCIPLES

1. Timing of operation
   - at least 1 year ?
   - As early as 3 months
2. Resource maximization into 1 or 2 simple functions
3. Minimize no. of operations
4. Never impair existing function
5. Reversibility of surgical procedure

GENERAL PRINCIPLES

6. Always START ON :
   - side with better function
   - side with better sensibility
   - dominant hand first if both are of the same level

7. Create two hands with different functions



GENERAL PRINCIPLES

8. One stage vs two stage key pinch reconstruction & elbow extension procedure

   (Allieu 2001 , Revol 2001, Ejeskar 2004)

BASIC PROCEDURES

1. **ELBOW EXTENSION**

   DELTOID TO TRICEPS TRANSFER

   BICEPS TO TRICEPS TRANSFER

2. **WRIST EXTENSION**

   BRACHIORADIALIS TRANSFER

3. **IMPROVE RELEASE**

   PASSIVE ⇒ EXTENSOR TENODESIS

   ACTIVE ⇒ TENDON TRANSFER

BASIC PROCEDURES

4. IMPROVE GRIP

PASSIVE ⇒ KEY PINCH (TENODESIS)

ACTIVE ⇒ TENDON TRANSFER +
INTRINSIC TRANSFER

5. IMPROVE MECHANICAL ADVANTAGE

ARTHRODESIS

TENODESIS

GENERAL SURGICAL STRATEGY

High-level Tetraplegia (Gp 0-2)

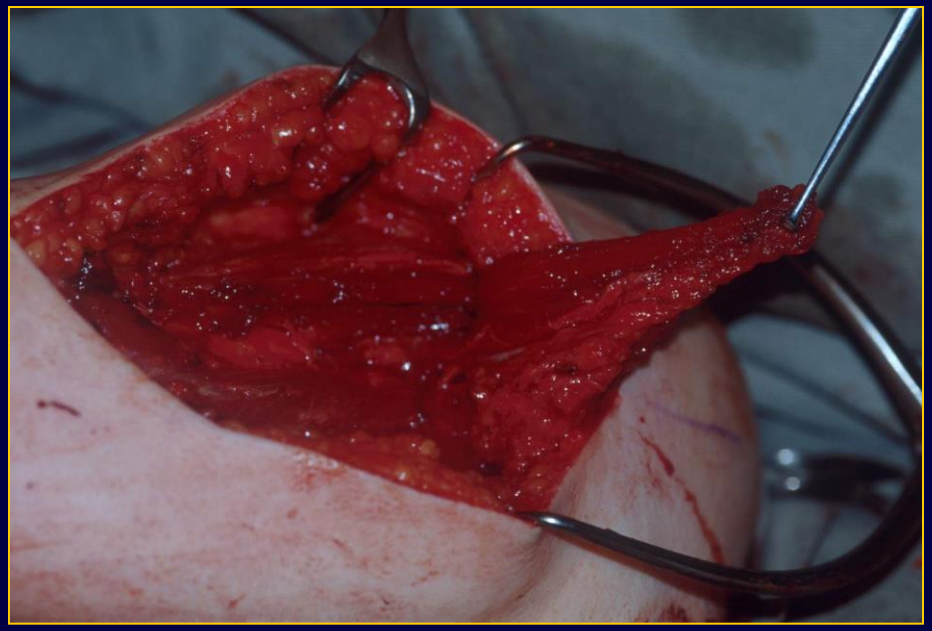
- Elbow extension
- Wrist extension
- Tenodesis key pinch

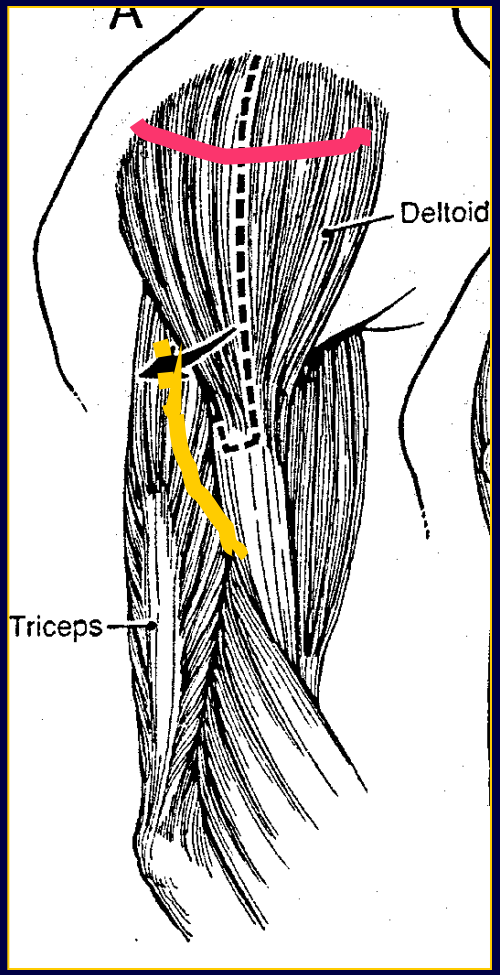
DELTOID TO TRICEPS TRANSFER (MOBERG)

- Purposes :
  - Stabilize patient himself in wheelchair
  - Improve control of self-help devices
  - Improve function of transferred BR

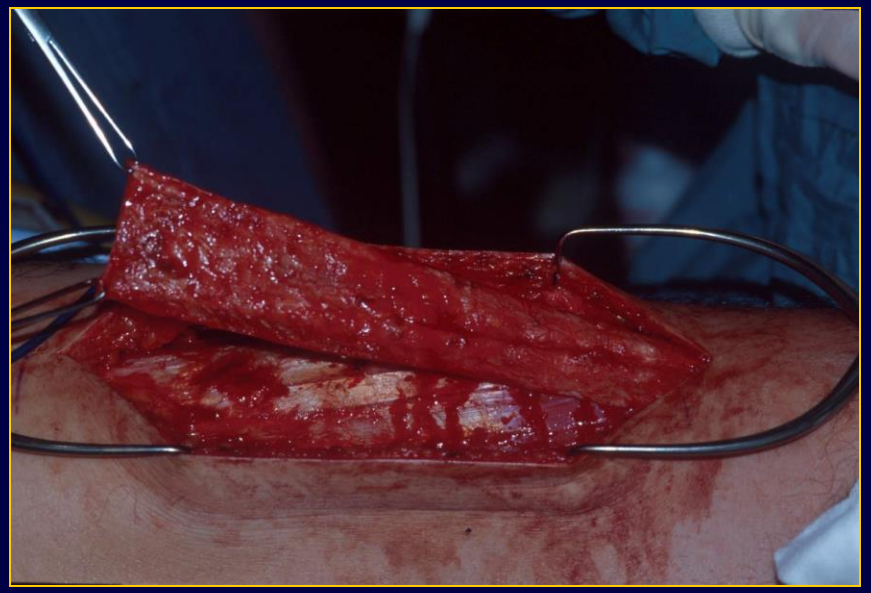
Technical Cue

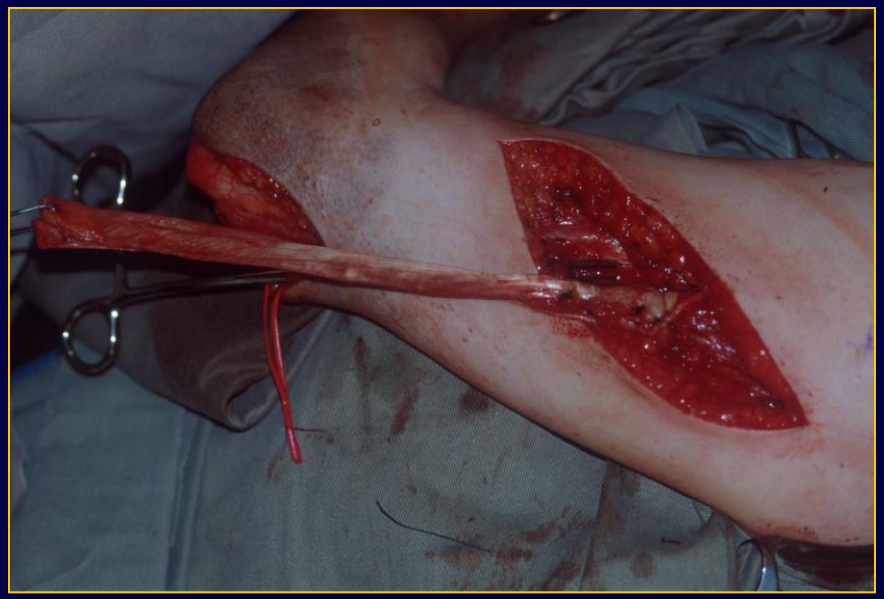
- Posterior 1/3 (independently innervated)
- Beware of axillary / radial nerve
- Ensure excursion> 3 cm

