# Upper Extremity Peripheral Nerve Injury and Management

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ASHT President

## Objectives

- Describe surgical techniques for peripheral nerve repair
- Explain peripheral nerve regeneration
- Select appropriate orthoses for use after UE peripheral nerve injury
- Describe 3 techniques to facilitate recovery following UE peripheral nerve repair

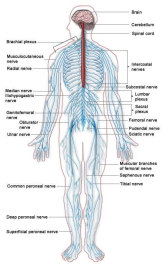
## Financial Disclosure

- There are no financial disclosures in this presentation

## Content Outline

- Review of peripheral nerve pathways
- Review of peripheral nerve anatomy and function
- Peripheral nerve injuries and classifications
- Sequence of events following injury
- Regeneration following injury
- Surgery for peripheral nerve lacerations/injuries
- Post operative guidelines following surgery
- Orthotics to prevent deformity and improve function
- Therapy principles and ideas following peripheral nerve repair

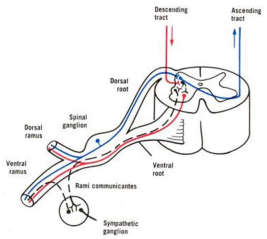
## PNS Connects CNS to limbs and organs




Wikipedia.com

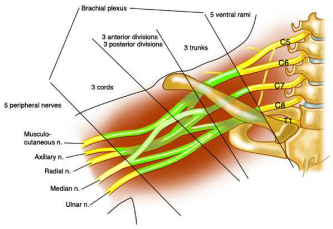
## Journey From Spinal Cord to Upper Extremity

- Motor
- Sensory
- Sympathetic



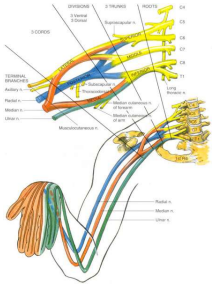
## Journey From Spinal Cord to Upper Extremity

- Brachial plexus
  - Roots
  - Trunks
  - Divisions
  - Cords
  - Branches




stepjourney.wordpress.com

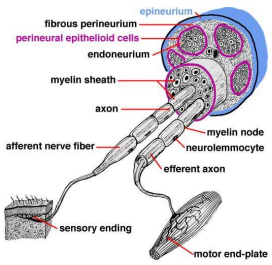
## Journey From Spinal Cord to Upper Extremity



itd.unair.ac.id

## Journey From Spinal Cord to Upper Extremity

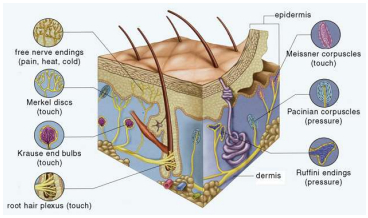
Terminate on End Organs
- Motor end plates
- Sympathetic (skin, smooth muscle, blood vessels)
- Sensory receptors




vanat.cvm.umn.edu

## Journey From Spinal Cord to Upper Extremity

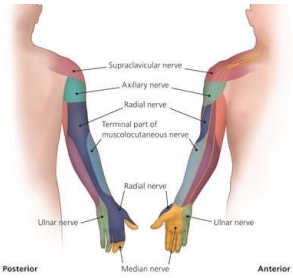
- Sensory Receptors




ecommunity.pwsd76.ab.ca

## Journey From Spinal Cord to Upper Extremity

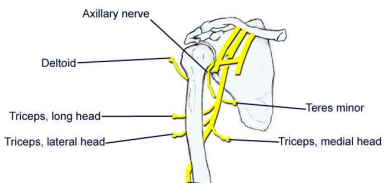
- Sensory Distribution of Peripheral Nerves




aafp.org

## Journey From Spinal Cord to Upper Extremity

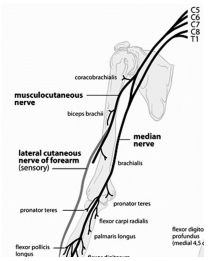
- Motor Supply
  - Axillary Nerve



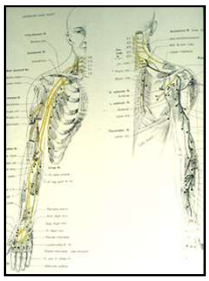

withealth.net

## Journey From Spinal Cord to Upper Extremity

- Musculocutaneous Nerve
  - Coracobrachialis
  - Biceps brachii
  - Brachialis
  - Lateral cutaneous n of forearm




