Traumatic Nerve Injury: Diagnosis & Outcomes

Karina Del Rosario, M.D.
Assistant Clinical Professor
Physical Medicine & Rehabilitation
UCSF Department of Orthopaedic Surgery
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Disclosures

- None

Objectives

Review:

- Etiology and diagnosis of traumatic peripheral nerve injuries
- Prognosis, management and recovery of nerve injuries
- Current and future of nerve injury care

Incidence

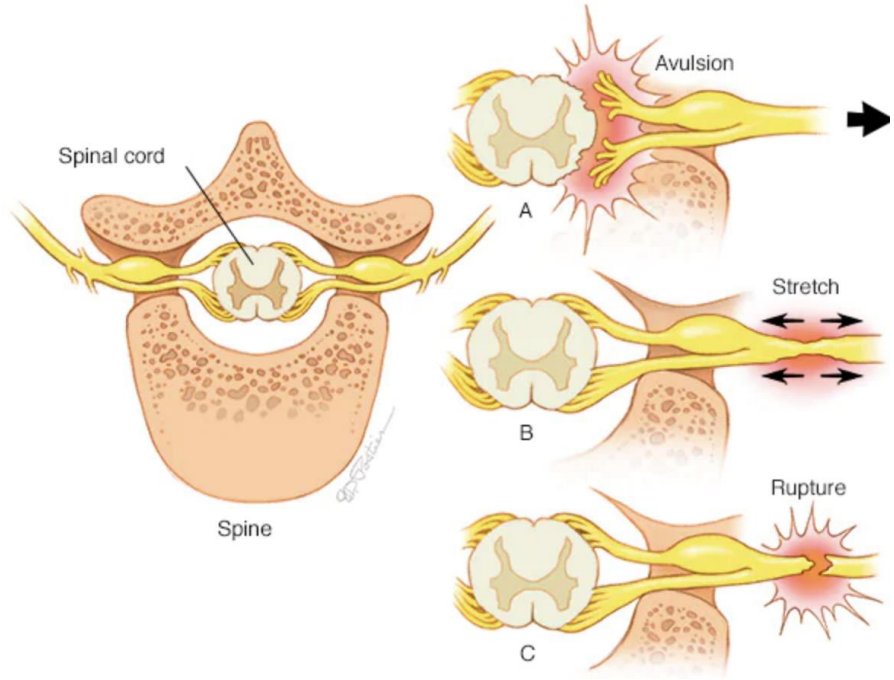
- Traumatic peripheral nerve injury is a significant cause of disability and morbidity

- 2-3% of all patients admitted to level 1 trauma center had peripheral nerve injury
  - 5% when root/plexus injury included

- Upper extremity more common than lower extremity
  - radial > ulnar > median
  - sciatic > peroneal > tibial/femoral

Etiology

- Compression, traction/stretch, ischemia, laceration, electric shock, radiation
- In trauma, stretch-related injuries are common but often is a combination
- Motor vehicle accidents (motorcycle) are the most common cause



Orthopedic injuries associated with nerve injury

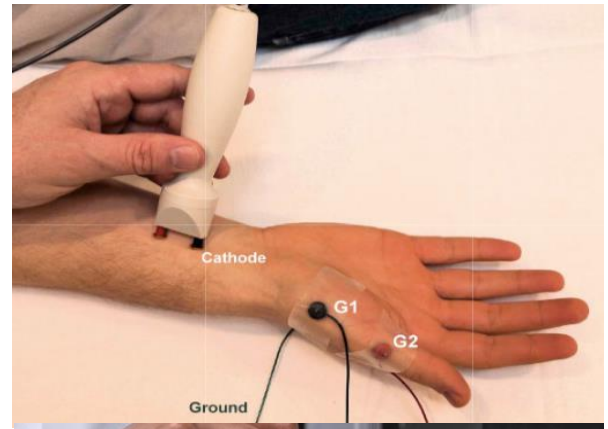
- **Upper extremity**
  - Crush Injury
  - Humerus fractures
  - Radius fractures
  - Ulna fractures
  - Shoulder dislocations
- **Lower extremity**
  - Crush Injury
  - Acetabular fractures
  - Femur fractures
  - Ankle fractures
  - Hip dislocations
  - Knee dislocations

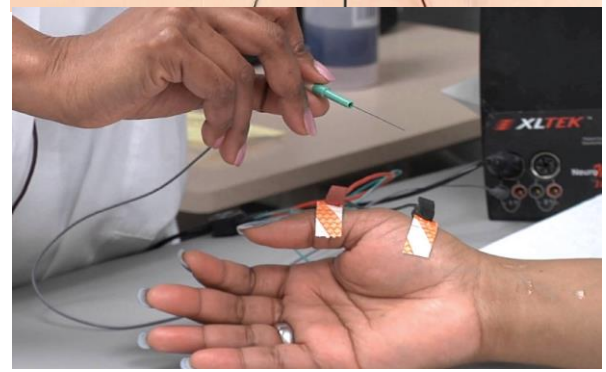
Crush injury: Trauma to body tissues resulting from an applied force that compresses or squeezes tissues, causing damage such as compartment syndrome, dislocation, fracture, laceration, or nerve damage.