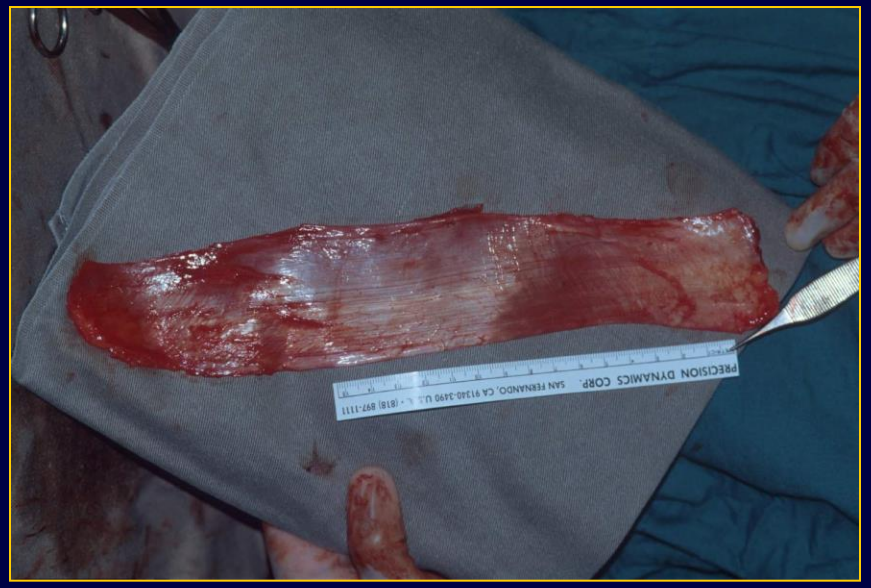


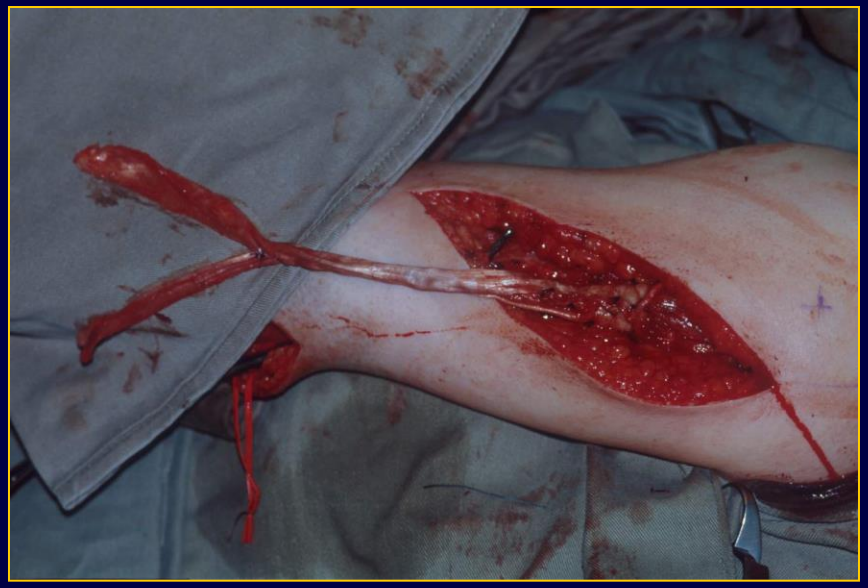


Fascia Lata Graft

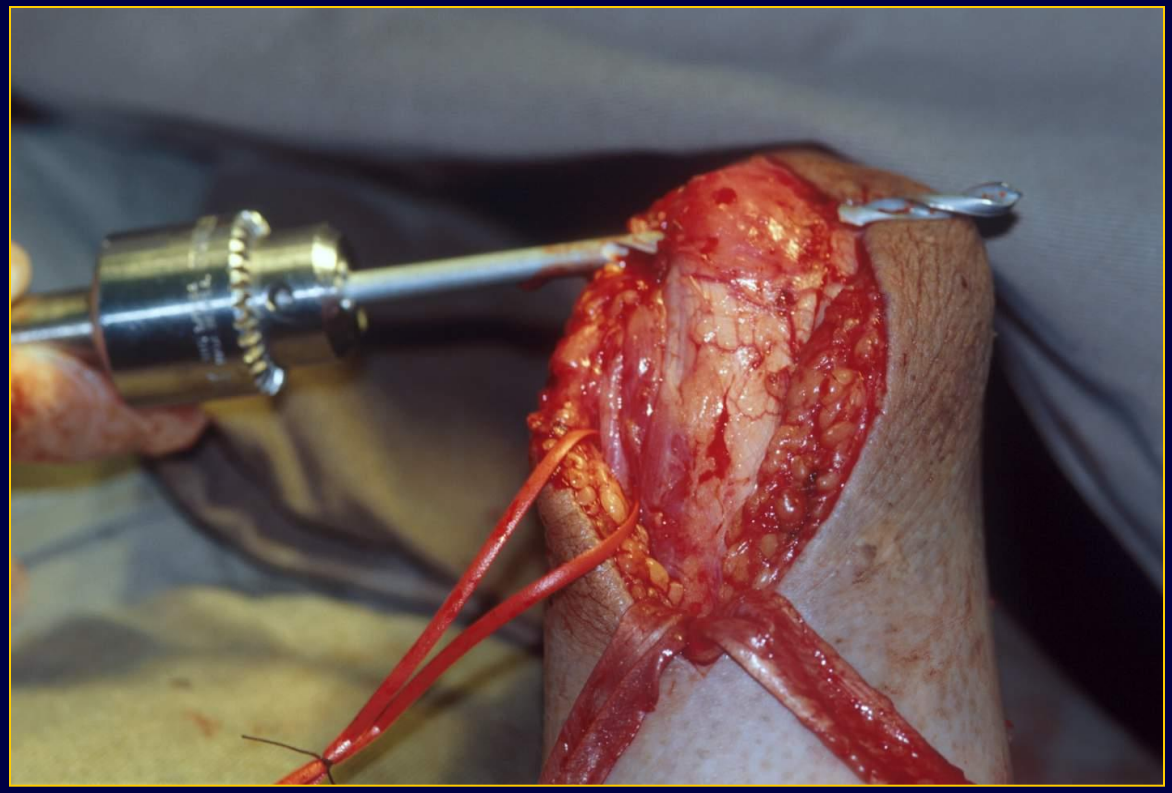


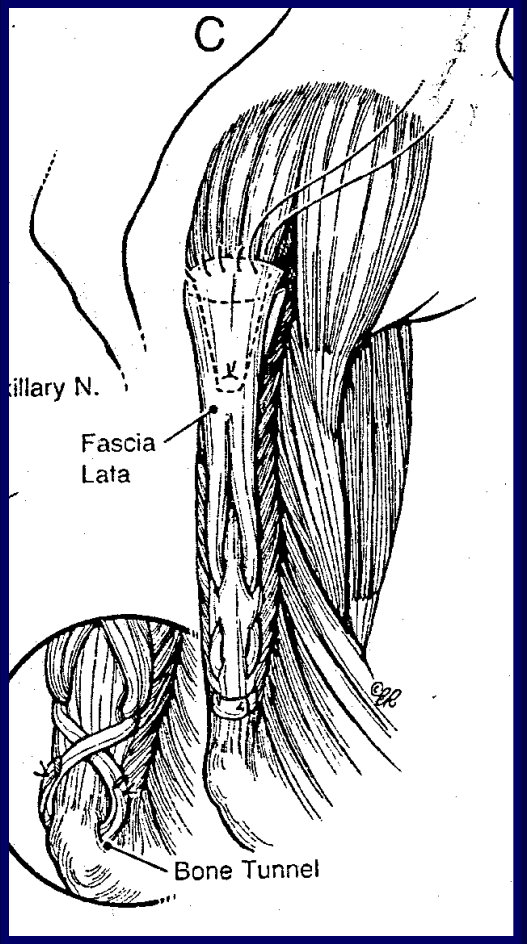






- Direct bone anchorage at olecranon
- Too tight rather than too loose !