## Journey From Spinal Cord to Upper extremity



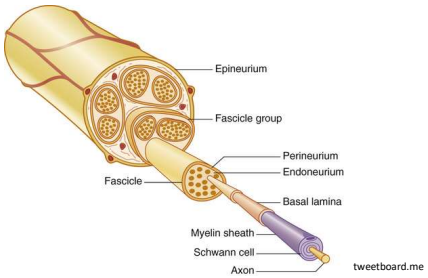
## Journey from Spinal Cord to Upper Extremity

| Median Nerve |
|---|
| Pronator teres |
| FCR |
| Palmaris longus |
| FDS |
| FDP I&II |
| FPL |
| PQ |
| Abd Poll Brev |
| Opp Poll |
| Flex Poll Brev (sup) |
| Lumbricals I&II |

| Ulnar Nerve |
|---|
| FCU |
| FDP III&IV |
| Palmaris Brevis |
| Abd Dig Minimi |
| Opp Dig Minimi |
| Flexor Dig Minimi |
| Palmar Interossei |
| Lumbricals III&IV |
| Dorsal Interossei |
| Flex Poll Brev (deep) |
| Add Pollicis |

| Radial Nerve |
|---|
| Triceps |
| Brachioradialis |
| ECRL |
| ECRB |
| Supinator |
| EDC |
| Ext Dig Minimi |
| ECU |
| Abd Poll Longus |
| Ext Poll Brevis |
| Ext Poll Longus |
| Ext Indicis Proprius |

Peripheral Nerve anatomy




# Peripheral nerve injuries

Peripheral nerve injuries

- **Trauma (Laceration**, crush)
- Traction/Avulsion
- Compression
- Ischemia
- Electrical Injury
- Radiation
- Injection
- Internal: Tumors, fracture, callus

## Peripheral Nerve Injury Classifications

| Seddon | Sunderland |
|---|---|
| • Neurapraxia | ◦ First degree |
| • Axonotmesis | ◦ Second degree<br>◦ Third degree<br>◦ Fourth degree |
| • Neurotmesis | ◦ Fifth degree<br>◦ Sixth degree (combination) Mackinnon |

Seddon HJ. Three types of nerve injuries. *Brain*. 1943;66:237.

Sunderland S. A classification of peripheral nerve injuries producing loss of function. *Brain*. 1951;74:491-516

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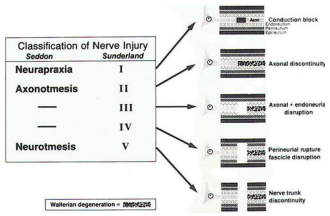
## Peripheral Nerve Injury Classifications

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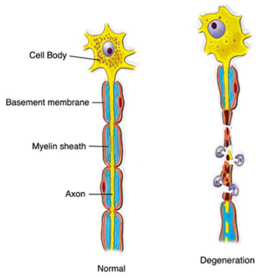
## Seddon Neurotmesis
## Sunderland 5th degree injury

- Total severance or disruption of the entire nerve
- Recovery is not possible without surgical treatment

## Peripheral Nerve injury

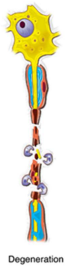
- Cell Body
- Segment Proximal
- Injury Site
- Segment Distal
- End Organ




painmd.tv

## Peripheral nerve injury sequence

- Cell Body: Chromatolysis - Nerve body swells, nucleus migrates to the periphery, Nissl granules break up and disperse. Cell body is reprogrammed to produce protein and lipid needed for axonal regrowth. If injury is severe and proximal, may cause cell body death




## Peripheral nerve injury sequence

- **Proximal segment:** Retrograde degeneration occurs proximal to the injury to at least the first node of Ranvier, or may extend completely back to cell body, resulting in its death.

## Peripheral nerve injury sequence

- **Injury site:**
  - Endoneurial tubes, fasicules disrupted- Schwann cells, axons no longer confined.
  - Epineurial, perineurial and endoneurial fibroblasts are present at severed ends within 24 hours, along with proliferating Schwann cells.
  - Capillary permeability , edema and macrophage infiltration follow.

Degeneration

## Peripheral nerve injury sequence

- Distal segment:
  - **Wallerian degeneration (anterograde degeneration) of the axon from the site of injury completely distally**
  - **Collapsed endoneurial tubes are referred to as "Bands of Bungner".**
  - **May take 1-3 months for complete phagocytosis of axon and myelin within the collapsed endoneurial tubes**

Degeneration

## Peripheral nerve injury sequence

Target Tissue/end organ

- Motor Nerves: Muscle paralysis, rapid atrophy
  - After 1-2 years reinnervation unlikely
- Sensory Nerves: Numbness
  - Axon terminal degenerates in ~9 months
  - Encapsulated nerve receptors may survive prolonged periods awaiting nerve terminal
- Trophic: dryness, cyanosis, brittle nails, fingertip narrowing

