



American Society  
of Hand Therapists™

# Upper Extremity Peripheral Nerve Injury and Management

*Presented by*

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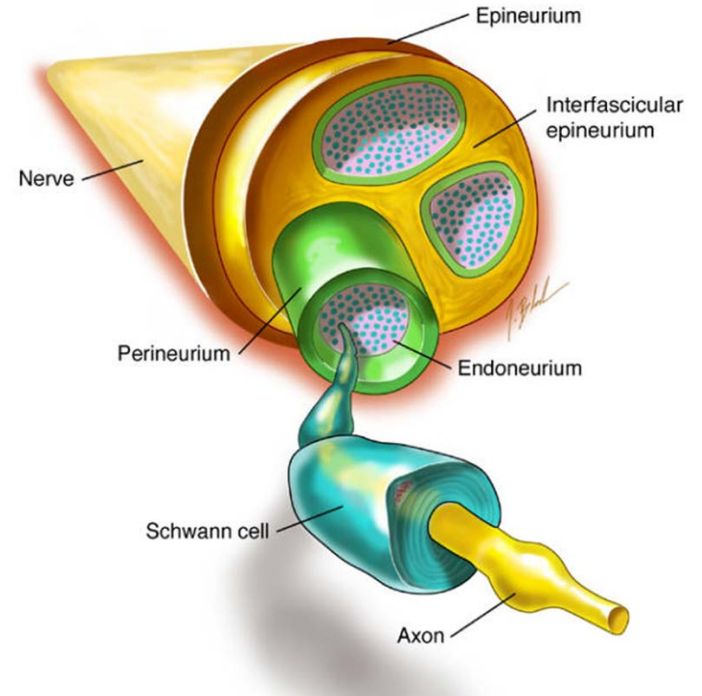
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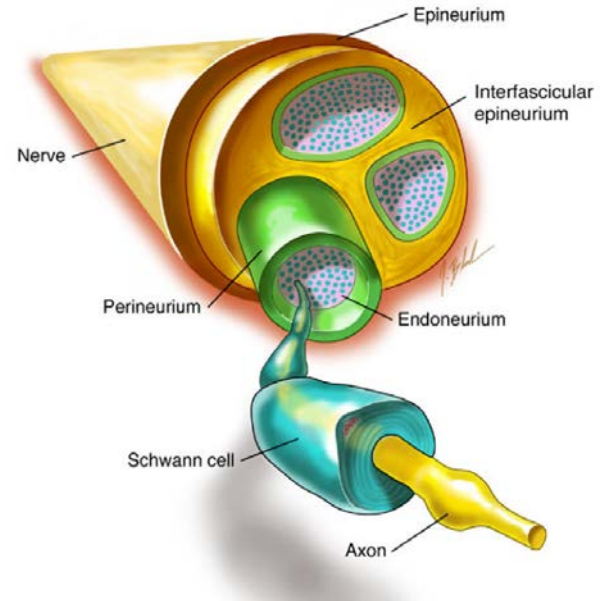
# Peripheral Nerve Anatomy

- Axon: Individual nerve fiber
- Endoneurium: Surrounds and separates axons within a fascicle
- Perineurium: Surrounds groups of axons. Dense, strong layer of tissue that protects against diffusion of elements and mechanical deformation of the fascicles  
Perineurium is layer most resistant to longitudinal traction



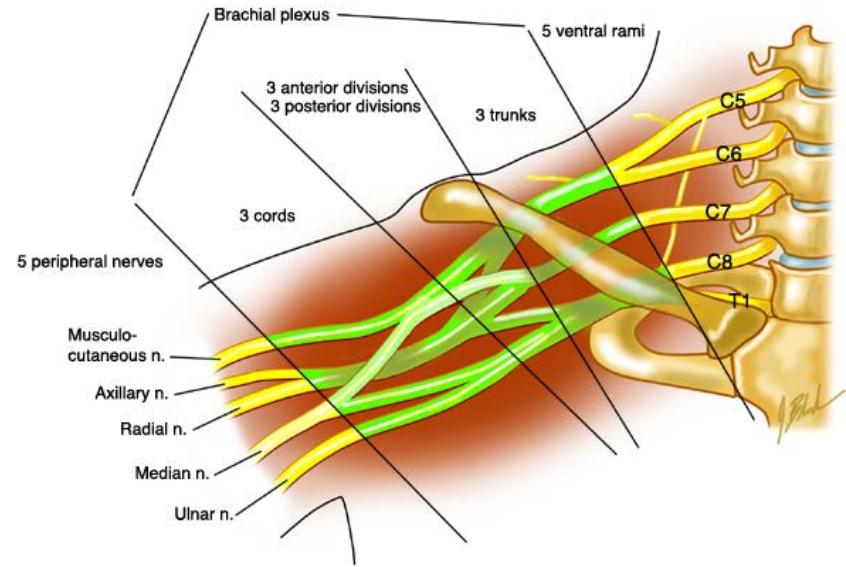
# Peripheral Nerve Anatomy

- Epineurium: Outermost layer of nerve
  - Internal epineurium: Loose connective tissue surrounding fascicles and perineurium. Cushions fascicles and axons
  - External epineurium: Outer layers of epineurium from a sheath that is the exterior of the nerve. Protects the nerve from external environment

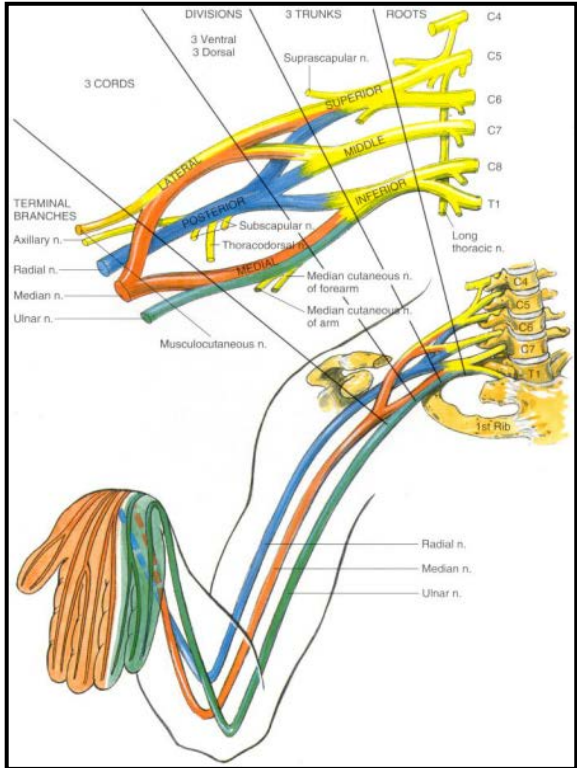


# UE Peripheral Nerve Pathways

- Roots: C5-T1
- Trunks: Superior, Middle, Inferior
- Divisions: Anterior and posterior divisions of each trunk
- Cords: Posterior, lateral and medial
- Branches:
  - **Axillary** (C5-6)
  - **Musculocutaneous** (C5-7)
  - **Radial** (C5-8, T1)
  - **Median** (C6-8, T1)
  - **Ulnar** (C8, T1)