Rehabilitation

Long arm cast in 0-10° extension x 4/52

↓

Hinged elbow brace

10-20° ↑ active flexion per week

↓

Passive flexion & strengthening 8-10/52

** Night time extension brace x 4-6 months


6 months PO

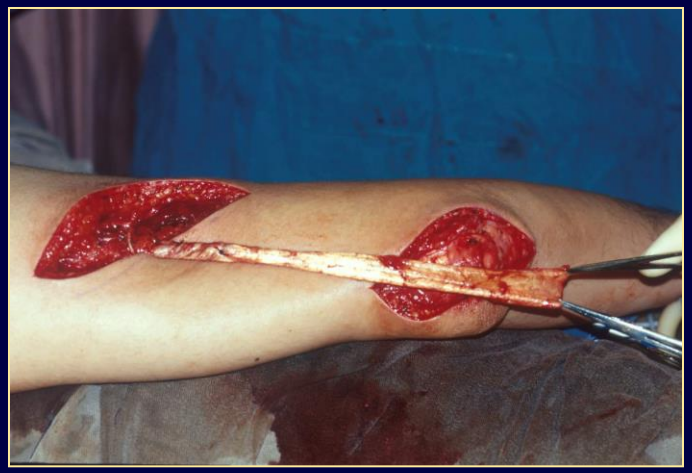
Deltoid to Triceps Transfer

M /49 Gp O- 0

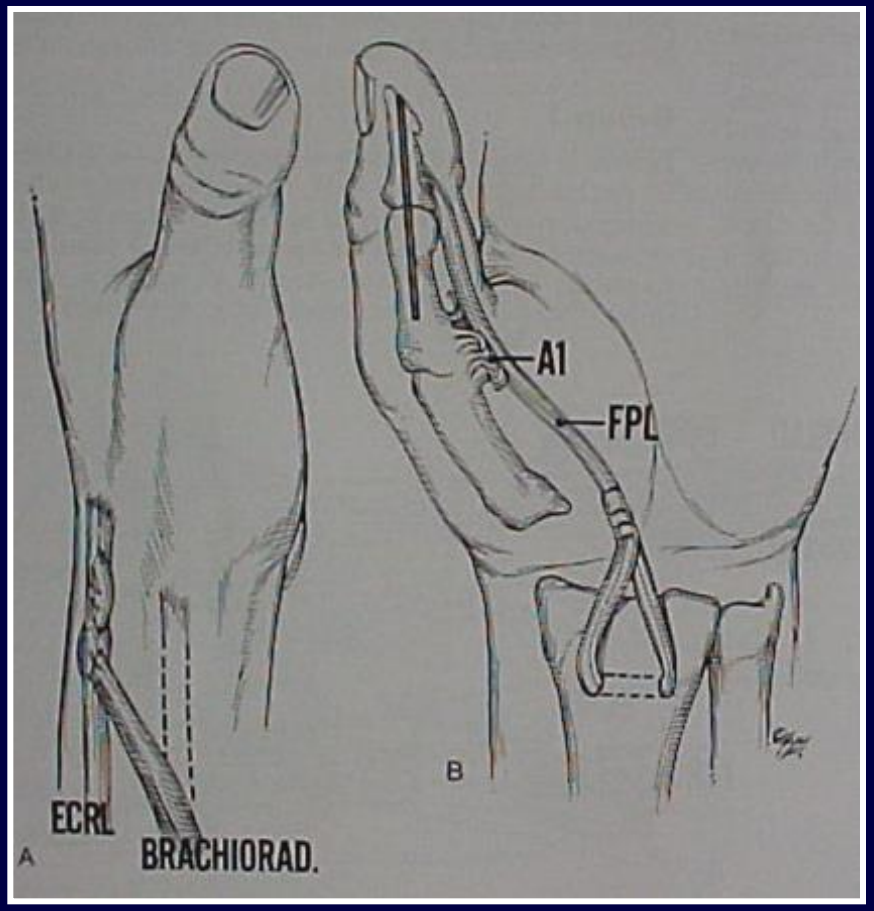
- C3-5 # Dislocation 1996
- Rt BEA shoulder 2/5
- Lt Post. Deltoid 4 /5
  Elbow Flex $4^{+}/5$
  Ext 0 /5
  BR $3^{+}/5$
- Elbow Flexion/Supination Contracture
- Finger Extension Contracture

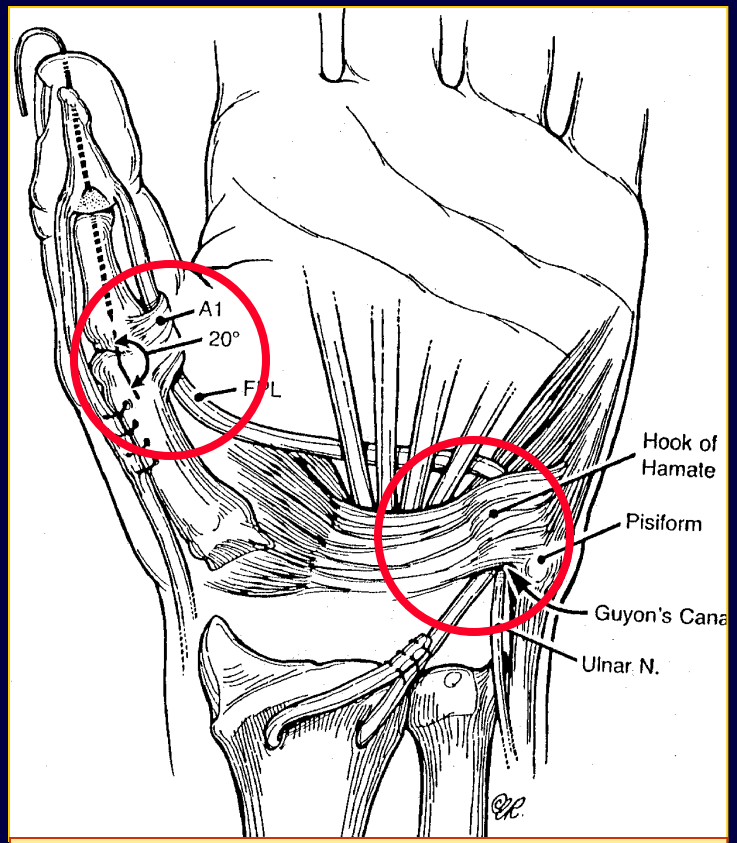
13.3.2000

Posterior Deltoid to Triceps
BR to Wrist Extensors
MCPJ Capsulectomy



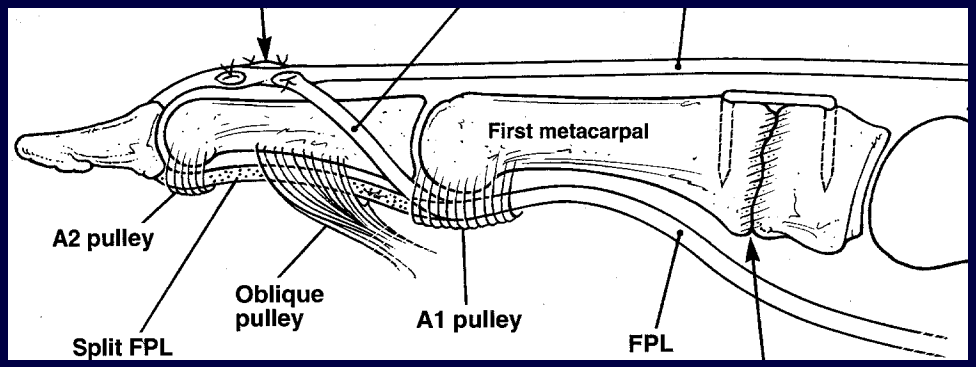
MOBERG KEY PINCH RECONSTRUCTION





Paul Brand modification

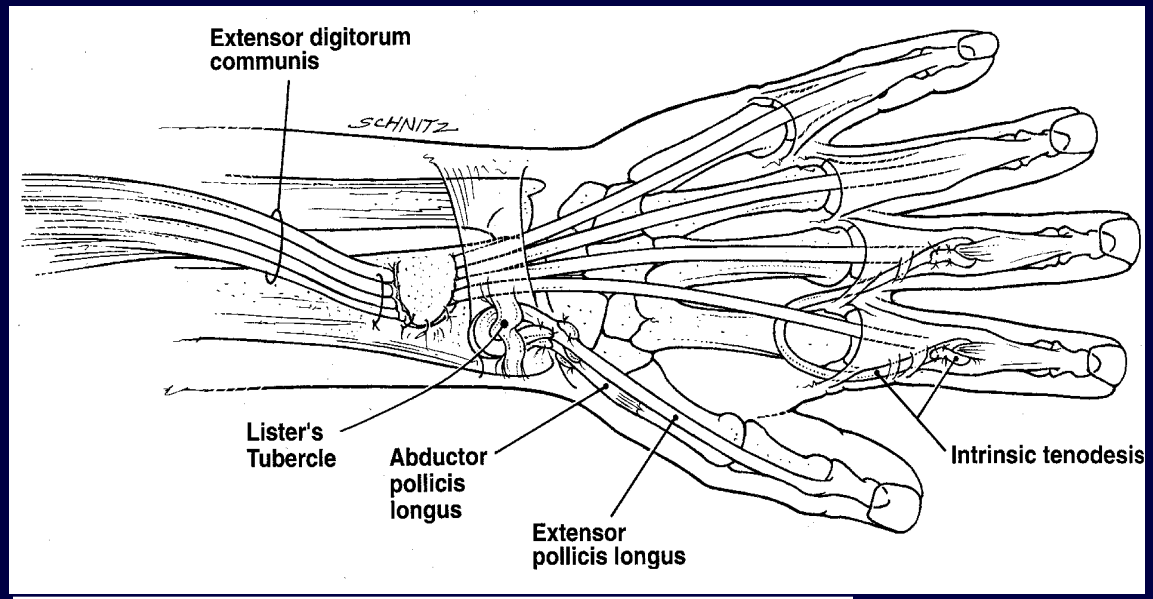
Split Distal FPL Tenodesis (Rothwell 1992)

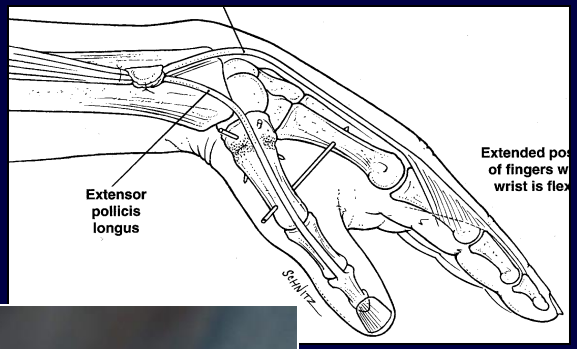


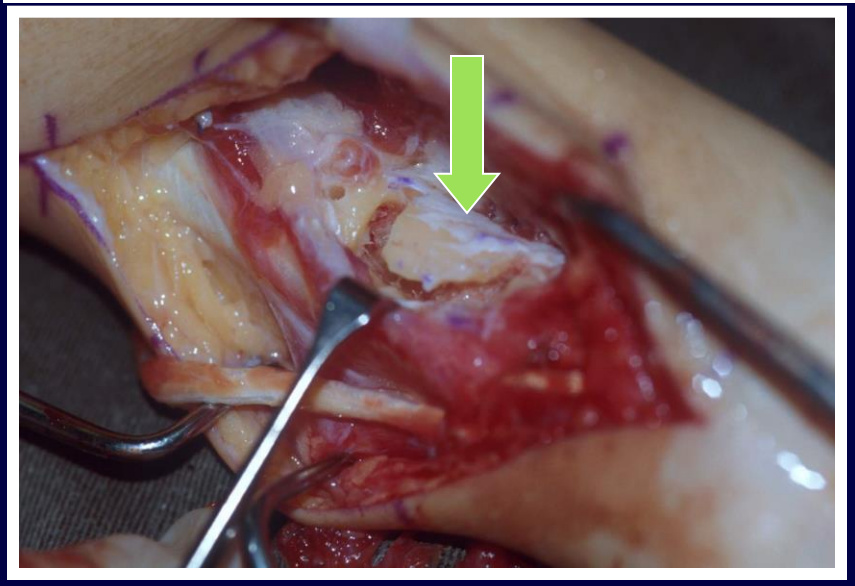
Mid-Level Tetraplegia (Gp 3-5)