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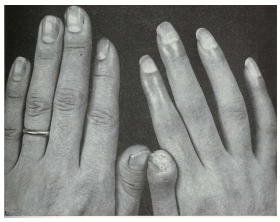
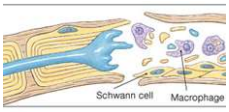
## Trophic changes



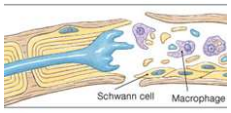
## Peripheral Nerve Regeneration

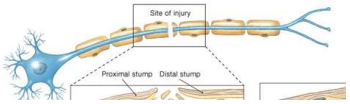
- Cell body nucleus returns to center, Nissl granules reorganize
- Axoplasm arises from proximal axon segment and cell body
- Axoplasmic transport supplies materials from cell body to sites of axonal regeneration
- Distal aspect of axon develops growth cone with filopedia to explore surroundings

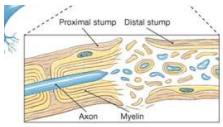


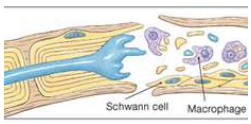

## Peripheral nerve regeneration

- Schwann cells align longitudinally, creating bands of Bunger, serve as a scaffold for the regenerating axon
- Contact guidance – growth cone draws the axon toward attractive substrate
- Regenerating axons that successfully enter the endoneurial tubes in the distal segment stand a good chance of reaching the end organ.
- Axonal sprouts regenerate down the distal segment at approx 1 mm per day





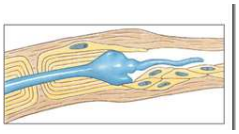




**1. Axon and myelin fragmentation distal to injury**

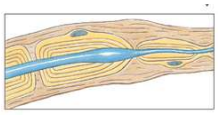
**2. Schwann cells grow into cut, unite ends. Macrophages clean injured myelin and axons**

medatrio.com

## Peripheral Nerve Regeneration



**3. Axon sends sprouts into network of Schwann cells, grows along cord of Schwann cells**



**4. Schwann cells enfold axon as it grows distally**

medatrio.com

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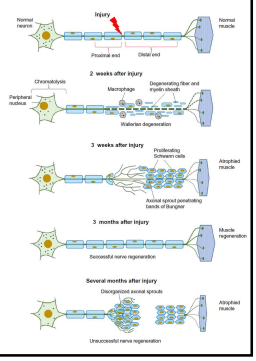
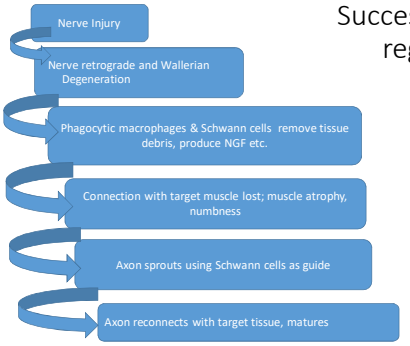
- **Dovepress**
- **Peripheral nerve conduits: technology update**
- **Authors Arslantunali D, Dursun T, Yucel D, Hasirci N, Hasirci V**
- **Published 1 December 2014 Volume 2014:7 Pages 405—424**
- **DOI https://doi.org/10.2147/MDER.S59124**



## Peripheral Nerve Regeneration

- Final result depends on # of axons that associate themselves with the appropriate Schwann cells and reinnervate appropriate end organs

## Successful nerve regeneration

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## Regeneration Challenges = need for repair

- Gap
- Scar at injury site
- Fibrosis of distal endoneurial tube due to prolonged time

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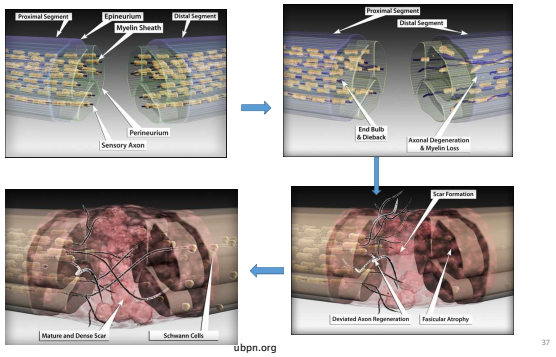


ubpn.org

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## Challenges to Axonal Maturation

- Regenerating axon reaches unrelated end organ (mismatch of proximal axon and distal endoneurial tube)
- End organ degeneration

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## Prognostic Factors

- Degree of Injury: Less severe better prognosis
- Level of Injury: More distal better prognosis
- Type of nerve: Mixed nerve worse prognosis
- Age: Younger is better
- Mechanism of Injury: Injury in continuity better prognosis than complete transection
- Timing of repair: Immediate repair better prognosis

