Assessment and Treatment of Nerve Entrapments of the Upper Extremity: Beyond Carpal Tunnel

LAURA CONWAY OTR/L, CHT, COMT UE

LCONWAY@SELECTMEDICAL.COM

Laura Conway MSOTR/L, CHT, COMT UE
Hand Therapy Coordinator-Gulf Coast/ Fieldwork coordinator
Select Live faculty
Center Manager Select Physical/Hand Therapy, Brandon, Florida, USA

I have no financial relationships to disclose within the past 12 months relevant to my presentation.

Nerve Entrapments

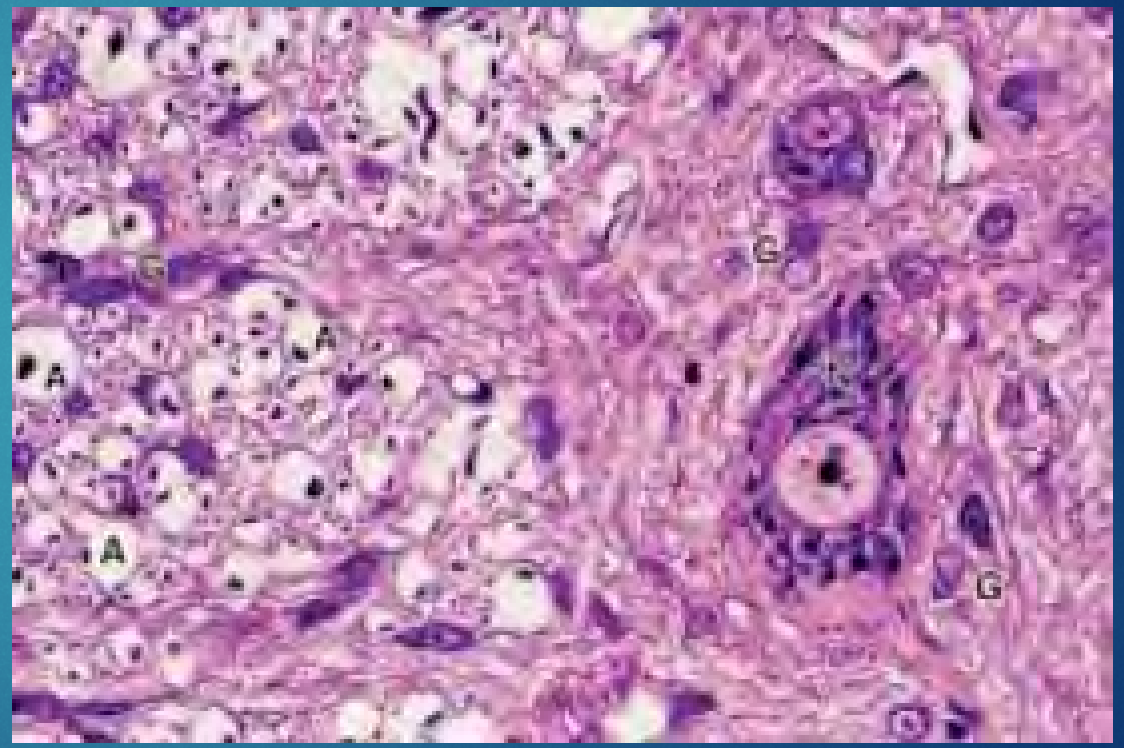
Nerves

- Like to move
- Like to breathe
- Don't like to stretch
- Don't like pressure

Brief Review of Nerve Anatomy & Physiology

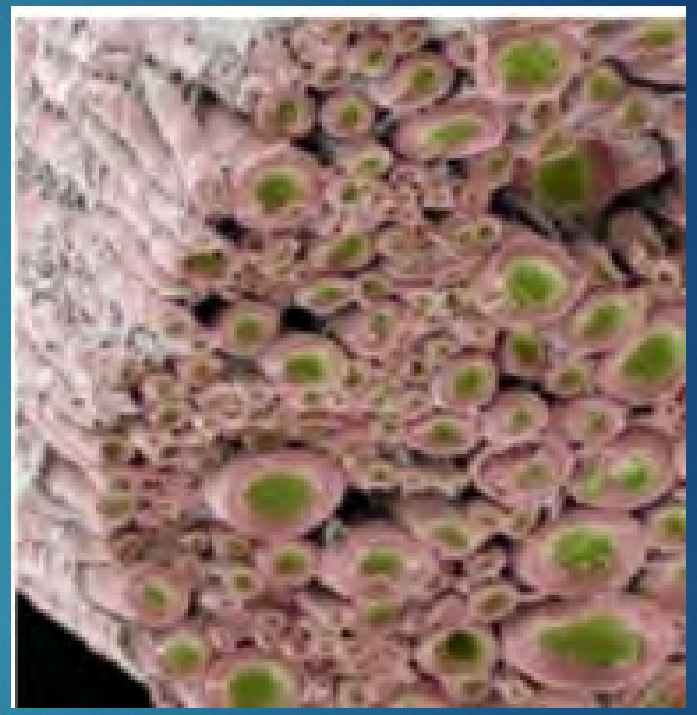
Protective and Connective Anatomy

- Endoneurium
- Perineurium
- Epineurium
- Mesoneurium



Endoneurium

- Separates individual axons
- Highly elastic

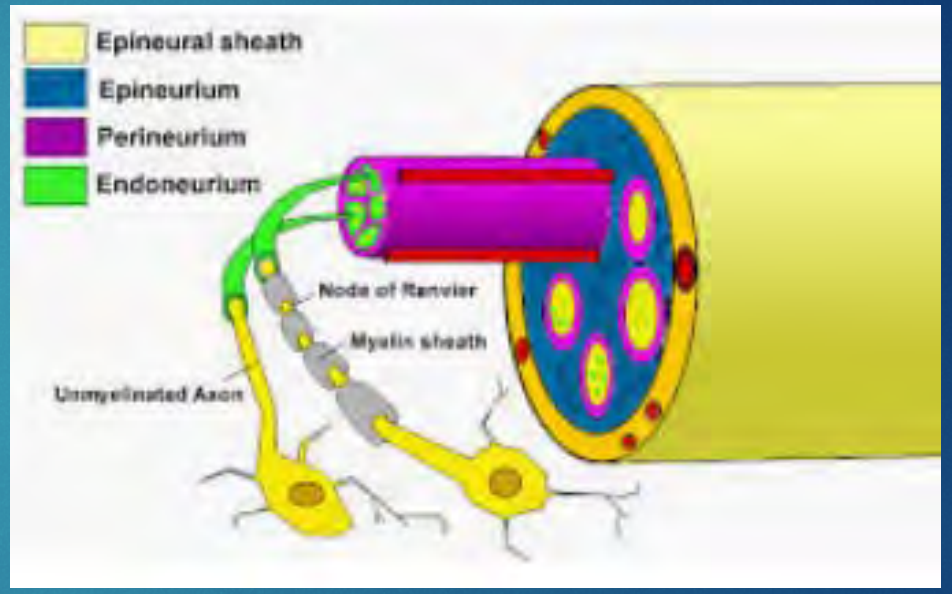


Perineurium

- Surrounds fascicles
- Contributes most to nerve's tensile strength
- Collagen based

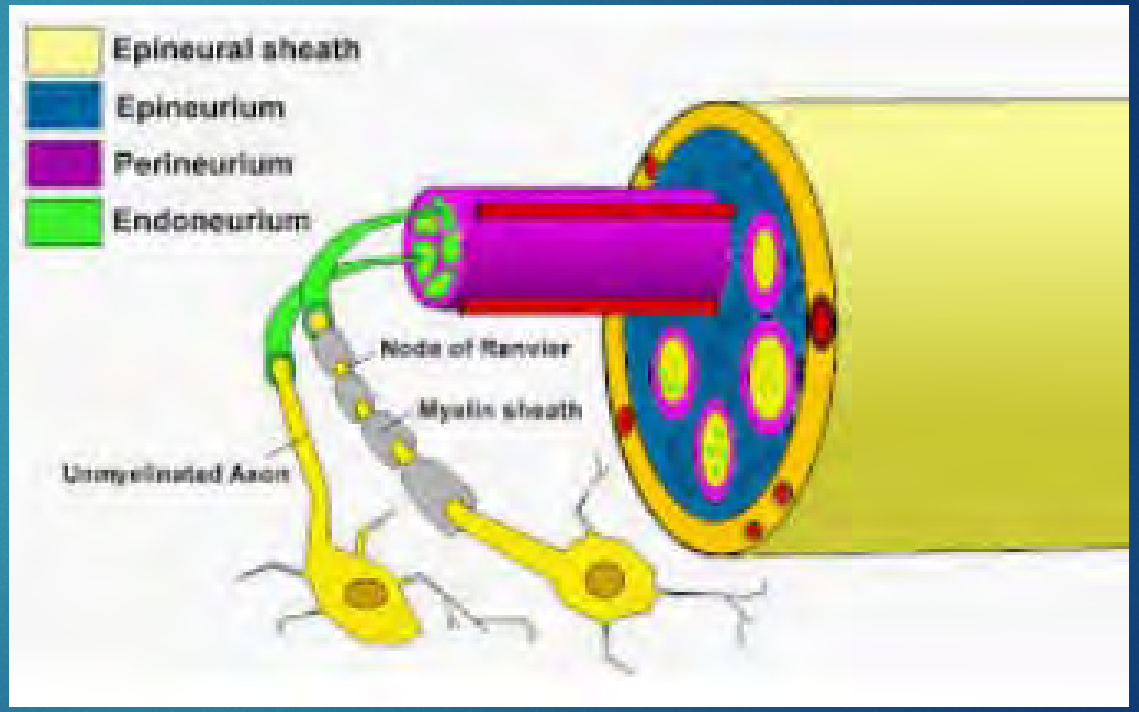
Epineurium-Internal

- Adipose
- Loose connective tissue



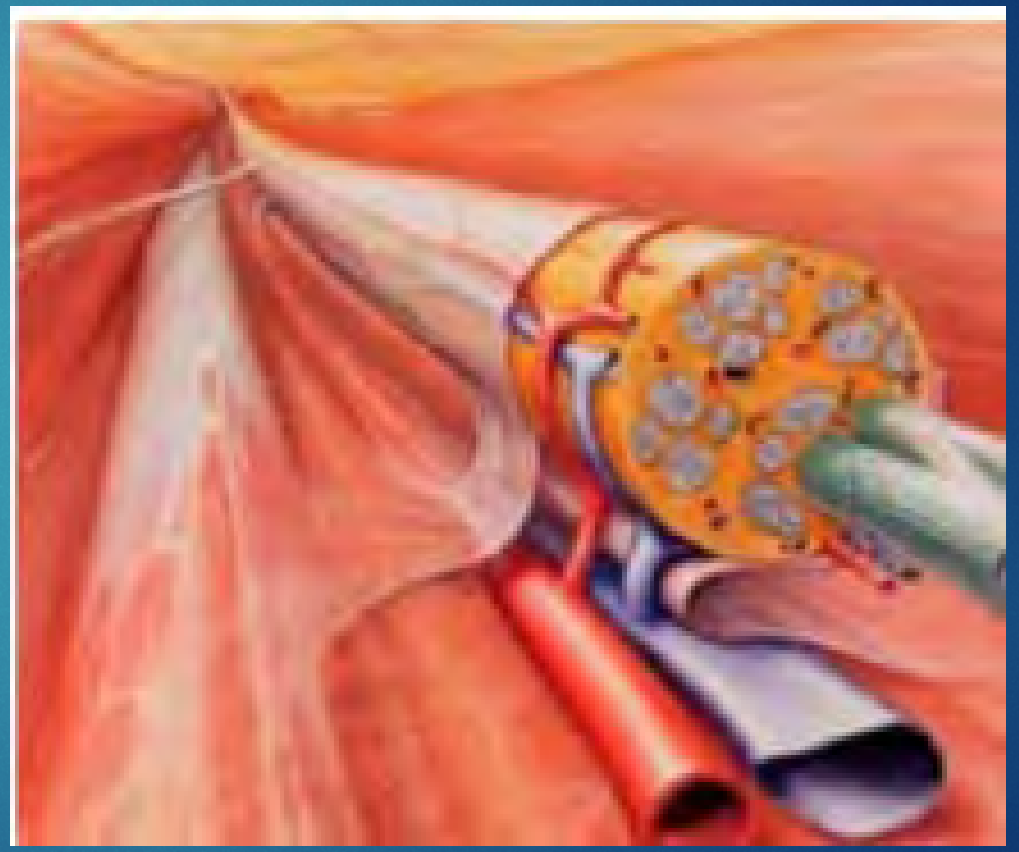
Epineurium- Sheath

- Collagen base
- Absorbs stress
- Thicker around joints



Mesoneurium

- Loose connective tissue
- Facilitates gliding



Nerve Entrapment

- Nerve passes through several tight anatomic compartments along nerve bed
- Conflict between free space and contents
- Diminished compartment space
- Increased volume of contents