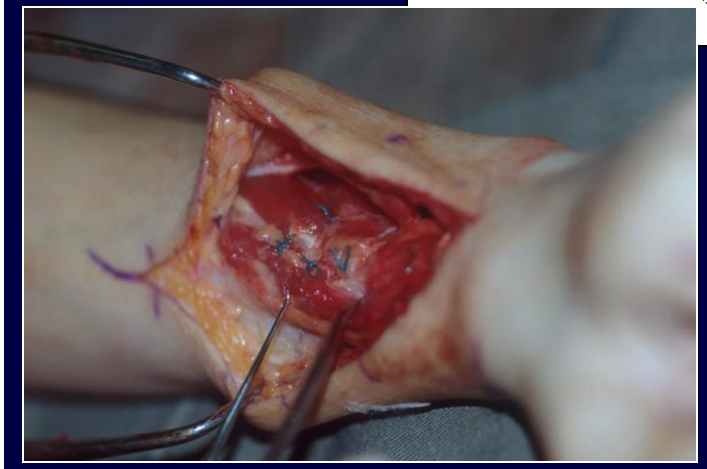
- Release - Passive Extensor tenodesis or active transfer
- Grasp - Active Flexor transfer
- Pinch - 1st CMCJ fusion /opponenplasty - Split Distal FPL Tenodesis
- Anti-Claw - Intrinsic tenodesis
- Staged procedures, Best sequence ??

