Restoration of Elbow Function Following Brachial Plexus Injury

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OrthoCarolina

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Case 1

- 29 yo pro football player injured on a tackle
- 5 months post injury
  - No shoulder flex/abd
  - No shoulder ER
  - No elbow flexion
  - EMG no polys

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Case 2

- 5 month old child after difficult delivery
- Erbs palsy
- No elbow flexion

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Case 3

- 66 yo M 2 years s/p C5 palsy
- No elbow flexion or shoulder function
- 5/5 strength C6-T1

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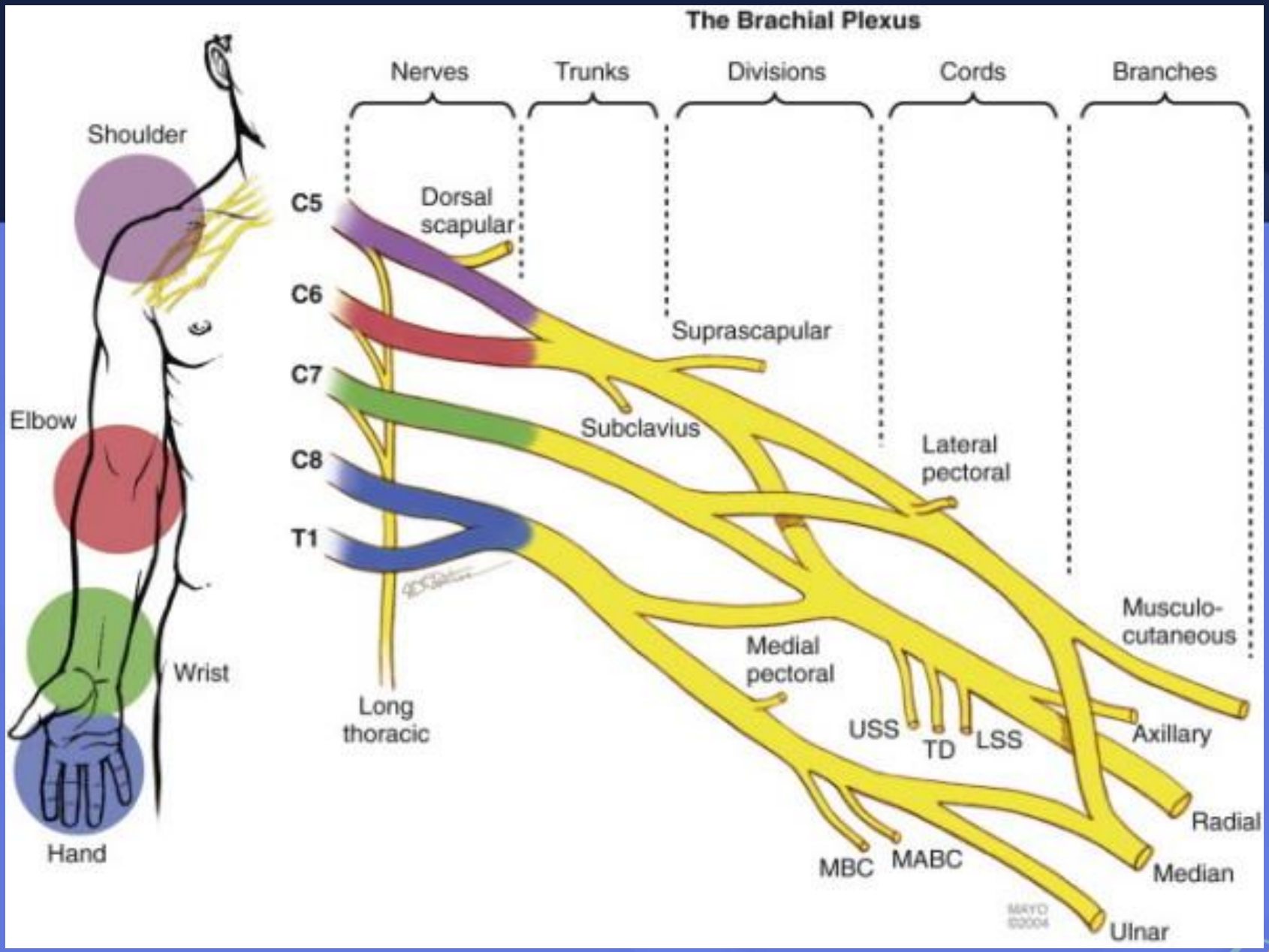
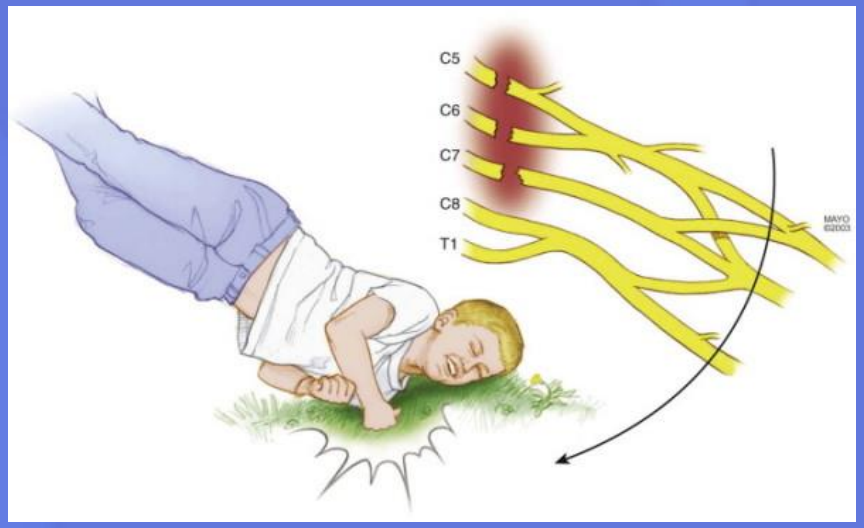
Case 4