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# Surgery Options for Peripheral Nerve Injury

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## Surgical nerve repair

- Primary end to end repair
- Conduit (nerve tube)
- Nerve transfer
  - End to end
  - End to side repair
- Nerve graft

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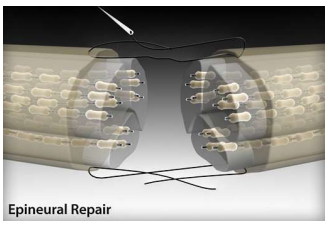
## Primary repair

- External epineurial repair

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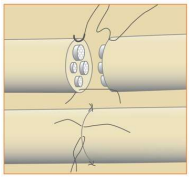
## Primary Nerve Repair



drisraelchambi.com

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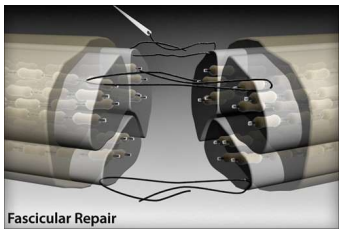
## Primary fascicular repair

- Larger, more proximal nerves

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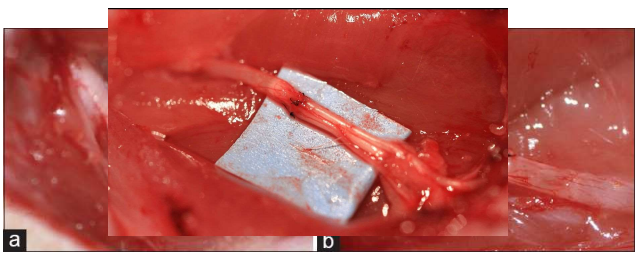
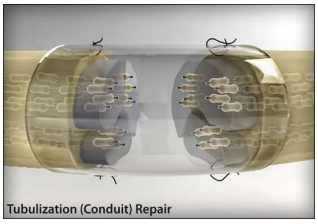
## Primary repair



## Nerve conduit

- Small gaps, up to 3 cm
- Synthetic, with nerve growth factor to facilitate recovery

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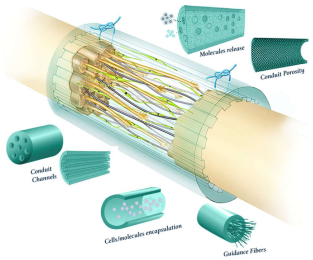
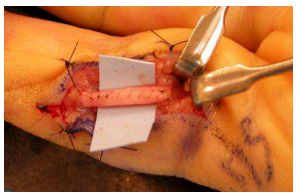
## Nerve conduits

- Use of nerve growth factors, channels, guidance fibers
- Reference:
- Atlasofscience.org
- Enhancing human abilities with the power of Neuroregeneration & Tissue Engineering
- November 16, 2016
- ***Kyriakos Dalamagkas , Magdalini Tsintou , Alexander***



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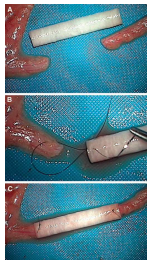
## Nerve conduit placement



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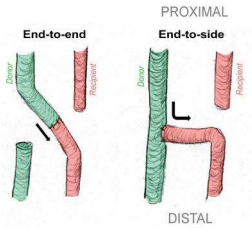
## Nerve transfers

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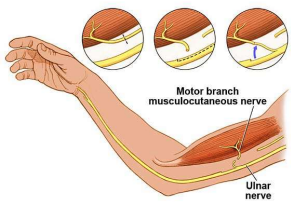
pnsrl.wustl.edu

## Nerve Transfers

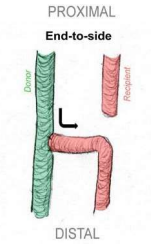
- End to End
- Use proximal portion of intact nerve to reinnervate distal portion of another nerve




mayoclinic.org[1]

## End to side repair

- Distal portion of injured nerve is sewn into the side of an uninjured nerve

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## Nerve Transfers

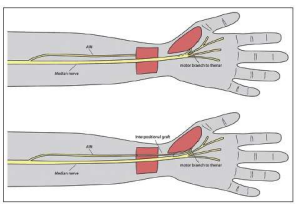
- Source of next slides:
- Plastic and Aesthetic Research
- Nerve transfers of the forearm and hand
- Paolo Sassu, Katleen Libberecht, Anders Nilsson
- Date of Web Publication 15-07-2015

**DOI:**10.4103/2347-9264.160887

## Nerve transfers

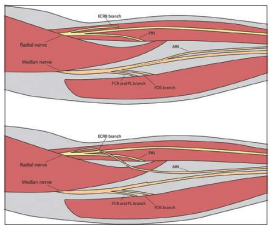
- Distal median nerve deficit

Transfer of the terminal branch of the anterior interosseous nerve to the motor branch to the thenar muscles, using an interpositional graft.