Extensor Tenodesis



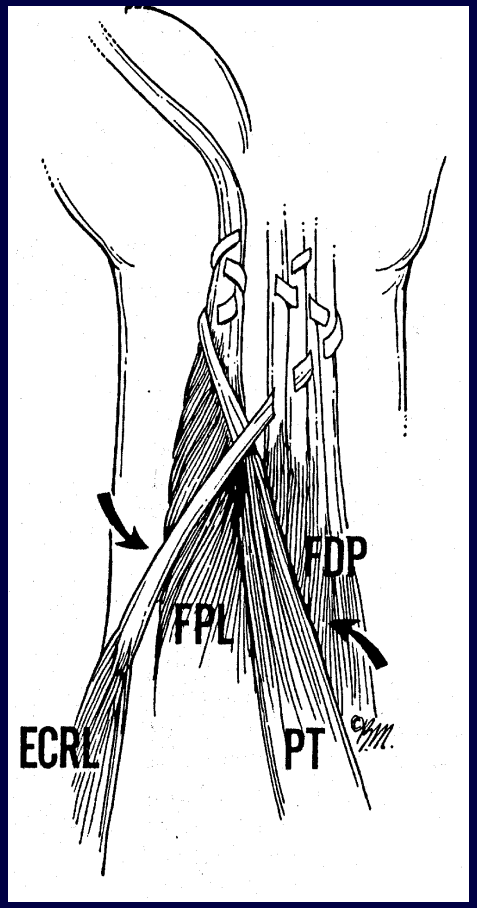


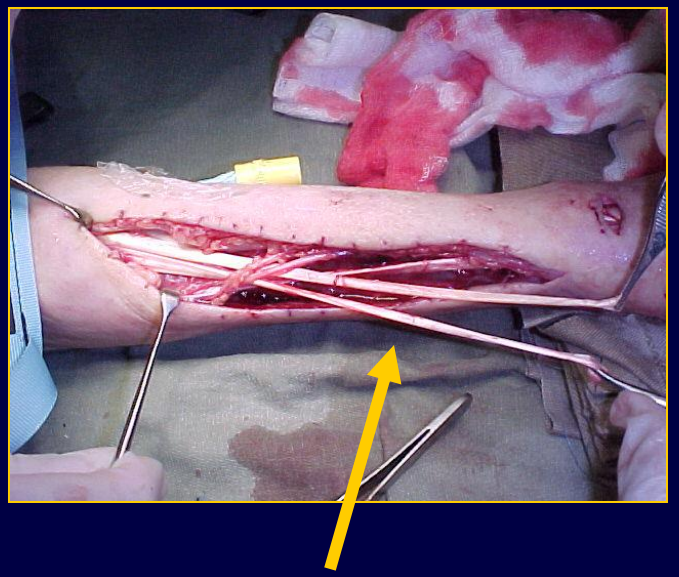




Active Flexor Reconstruction

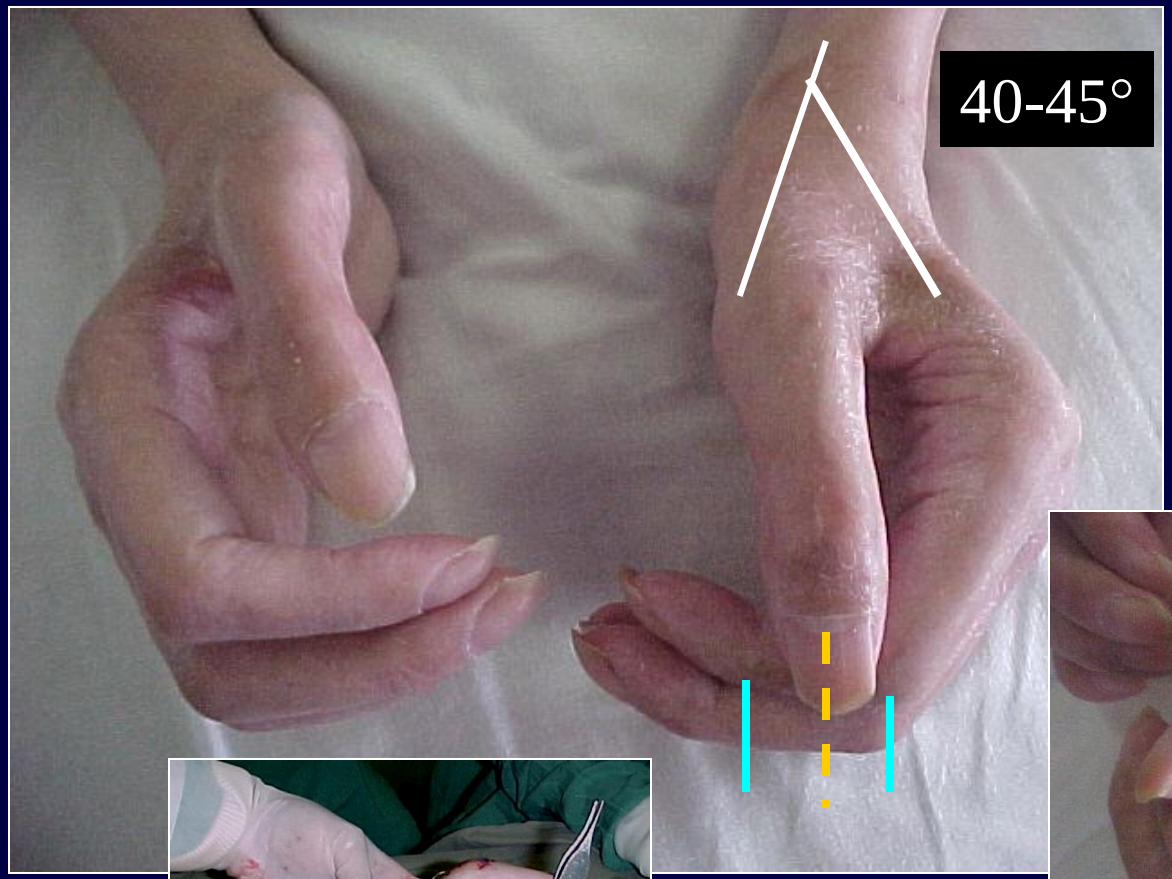
- BR / PT → FPL
- ECRL → FDP

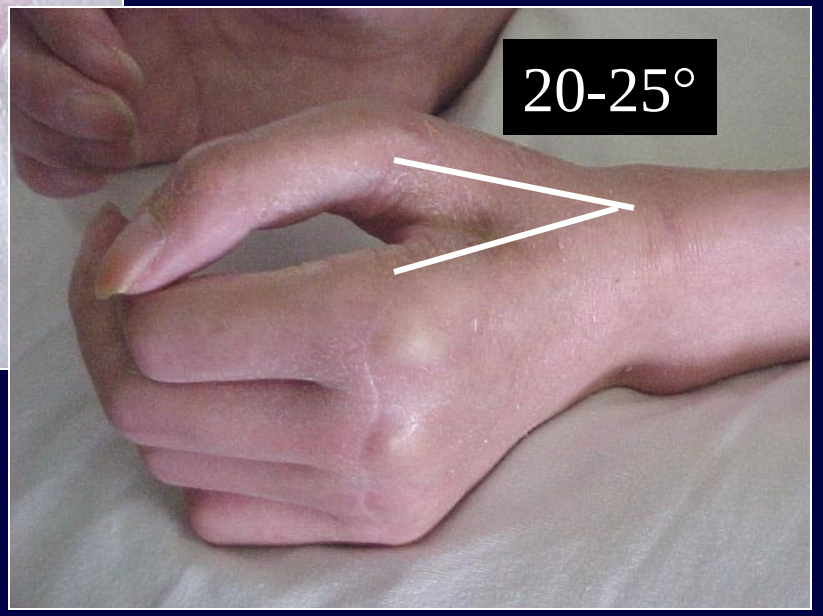


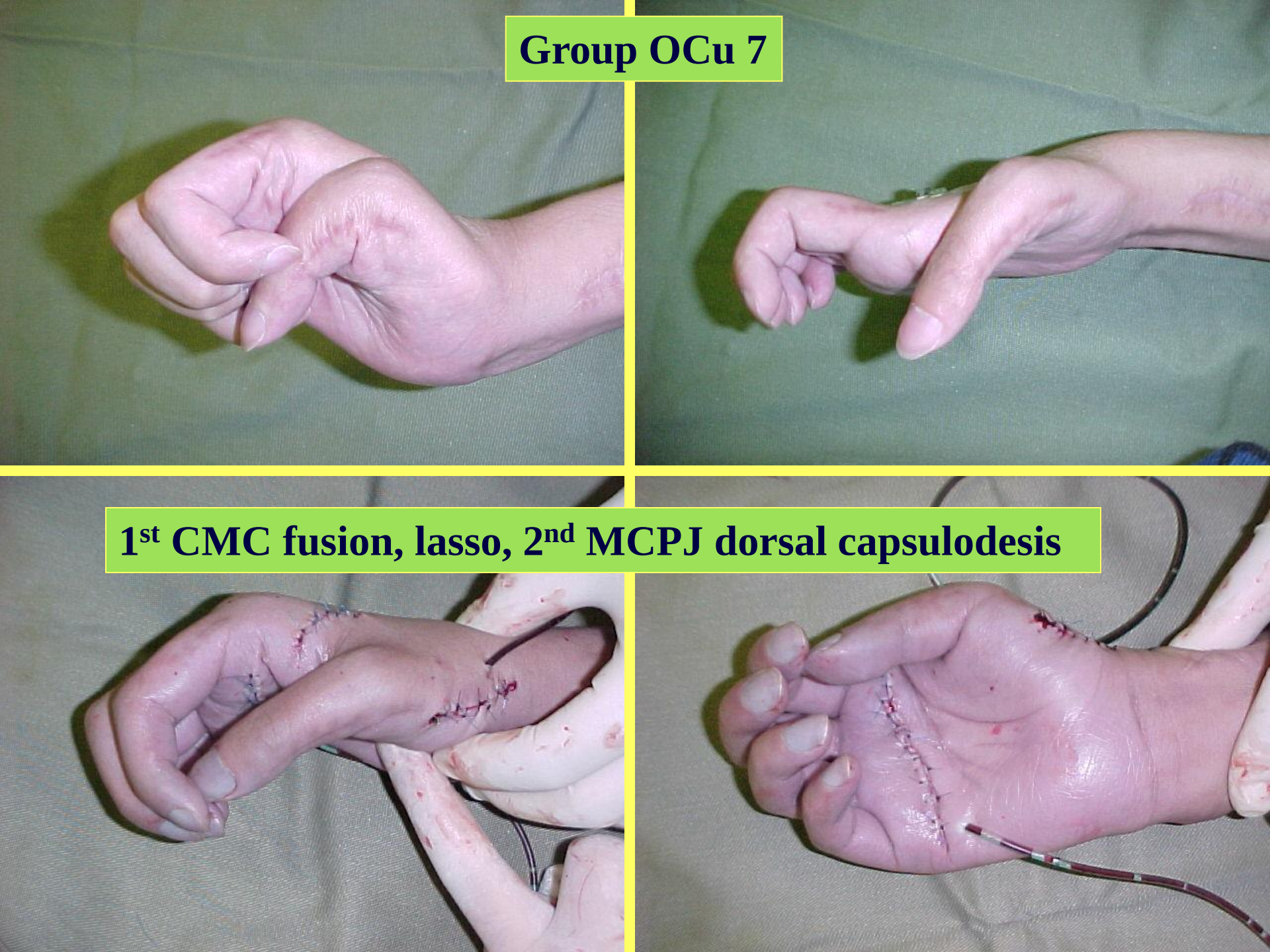


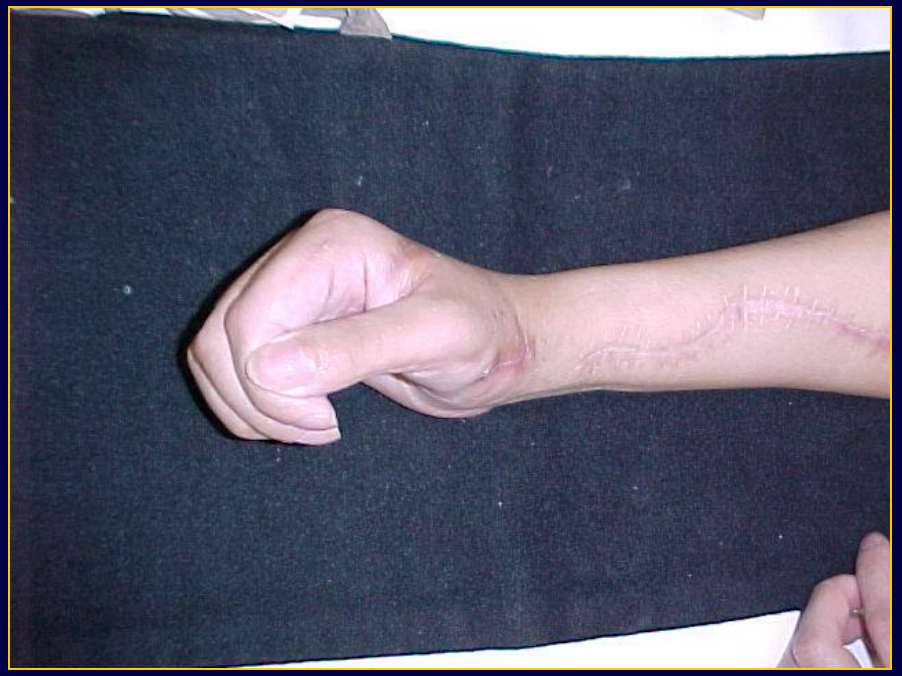
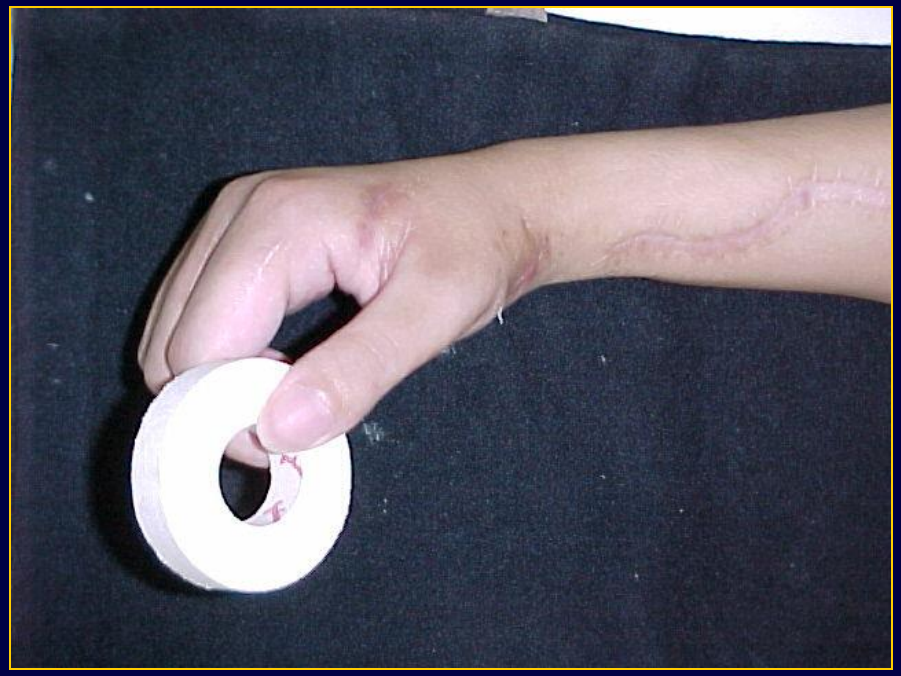
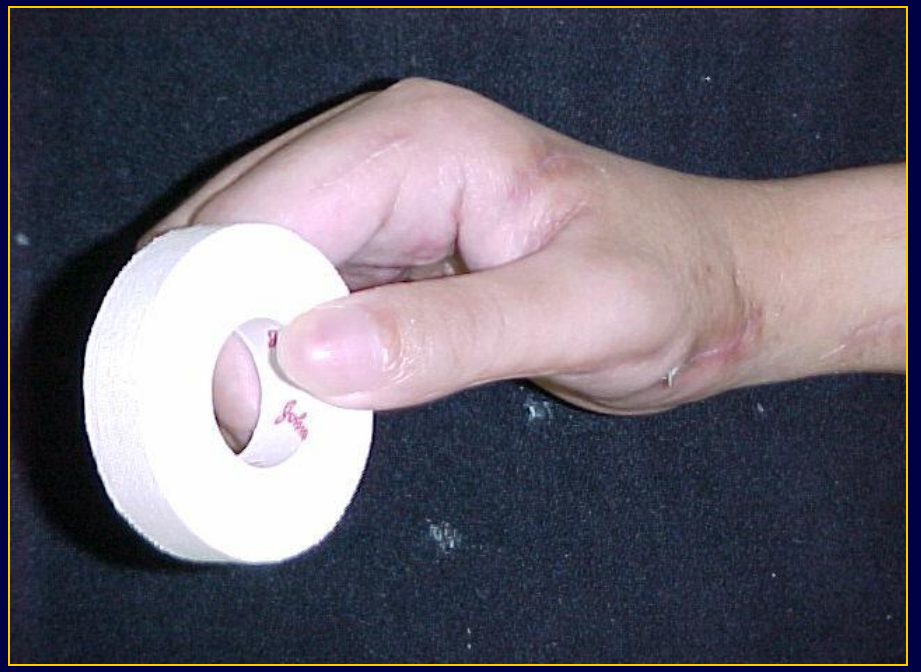
Supernumerary Extensor