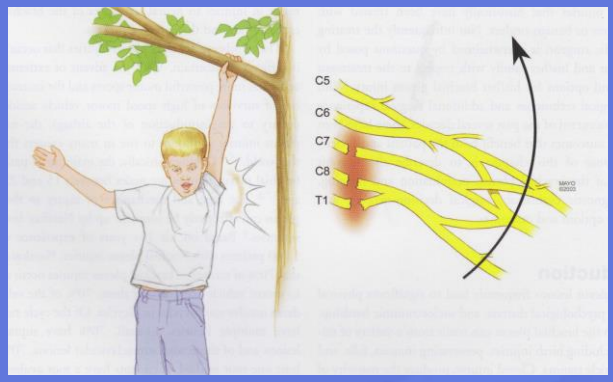
- 45 yo M s/p auger injury to left arm
- Open 5 root plexus avulsion with subclavian artery rupture


The Brachial Plexus
Nerves
Trunks
Divisions
Cords
Branches
Shoulder
Elbow
Wrist
Hand
C5
C6
C7
C8
T1
Dorsal scapular
Long thoracic
Suprascapular
Subclavius
Lateral pectoral
Medial pectoral
Musculo-cutaneous
Axillary
Radial
Median
Ulnar
MBC
MABC
USS
TD
LSS

BPI Epidemiology

- Supraclavicular Injuries
- – C5-6: ~25%
- – C5-7: ~25%
- – C8-T1: ~1%
- – Pan-plexus (C5-T1): ~50%
  - Dictates available donor nerves





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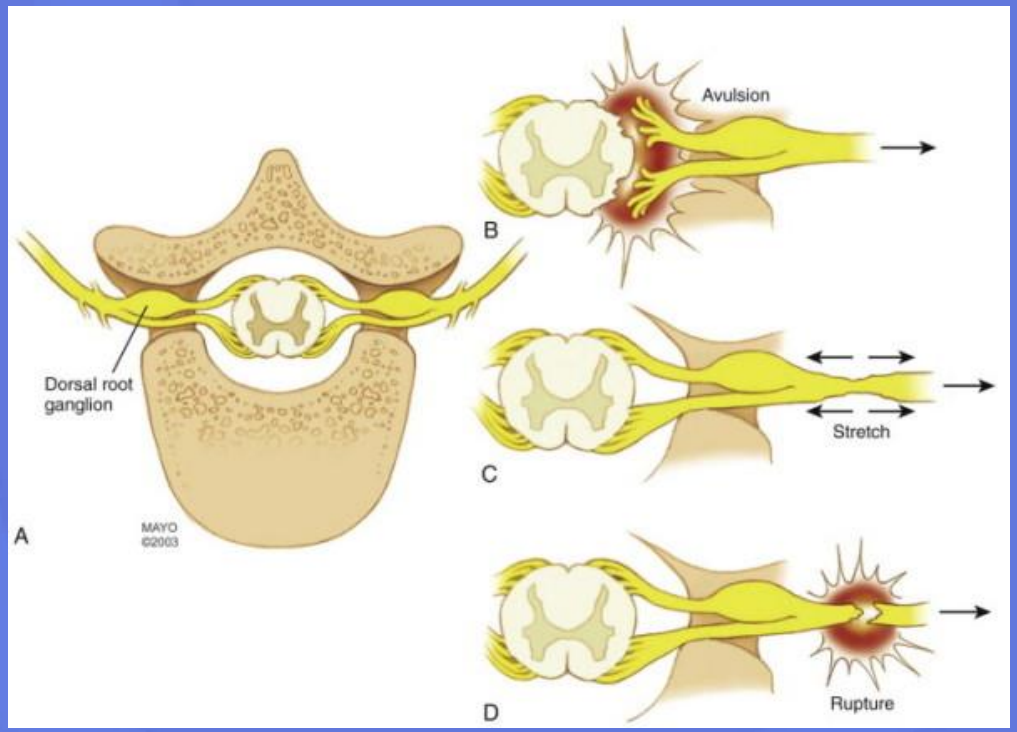
BPI Management Strategy

- Neurolysis
  - Rare in isolation
  - NAP across neuroma
- Nerve repair
  - Acute lacerations
- Nerve Graft
  - Ruptures
- Nerve Transfer
  - Avulsion
  - Rupture



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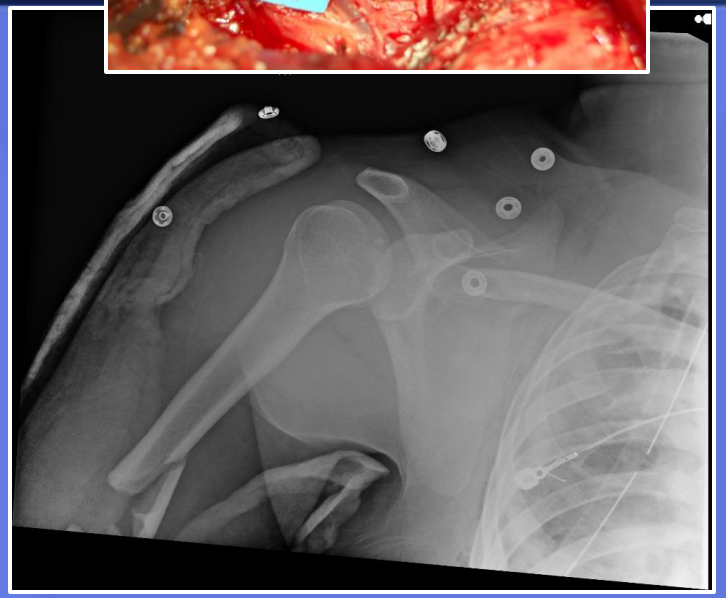
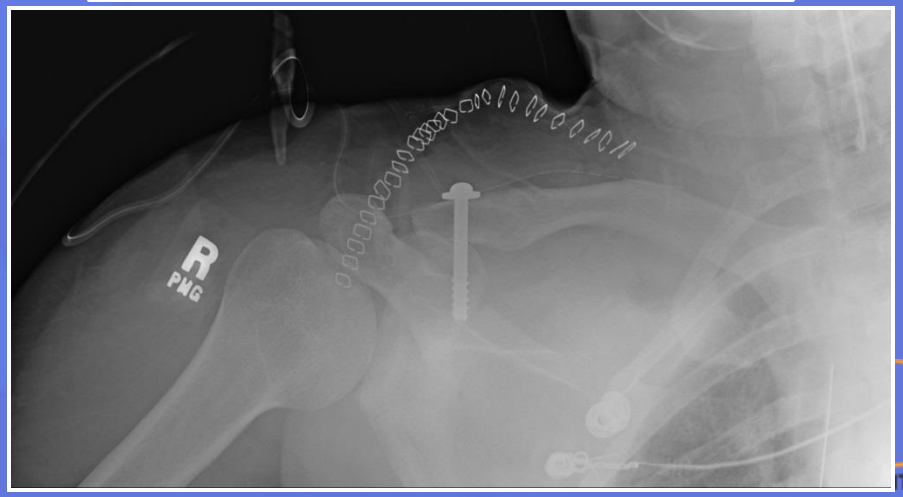
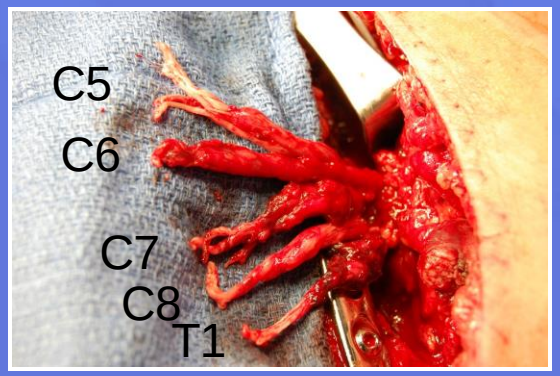
Timing of Surgery