Diagnosis

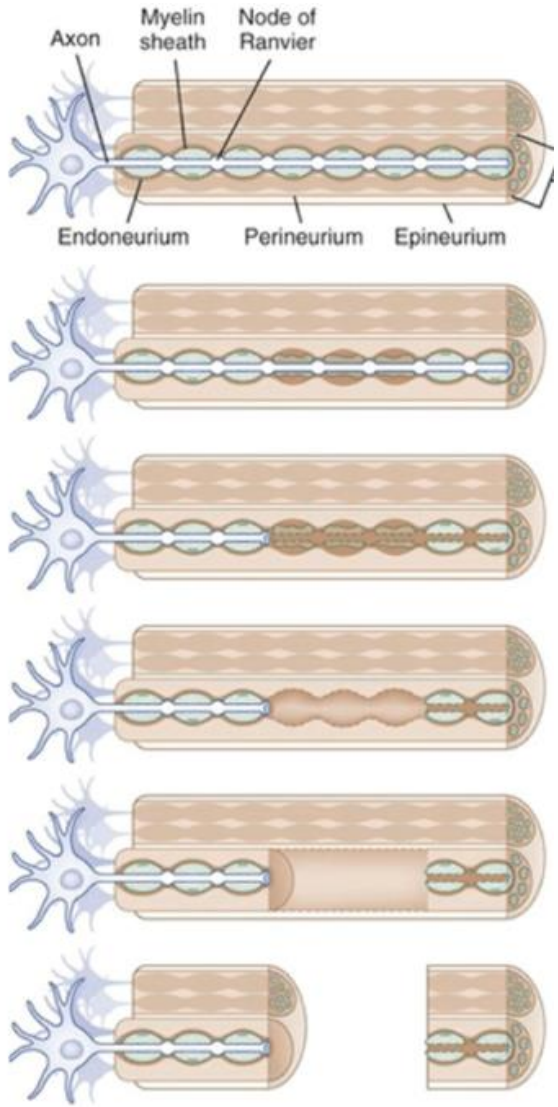
EDX: Localize and determine severity of injury

- History and physical exam
- Electrodiagnostic testing (EDX)
  - Nerve Conduction Study + Electromyography
- MRI
- Ultrasound
- Somatosensory evoked potentials





Seddon/Sunderland Classification



Grade 1 – **Neuropraxia**

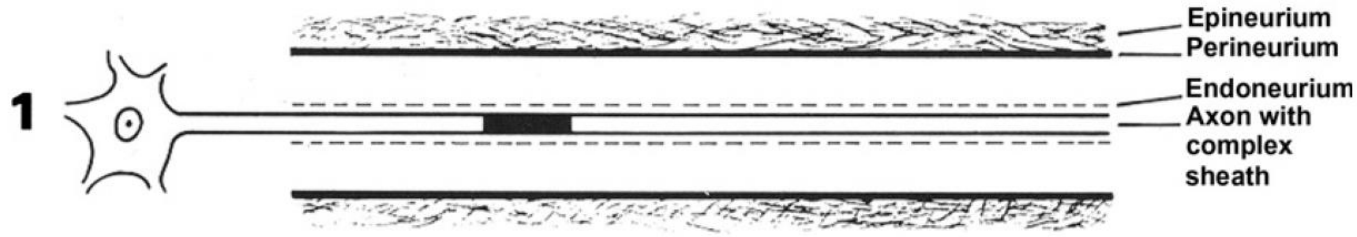
Grade 2 – **Axonotmesis** (disruption of axon)

Grade 3 – Axonotmesis (disruption of axon and endoneurium)