Result

- Restricted gliding between tissues in the compartment
- Interrupted nerve physiology
- Impaired blood supply

Axonal Transport

- Uninterrupted axonal transport is necessary for neuron health
- Activity affects intra-cellular motility
- Inflammation disrupts axonal transport

Nerve's Response to Injury

- Mild focal compression
- Injury to Schwann cell
- Demyelination results

More Severe Trauma

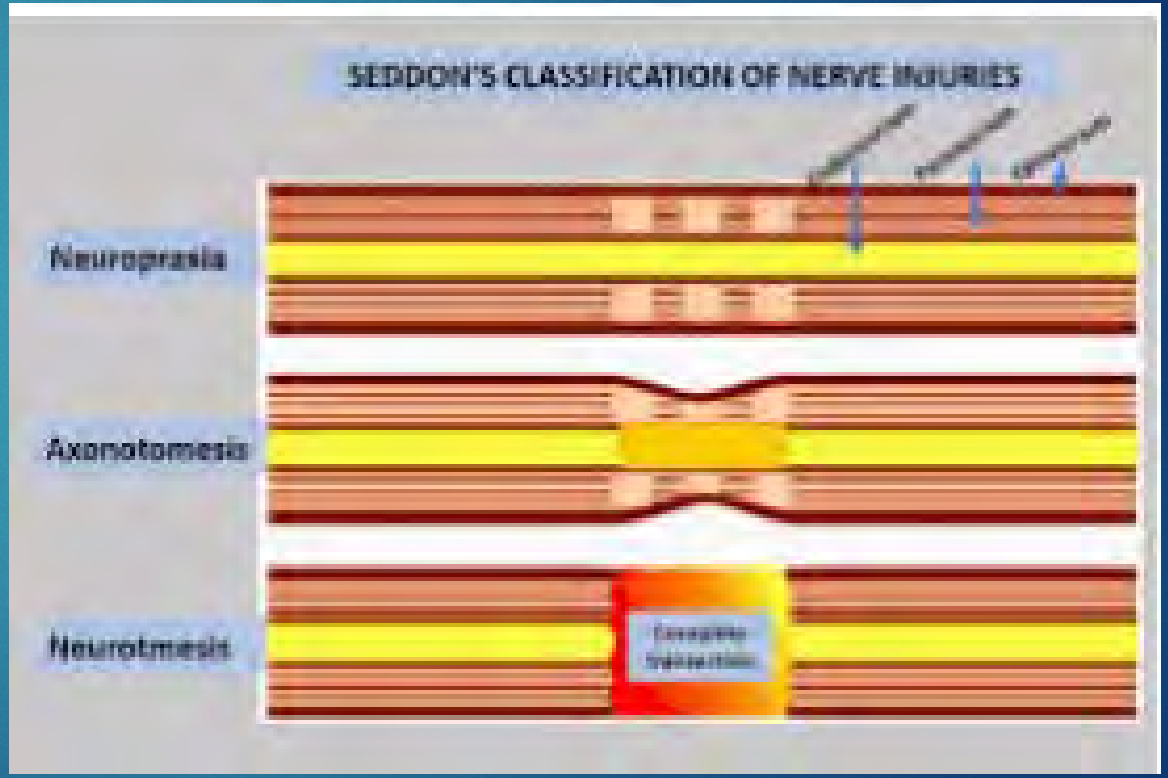
- Degeneration of the distal axon
- Reactive changes to the nerve cell body
- Wallerian degeneration
- Potential for axonal death

Seddon's Classification

- Published in 1943
- 3 stages of injury
- Useful in predicting outcome and formulating treatment

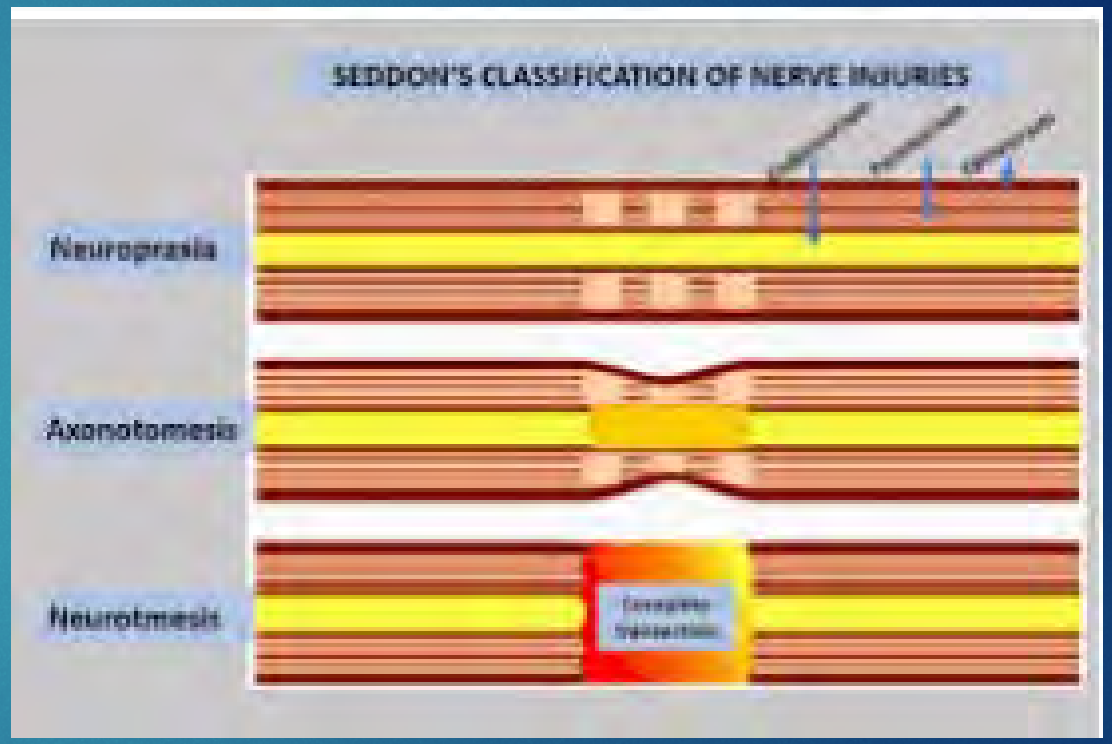
Neuropraxia

- Segmental reduction or block of conduction
- Axonal continuity preserved
- No wallerian degeneration
- Nerve conduction preserved distal and proximal to the lesion
- Full recovery



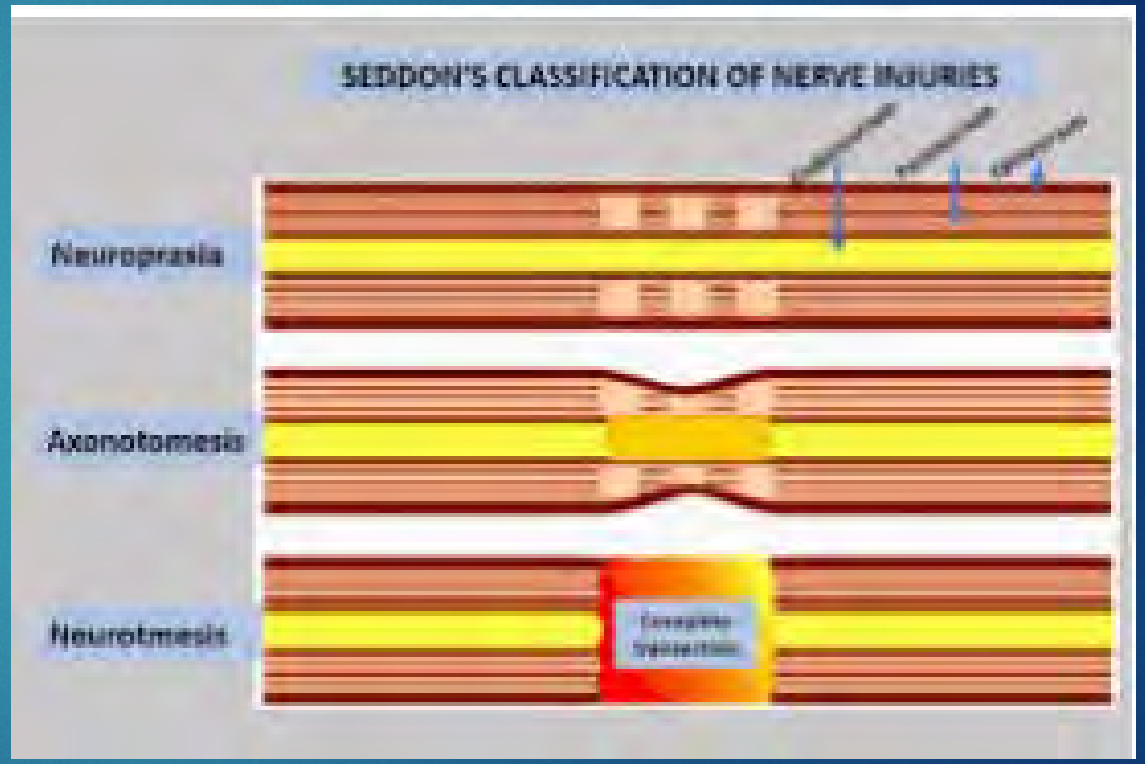
Axonotmesis

- Axonal damage with preservation of endoneurium
- Distal wallerian degeneration occurs
- Endoneurial tubes guide re-growth of axon
- Crush, fracture, chronic compression