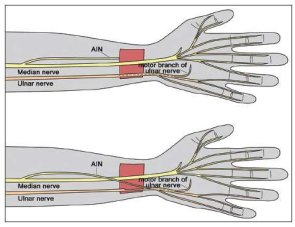
- High median nerve deficit

Transfer of the motor branch to extensor carpi radialis brevis to the anterior interosseous nerve.



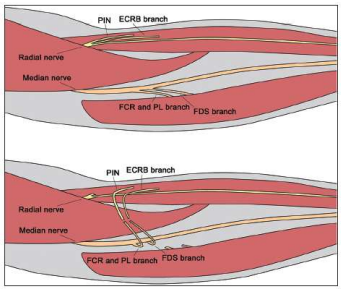
## Nerve transfers

- Ulnar nerve deficit:
- Transfer of the terminal branch of the AIN to the motor branch of the ulnar nerve

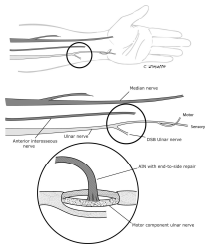



## Nerve transfers

- Radial nerve deficit. Transfer of the motor branch to FDS to the ECRB, and the motor branches to FCR muscle and palmaris longus muscle to the PIN.

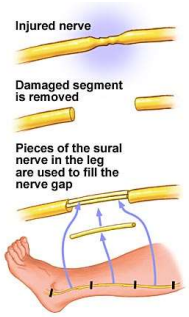



## End to side nerve transfer



## Nerve Grafts

- Use a donor nerve to bridge large gaps

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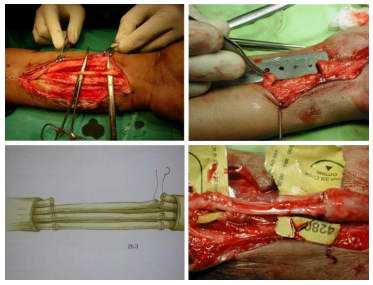
## Nerve Graft



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## Nerve Surgery Postoperative Care

Duff S, Estilow T: Therapist's management of peripheral nerve injury. In Skirven, Osterman, Fedorczyk, Amadio (eds), Rehabilitation of the Hand and Upper Extremity 6th ed. Elsevier Mosby, Philadelphia, 2011

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Forearm, wrist, hand

Immobilize: 2-3 wks - Place nerve on slack

Exact position and length of time varies by injury, surgery and surgeon.

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## Post op- place repair on slack

Median or Ulnar nerve forearm to hand: Dorsal blocking orthosis
Wrist 20-30° flexion, MP's 45° flexion

- Radial Nerve forearm to hand: Extension resting pan style orthosis

## Nerve Surgery PostoperativeCare

- 3 wks:
  - A/PROM (minimize stress on repair initially)
  - Monitor sensory and motor recovery
  - Orthotics to prevent deformity
  - Scar and edema management
  - Sensory reeducation/desensitization
  - Patient education

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## Digital Nerve Post Operative Care

- Orthosis: Finger or hand based dorsal blocking orthosis to keep repair on slack

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## Digital Nerve Postoperative Care

- Exercise: Varies by surgeon
  - Immediate active, gentle passive flexion from dorsal blocking orthosis

OR

  - Immobilize for 2-3 weeks
    - Treatment for stiffness
    - Potential flexor tendon adhesion

For either approach, treat with scar management and desensitization as needed

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## Evidence: Immobilization of digital nerve repair

- Postoperative Splinting for Isolated Digital Nerve Injuries in the Hand- Vipond, Taylor, Rider Journal of Hand Therapy 20(3), July–September 2007, Pages 222–231
  - 26 subjects, half 3 wks in orthosis, no difference at 6 months
- Rehabilitation of digital nerve repair: is splinting necessary? Clare, de Haviland Mee, Belcher
- Journal of Hand Surgery: British&European 29(6), Dec 2004, 552-556
  - 40 nerve repairs evaluated approx 20 months post repair – half immobilized, half not. Non splinted RTW significantly quicker
  - Conclude that, after repair of sharp, uncomplicated digital nerve divisions, splinting beyond the immediate postoperative period is at least unnecessary and may be deleterious.