# UE Peripheral Nerve Pathways

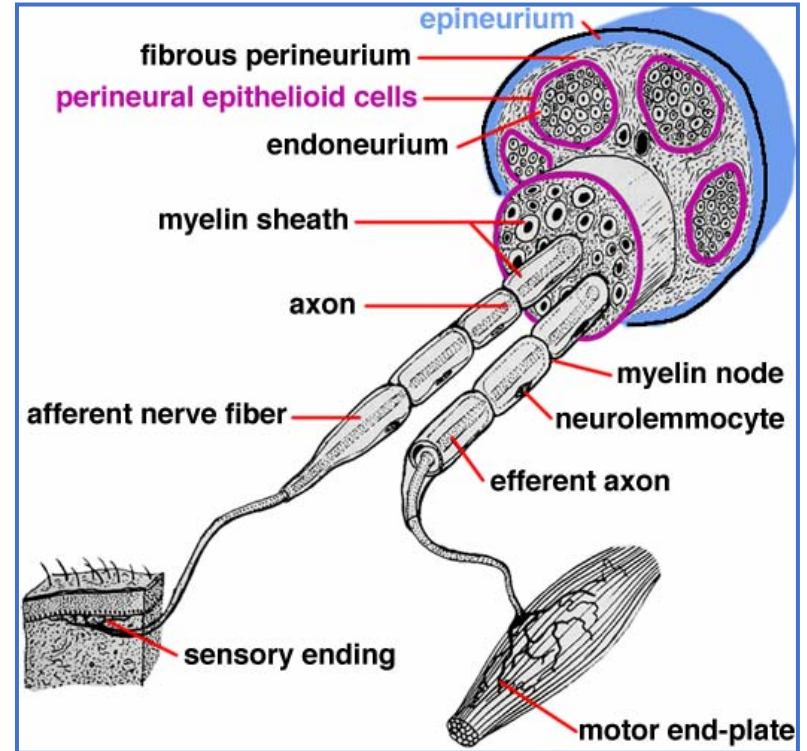




# UE Peripheral Nerve Pathways

## Terminate on End Organs

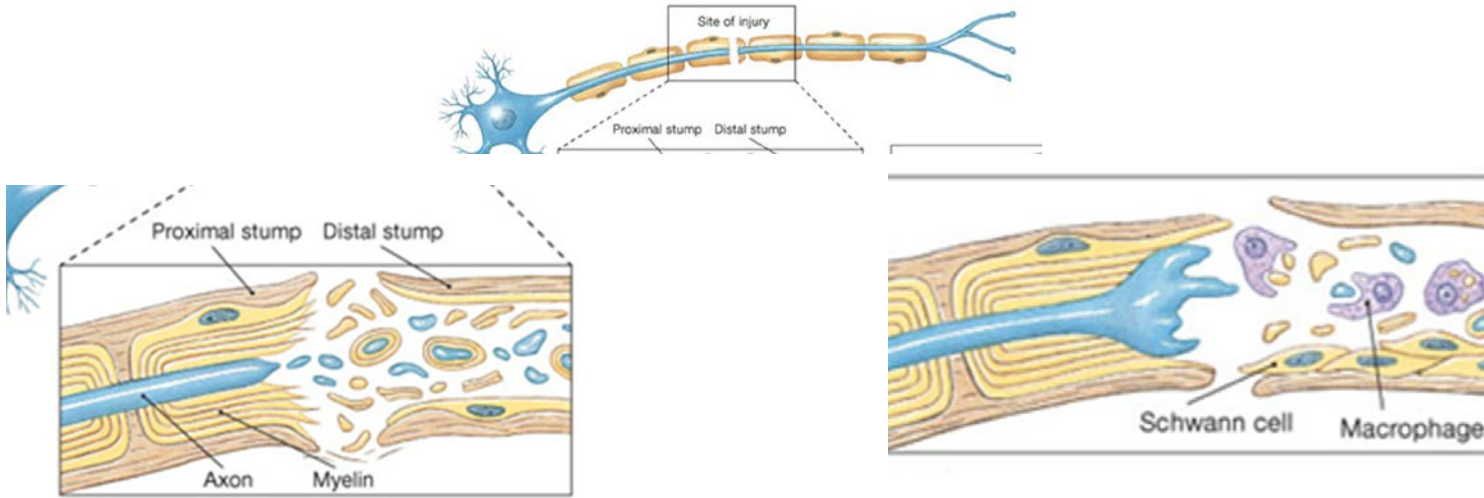
- Motor Axons: Motor end plates (Degenerate after 18-24 months)
- Sympathetic Axons: Skin, smooth muscle, blood vessels
- Sensory Axons: Sensory receptors







# Peripheral Nerve Regeneration

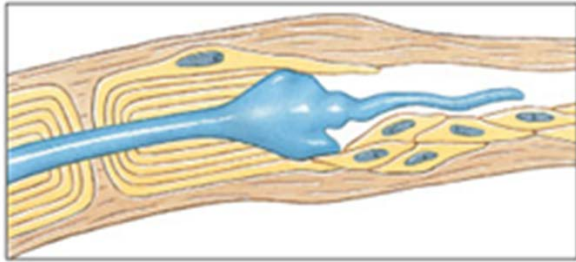


Distal stump: Axon and myelin fragmentation

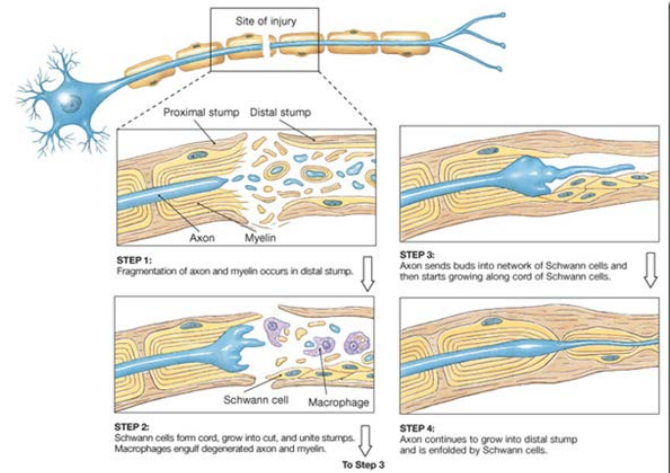
Schwann cells begin clean up of debris, joined by macrophages (Wallerian degeneration)