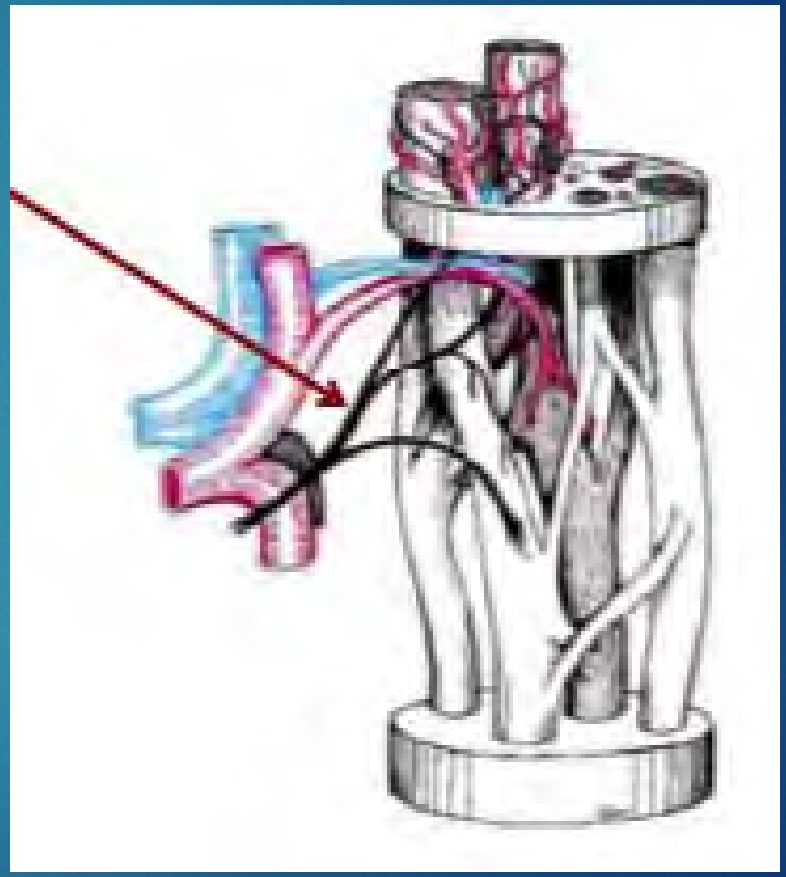
Neurotmesis

- Most severe of nerve injuries
- Connective tissue components of nerve damaged or transected
- Recovery cannot occur through axonal regeneration alone
- Surgical intervention required



Injury Without Axonal Degeneration

- The nerve to the nerve
- Consists of C and Aδ fibers
- Protective and pro-inflammatory function

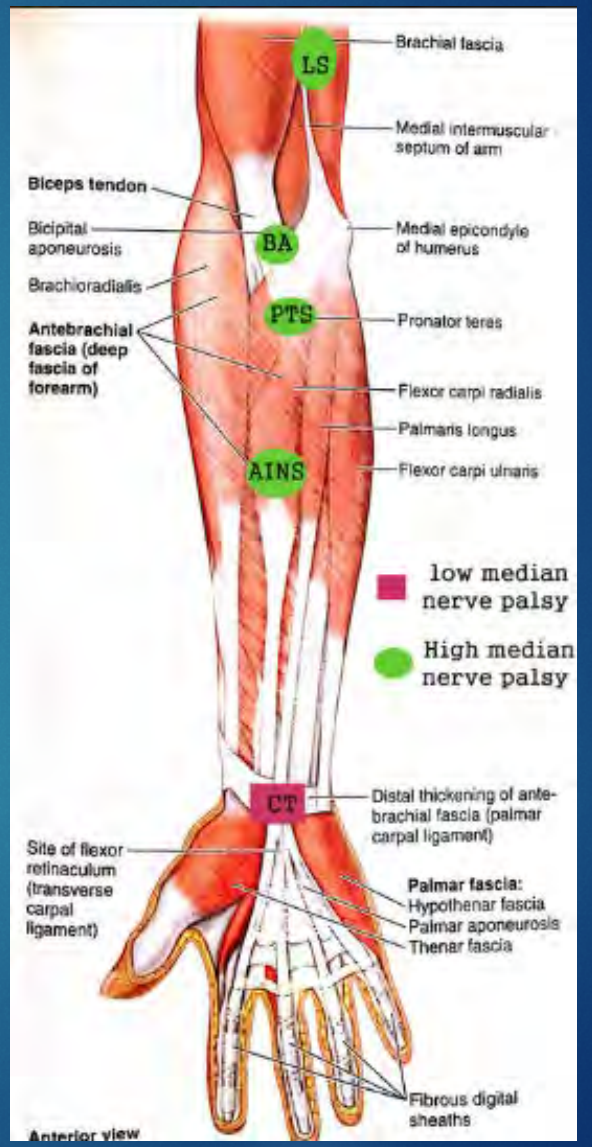


Mechanism of Occurrence

- Inflammation in and around the nerve (Dilley et al, 2005; Bove, 2009)
- Interruption of axonal transport (y Dille & Bove, 2008, Dilley et al, 2013)
- Mechanical stress of stretch and/or compression
- Neuropraxia

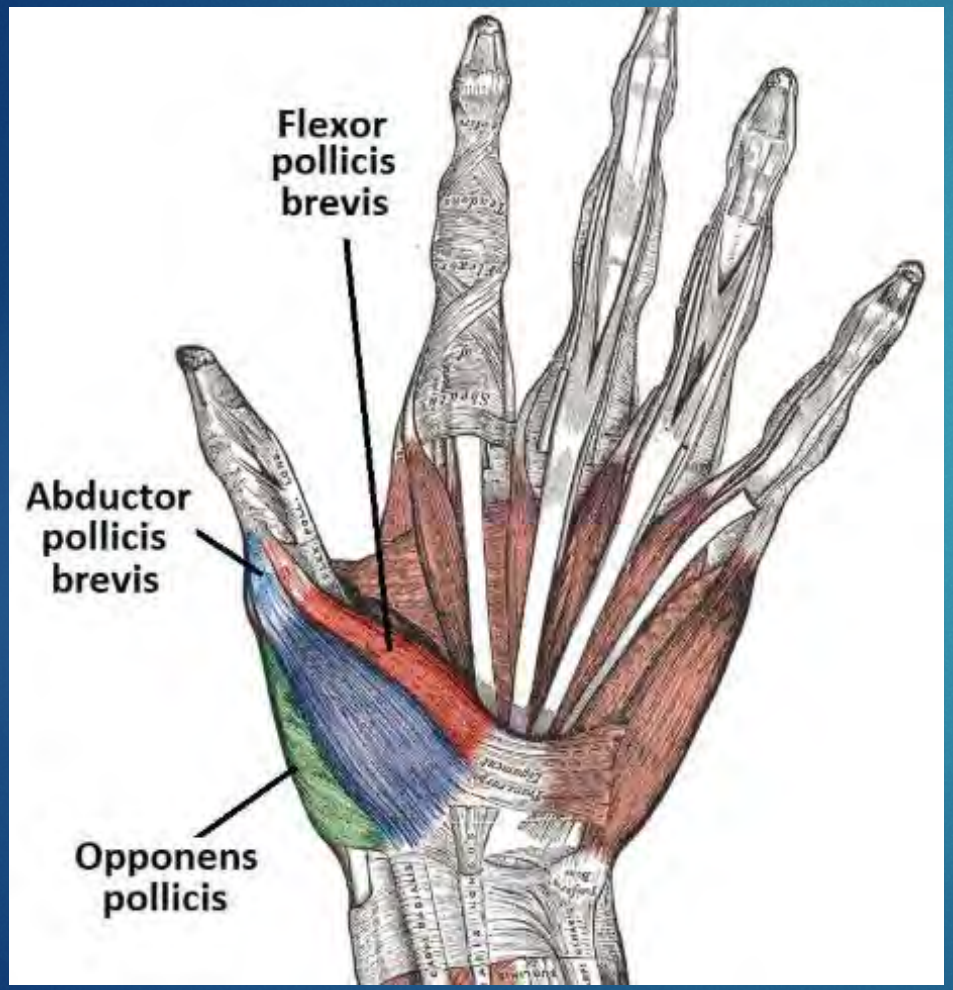
Median Nerve Entrapment

- CTS- Thenar atrophy, parastesia
- Biceps aponeurosis- pronator weakness
- Pronator teres- sensory, pain volar forearm, parastesia PCB median n
- FDS arch



Michael J. Lee, DPT1 Paul C. LaStayo, PT, PhD, CHT Pronator Syndrome and Other Nerve Compressions That Mimic Carpal Tunnel Syndrome. J of Ortho & Sports Phys Ther. 2004;34:601-609

Median N Innervation: Thenar



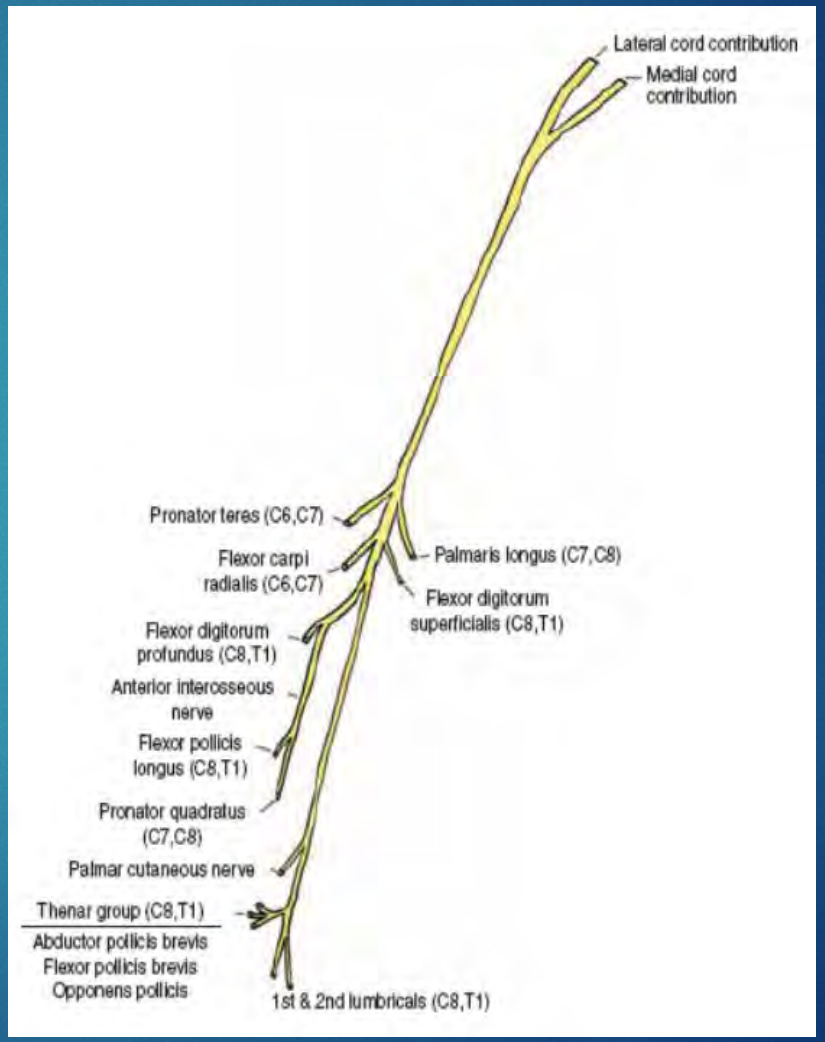
- Opponens pollicis- opposes thumb, medially rotated and flexes metacarpal-Median N
- Abductor pollicis brevis- Abducts the thumb- Median N
- Flexor pollicis brevis- Flexes MCP- superficial median N, Deep ulnar nerve

Function

Gives humanity an opposable thumb

Median Nerve Forearm

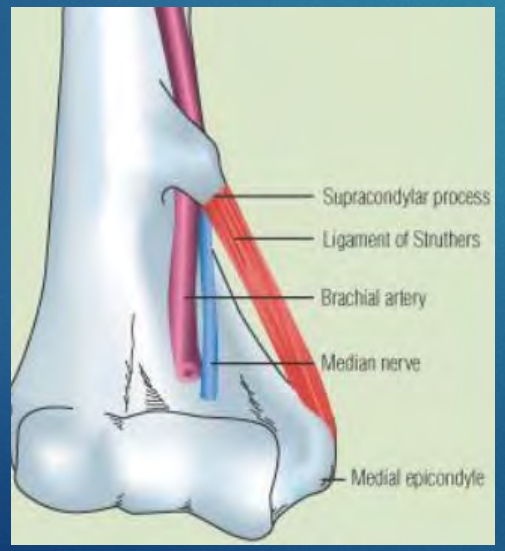
- Pronator teres
- FDS, FDP
- FPL
- Power