- Acute
  - Open injuries
  - Lacerations
  - Need for shoulder surgery
  - Vascular injuries

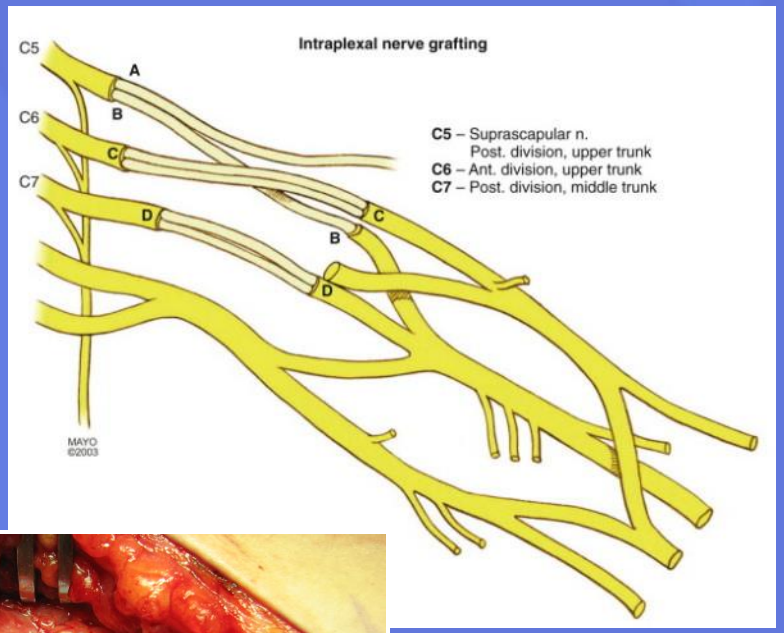


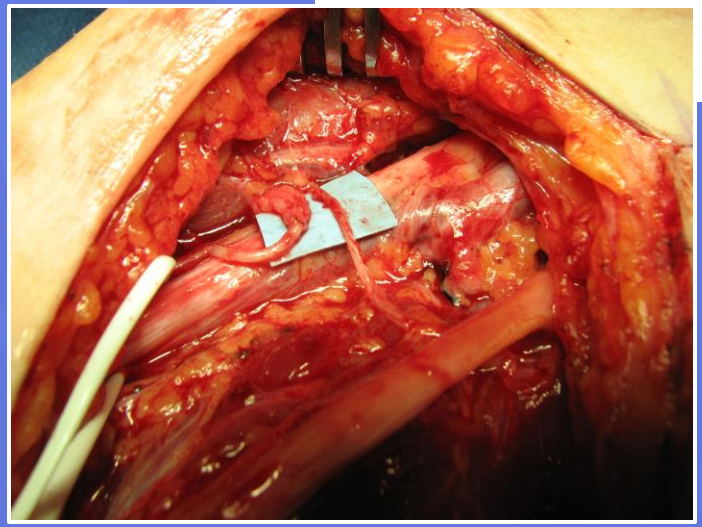




Timing of Surgery

- Subacute (3-5 months)
  - Majority of cases
  - Plexus neurolysis
  - Nerve grafting
  - Nerve transfers





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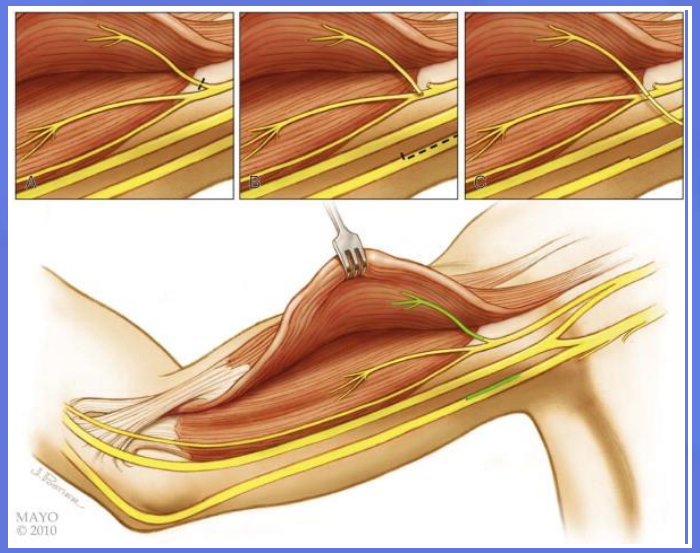
Timing of Surgery