Schwann cells proliferate and create bands that connect the proximal and distal portions. Proximal axon develops growth cone, which is drawn toward the Schwann cell bands by nerve growth factor and other chemicals secreted by the Schwann cells

# Peripheral Nerve Regeneration

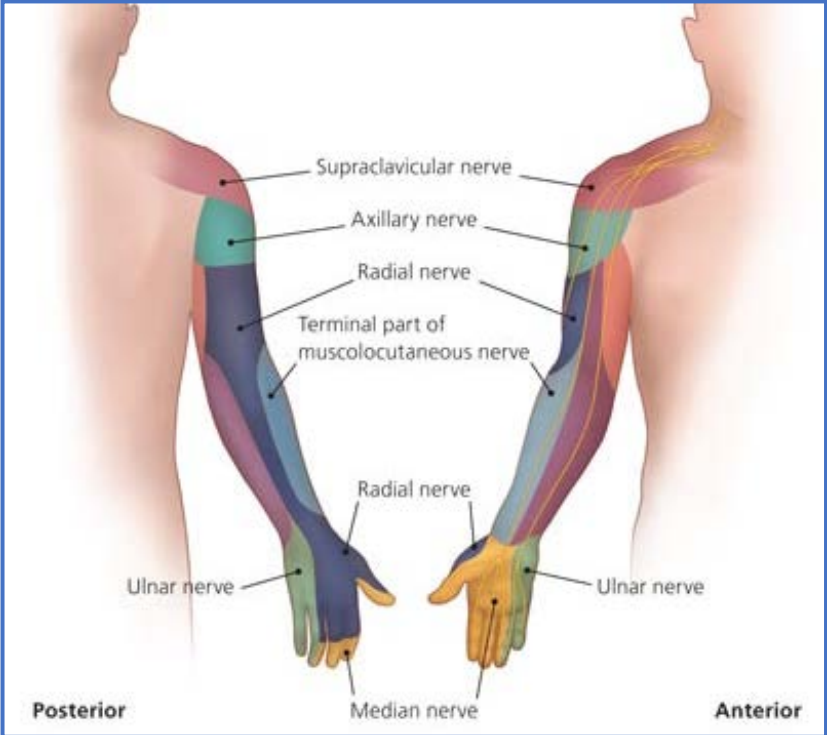


Axon sends sprouts into network of Schwann cells,  
grows along cord



Schwann cells enfold axon as it grows distally

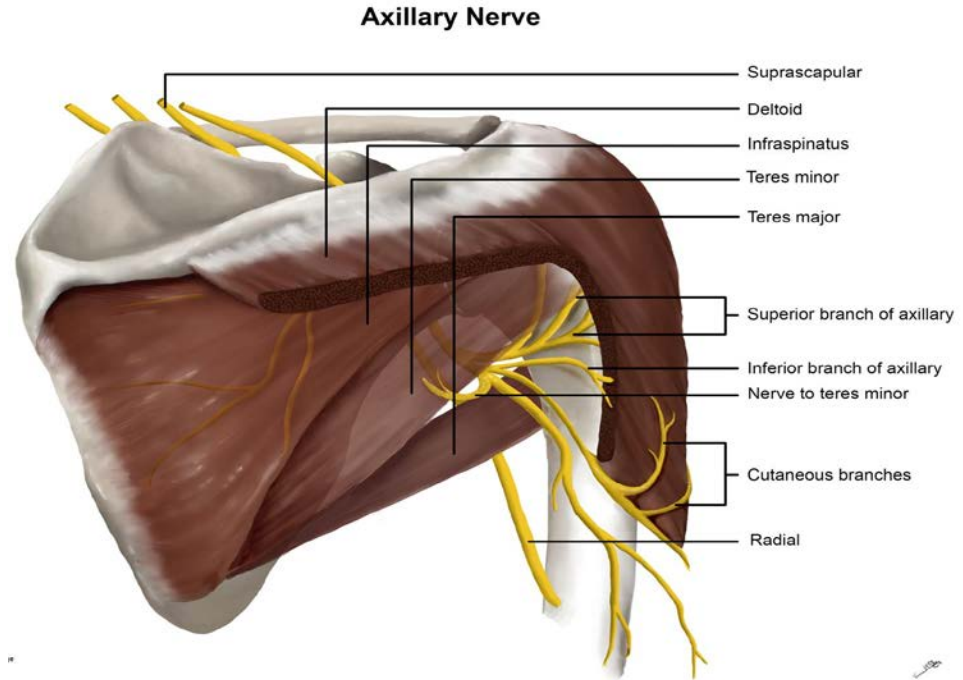
# *Sensory Nerve Distribution of Peripheral Nerve*