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## Nerve Conduit Postop Care- Digital Nerve (Tension free)

Taras J, Nanavati V, Steelman P: Nerve conduits. J Hand Ther 18(2): 191-197, 2005

2-3 days post repair
- No orthosis
- Wrist neutral, short arc motion of fingers
- Gentle composite flexion
- Edema instruction
- No functional use of hand – 4weeks

2 Weeks post op
- PROM
- No dynamic orthosis
- NO Ultrasound (Taras)
- Personal communication with manufacturer: No US for one month post op

4 Weeks- functional flexion

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## Nerve conduit post op care – Med/ulnar nerve or digital nerve with tension

- Dorsal blocking orthosis: wrist 0-30° flexion, MP 45° flexion, IP's neutral - removed for ex and bathing - AROM within orthosis
- No Ultrasound per Taras
- 2 weeks begin therapy
  - Edema, wound/scar care
  - Protected passive ROM
    - Isolated joint and composite ROM with wrist held in flexion passively
    - Wrist ROM with digits relaxed

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## Nerve conduit post op care – Med/ulnar nerve or digital nerve with tension

- 4 weeks: D/C protective orthosis
  - Orthosis to prevent deformity prn
  - No scar massage (6-8 wks)
  - Silicone or gel pad if tolerated
- 6 weeks:
  - Composite digital and wrist ROM
  - Resistance

Taras J, Nanavati V, Steelman P: Nerve conduits. J Hand Ther 18(2): 191-197, 2005

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## Complete Nerve Injury Goals

- Prevent deformity
- Maximize function while waiting for recovery
- Monitor sensory and motor recovery
- Protection from sensory loss
- Reduce pain
- Minimize adhesions
  - Scar management
  - Nerve gliding
- When recovery begins
  - Sensory reeducation
  - Desensitization
  - Gentle muscle strengthening-avoid fatigue

## Prevent deformity

PROM for motions lost

- Median nerve
  - Web space
  - Opposition
- Ulnar nerve
  - MP flexion, IP extension RF/SF
- Radial nerve
  - Composite wrist/finger/thumb extension

## Complete Nerve Injury Goals

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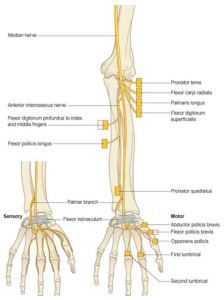
  - Gentle muscle strengthening-avoid fatigue

## Orthotics to prevent deformity and improve function

Median nerve
Ulnar nerve
Radial nerve

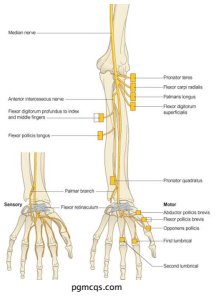
## Median nerve complete injury

- Wrist level:
  - Cause: laceration, severe prolonged compression
  - Sensory loss of volar thumb, index, long, radial ring
  - Lose thumb abduction, opposition
  - Thenar atrophy
  - Trophic changes




## Median nerve complete laceration

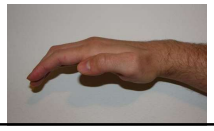
- Elbow level or above
  - Cause: Humeral fracture, elbow dislocation, laceration
  - Additional loss of pronation, radial wrist flexion, index/middle flexion, weakened ulnar finger flexion, thumb IP flexion

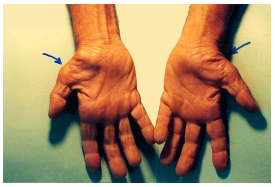



pgmcqs.com

## Median nerve complete injury

- Thenar atrophy
- Loss of thumb abduction and opposition
- Deformity: Web space contracture





## Median nerve orthoses fabricated

- To increase function place in opposition-day
- To prevent deformity may place in web space orthosis-night prn (avoid MP lateral stress)

## Median nerve orthoses to prevent deformity - prefabricated

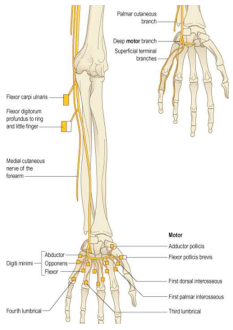
- Day functional position challenging to find prefabricated orthosis that holds thumb under index without rigid support
- Night spacer to prevent web contracture

ncmedical

Benik.com

## Ulnar nerve

- Low level
  - Loss of all interossei, 3rd/4th lumbricle, adductor pollicis flexor pollicis brevis deep head, hypothenar intrinsics
- High level:
  - Add loss of FDP to ring and small fingers (loss of power grip), ulnar wrist flexor

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## Ulnar nerve

- Loss of function:
  - Abd/adduction of fingers
  - Thumb adduction
  - Grip and pinch strength
- Deformity
  - Claw deformity of ulnar 2 fingers
  - Atrophy of intrinsics
  - Wartenberg's sign
  - Froment's sign
  - Jeanne's sign