Assessment

Ligament of Struthers

- Supracondylar process syndrome
- Abduct the shoulder
- Position the elbow in flexion between 120-135 degrees
- Resist elbow flexion 60 seconds

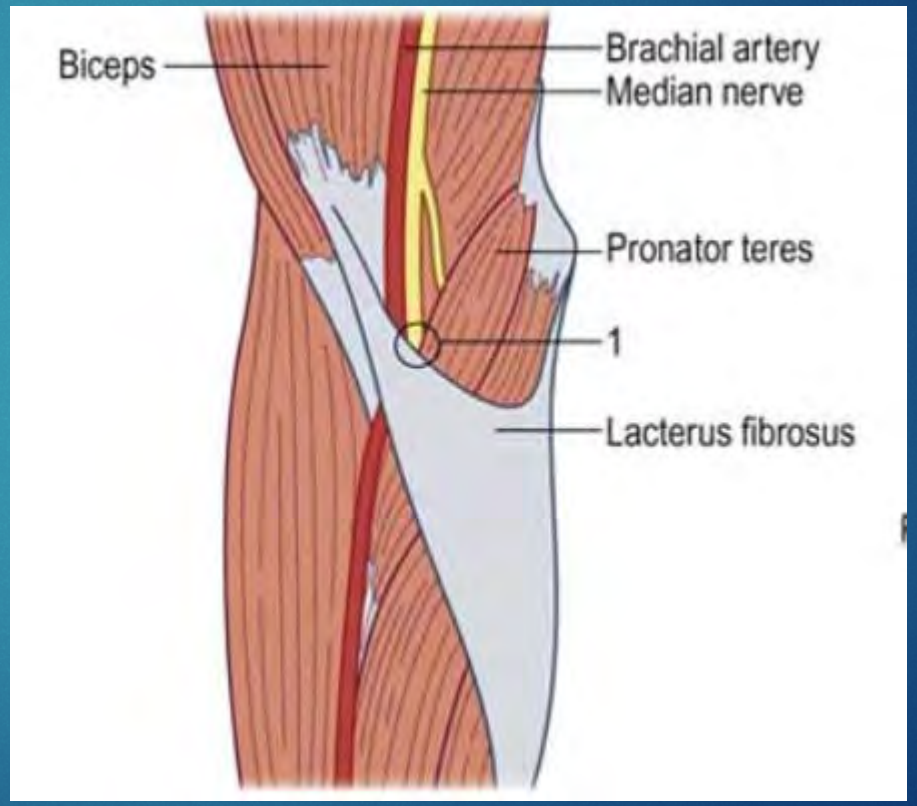


Lacertus Fibrosis

- Incoordination
- Loss of tip to tip and lateral pinch strength
- FPL, FDP II, FCR weakness
- Not usually numb

Lacertus Fibrosis

- Place the patient in full active or passive pronation
- Resist flexion



Pronator Syndrome

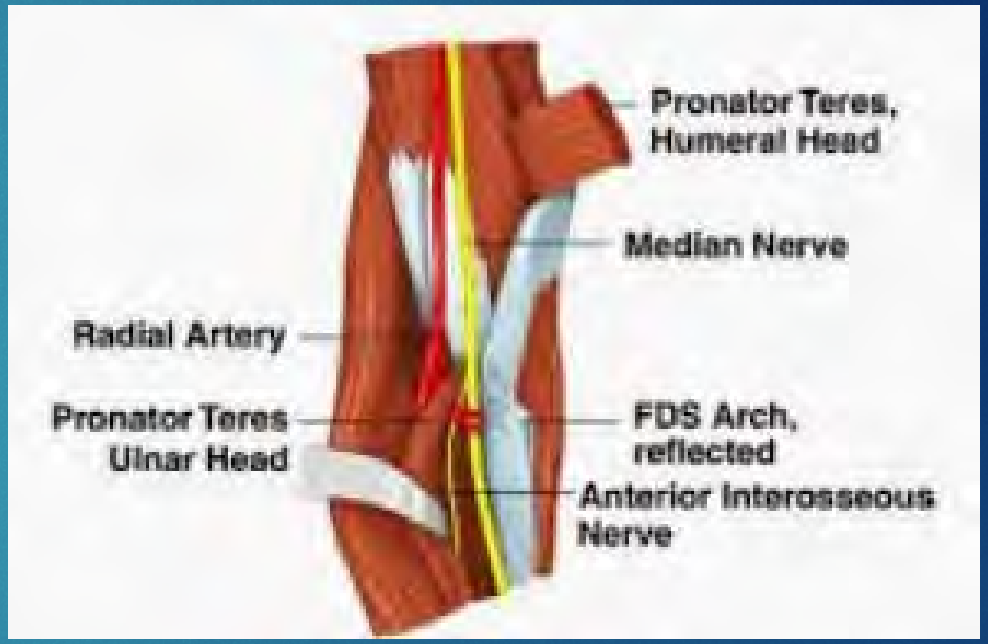
- Forearm ache
- Tenderness over pronator teres
- Weakness
- Numbness and pain in daytime not night

Pronator Syndrome

- Place the forearm in a supinated position
- Resist pronation of the forearm in a supinated position, held for 60 second

FDS Arch

- Resist middle finger flexion with the resistance placed over the middle phalanx



Anterior Interosseous Nerve-

- Flexor Pollicus Longus
- Pronator Quardatus
- Flexor Digitorum Profundus I impairment
- Trauma
- Inflammatory neuritis

CTS

- Motor loss is primarily

of the thenar

musculature and

Lumbricals I& II

- Not painful

Carpal Compression Test/Durkan's Sign

- Compress the carpal tunnel for 30 seconds.
- Pain and parasthesia are positive for carpal tunnel syndrome.
- Specificity 91% Sensitivity 89%

Durkan JA; A new diagnistic test for CTS. J Bone and Joint Surgery 73:535-538, 1991

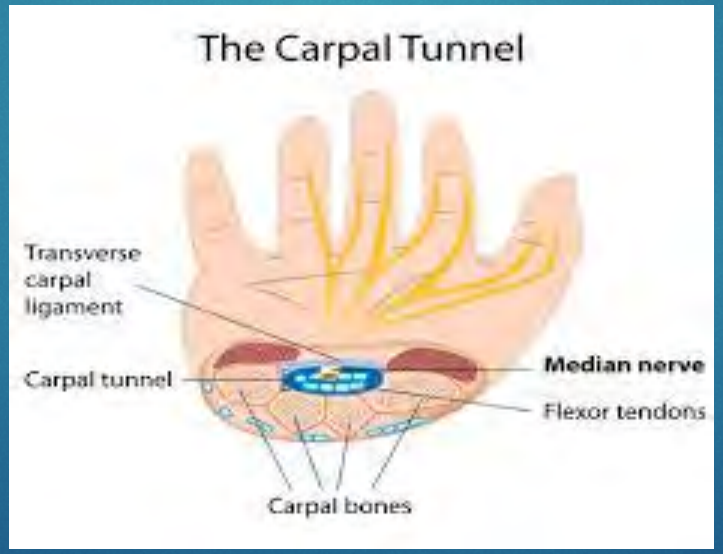
- EMG
- Cortisone shot

Its All About the Pressure

- Average tissue fluid pressure in subject with CTS is 32 mm HG vs. 2.5 mm HG in the normal individual
- When increased to 50-60 mm HG complete motor and sensory block occurs
- Gripping and wrist position further increase pressure
- Many people sleep in extreme postures

Dynamic Ischemia

- At night lack of muscular contraction effects redistribution of fluid
- May explain negative EMG findings
- Maybe dynamic ischemia rather than structural injury



Lumbrical incursion

- Lumbrical muscles arise from FDP

as they cross the palm, share the carpal canal

- Incursion occurs with gripping, composite fist
- Pressure begins to increase at 50% of a composite fist
- Size and shape of muscles influence significance of phenomenon

Source: Rehabilitation of the Hand and Upper extremity

Intervention

- Behavioral modification
- Orthosis
- Neural mobilization
- Surgery-CTR
- Opponensplasty

Behavioral modification

- Ergonomics
- Tool handle size
- Night splinting
- NSAIDS

Neural Mobilization

- Y.H. Lim et al. Median nerve mobilization techniques in the treatment of carpal tunnel syndrome: A systematic review Journal of Hand Therapy 30 (2017) 397e406
- Inconclusive

- Butler M et al. Reliability and accuracy of the brachial plexus neurodynamic test. M.W. Butler et al. / Journal of Hand Therapy (2018) 1-5

- Mohamed FI, Hassan AA, Abdel-Magied RA, Wageh RN. Manual therapy intervention in the treatment of patients with carpal tunnel syndrome: median nerve mobilization versus medical treatment. Egypt Rheumatol Rehabil 2016;43:27-34

- Found improvement in subjective function, parastesia and pain

Treatment: Nerve glides

- Manual technique
- Glide to feeling of tension
- Note position
- Slowly progress to uncomfortable
- Move between positions
- 8-10x
- Retest
- Procedure is the same with all glides

Median Nerve Glide

*Standing at patients head

0/5 Shoulder IR, elbow 90, wrist and fingers neutral

1/5 Depress shoulder 1", SH ER to neutral, ABD 45

2/5 SH ER to 90

3/5 Elbow extension

4/5 Forearm supinated

5/5 Extend wrist, radially abduct thumb

*Different than ULTT

Butler M et al. Reliability and accuracy of the brachial plexus neurodynamic test. M.W. Butler et al. Journal of Hand Therapy (2018) 1-5

Glide don’t stretch

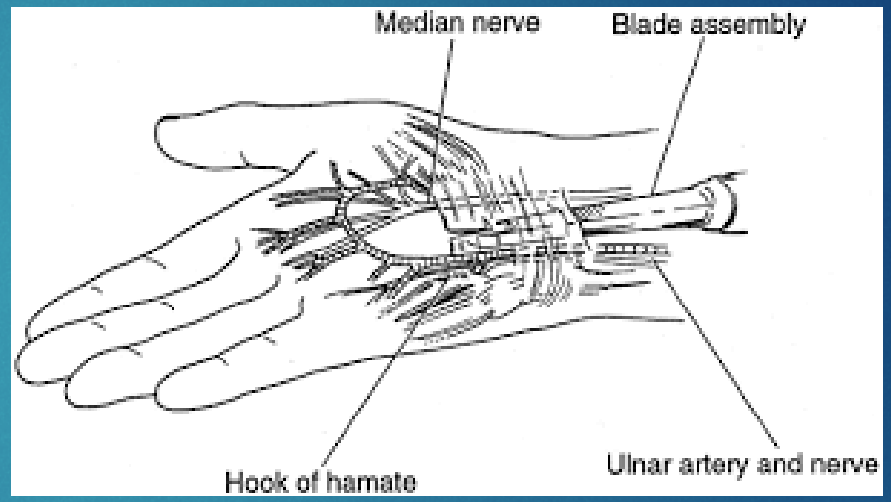
Self mobilization

- Flossing
- Not painful

Surgical Intervention

- Open procedure
- Mean 24% increase in space
- Preferred due to high degree of structural variability

- Endoscopic Procedure
- Faster return to pinching and griping
- Faster return to work
- Higher rates of incomplete release, median nerve injury, Ulnar neurovascular bundle injury