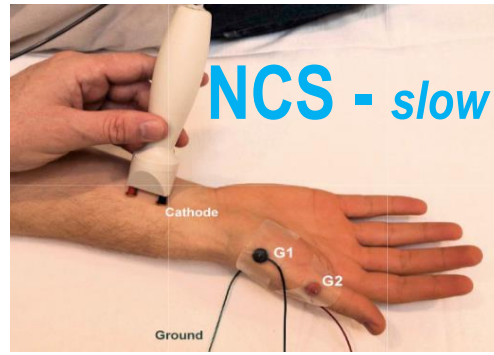
Grade 4 – Axonotmesis (disruption of axon, endoneurium, perineurium)

Grade 5 – **Neurotmesis** with complete transection of nerve trunk

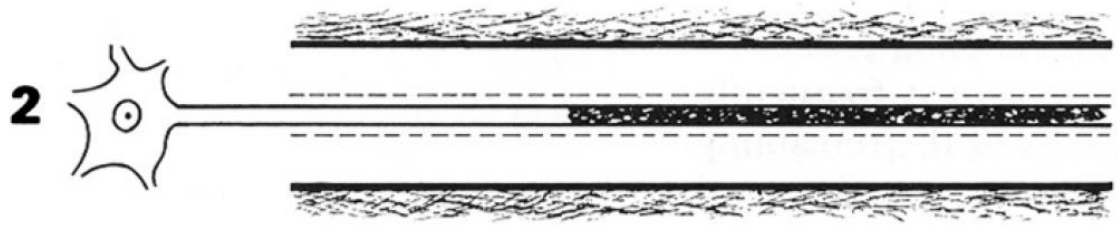
Neuropraxia (Grade 1)



- **Focal demyelination**
  - Excellent prognosis
  - Return of function when remyelination occurs
  - Full spontaneous recovery possible
    - Most resolve within 3-6 months

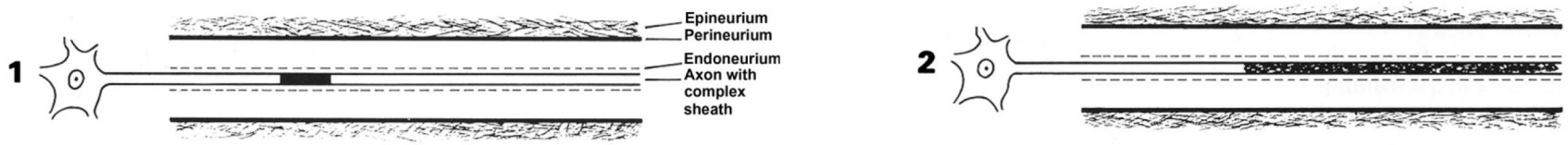


Axonotmesis (Grade 2)



- **Axonal injury (denervation)**
  - Good prognosis
  - Partial preservation of supporting structures
  - Full spontaneous recovery possible (slow)
  - Reinnervation dependent on degree of internal disorganization and “time-distance” factor

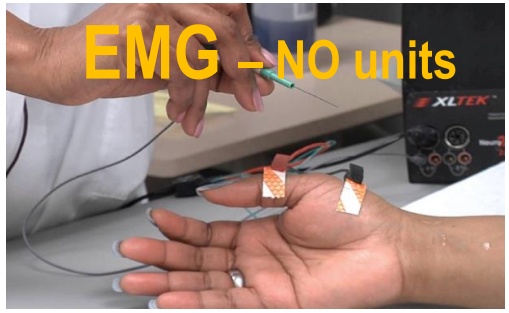
Mixed Injury (Grade 1 & 2)