- Delayed (9-12 mos)
  - Nerve transfers
  - Muscle transfers



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Managing the Elbow

- Elbow flexion highest priority in adult plexus (behind hand in kids)

- Options
  - Nerve grafting
  - Nerve transfers
  - Tendon/muscle transfers

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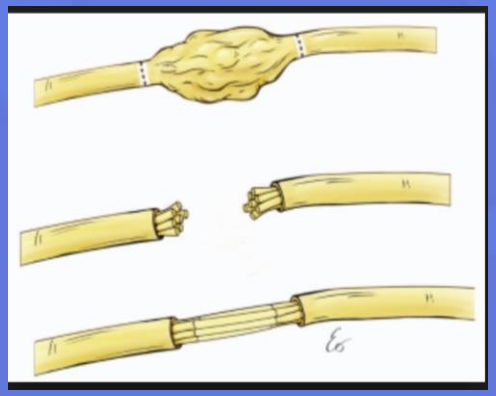
Nerve Grafting

- Indications
  - Acute or subacute injury
  - Good roots present
    - SSEP present
    - Minimal scar on path



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Nerve Grafting Surgical Technique

- Plexus neurolysis
- Resect neuroma
- Confirm roots
- Sural harvest
- Cable graft
  - Suture vs glue
- Often long grafts

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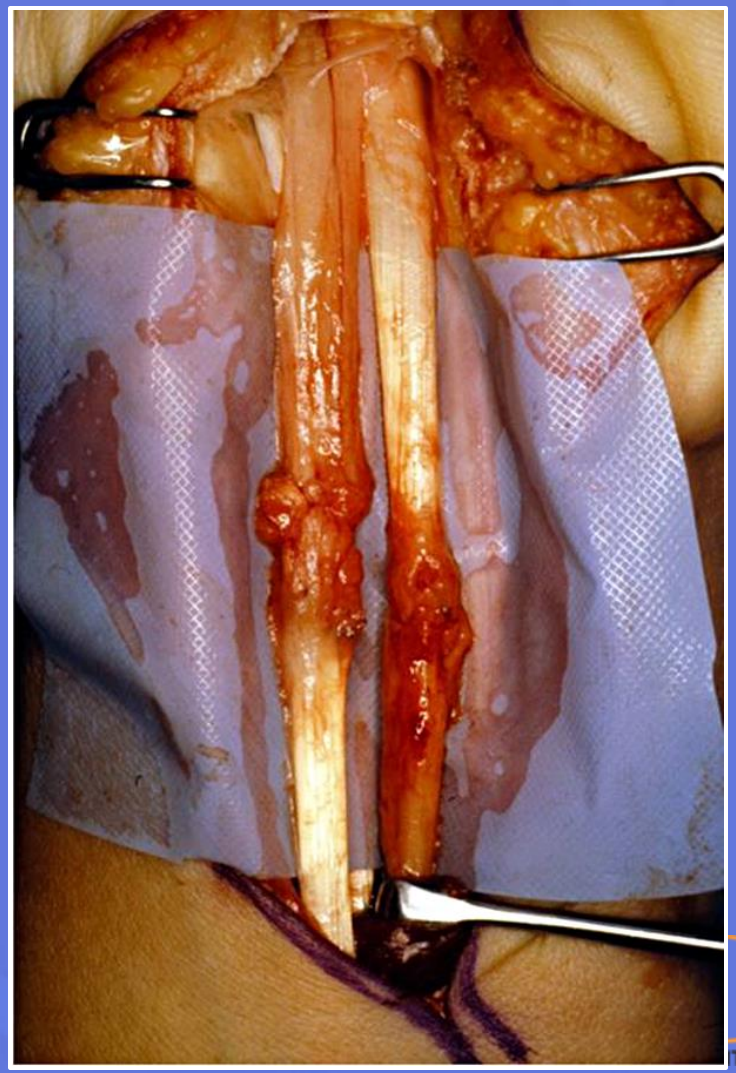
Nerve Transfers

- Indications
  - Acute, subacute injury
  - Some delayed injuries
    - Donor EMG normal
- Advantages
  - Shorter re-innervation time
  - Bypass zone of injury
  - Avoid graft morbidity
  - More predictable?



Nerve Transfer Donors

- Intraplexal
  - **Ulnar fascicles**
  - **Median fascicles**
  - Thoracodorsal
  - Medial & lateral pectoral
  - Long thoracic
  - Radial
  - Subscapular
- Extraplexal
  - **Intercostal**
  - Phrenic
  - Spinal accessory

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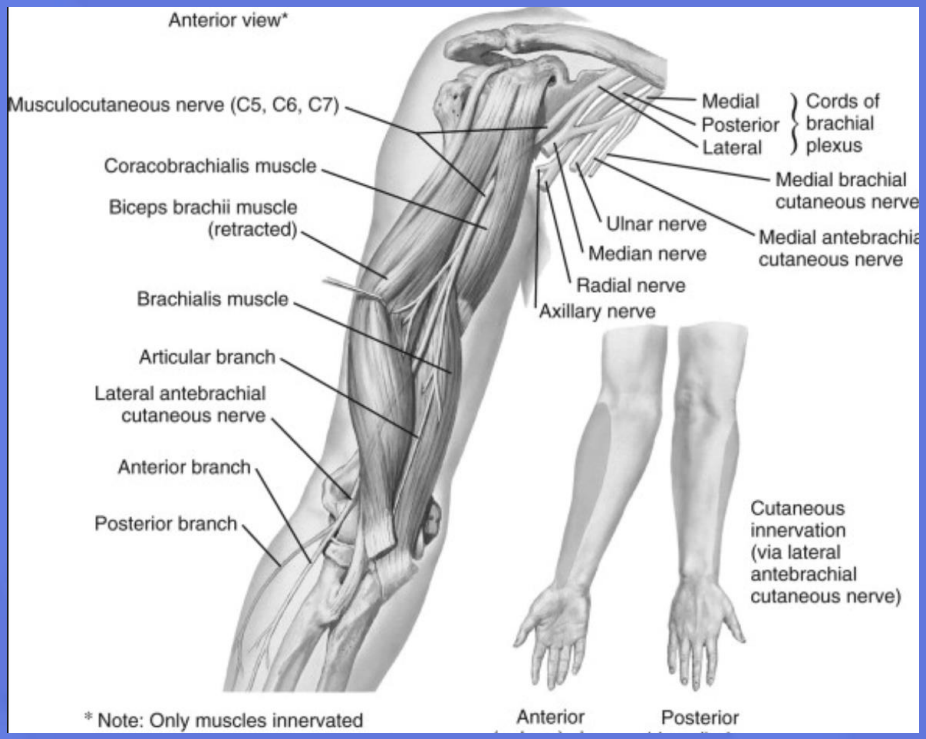
Musculocutaneous Nerve Anatomy