## Ulnar nerve claw deformity

- Early stage

Moderate stage

Late stage

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## Ulnar nerve deformity

- Froment's sign: IP hyperflexes to compensate for loss of adductor pollicis during lateral pinch
- Jeanne's sign: MP hyperextends due to loss of stabilizing force from adductor pollicis during lateral pinch


maitrise-orthop.com

## Ulnar nerve deformity

- Wartenberg's sign
  - Unable to adduct small finger
  - Extensor digiti minimi has an ulnodorsal insertion, resulting in ulnar deviation of SF if no opposition from palmar interossei

## Ulnar nerve orthoses fabricated

- Prevent imbalance caused by MP hyperextension and IP flexion (unopposed EDC and FDP)
- Hold MP's of ring and small finger flexed

## Ulnar nerve orthoses prefabricated

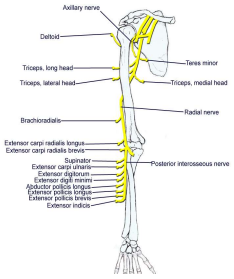
ncmedical.com
Performancehealth.com

## Radial nerve motor loss

Very High Level
- Loss of elbow extension
- Wrist, finger MP ext
- Thumb extension
- Supination

High level
- Supination limited
- Wrist drop
- Finger/thumb MP drop

Lower level
- Depends on level of injury
- Maintains wrist extension




withealth.net

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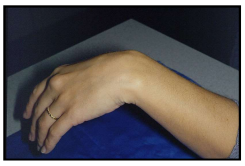
## Radial nerve deformity

- Wrist drop: extrinsic extensors on stretch, extrinsic flexors on slack (tighten)
- Orthosis: Wrist cock up day
- Night full ext resting pan

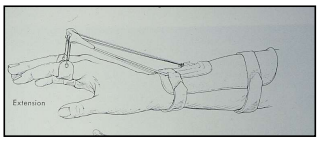


## Radial nerve functional loss

- Lose ability to position hand in space to grasp object
- Loss of dexterity
- Affects all functional use of hand

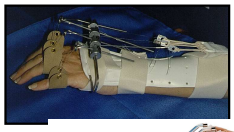
## Radial nerve orthoses to improve function

- Wrist cock up improves position in space, dexterity still lost
- Dynamic MP extension orthoses improves dexterity: many designs
  - Wrist tenodesis orthosis




## Radial nerve orthoses to improve function

- Dynamic MP extension orthoses: many designs
  - MP dynamic extension with static wrist



## Radial nerve orthoses for function prefabricated

Alimed.com

Saebo.com

Benik.com

## Maximize function

- Adaptive equipment

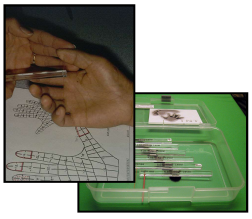



## Complete Nerve Injury Goals

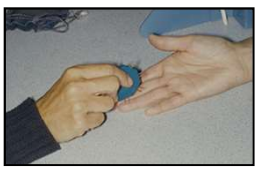
- Prevent deformity
- Maximize function while waiting for recovery
- Monitor sensory and motor recovery
- Protection from sensory loss
- Reduce pain
- Minimize adhesions
  - Scar management
  - Nerve gliding
- When recovery begins
  - Sensory reeducation
  - Desensitization
  - Gentle muscle strengthening-avoid fatigue

## Monitor sensory & Motor recovery

- Sensory: Semmes Weinstein monofilaments

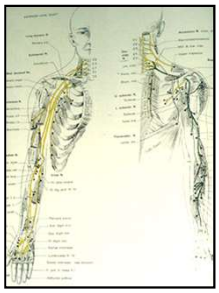


- 2 point discrimination returns later



## Monitor Sensory and Motor Recovery

- Motor recovery: Watch for trace motion in next muscle to be reinnervated
- Educate
  - motions to attempt as muscle becomes reinnervated
  - gravity eliminated positions
  - progression of exercises, avoiding fatigue



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  - Desensitization
  - Gentle muscle strengthening-avoid fatigue

## Compensation techniques

- Protection!
  - Use other senses (watch)
  - Use other hand or body part to check temperature
  - Check skin condition
  - Wear gloves
  - Avoid continuous pressure

## Complete Nerve Injury Goals

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## Reduce pain

- Modalities as beneficial – avoid excessive heat or cold
- Mirror therapy
- Team approach – pain management

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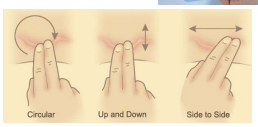
## Minimize adhesions/scar

- Surface scar:
  - Scar management products ***as needed***
    Elastomer, silicone sheets
  - Scar massage - avoid excessive pressure and shear forces over healing nerve in first month