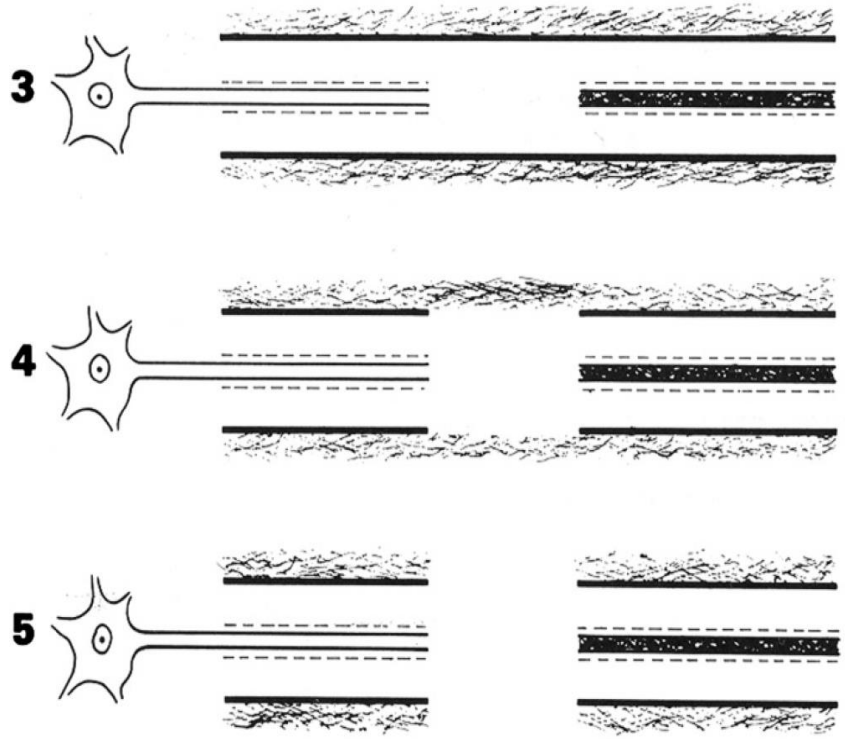


- **Mixed (Neuropraxia + Axonotmesis)**
  - Good prognosis
  - Biphasic spontaneous recovery
  - Usually rapid but incomplete + slower recovery

Axonotmesis to Neurotmesis (Grade 3-5)

- **Axonotmesis**
  - **Grade 3**
    - Fair prognosis
    - Spontaneous recovery unlikely
  - **Grade 4**
    - Poor-nil prognosis
- **Neurotmesis**
  - **Grade 5**
    - Nil prognosis





» Grade 4,5 - poor prognosis without surgery

Welcome to the UCSF Peripheral Nerve and Complex Limb Reconstruction Center

Multidisciplinary Team

Dr. Igor Immerman, Orthopaedic Surgeon (Hand and Upper Extremity)

Dr. Igor Immerman is an orthopaedic surgeon with specialty training in hand and upper extremity surgery. Treating all conditions of the upper extremity, from the simple to the complex, Dr. Immerman's philosophy of care is that each patient should be treated as a unique person and not by a cookie-cutter, protocol-only approach. He spends time getting to know each patient, and he works with the patient to choose the right treatment, whether surgical or nonsurgical, that is best for a patient's specific situation.

Dr. Nicolas Lee, Orthopaedic Surgeon (Hand and Upper Extremity)

Dr. Lee is an orthopaedic surgeon with clinical interests include upper extremity elective and trauma care from the fingertip to the shoulder. He has an additional interest in soft tissue coverage and microvascular surgery.

Dr. Michael Terry, Plastic Surgeon

Dr. Terry's areas of clinical expertise include the treatment of disorders of the hand and wrist; surgical reconstruction of defects of the head and neck, torso, and extremities; aesthetic surgery of the eyelids, nose, face, and neck; and body-contouring surgery of the breasts, abdomen, arms, and legs.

Dr. Karina Del Rosario, Physiatrist

Dr. Karina Del Rosario is a board-certified specialist in Physical Medicine & Rehabilitation (PM&R) and Electrodiagnostic Medicine focused on non-operative and interdisciplinary care of patients with musculoskeletal and neuromuscular conditions. She specializes in performing electromyography and nerve conduction studies (EMG/NCS) to identify nerve and muscle injuries, along with neurological rehabilitation and management of musculoskeletal injuries and pain.

Ortho + Plastic Surgery + PM&R

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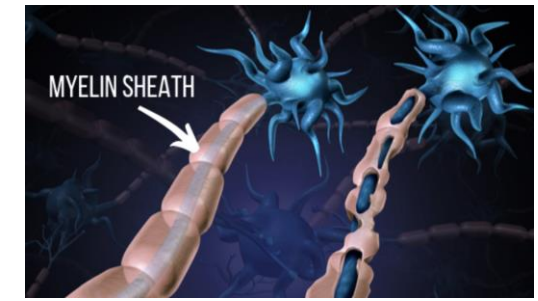
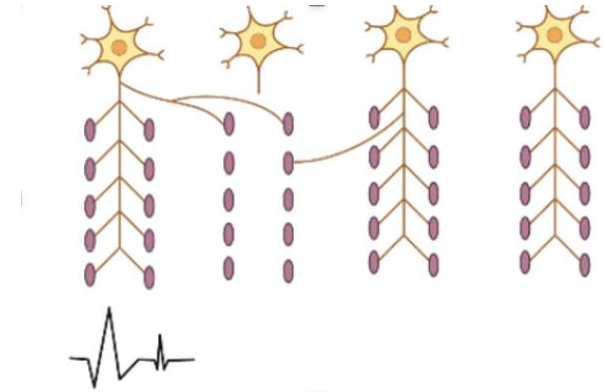
Nerve Recovery