Complications

- Infection
- Pillar pain
- Worsening of condition
- Incomplete sensory or motor return
- Flexor tendon laceration
- Wound dehiscence***BE CAUTIOUS OF EARLY SUTURE REMOVAL***
- Trigger fingers
- Perineural scarring
- CRPS
- Palmaris Longus inflammation

- 70-75% of surgeries result in some improvement
- Full restoration in less then 50-60%
- 7-15% will have worse symptoms after release due to scar formation and tunnel narrowing

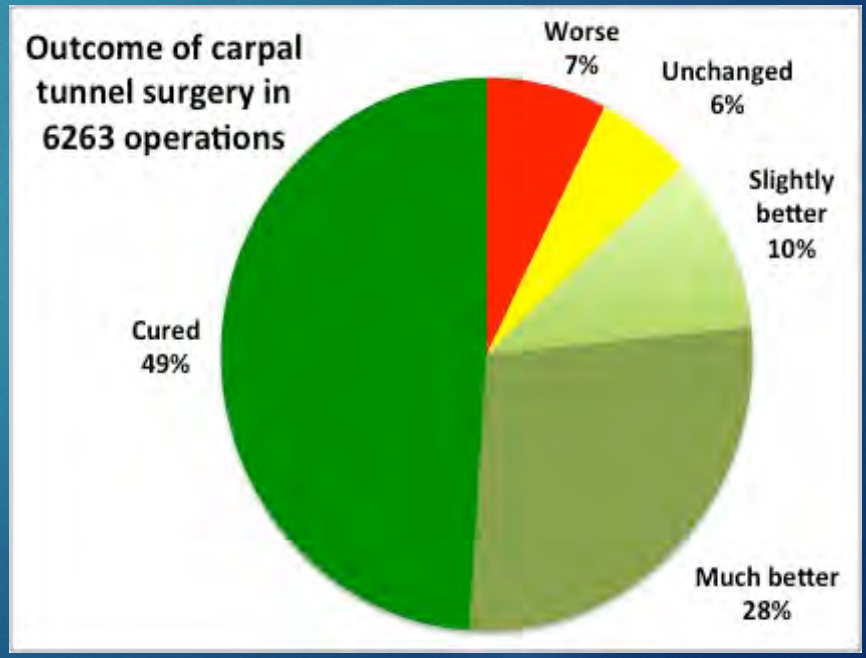


Chart from BLS

Why Didn’t it Work?

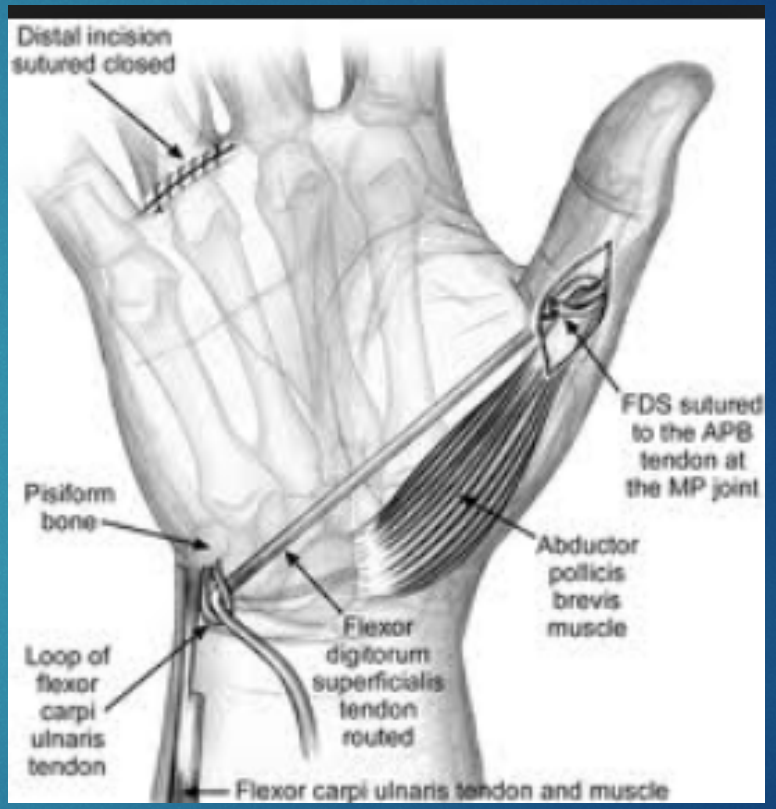
- Incomplete release
- Incorrect diagnosis
- Intra-neural scarring
- Adherence to the median nerve with traction dysthesia’s
- Re-growth of the flexor retinaculum
- Nerve subluxation

High median nerve lesions

- Index has no lumbrical or long flexors
- Interossei and EDC intact
- “Pointing finger deformity”
- Long finger also deprived but Quadriga phenomenon compensates with FDP connection

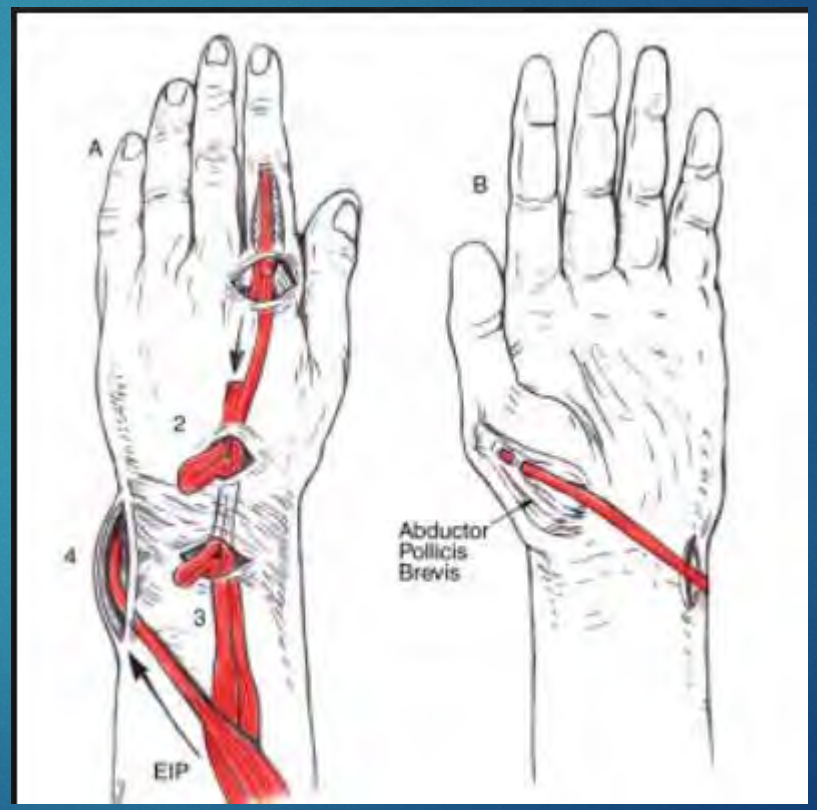
Opponensplasty

- Resume opposition and power
- Palmaris longus
- FDS ring
- EIP
- ADQ-Huber-congenital



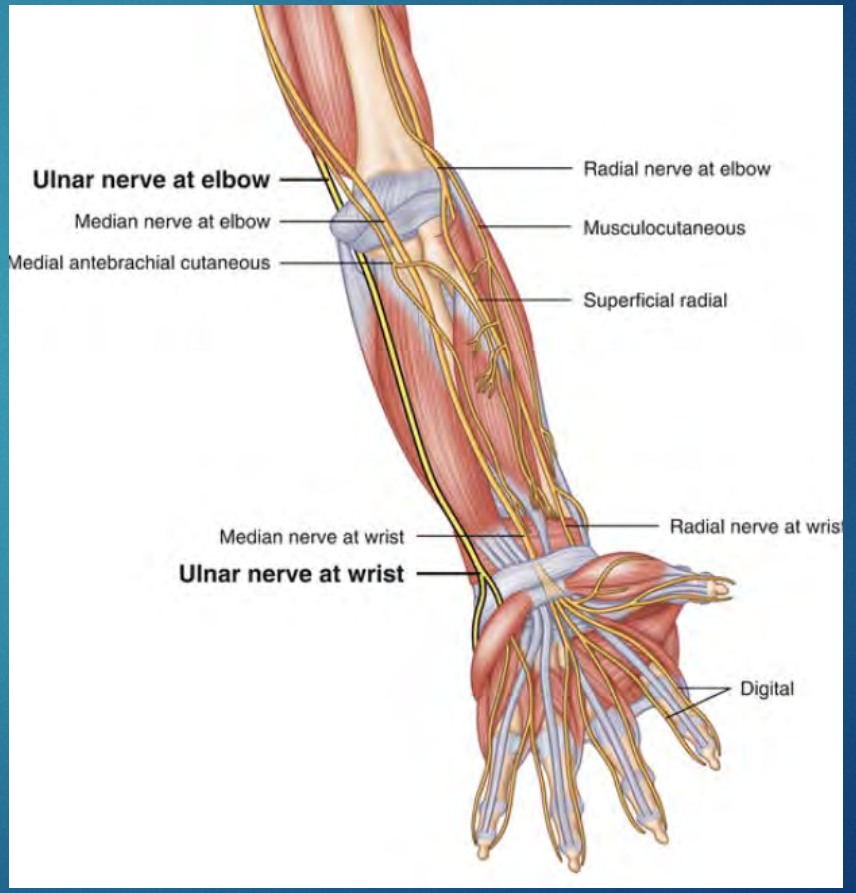
EIP to opponens

- Better in more flexible hands
- Better line of pull and excursion vs. FDS
- Lower morbidity

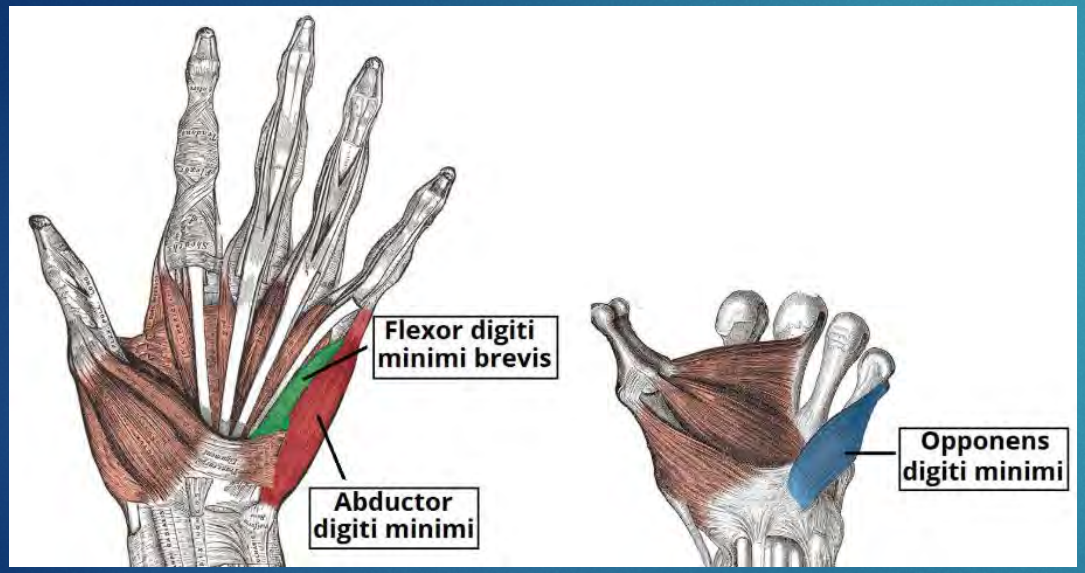


Ulnar Nerve entrapment

- Cubital Tunnel
- Guyon's Canal



Hypothenar Musculature



- Deep branch of the Ulnar N.
- ADM-SF abduction
- ODM- flex and laterally rotate 5th MC
- FDM- aids in MCP flexion
- ADM-acts similar to 1st dorsal interosseous, vital to extended large object grasp pattern, can aid in PIP extension. OM allows SF to reach the thumb