# *Motor Nerve Distribution of Peripheral Nerve*

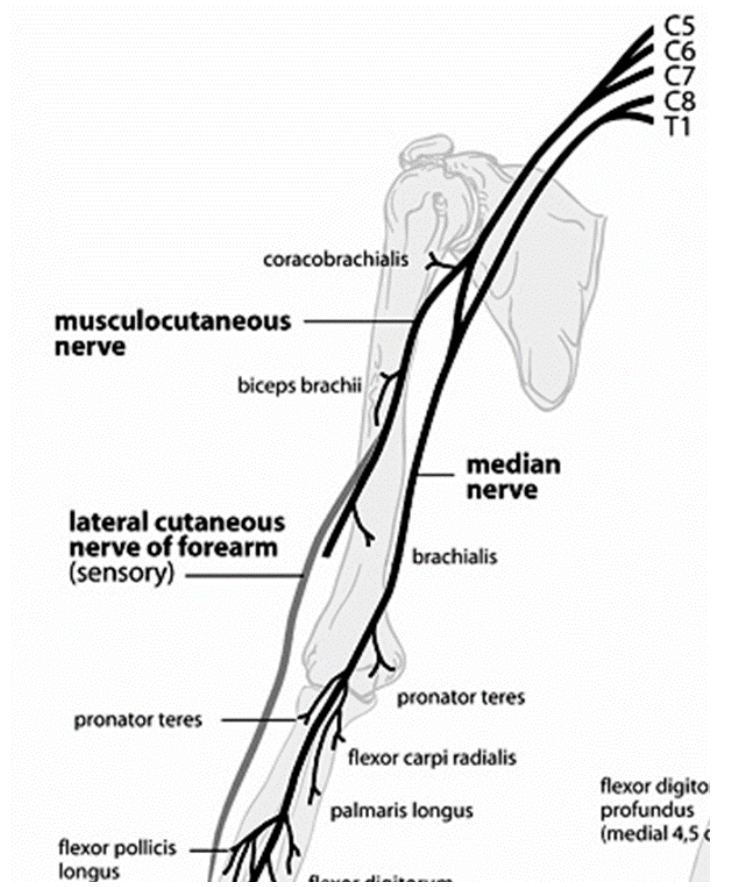
## Axillary Nerve

- Deltoid
- Teres Minor



# Motor Nerve Innervation

- Musculocutaneous Nerve
  - Coracobrachialis
  - Biceps brachii
  - Brachialis



# ***Motor Nerve Innervation***

## 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



# Median Nerve Injury

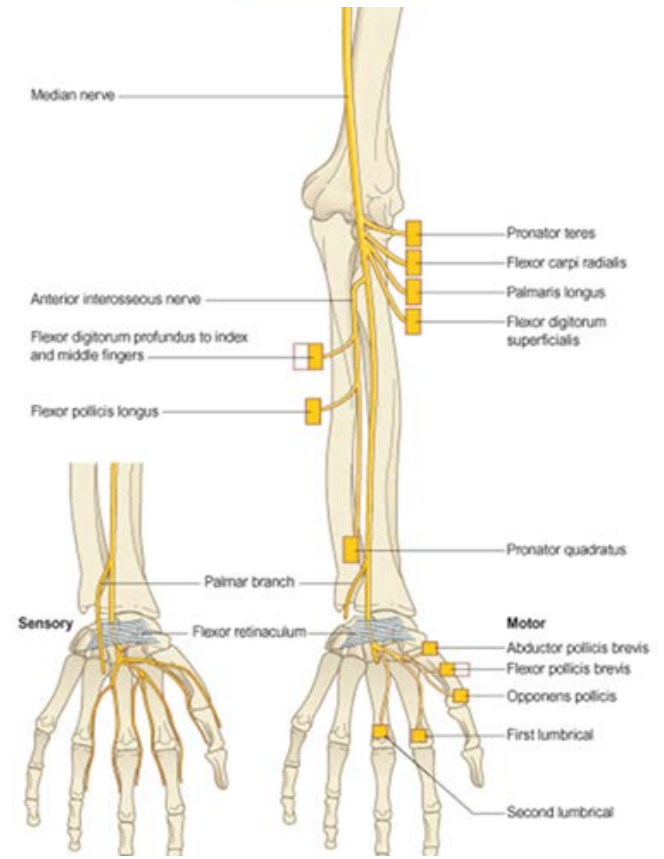
## Functional Loss

### Wrist level:

- Loss of sensation to thumb, index, middle, radial ring finger
- Loss of opposition
- Weak thumb abduction/flexion
- Weakened pinch

### High level:

- Add loss of pronation
- Unable to flex index and middle (loss of FDS and FDP)
- Weakened grip, loss of pinch



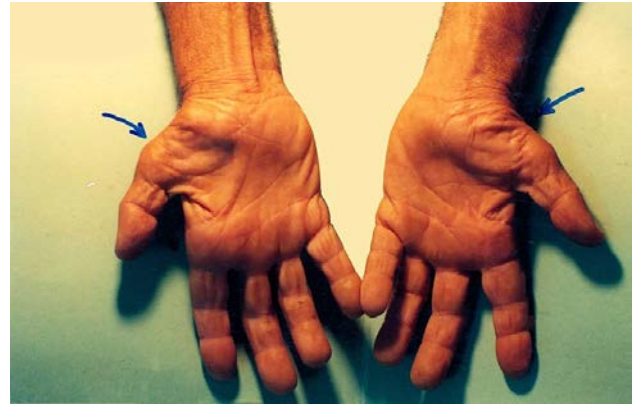
# Median Nerve Injury

## Deformity:

- Lower level: Ape hand - Inability to oppose/abduct (loss of thenars)
- High level: Benediction Hand: Inability to flex index, middle, thumb (loss of FDS/FDP, FPL)
- Potential for web space contracture



- 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



# ***Median Nerve Positioning***

Web spacer for night



Functional opposition during the day



Taping option



# Ulnar Nerve Injury

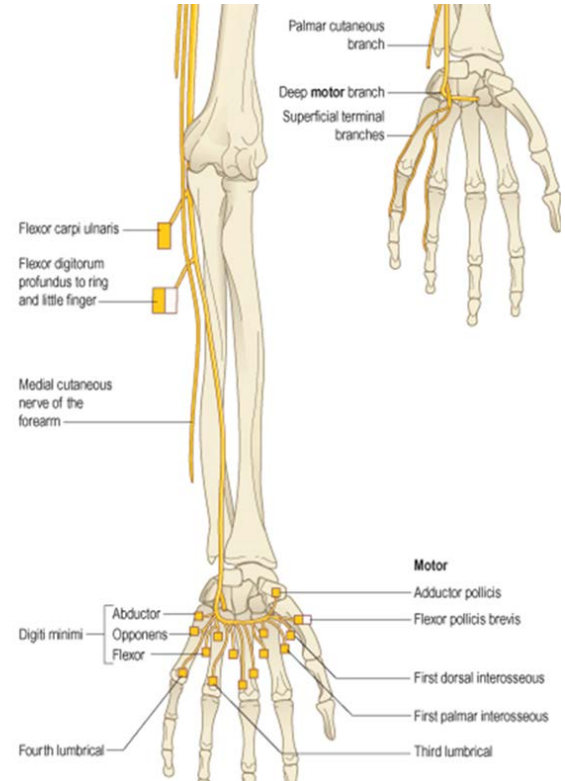
## Functional Loss:

### Wrist:

- Ulnar claw hand (EDC is unopposed due to loss of 4th and 5th lumbricals)
- Thumb adductor and first dorsal interossei atrophy
- Froment's sign
- Wartenberg's sign
- Can't cross fingers

### High level:

- Add loss of FDP (sole flexor of DIPs) to ring and small fingers (loss of power grip)



# *Ulnar Nerve Injury*

Different presentations

Severe adductor atrophy



Severe clawing but no adductor atrophy



Thumb add atrophy, subtle claw, postures thumb IP in flexion





# *Ulnar Nerve Injury*

Froment's sign:

FPL (flexor pollicis longus) substitutes for  
absent AP (adductor pollicis)





# ***Ulnar Nerve Injury***

## Wartenburg's Sign

- Abducted position of small finger
- Lack of palmar interossei to adduct the small finger
- SF abd is more noticeable



# ***Ulnar Nerve Injury***

Positioning to prevent claw hand

- Prevent hyperextension of MPs

Figure 8 (easy)



Loop rubber bands around watch  
or velcro strap (remember- all fingers  
point to scaphoid)



# Effects of a dynamic orthosis in an individual with claw deformity- JHT 2015

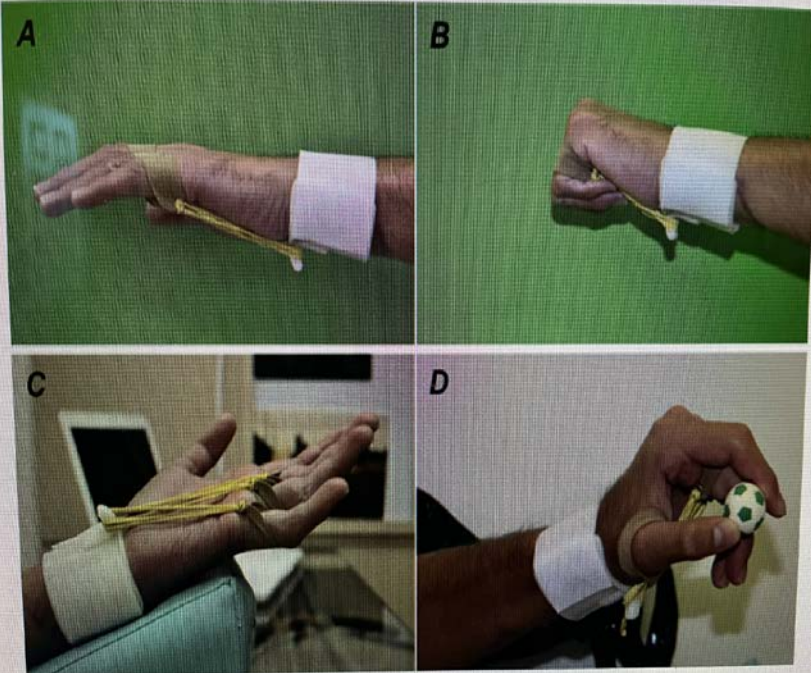
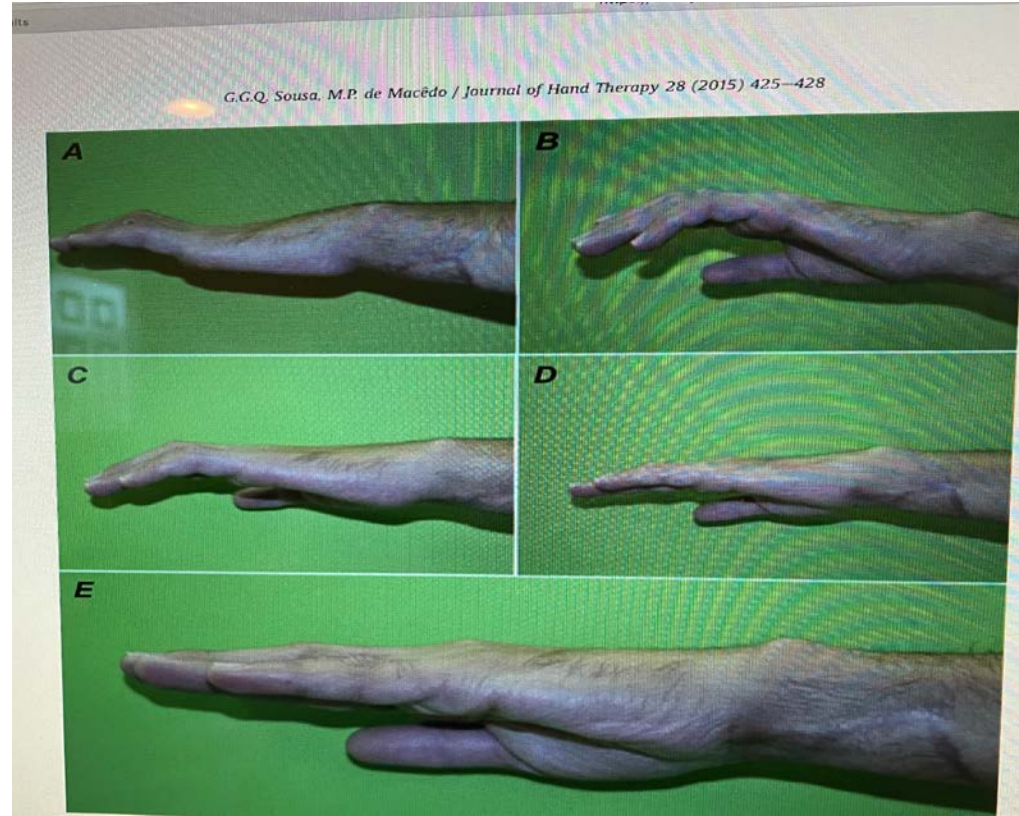


Fig. 1. Dynamic MCP orthosis. (A and B) Lateral view. (C) Volar view. (D) Patient showing the ability to pinch a mini soccer ball.