Thumb CMCJ Fusion



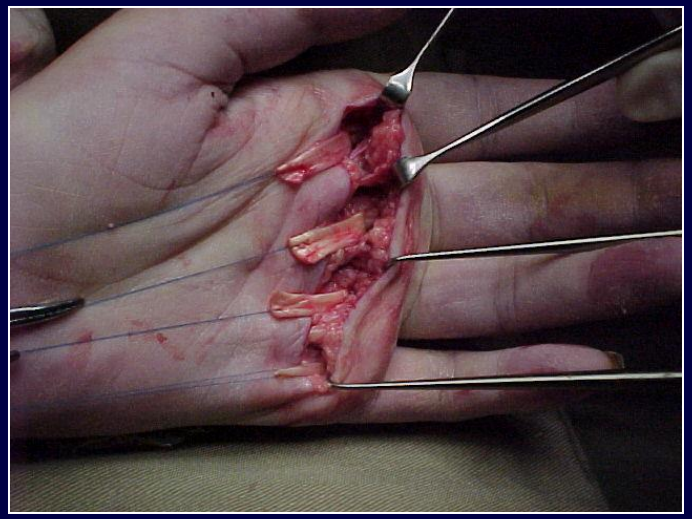


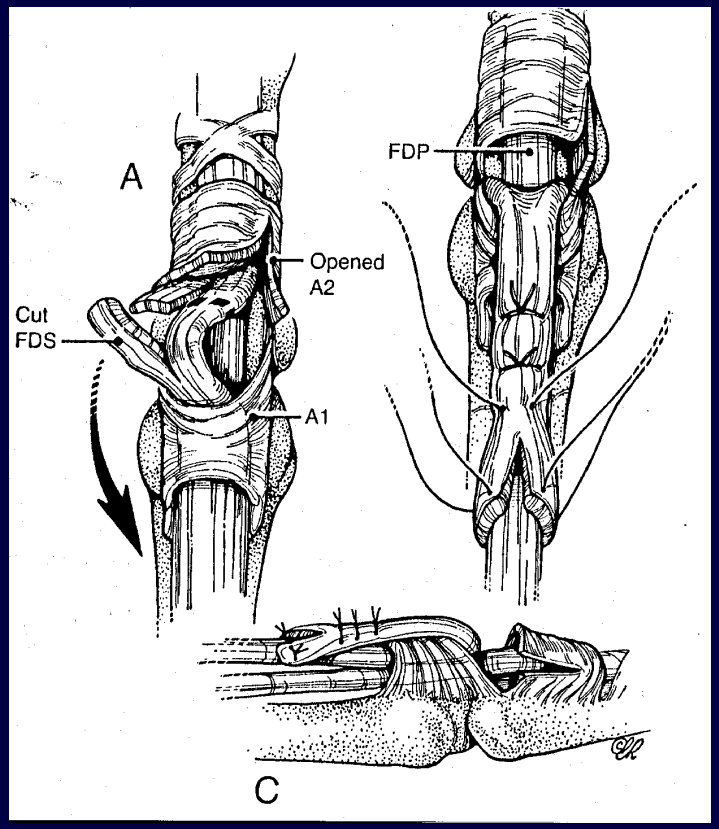

Group OCu 7
1st CMC fusion, lasso, 2nd MCPJ dorsal capsulodesis

INTRINSIC TENODESIS

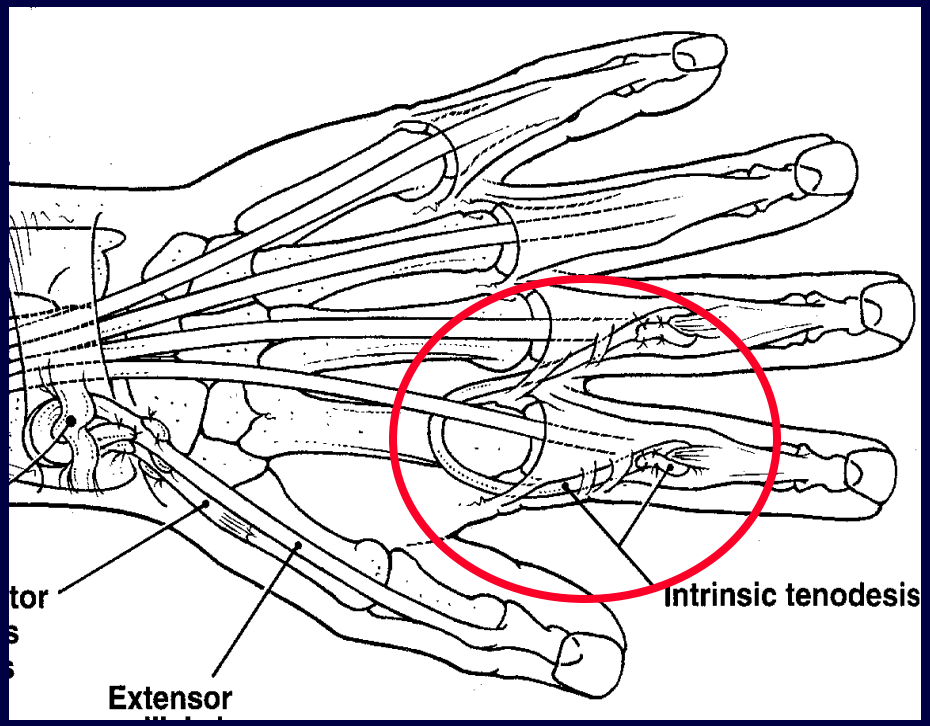
- FDS LASSO Procedure
  (ZANCOLLI 1975)





INTRINSIC TENODESIS

- Intrinsic Grafting (HOUSE 1985)



Case Illustration

- M / 40
- RTA Victim
- C5/6 Subluxation with Tetraplegia
- Compound # Rt Forearm & Humerus with compartment syndrome
- Good family support
- No spasticity / Bed Sore

At 2 years post-injury

LEFT (OCu 5)

- BR 4
- ECRB 4
- ECRL 4
- PT 3+
- ECU 4-
- Thumb/Finger Extensor 3-

RIGHT (OCu 3)

- BR 3+
- ECRB 4
- ECRL 4

- * Static Claw Hand Deformity
- * Flexor contracture

Operations

LEFT

- ECRL → FDP
- BR → FPL
- ECU → PL graft → Opponen
- FDS Lasso → Intrinsic

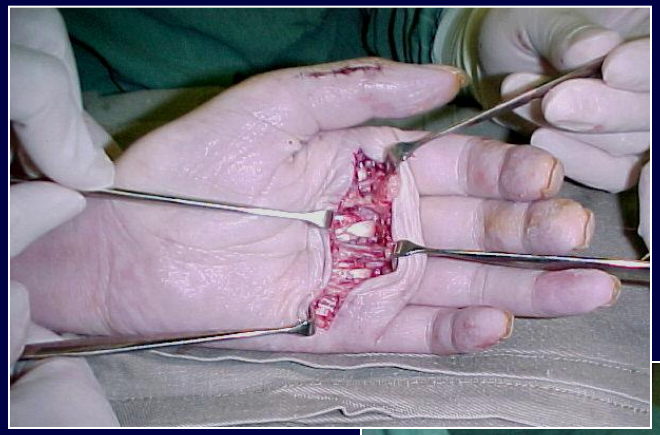
RIGHT

- ECRL → FDP
- BR → FPL
- FDS Lasso → Intrinsic
- MPJ Capsulectomy
- Flexor Release
- Thumb IPJ Stabilization (K Wire)