- Lateral cord
- Pierces CB 7-8 cm distal to acromion
- Travels between biceps and brachialis
- Biceps br 12cm distal acromion
  - Single branch bifurcates 60%
  - 2 braches 33%, 3 branches 5%
- 4-5cm distal single brachialis br arises (92%), often small artery there
- Continuation as LABCN



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Surgical Technique Oberlin

- Identify median, ulnar and MC nerves
- Internal neurolysis median and ulnar
- Identify biceps and brachialis branches
- Donor distal
- Recipient proximal
- Check with vessel loupe
- Transect and coapt

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Surgical Technique Oberlin

Individual fascicular stimulation targeting FCR and FCU

Some studies suggest unnecessary

Beware anesthesia paralytics

Tourniquet palsy possible

Results SFT vs DFT same

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Surgical Technique Intercostals

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Nerve Transfer Outcomes

- Success up to 14 months post injury and up to 66 years of age
- M4 in over 80% in almost all published series
- Intercostal results 70% M3, 40% M4

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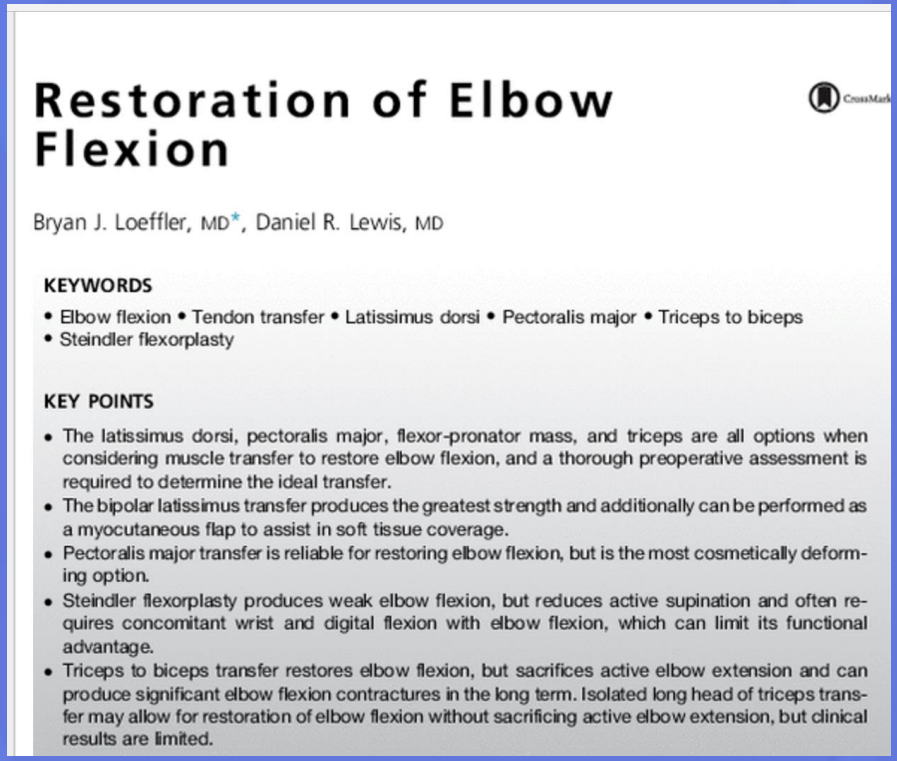
Muscle Transfers

- Steindler
  - Forgotten jewel
- Latissimus
- Pectoralis
- Free gracilis

- Triceps
- Pec minor
- SCM



Restoration of Elbow Flexion

Bryan J. Loeffler, MD*, Daniel R. Lewis, MD

KEYWORDS

• Elbow flexion • Tendon transfer • Latissimus dorsi • Pectoralis major • Triceps to biceps • Steindler flexorplasty

KEY POINTS

- The latissimus dorsi, pectoralis major, flexor-pronator mass, and triceps are all options when considering muscle transfer to restore elbow flexion, and a thorough preoperative assessment is required to determine the ideal transfer.
- The bipolar latissimus transfer produces the greatest strength and additionally can be performed as a myocutaneous flap to assist in soft tissue coverage.
- Pectoralis major transfer is reliable for restoring elbow flexion, but is the most cosmetically deforming option.
- Steindler flexorplasty produces weak elbow flexion, but reduces active supination and often requires concomitant wrist and digital flexion with elbow flexion, which can limit its functional advantage.
- Triceps to biceps transfer restores elbow flexion, but sacrifices active elbow extension and can produce significant elbow flexion contractures in the long term. Isolated long head of triceps transfer may allow for restoration of elbow flexion without sacrificing active elbow extension, but clinical results are limited.