Function

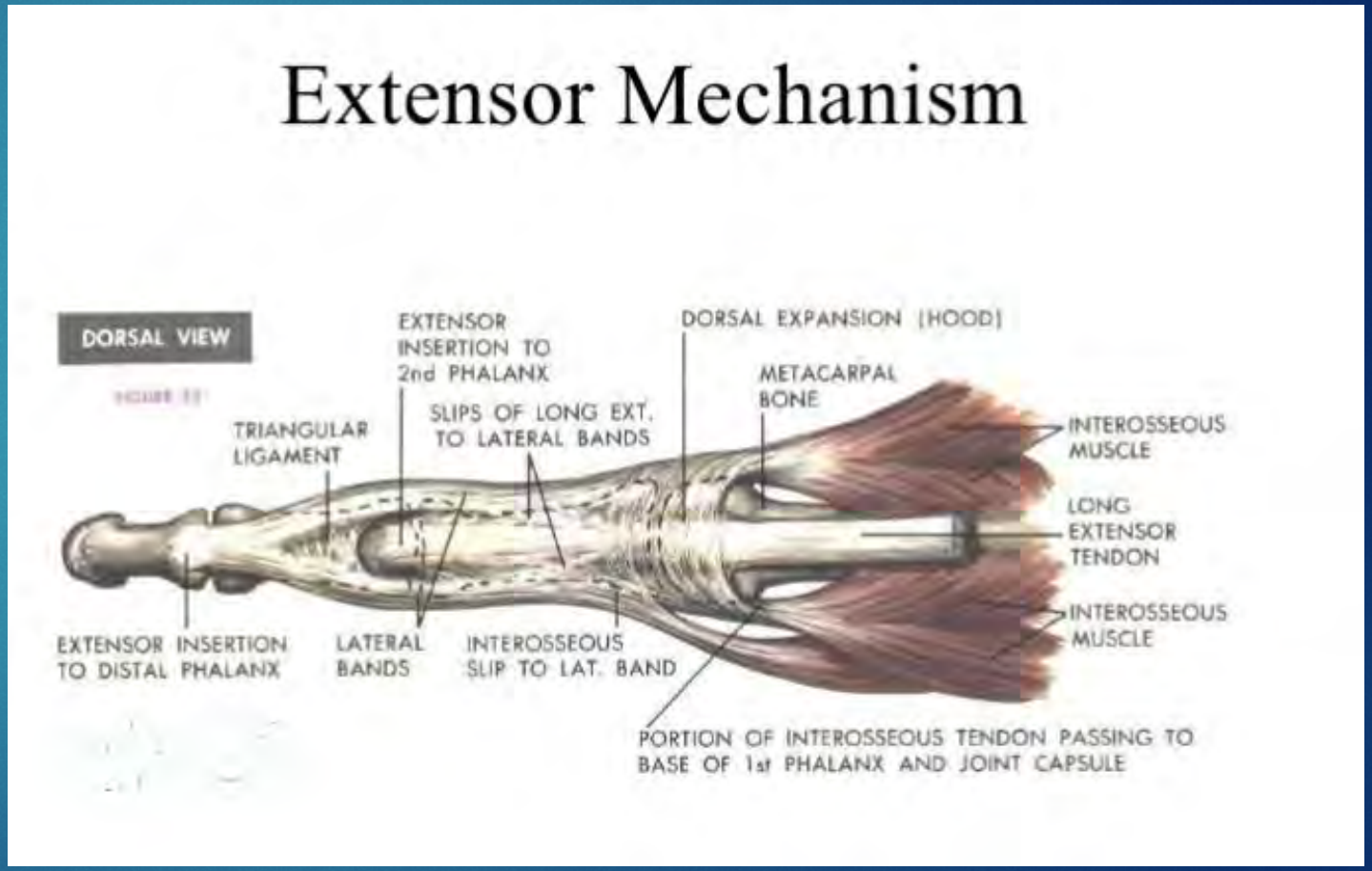
- Cascade
- Power grip
- Grasping large objects

Presentation

- Claw deformity/ benediction hand
- 3rd and 4th lumbrical incompetence
- Interosseous incompetence
- Flattened palmar arch
- EDC extends the 4th and 5th digit unopposed
- Lessened in high lesions

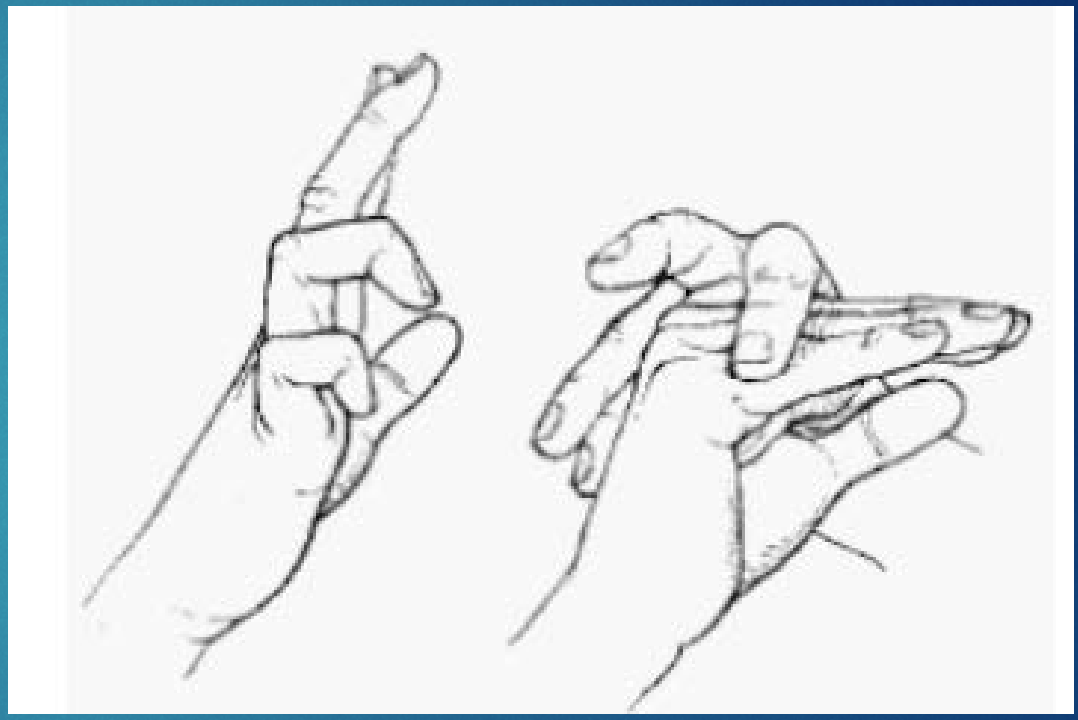
Digital Extensor Mechanism

- Extrinsic extensors
- Intrinsic extensors
- Retinacular system



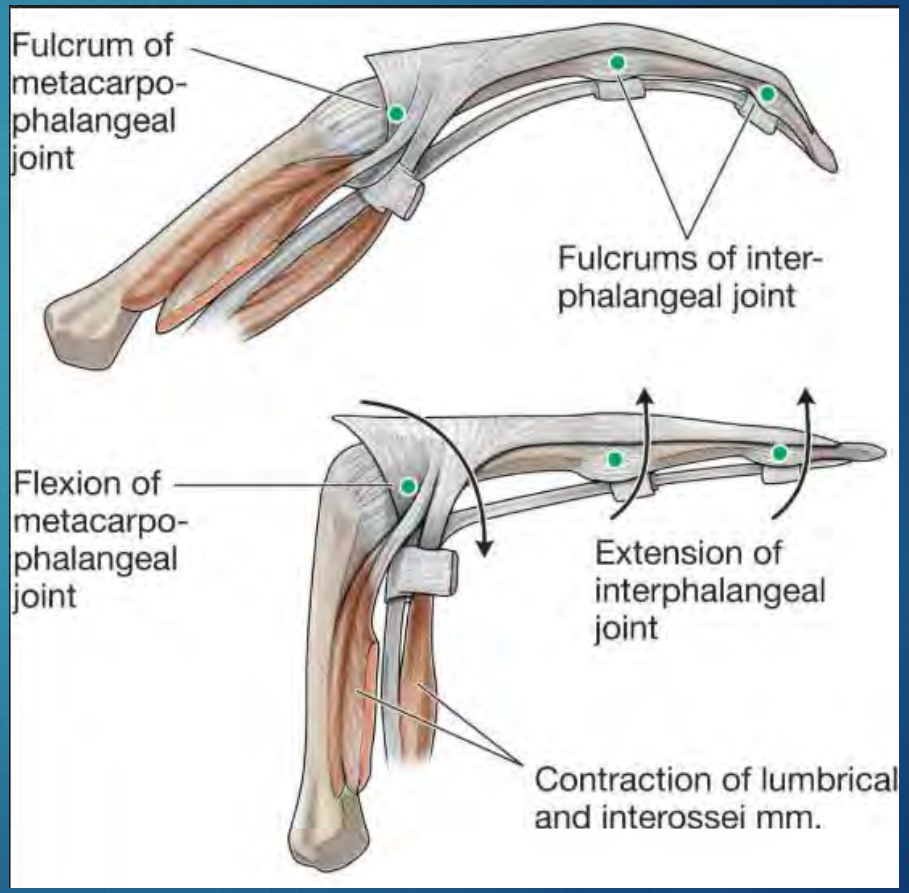
Bouvier's Test

- Determines if PIP joint capsule & extensor mechanism are working
- Blocking MCP joint hyperextension allows IP joint extension
- Indication for surgery/relative motion/ anticlaw orthosis



Intrinsic Function

- MCP flexion / stabilization
- Extension of the interphalangeal (IP) joints.



Cubital Tunnel

- Between the two heads of FCU/aponeurosis (most common site)
- Arcade of Struthers (hiatus in medial intermuscular septum)
- Osborne's ligament and MCL

Cause

- Repetitive trauma
- External traction/compression-Hand therapists
- Fractures and medial epicondyle nonunion
- Osteophytes
- Heterotopic ossification
- Tumors and ganglion cysts

Guyon's canal

Location	*Common Causes of Compression*	*Symptoms*	
Zone 1	Proximal to bifurcation of the nerve	Ganglia and hook of hamate fractures	Mixed motor and sensory
Zone 2	Surrounds deep motor branch	Ganglia and hook of hamate fractures	Motor only
Zone 3	Surrounds superficial sensory branch	Ulnar artery thrombosis or aneurysm	Sensory only

Cause

- Ganglion cyst (80% of nontraumatic causes)
- Lipoma
- Repetitive trauma-cyclists
- Ulnar artery thrombosis or aneurysm
- Hook of hamate fracture or nonunion
- Pisiform dislocation
- Inflammatory arthritis
- Fibrous band, muscle or bony anomaly
- Congenital bands
- Palmaris brevis
- Idiopathic

Wartenburg's Sign

- Inability to adduct SF following abduction
- 11% sensitive, 95% specific

Guyon's Canal Compression Test

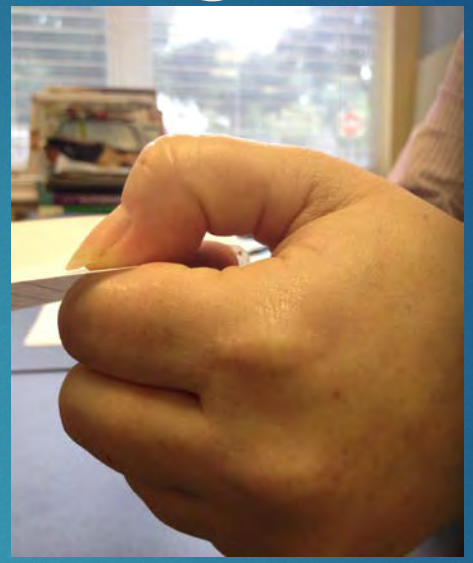
- Compress 1 min medial of the pisiform.
- Indicates ulnar nerve pathology at Guyon's canal.