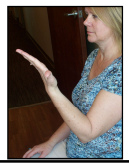

## Neural mobilization

- Does it have a place in rehabilitation after peripheral nerve repair
  - Decrease adhesions
  - After initial immobilization in protected protection of nerve
  - Move slowly, avoid excessive tension on repair
  - Flossing or gliding through surgical section of nerve:
    - Keep proximal section of nerve slack when providing distal tension
    - Keep distal section of nerve slack when providing proximal tension
  - DO NOT TENSION THE NERVE AFTER REPAIR

## Minimize adhesions

- Keep proximal section of nerve slack when providing distal tension
- Keep distal section of nerve slack when providing proximal tension

- Example: Median nerve
- Elbow flexed (slack proximal), extend fingers/wrist glides nerve distally in forearm
- Elbow extended with fingers/wrist flexed assists to glide nerve proximally in forearm, bring arm out to side for more proximal glide



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  - Desensitization
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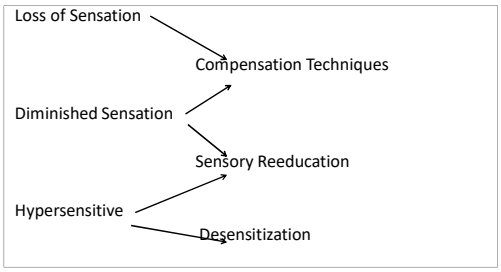
## Sensory Retraining

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## Sensory Reeducation - Traditional

- Begin when pt feels deep, moving touch
- Handle object eyes closed, then open, then closed
- Handle with uninjured hand to reinforce "normal"
- Progress from larger to smaller, more subtle differences
- Discriminate textures
- Incorporate into activity (locate objects in rice or putty)

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## Sensory Reeducation Update

- Sensory Reeducation – Lundborg, Rosen
- Initiate sensory reeducation immediately after injury due to immediate cortical changes
- Incorporate other senses, mirror training, etc

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## Sensory Reeducation Update Lundborg/Rosen

- Loss of sensation affects quality of life
- Decreased cortical representation (silent area)
- Cortical representation needed for recovery
- Goal of sensory re-ed=improve cortical representation or ability to interpret input

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## Sensory Reeducation Phases

Phase I = Immediately post injury/repair
- Cortically silent time
- Other areas expand/invade the silent area
- Goal is to minimize this, maintain area for correct sensory input

Phase II = After reinnervation (3-4 months post)
- Traditional sensory reeducation
- Distorted representation in brain
- Reorganize/Relearn
- Based on vision guiding touch and higher cortical functions

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## Phase I – Silent Period

- Immediately after injury until able to percieve largest monofilament
- Goal = Activate and maintain the hand map in the brain to make sensory relearning easier once the axons have regrown. Gives the brain the illusion of sensibility in the hand.
- Rationale = By time traditional sensory re-ed is started, incorrect reorganization of the brain is present and may not be correctable

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## Sensory Reeducation Techniques

- Must be individualized
- Following are ideas and suggestions
- Find what works for patient
- Must be motivated and compliant for success

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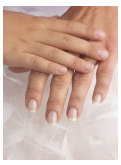
## Sensory Reeducation Phase I Techniques

Sensory imagery of touch
- Imagine touch of the hand

Other senses
- Touch an object that has color, smell, flavor
- Touch it with other hand



111

## Vision

- Watch hand being touched - concentrate

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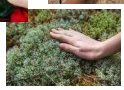
## Vision

- Look at sensory pictures



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## Vision

- Mirror training

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## Vision

- Read sensory words
- Rough, prickly, soft, smooth, silky, etc

- OR COMBINE words with pictures-
  "imagine" how it feels

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## Phase II

- Uses traditional sensory reeducation techniques
- Begins when some sensation is present
- Desensitize prn
- Touch objects of increasing difficulty with and without vision
- Compare with other hand
- Incorporate into daily life

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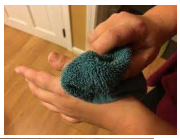
## Desensitization

- 3-4x/day
- Begin at level of tolerance
- Advance
  - Touch – static to moving
  - Textures - Soft to coarse
  - Contact particles




## Desensitization

- Pressure to tapping
- Vibration
- Progress
  - Force
  - Duration
  - Intensity

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  - Sensory reeducation
  - Desensitization
  - Gentle muscle strengthening-avoid fatigue

## Complete nerve injury

- Muscle strengthening
  - Educate pt on muscle reinnervation order
  - Watch for trace motion, advance to gravity eliminated
  - Isometric, gradually advance to concentric and eccentric
  - Resistive exercises

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