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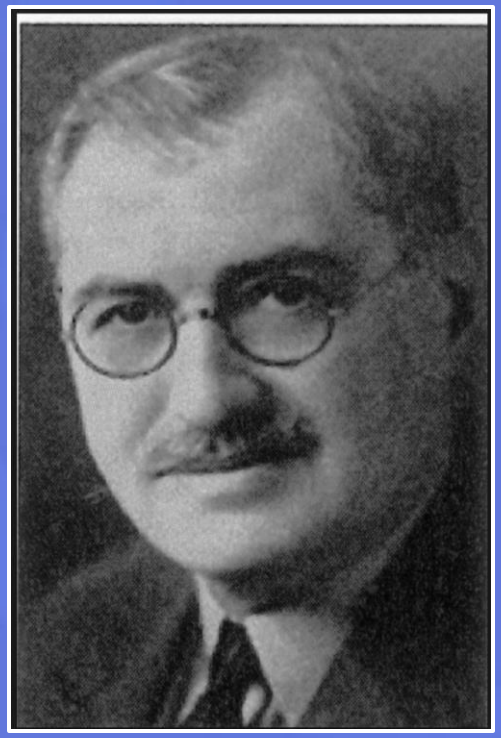
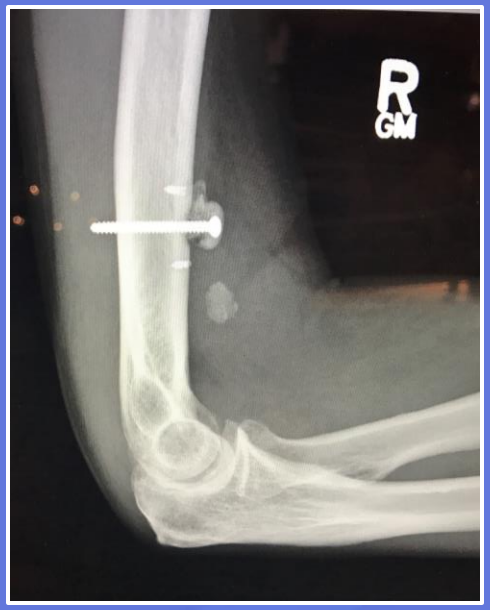
Steindler Flexorplasty

- Steindler (1918)
- Flexor-pronator mass transferred proximal to humerus
- “Steindler effect”
  - Preop test strength
- Technically simple
- Very effective





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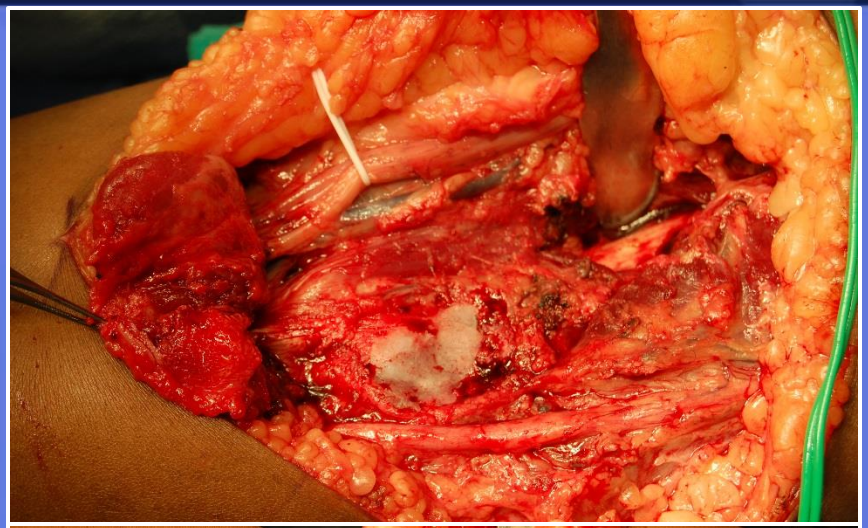
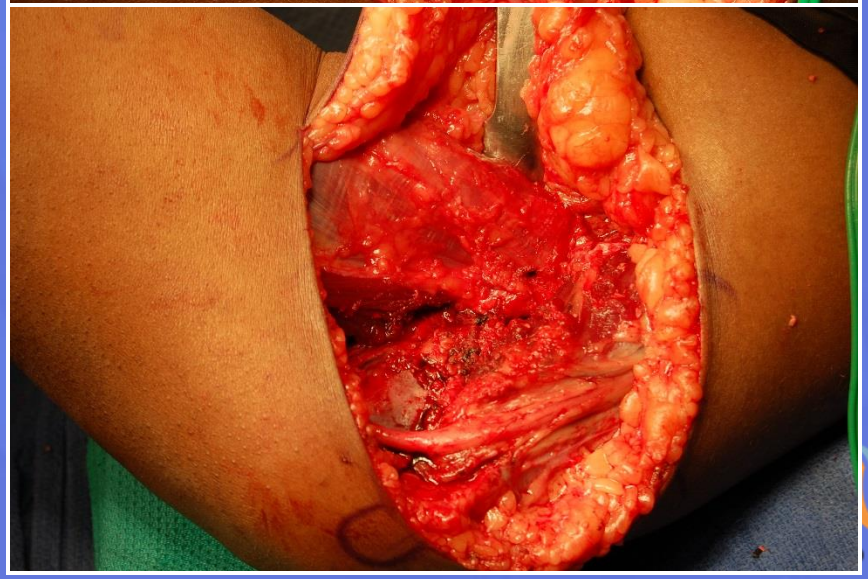
Steindler Surgical Technique

- Expose F/P mass
- Identify median & ulnar nerves
- Predrill epicondyle
- Osteotomy
- Transfer 5cm proximal to humerus





Steindler Outcomes

- Mean M4 strength
- Mean ROM
  - Flexion 107-142
  - Extension 20-42
    - » Liu et al. CORR 1993
    - » Eggers et al JHS 1992
    - » Dutton JBJS 1981

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Pectoralis & Latissimus Indications

- Indications
  - >2yrs post injury
  - Passive ROM
  - No arthritis
  - 5/5 donor strength
    - Partial denervation with C5/6 palsy
    - Poor cosmesis pec

- Unipolar vs bipolar

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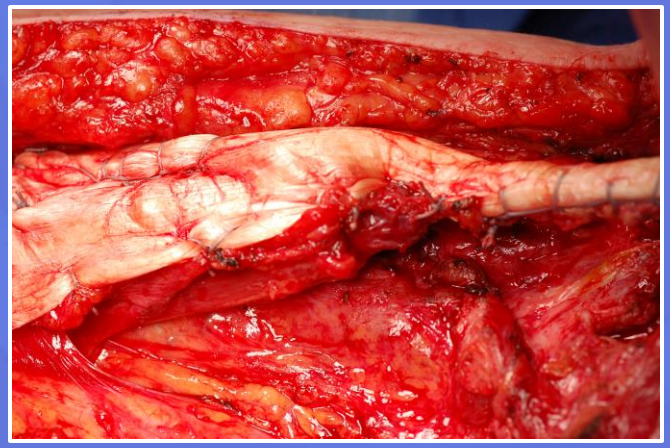
Pectoralis Transfer Technique

- Unipolar "flexorplasty"
  - Release insertion & transfer to biceps
    - Sternocostal head pec +/- graft
      - » Clark JMP Br J Surg 1946

- Bipolar
  - Origin to coracoid or acromion
  - Insertion to biceps



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Latissimus Transfer Technique

- Unipolar
  - Transfer insertion into biceps
    - » Schottstaedt JBJS 1955
- Bipolar
  - Origin to coracoid or acromion
  - Insertion to biceps of proximal forearm
    - » Zancolli JBJS 1973
  - Myocutaneous flap poss.