Egawa's Sign

- Flex middle digit.
- Radially and ulnarly deviate.
- Demonstrates interosseous function.
- Inability indicates ulnar nerve pathology.

Froments and Jeanne's signs

- Patient pinches paper in an attempt to keep the tester from pulling it away.
- IP flexion indicates ADD pollicus incompetence.
- If the MCP hyperextends it is Jeanne's sign.



Treatment

- Activity modification
- Night orthosis
- Handle bar modification
- Headset
- Padding
- Release/transposition

High Ulnar Nerve compression Splinting

- Elbow flexed 30- 45 degrees
- Wrist is positioned in neutral to 20 degrees of ext, if included
- Including the wrist decreases the effects from flexor carpi ulnaris contraction
- Pilo splint can be a comfortable alternative

Ulnar Nerve Glide

0/5 SH IR, elbow 90, arm across stomach, wrist and fingers neutral

1/5 SH ER to neutral, SH ABD 45, block SH elevation

2/5 ER 90

3/5 ABD 110,stabalize SH to prevent hiking

4/5 Pronate, extend wrist, ring, small

5/5 Flex elbow

Stand below shoulder

Anticlaw Orthosis

- Ring and little finger in 30- 45 flex
- Maintains MCP collateral ligament length
- This splint aids functional grasp
- Prevents PIP contracture
- Aquaplast tubes

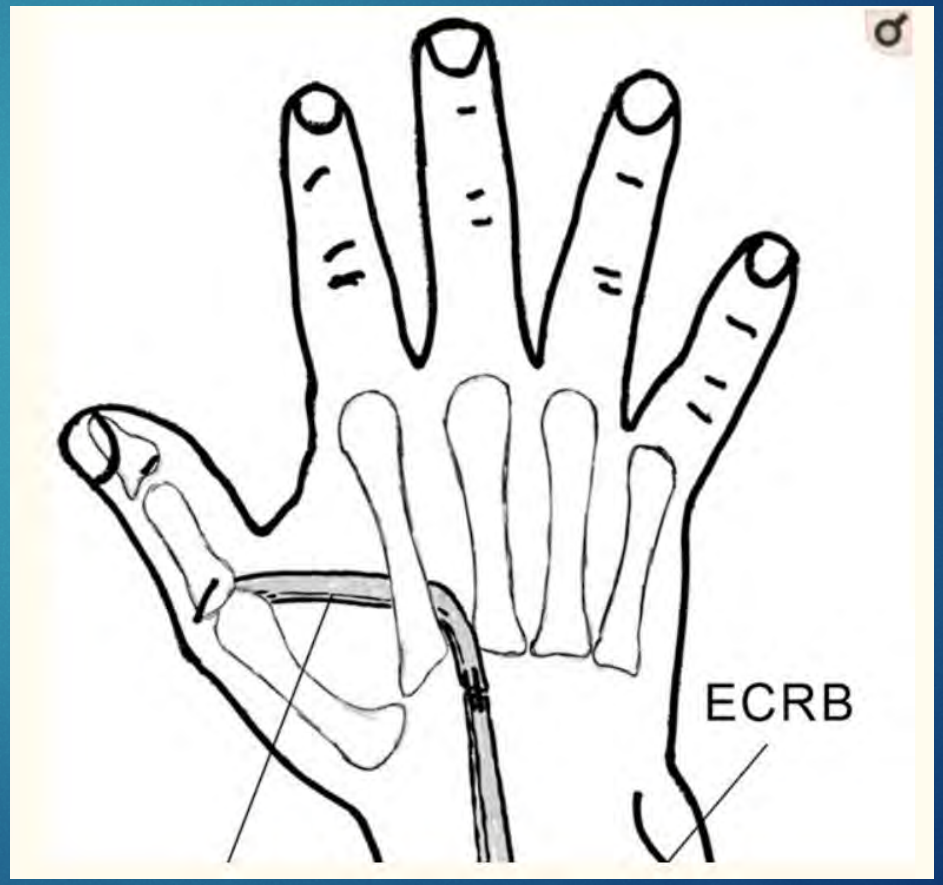
Tendon Transfer

- Restoration of small and ring finger DIP flexion
- Restoration of key pinch
- Correction of clawing
- Integration of MCPJ and IPJ flexion
- Improvement in grip strength.

Sammer et al. Tendon Transfers Part II: Transfers for Ulnar Nerve Palsy and Median Nerve PalsyPlastic and Reconstructive Surgery. 124(3):212e-221e, SEP 2009.

Key pinch

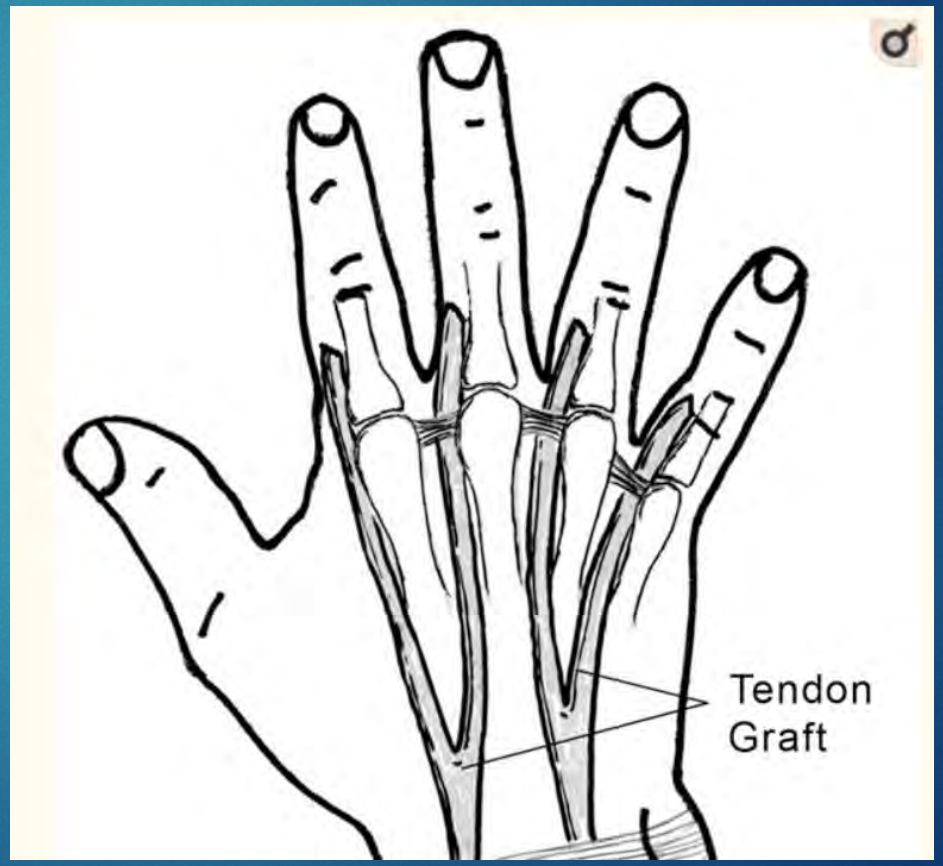
- Key pinch-ECRB or brachioradialis
- Adductor pollicis not usually needed to functional key pinch
- Index finger can be stabilized against the adjacent fingers during pinch
- Only in high fine motor demand individuals



Claw deformity correction-options

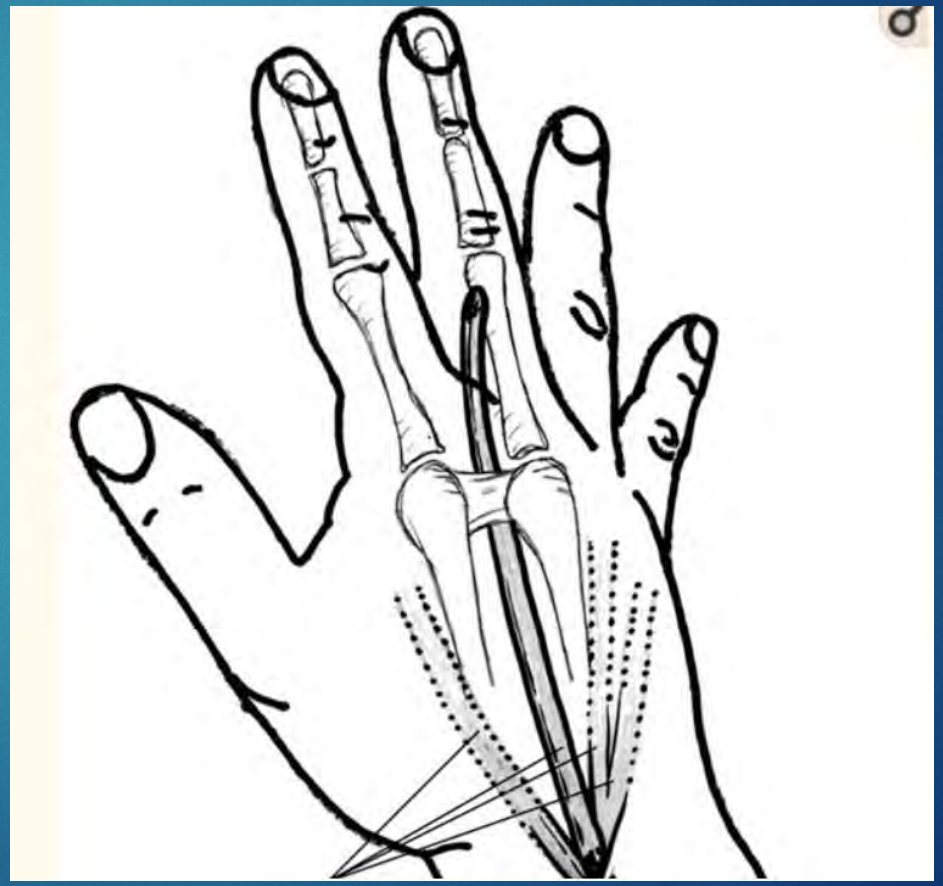
1. MCPJ capsulodesis-static correction like orthosis
2. Static tenodesis with a tendon graft
3. Dynamic tenodesis-dorsal tendon graft tied to lateral bands

*Wrist flexion generates mcp flexion and IP extension



Dynamic tendon transfers

- Superficialis transfers
- Middle finger superficialis tendon is divided
- Passed along the path of the lumbrical, volar to the deep transverse metacarpal ligament, and back into the finger, where it is inserted on the lateral band
- PIPJ hyperextension



Therapists management

- Week 1-4: Orthosis to maintain non-contractile tissue in optimal position. PROM. Scar Management
- Week 4-6: Gentle A/PROM, explicit motor imaging, NMES
- Week 4: Focus on transfer training, biofeedback
- Week 8: Strengthening, orthosis is weaned
- Week 12: resume normal activity