- Spontaneous nerve recovery is usually better than surgical treatment
- Recovery depends on…
  - Degree of nerve injury
  - Location of nerve injury and distance to muscle
  - Nerve root involvement
  - Age
  - Type and timing of surgery

Nerve Repair Mechanisms

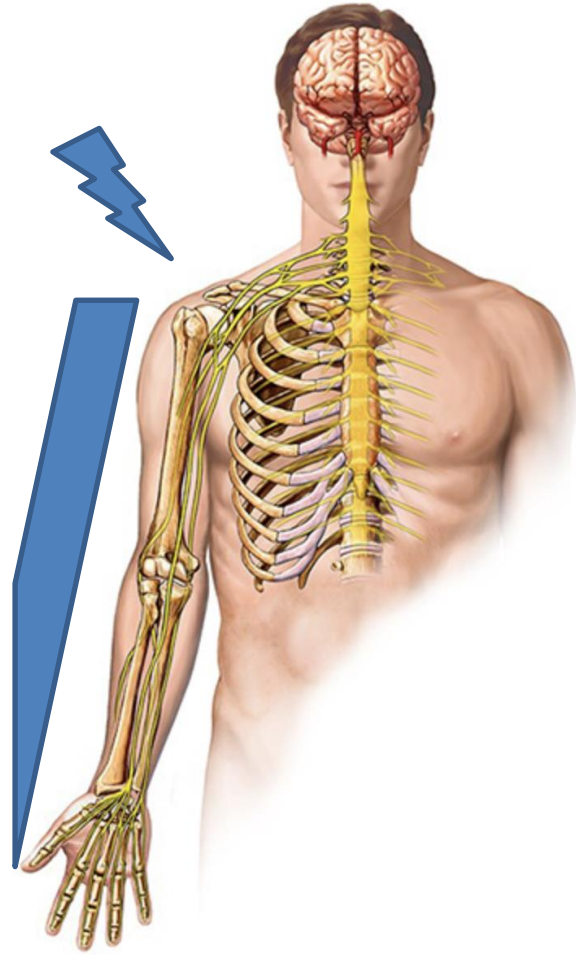
- Remyelination
- Collateral sprouting distally from preserved axons
- Axonal regeneration from the site of injury
  - 1 mm/day or 1 inch/month
  - 12-18 months – muscle cannot be reinnervated

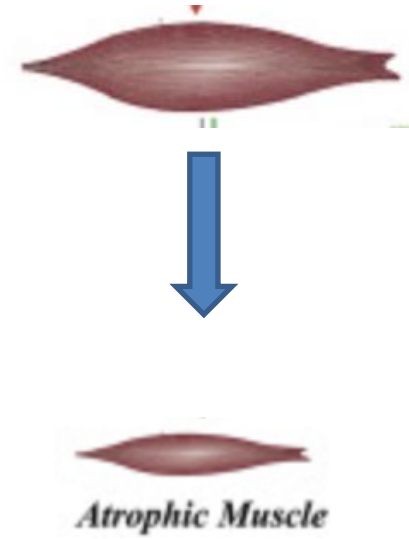




Nerve Recovery

~22 in[illegible] months





12-18 months: irreversible muscle atrophy and fibrosis

Paradigm Shift

Nerve Repair → Nerve Grafting → Nerve Transfers

Autograft
Allograft
Conduits

End-to-end
End-to-side

Paradigm Shift: Nerve Transfers

- Time is muscle
- Transfer healthy ne
- Shorten the distanc muscles
  - *proximal injury is cr*

Table 1
Nerve transfers for restoration of shoulder function.

- Spinal Accessory to Suprascapular (End-to-end) Nerve Transfer
- Spinal Accessory to Suprascapular (End-to-side) Nerve Transfer
- Lateral and Medial Triceps Branch to Axillary Nerve Transfer
- Thoracodorsal to Long Thoracic Nerve Transfer
- Pectoral Fascicle to Long Thoracic Nerve Transfer
- Double Level (Pectoral Fascicle and Thoracodorsal) Nerve Transfer for Long Thoracic Nerve Function
- Pectoral Fascicle to Spinal Accessory Nerve Transfer
- Intercostal Nerve to Axillary Nerve Transfer
- Intercostal Nerve to Long Thoracic Nerve Transfer
- Combined Nerve Transfers

Table 3
Restoration of finger flexion.