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Pectoralis and Latissimus Outcomes

- Unipolar
  - M3-M4 power
  - 25-120 mean ROM
    - » Brooks DM Bone Joint 1959
    - » Beaton DE. JHS 1995
- Bipolar
  - M4 power
  - 25-130 mean ROM
    - » Carroll RE JHS 1979
    - » Botte MJ. CORR 1989

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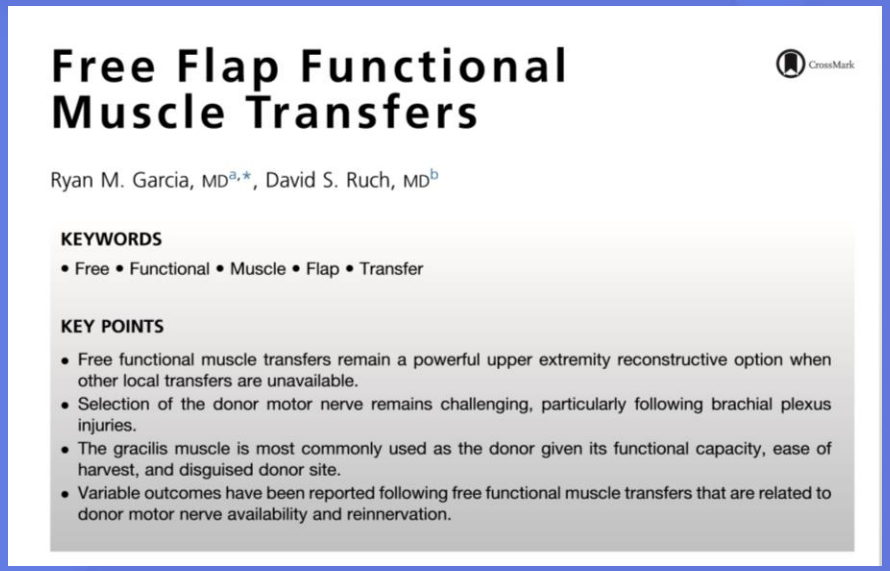
Free Gracilis Indications

- Delayed presentation
- Simpler options unavailable
- Skeletal maturity
- Donor nerve/artery available for motor
  - May “bank” donors
- Can add skin paddle



Free Flap Functional Muscle Transfers

Ryan M. Garcia, MD[a,*], David S. Ruch, MD[b]

KEYWORDS

• Free • Functional • Muscle • Flap • Transfer

KEY POINTS

- Free functional muscle transfers remain a powerful upper extremity reconstructive option when other local transfers are unavailable.
- Selection of the donor motor nerve remains challenging, particularly following brachial plexus injuries.
- The gracilis muscle is most commonly used as the donor given its functional capacity, ease of harvest, and disguised donor site.
- Variable outcomes have been reported following free functional muscle transfers that are related to donor motor nerve availability and reinnervation.

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1st reported 1979 for elbow flexion restoration

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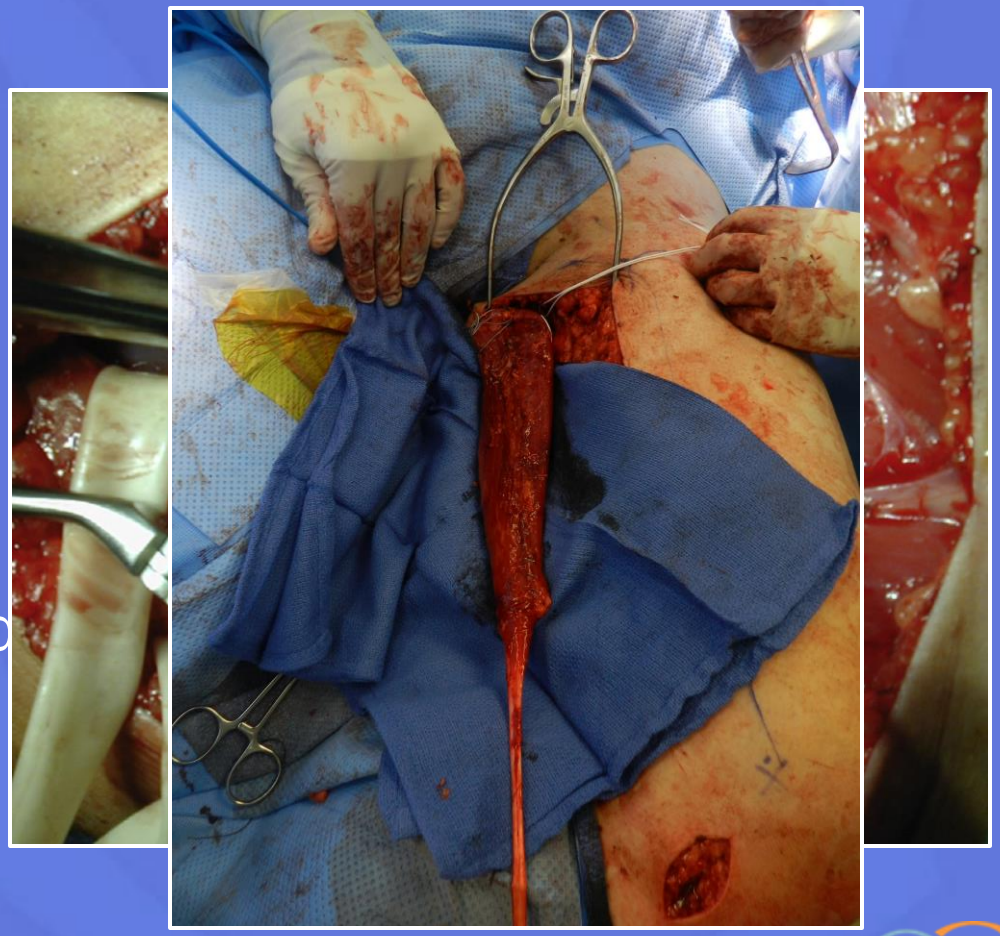
Free Gracilis Technique