A re-evaluation was performed four and eight v

# Radial Nerve Injury

## Functional Loss: (extrinsic)

Forearm level- PIN (posterior interosseous nerve) motor branch of RN (radial nerve)

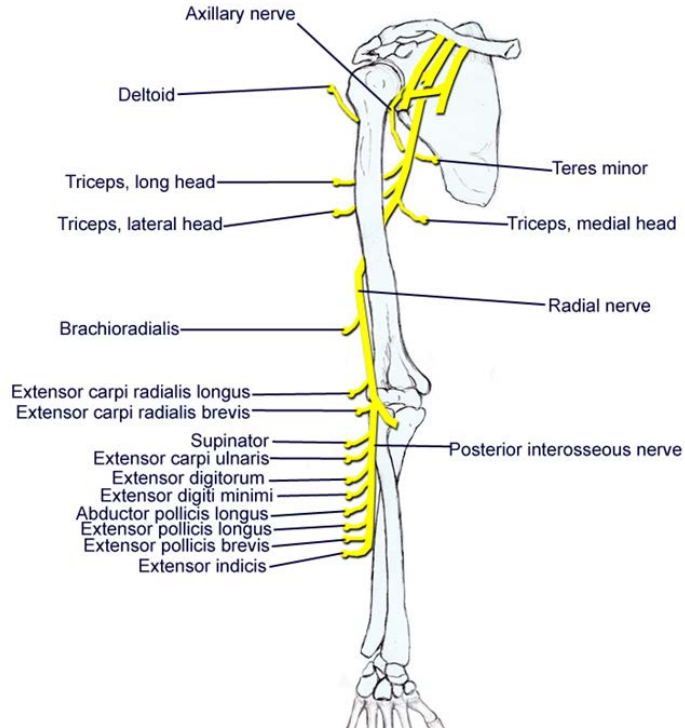
- Supinator is spared
- Weak wrist extension, no thumb or MCP extension
- Can extend IPs. Lumbricals (primary IP extensors) are median and ulnar innervated

## Elbow Level

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

## Very High Level

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





# *Radial Nerve Injury*

Deformity:

Finger/thumb MP drop, IPs ext

Wrist drop

Radial nerve divides at supinator  
muscle PIN and SBRN (sensory  
branch radial nerve)

-most common minor causalgia

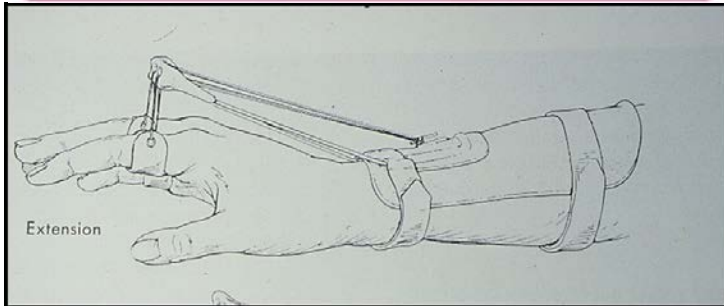
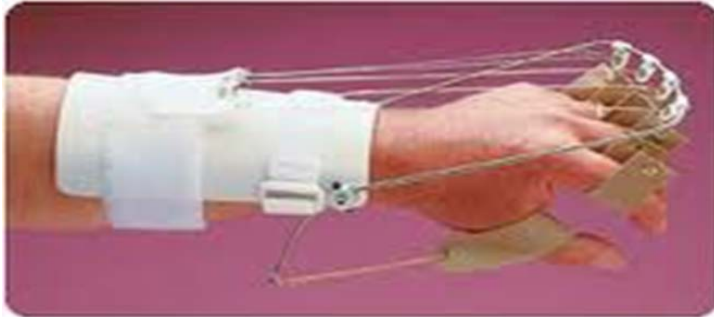
-in anatomic snuff box

-little functional loss w SBRN



# Radial Nerve Orthotics

Unlike median and ulnar lesions, radial nerve orthosis can restore relatively normal use of hand. Advantage: Restores normal function and tenodesis  
Disadvantage: High profile



Advantage: Low profile

Disadvantage: Immobilizes wrist





# *Radial Nerve Orthosis made from plastic container*



# *Radial Nerve Injury*

Positioning to prevent wrist drop:

Wrist orthosis

- Advantage: Easier
- Disadvantage: Does not address MCP loss
- Good option for sleep

Custom fabricated



Prefabricated

# *Radial Nerve Injury*

Prefabricated options

- Benik, Alimed



# ***Therapy intervention following nerve injury take on a variety of forms.***

Intervention	Examples
Orthotics	Radial nerve orthosis; anti-claw orthosis
Education	Activity modifications; joint preservation techniques
PROM	Digit extension; thumb abduction
Pain Control	TENS; Compression garments
Sensory/motor testing (periodic)	Standardized assessments and frequencies
Motor home exercises/Electrical stimulation	Gravity eliminated; graded motor imagery
Sensory reeducation	Imagery; textures; temperatures

## ***There are several uses for orthosis following nerve repair.***

- Protection of the repair
- Prevention of deformity over time
- Position to improve hand function



# ***Patient education is integral for patient success following a nerve injury.***

## Education

- Loss of sensation: Compensation, protection
- Motor function
- Adaptive equipment/activity modifications
- Expectations for recovery





# ***The patient should perform range of motion for tissue and joint integrity.***

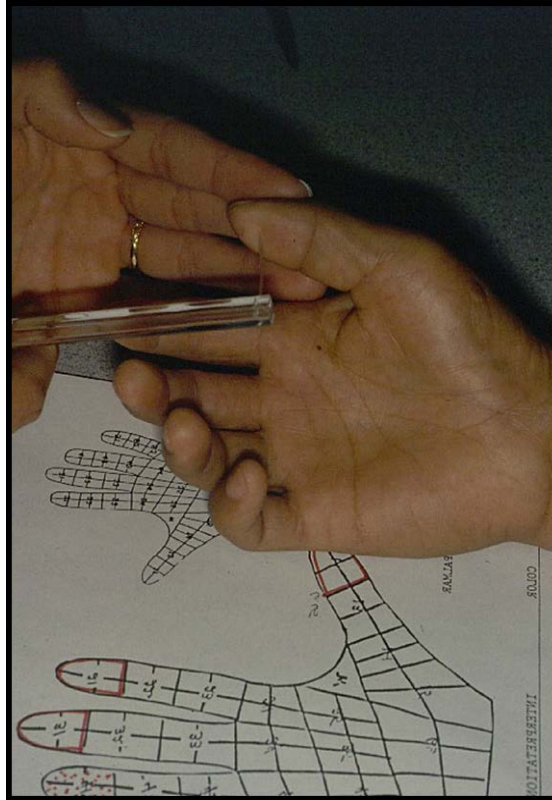
- Passive ROM: Education patient to prevent contracture/maintain length of muscles awaiting recovery
- Pain control: Modalities if beneficial