- 1st CMCJ & 2nd MCPJ fusion in 2001

8 years PO

Ankylosing Spondylitis



5 years PO

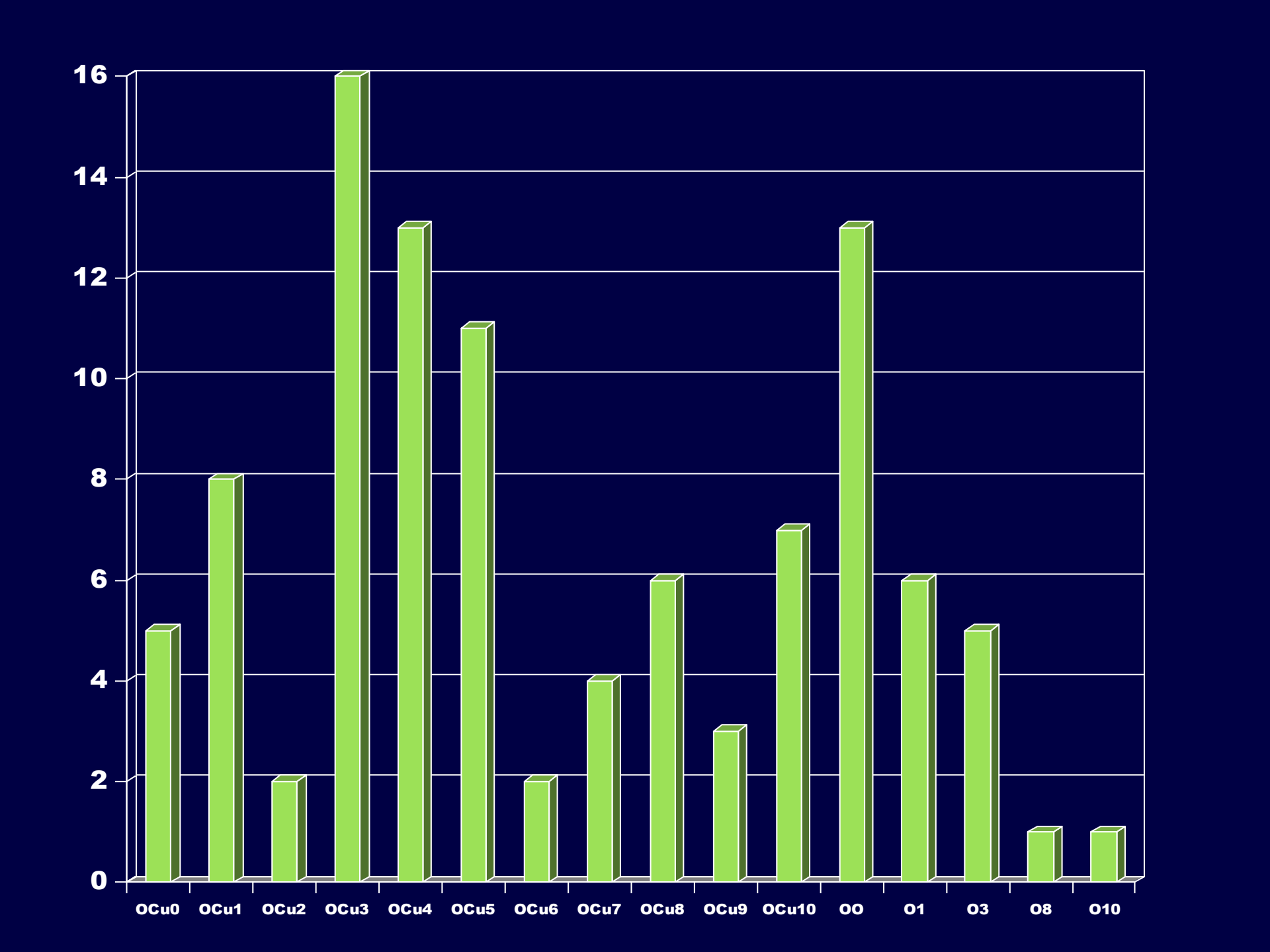
Low-level Tetraplegia (Gp 6-9)

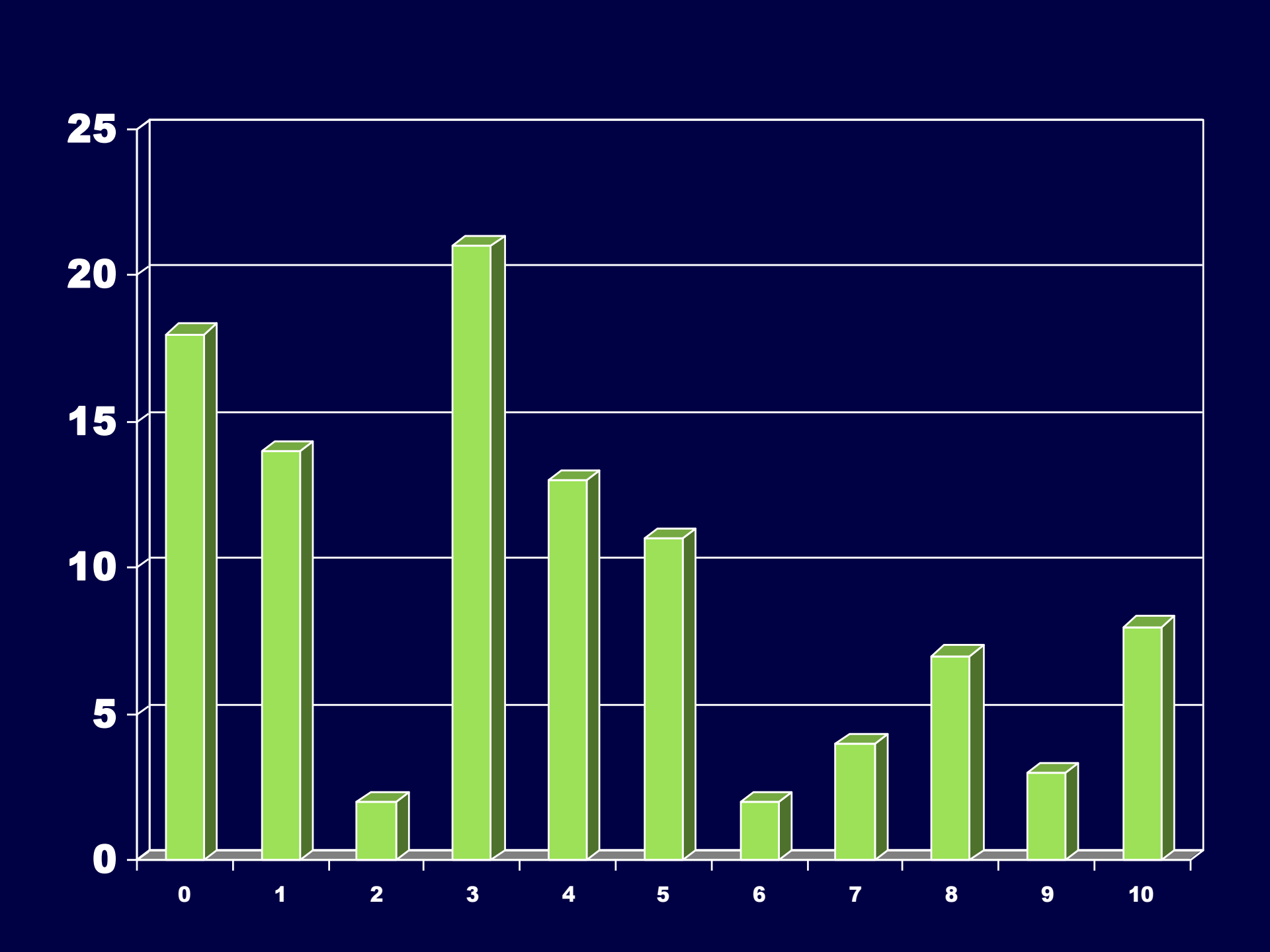
- Simulate Median / Ulnar Nerve Palsy
- Active Flexor Reconstruction
- Intrinsic Control

OUTCOME OF SURGICAL RECONTRSUCTION

1996-2006

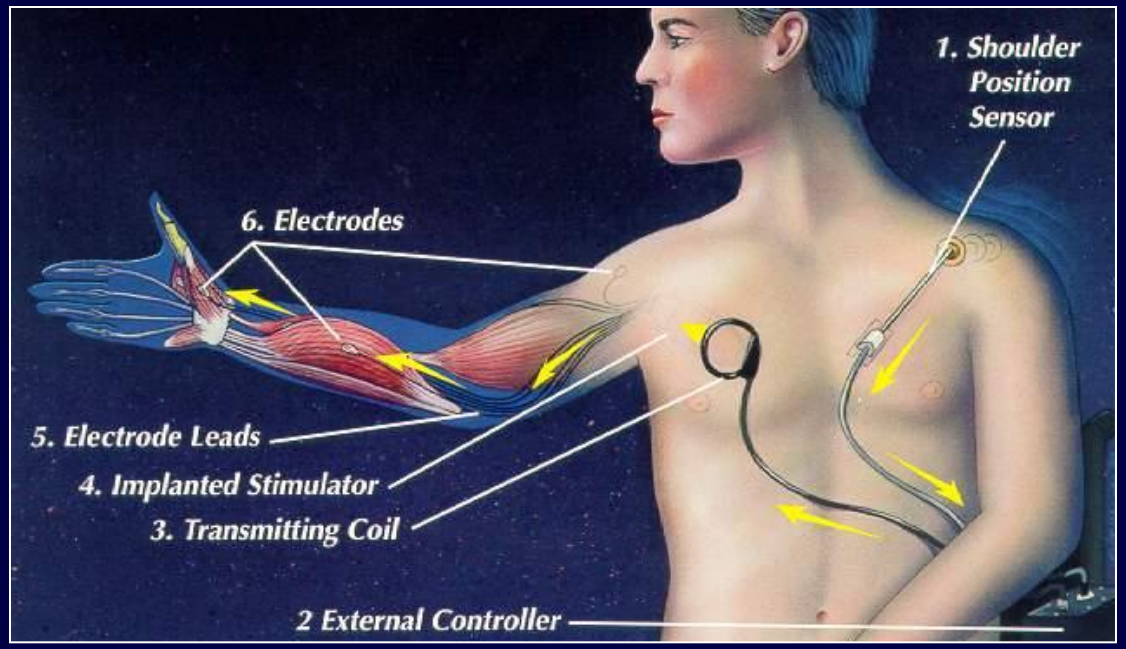
- Case registry : 56
- M:F = 49 :7
- Av Age : 40.1 (17-67)
- Median interval from injury : 11 months
  (10 days to 204 months)
- Surgical candidate : 40 **(71.4%)**
- Operated case : 12 **(30%)**