- Incision pubic tubercle (origin) to medial condyle
  - Most posterior adductor
  - Sartorius off ASIS
- Separate insertion from pes
- ID pedicle (ant. br obturator)
- Med circ. artery/veins ligated at origin (6cm length)
- Acromion/clavicle to biceps insertion
- Anastamosis/coaptation



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Free Gracilis Outcomes

- Most data in Volkmans/trauma
- Plexus data
  - 55% M4+ in 29 cases using intercostals
    - » Barrie et al Neurosurg Focus 2004
  - 41% M4+ using intercostals
    - » Chuang et al JHS 1993
  - Intraplexal donors better when available

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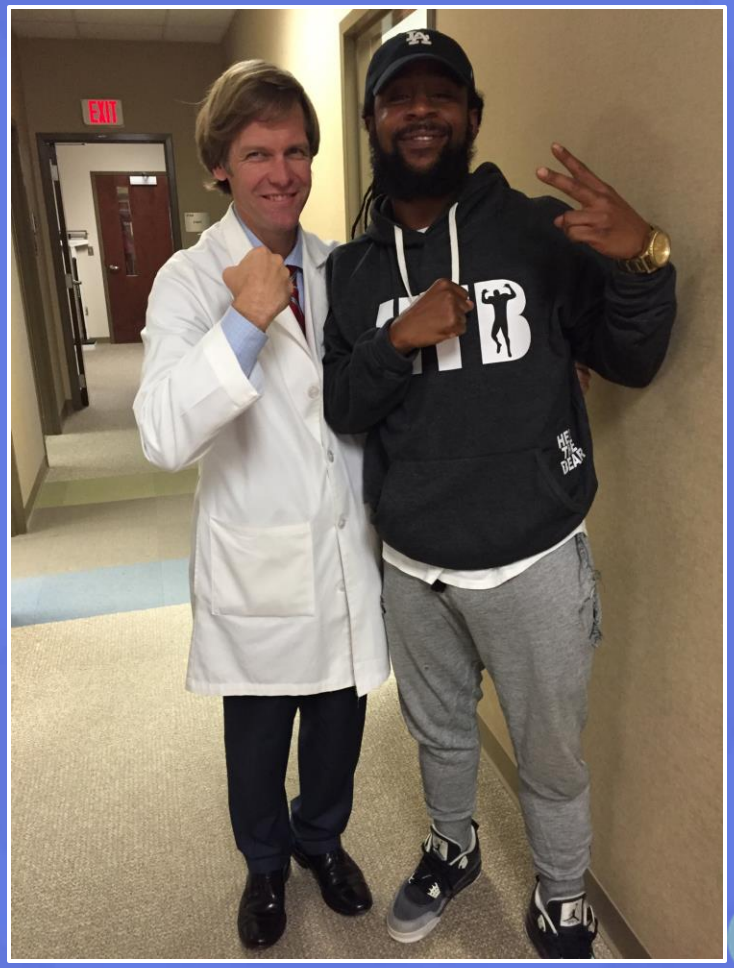
Case 1

- Underwent double Oberlin procedure
  - Radial to axillary
- Restored elbow flexion at 5 months
  - M4 strength now
- Awaiting shoulder function



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Case 2

- Underwent plexus neurolysis, neuroma resection, & sural nerve grafting
  - C5 to anterior division
  - C6 to posterior division

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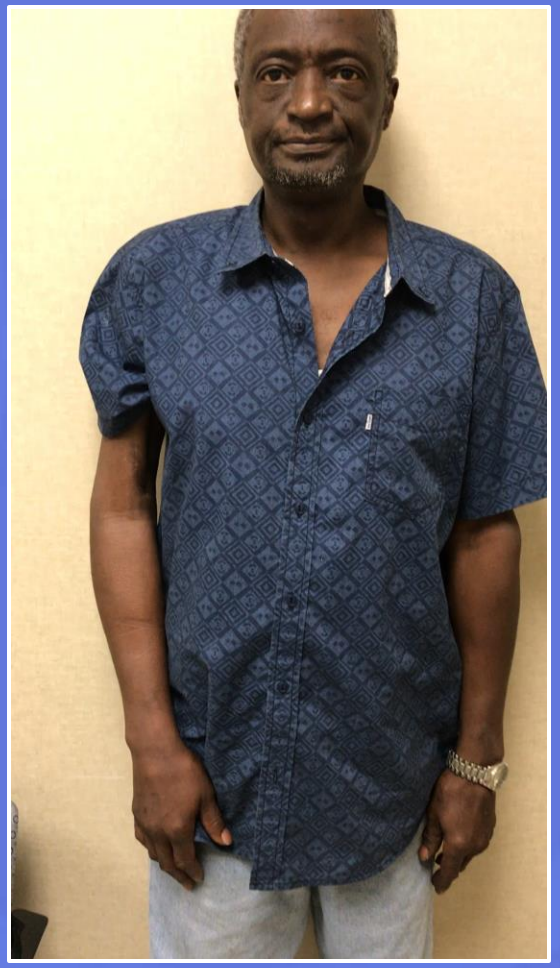
Case 3

- Underwent Steindler flexorplasty
- LAC x 6 weeks
- Hinged elbow brace



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Case 4

- Underwent intercostal to musculocutaneous transfer & SAN to supraspinatus transfer (M3 elbow flexion)
- Pending gracilis for wrist/hand

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Thank You

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