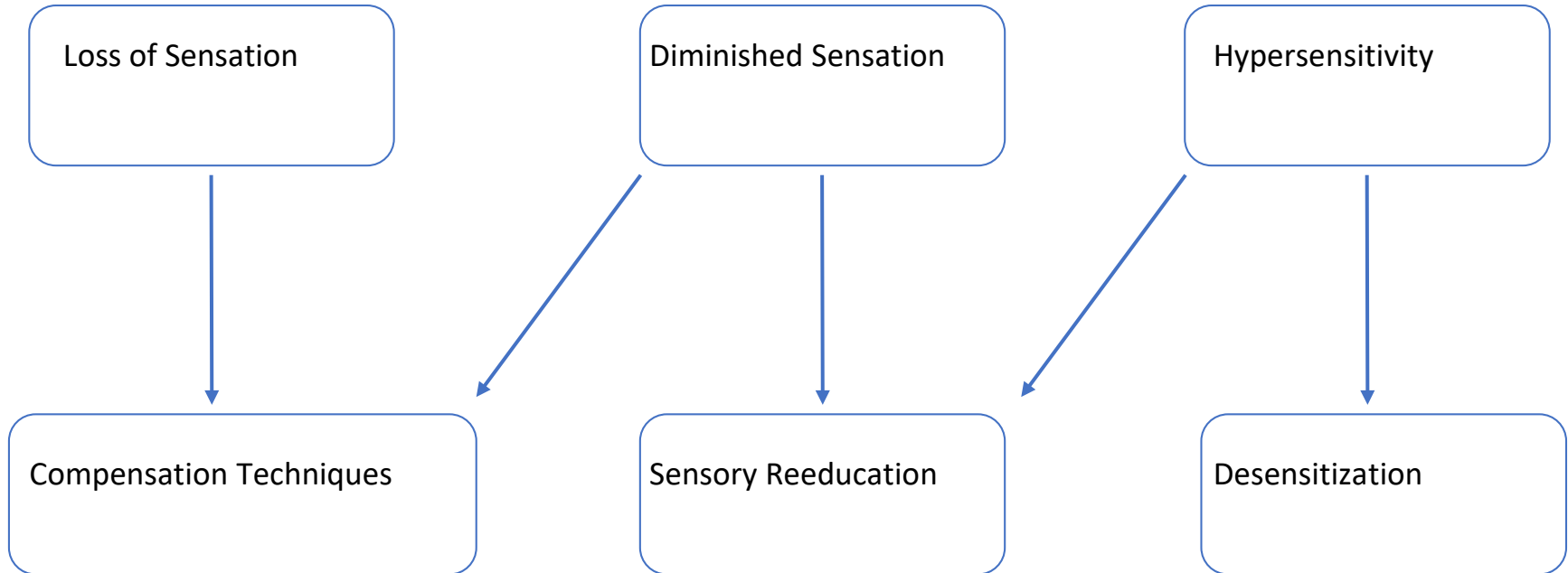
# ***Therapist should monitor and track nerve recovery.***

## Periodic retesting

- Semmes Weinstein Monofilaments
- 2 point discrimination
- Sensory reeducation
- Desensitization



# ***Sensory retraining can look different throughout the stages of recovery.***



# ***Compensation techniques for sensory dysfunction are important for safety.***

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



## ***Traditional sensory reeducation can start with familiar objects.***

- Begin when patient 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)



## ***Updated sensory reeducation supports a multisensory, phased approach. (Ref 1,2)***

I = Immediately post injury/repair

II = After reinnervation (3-4 months post)

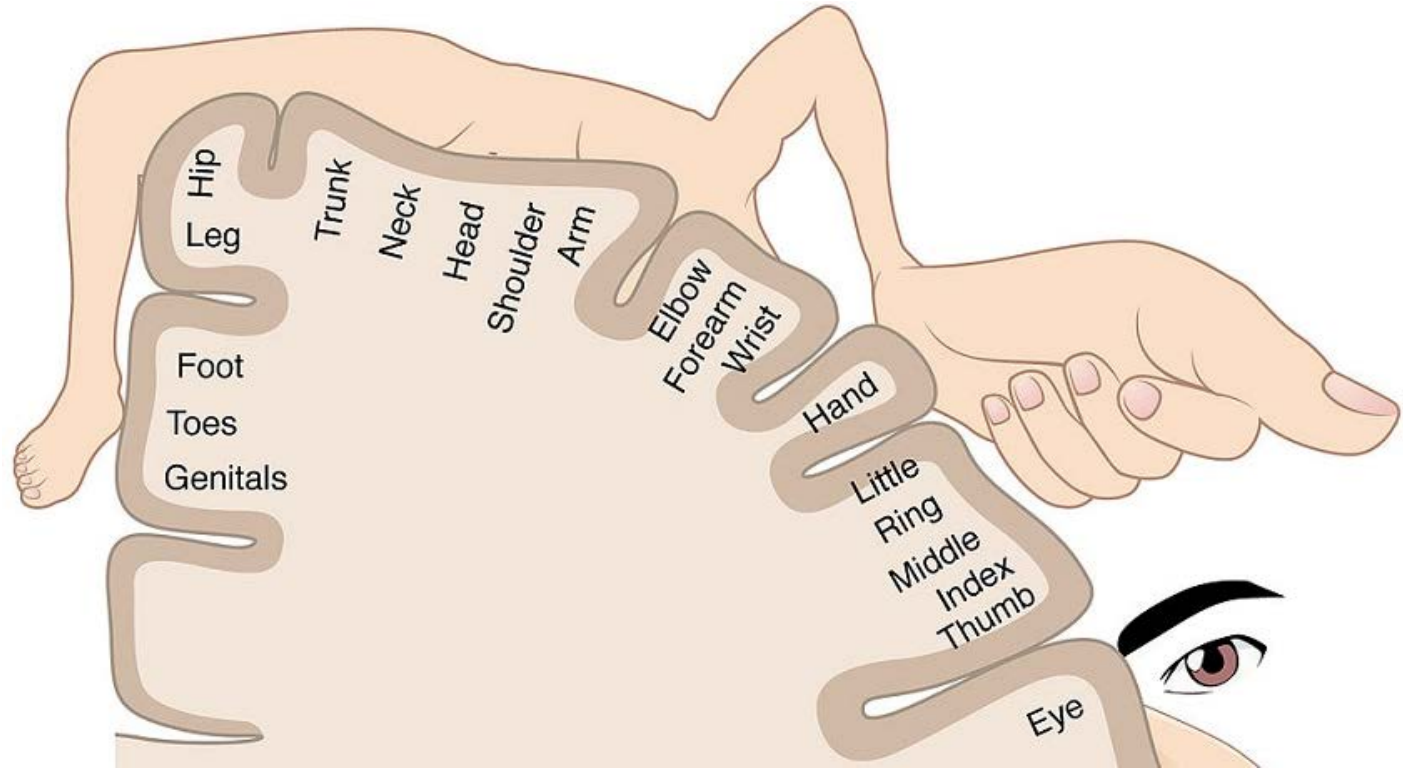
- Silent period
- Other areas expand/invade the silent area
- Goal is to minimize this, maintain area for correct sensory input
- ***Rationale = By time traditional sensory re-education is started, incorrect reorganization of the brain is present and may not be correctable***