- Flexor Digitorum Superficialis to Anterior Interosseous Nerve Transfer
- Brachialis to Anterior Interosseous Nerve Transfer for Lower Plexus Injuries
- Extensor Carpi Radialis Brevis to Anterior Interosseous Nerve Transfer
- Extensor Carpi Radialis Brevis to Pronator Teres and Supinator to Anterior Interosseous Nerve Transfer
- Flexor Digitorum Superficialis to Flexor Pollicis Longus Nerve Transfer for Partial Median Nerve Injury

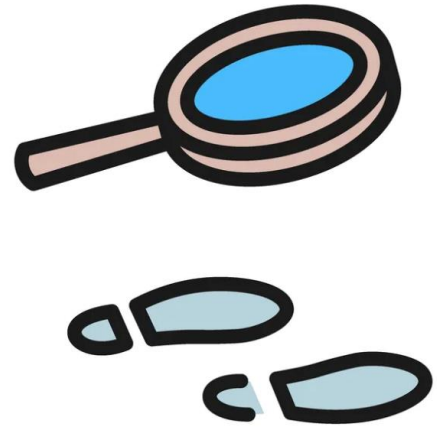
uction

Moucharafieh et al 2020

When to watch & wait?

7 days to 3 months after injury

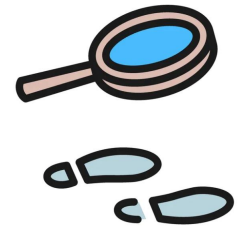
- Clues from EMG/NCS for signs of recovery
  - Voluntary motor unit recruitment on EMG in muscle immediately distal to injury site
  - Normal or reduced CMAP amplitude distal to injury site