16
14
12
10
8
6
4
2
0
OCu0
OCu1
OCu2
OCu3
OCu4
OCu5
OCu6
OCu7
OCu8
OCu9
OCu10
OO
O1
O3
O8
O10


25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10

NEUROPROSTHESIS (FUNCTIONAL ELECTRICAL STIMULATION)

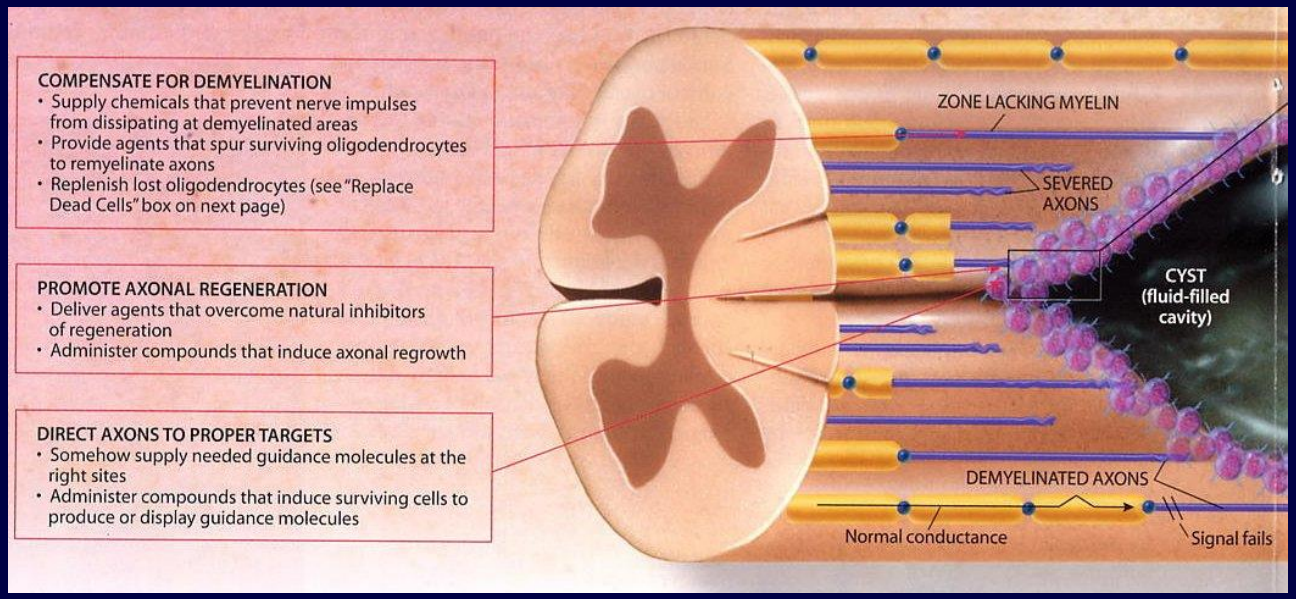
- mainly to restore grasp & release for C5 & C6 level injury

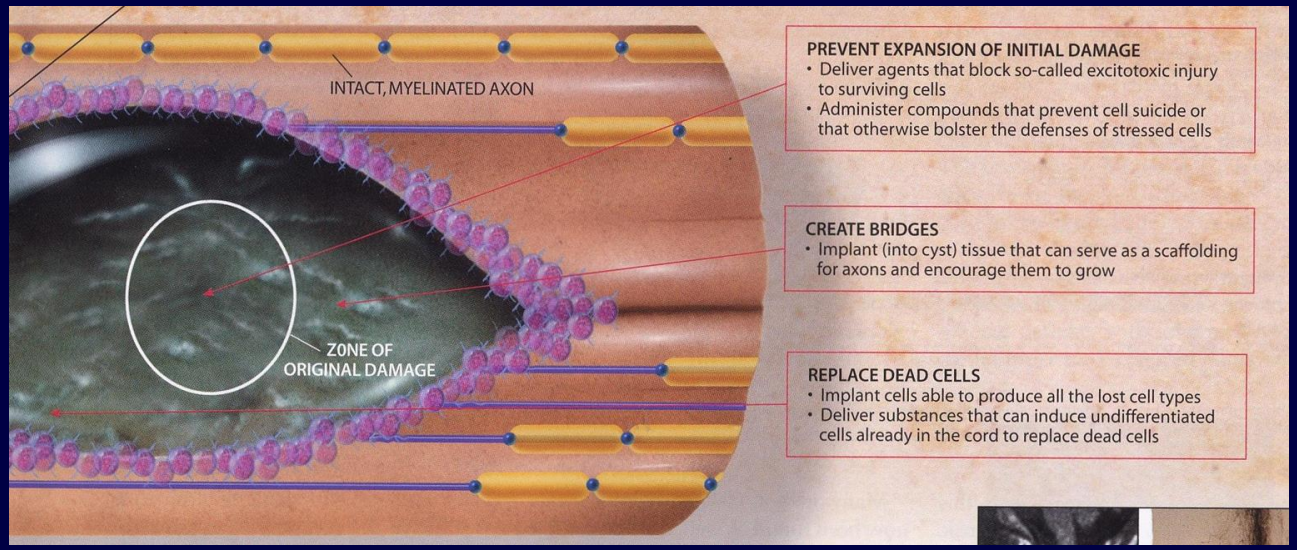


Surgically implanted device

- 8 channels of stimulation
- programmable to synchronise movement
- Shoulder / wrist control

FUTURE PROSPECT



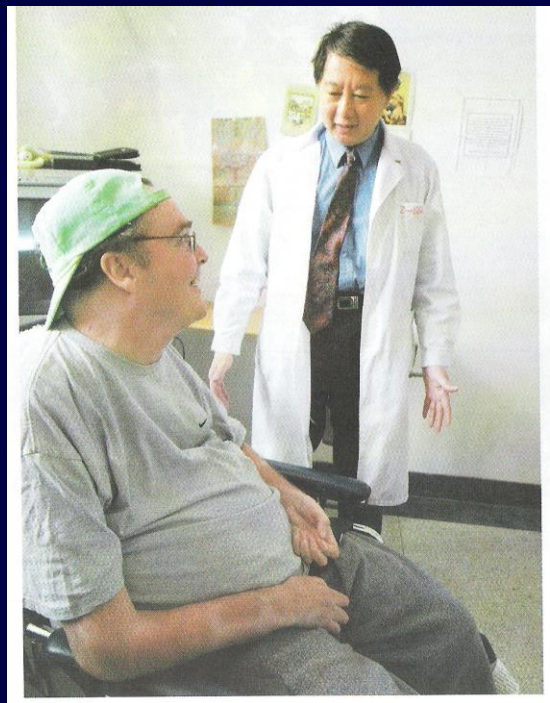


FUTURE PROSPECT

Dr Huang Hongyun operates on Leo Per Hallan at Beijing's Chaoyang Hospital. Left: the OEG cells, in a pink solution, injected into Hallan's spine close to where it was damaged.

Spinal Cord Repair

Olfactory Ensheathing Cell



Subject and saviour? Huang debriefs Hallan after his operation. The rights activist has been disabled for almost 30 years.

because it means inconvenience with no immediate visible advantage. Young hopes that attitude will change.

"In China no one would sign up for placebo treatment," he says. "Participating in a clinical trial is a service to your community that requires a degree of sacrifice. If they just get the therapy and disappear then there's no data."

Huang dreams of setting up an international centre in Beijing offering his operation to people from around the world. They are arriving already. Despite a five-month waiting list the team tries to limit the number of patients on the ward to four owing to a lack of staff. Throwing his arms wide, Huang says: "We are open to the whole world."

But again Huang stresses his treatment is no cure. "This is a very important point. It's not a cure," he reiterates. "I say, 'I never promised you would walk after my procedure. You can improve. But you won't be healed.' Expectations shouldn't be too high. What's important is that it has proved the old way of thinking is wrong. In three years we won't have the cure but we may have new methods."

The website of the Christopher and Dana Reeve Paralysis Resource Centre echoes Huang's optimism and caution. Asking "Is there hope for a cure?" it answers by saying: "If by 'cure' you mean full return to the way a person was before injury or disease, that may be asking more than the research can deliver for now."

While acknowledging the results so far, Young puts it more bluntly: "Nobody's getting out of bed and running a marathon," he says.

What do I learn from them?

CONCLUSION

What we can do now is only a little

BUT…..

“ IF YOU HAVE NOTHING,
A LITTLE IS A LOT ! ”

Sterling Bunnell

THANK YOU