II = After reinnervation (3-4 months post)

- Traditional sensory reeducation
- Application of forearm anesthesia (?)
- Distorted representation in brain
- Reorganize/Relearn
- Based on vision guiding touch and higher cortical functions



***Phase I is immediately after an injury until perception of the largest monofilament is perceived.***





***Techniques for sensory reeducation during phase I combine the other senses.***



***The patient should watch and concentrate on the sensation of the hand being touched.***



***Mirror training has strong evidential support.***

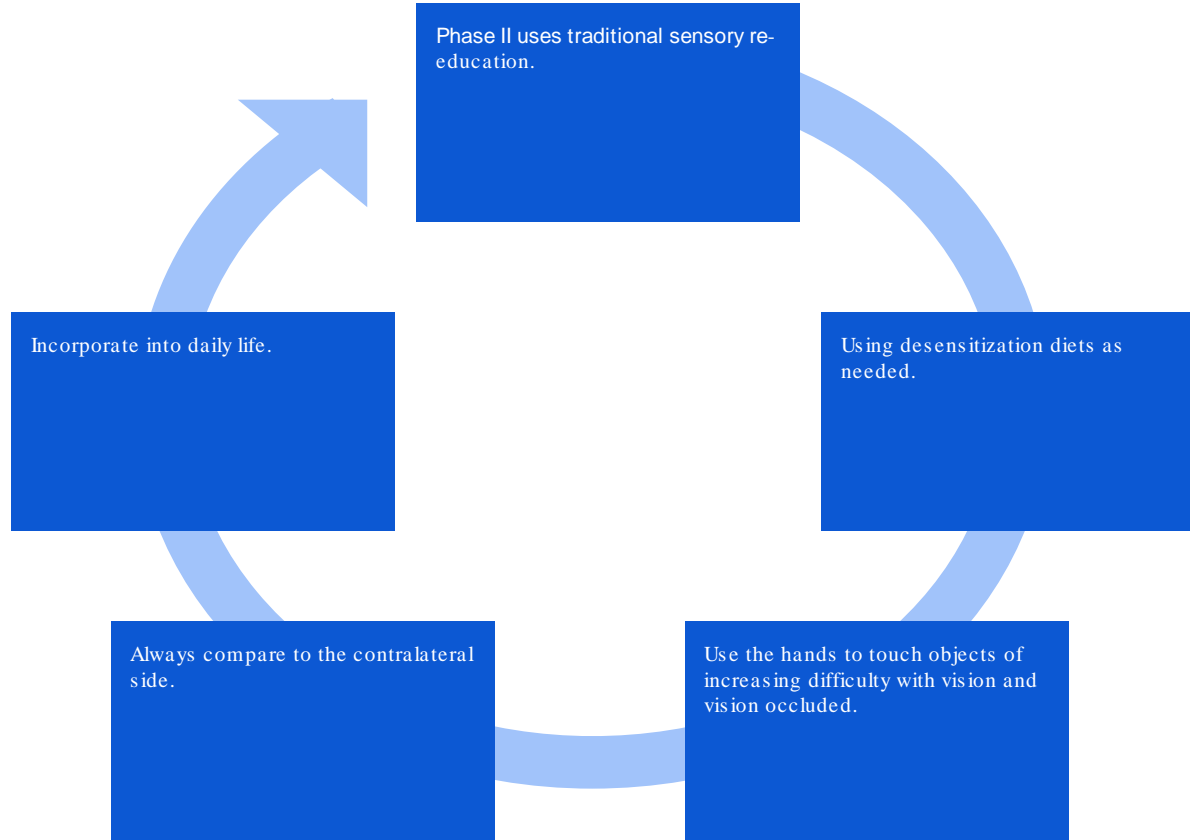




***Visualization and imagery are also components of phase I.***



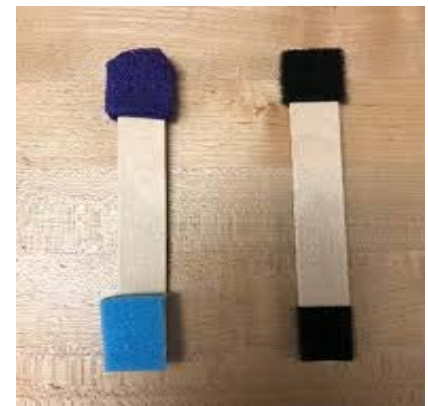
# *Phase II begins when some sensation is present.*



# ***The traditional desensitization diet is a major component of phase II.***

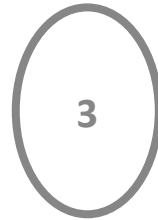
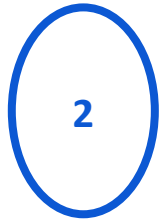
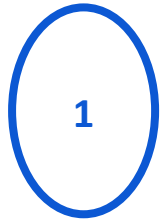
Perform for 5 minutes, 3-4x/day

- Begin at level of tolerance
- Advance
  - Soft to coarse
  - Static to moving touch
  - Pressure to tapping
- Progress
  - Force
  - Duration
  - Intensity





# *Motor recovery following nerve injury is also a staged process.*



Gravity eliminated

Against gravity

Isometric against  
resistance

Concentric/Eccentric  
against resistance

***Thank you for participating, are there any questions?***

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## References:

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