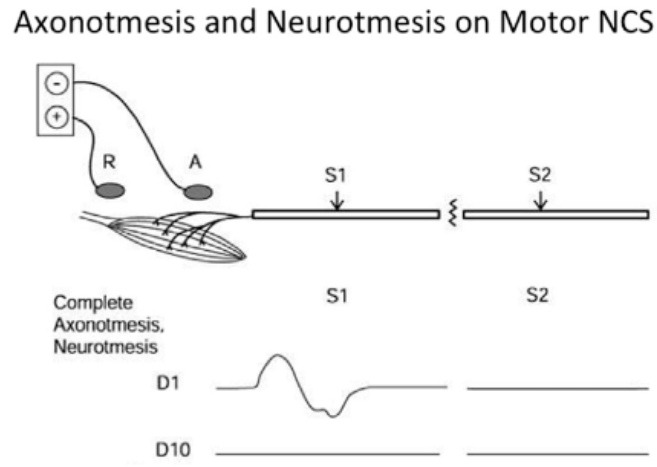
…consider waiting

Robinson 2018

Signs of Poor Prognosis

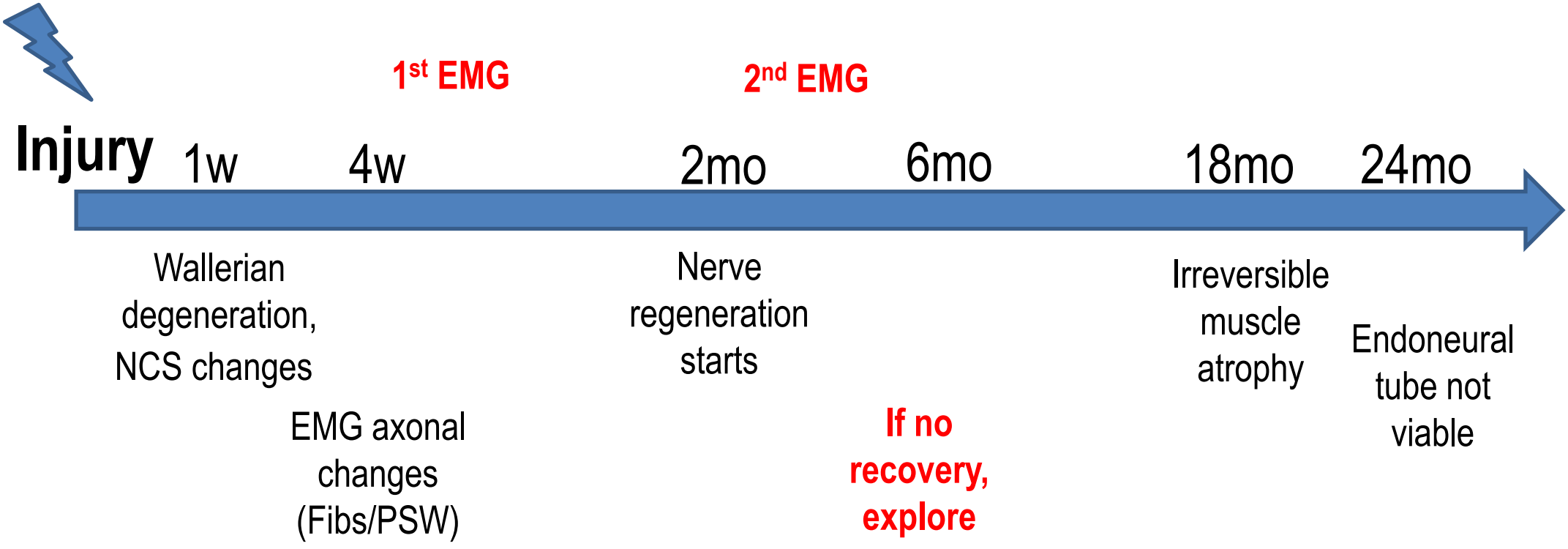


- Lower trunk or medial cord plexus injury
- Root avulsion
- Neuroma, scarring/fibrosis
- Absent motor unit recruitment on EMG
  (Sunderland Grade 4-5)
- Absent CMAP amplitude distal to injury site on NCS



…consider surgery

Timing of nerve injury



Case

35yo RHD man s/p motorcycle accident (10/2019) with left shoulder dislocation, left clavicle and scapula fracture.

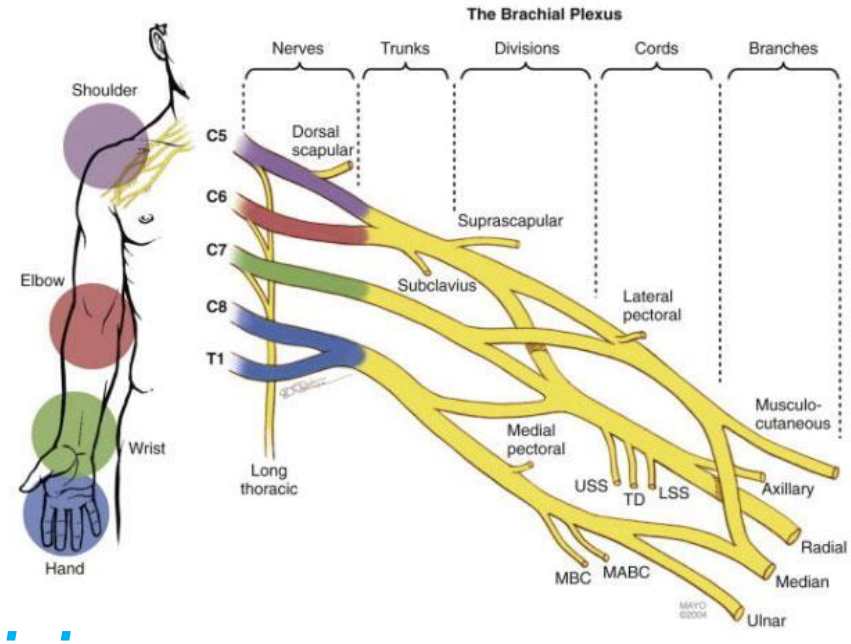
He reports being unable to move the shoulder or flex elbow.

He can use the hand but feels numbness in the thumb

Physical exam

- Inspection shows atrophy of the deltoid and supra/infraspinatus fossa
- Strength in LUE is 0/5 shoulder abduction, 0/5 biceps, 4/5 triceps, 3/5 wrist extensors, 5/5 wrist flexors, 5/5 finger flexors, 5/5 finger abductors
- Sensation altered to light touch and pinprick in digit 1-2

Electrodiagno



Date of Injury: 10/2019

EMG/NCS 7/22/20

9 months from injury

Conclusion:

Abnormal study

1. There is electrodiagnostic evidence suggestive of a chronic axonal left brachial plexopathy involving the upper trunk and to lesser extent the middle trunk

a. Findings in the upper trunk are severe and concerning for neurotmesis as no motor units could be recruited from C5-C6 muscles (biceps, deltoid). The middle trunk appears much less affected and is more consistent with axonotmesis

b. Cervical root involvement could not be fully excluded given mild abnormalities were seen in the cervical paraspinal muscles. Testing of the rhomboids was limited today

2. In regards to potential donor muscles, the long head of the triceps, FCU and FCR were normal on EMG testing of the left upper limb

Case

Oberlin Procedure – Double fascicular transfer

Date of Injury: 10/2019
Date of Surgery: 8/13/20
Procedure performed: OPERATION:

1. Exploration of left brachial plexus, supraclavicular, with neurolysis (CPT 64713)
2. Left upper extremity transfer of motor fascicle of ulnar nerve to biceps branch of musculocutaneous nerve (CPT 64905)
3. Left upper extremity transfer of motor fascicle of median nerve to brachialis branch of musculocutaneous nerve (CPT 64905)
4. Left upper extremity/shoulder exploration and decompression and external neurolysis of left axillary nerve (CPT 64708)

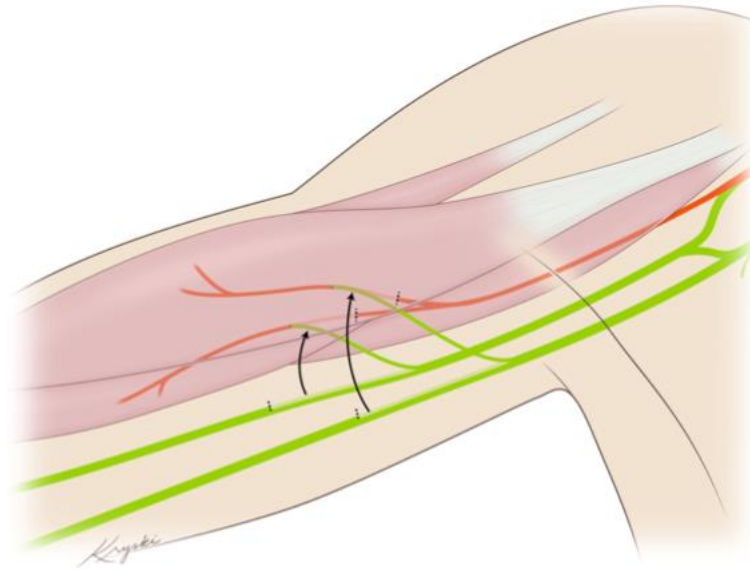


FIGURE 1: This illustration shows the ulnar and median fascicular transfers to the two branches of the musculocutaneous nerve.

Texakalidis et al 2019

Case

Date of Injury: 10/2019

Date of Surgery 8/13/20

- **Pre-op:** 0/5 deltoid, 0/5 biceps, 3/5 wrist extensors, 4/5 triceps, 5/5 APB, 5/5 FDI
- **6 mo post-op** (2/12/21): able to slightly flex the elbow and internally rotate the shoulder now. +Biceps activation when making a fist and flexing wrist, 1/5 biceps, 1/5 posterior deltoid, 0/5 middle deltoid
- **7 mo post-op EMG** (3/12/21): motor units recruited in left deltoid and biceps (new from pre-op EMG)
- **13 mo post-op** (9/10/21): more improvement, can flex elbow and touch his face now. Can pick up 12 pack of soda. 2/5 deltoid, 4+/5 biceps


5 lb.
(2.27 kg)

Nerve Transfers: Future Perspectives

- Peripheral nerve/plexus injury
  - Exploration, possible reconstruction with grafting at injury site
  - Targeted distal nerve fascicular transfer

- CNS pathology
  - Spinal cord injury
- Amputee
  - Myoelectric prosthesis (TMR), phantom limb pain/neuroma

Midha et al 2019

Thank You

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Karina.delrosario@ucsf.edu

References

Houdek MT, Shin AY. Traumatic Peripheral Nerve Injuries. Hand Clin 31, 2015; 151-163

Midha R, Grochmal J. Surgery for nerve injury: current and future perspectives. J Neurosurg Volume 130. March 2019

Preston C, Shapiro B. Electromyography and Neuromuscular Disorders. Third Edition. Elsevier Inc, 2013

Robinson L. How electrodiagnosis predicts clinical outcomes of focal peripheral nerve lesions. Muscle Nerve, 2015 Sep; 52(3):321-33

Robinson L. Predicting Recovery from Peripheral Nerve Trauma. Phys med Rehabil Clin N Am 29, 2018: 721-733.

Sunderland S. Nerve Injuries and Their Repair: A Critical Appraisal, Churchill Livingstone, Edinburgh 1991

Texakalidis P, Tora M S, Lamanna J, et al. Double Fascicular Nerve Transfer to Musculocutaneous Branches for Restoration of Elbow Flexion in Brachial Plexus Injury: Cureus 11(4): e4517. April 2019.

Taylor CA, Braza D, Rice JB, Dillingham T. The incidence of peripheral nerve injury in extremity trauma. Am J Phys Med Rehabil 2008;87:381-385