Factors influencing the timeline/ treatment

- Strength of transfer/graft
- Health of the patient
- Synergy of the graft/transfer
- Cognitive status/ motivation
- Communication
- Power of the donor

Interosseous plus

- Paradoxical PIP extension
- Interosseous dominance overwhelms
- Long flexors are weak or poorly activated
- High median nerve
- Maladaptive motor pattern
- Isolate long flexors to retrain

Radial Nerve

Radial Nerve Palsy

- Absent supination
- Absent wrist extension
- Absent digital extension
- Absent thumb extension and radial abduction
- “Saturday Night Palsy”

Causes

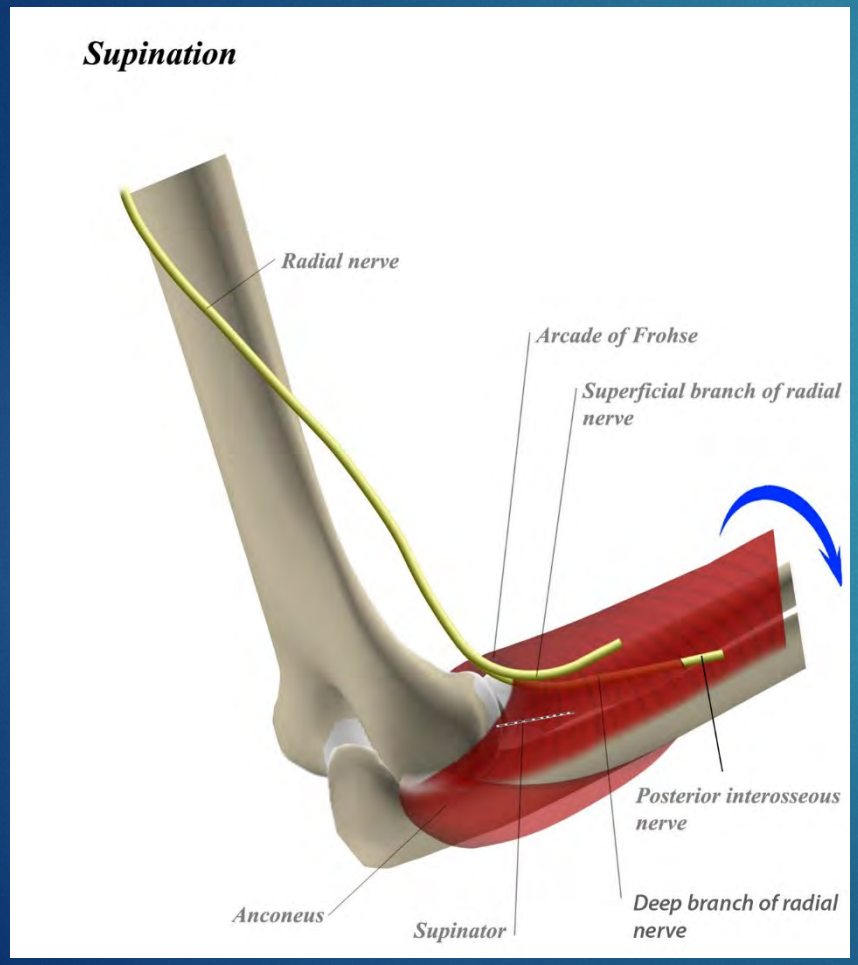
- Trauma
- Lead poisoning
- Humoral fracture
- Dislocation
- Repetitive motion

Orthosis

- Benik

Therapy

- NMES
- Tapping
- Vibration
- Gravity eliminated
- Place and hold
- Eccentric
- Taping



- Arcade of Froshe
- Supinator
- Leash of Henry

Radial Tunnel vs PIN

Radial Tunnel

- Pain-dull
- Fatigue
- May radiate
- No weakness

PIN

- Purely motor
- Weak wrist extension into radial deviation-ECRL intact
- Absent digital extension

Rule of Nine

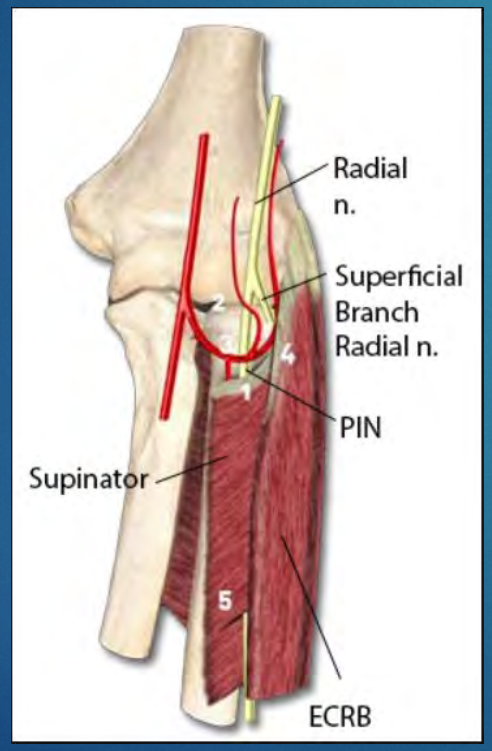
- Red indicates radial nerve
- Yellow median nerve
- Blue control

Left Forec ase

Arch Bone Jt Surg. 2015 Jul;3(3):156-162

ECRB entrapment

- Resist middle finger extension



Supinator Syndrome

- Place the forearm in a pronated position
- Resist supination

Treatment

- Patient education-link posture to recovery
- Ergonomics
- HEP
- Stretching
- Proximal strengthening
- Nsaids
- Soft tissue
- Neural mobilization
- Diaphragmic breathing
- Examine sleeping position

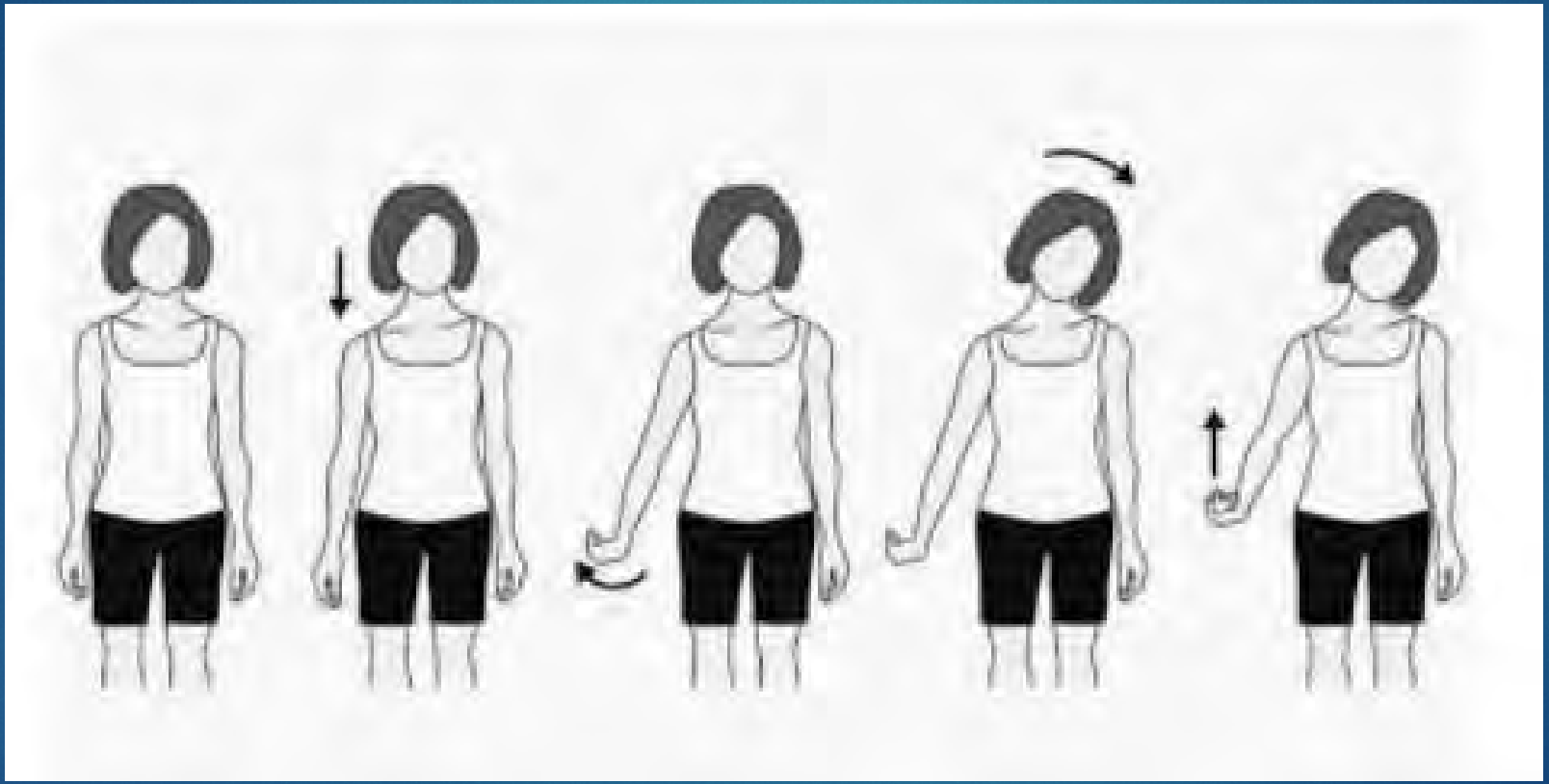
HEP

- Postural correction
- Proximal glides
  - Postural correction with “D” posterior rolls
- Nerve glides
- Scapular clock

- Maximize space along nerve bed
- Maximize nerve bed length
- Minimize sustained adverse tension on neural tissue

Radial Nerve Glide

1. Stand at patients head, shoulder just off the table, SH IR, elbow 90,wrist and fingers neutral
2. Depress SH 1", SH ER neutral, SH ABD 45
3. SH IR, elbow 90
4. Elbow extension, forearm neutral, wrist and fingers neutral, SH IR
5. Pronate forearm
6. Wrist and finger flexion, ulnar deviation



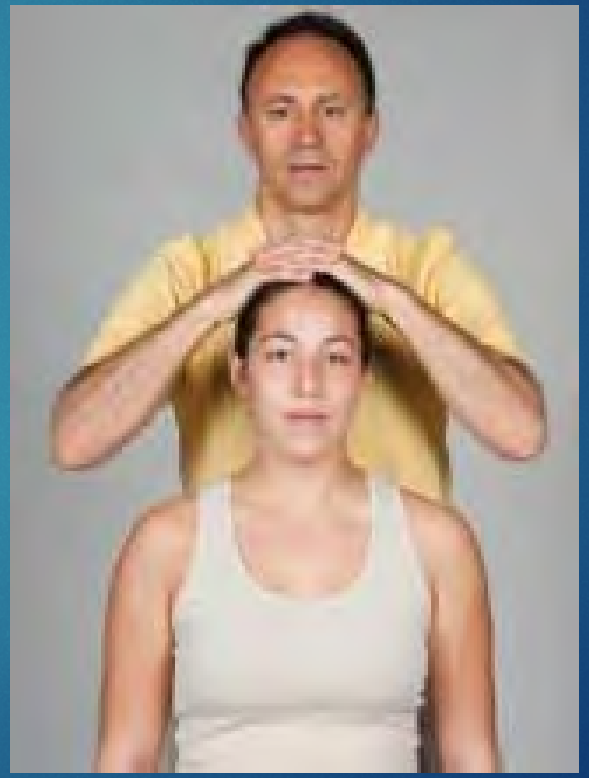
Cervical Radiculopathy

- Spurling's A test
- ULTT A test
- Cervical distraction
- Cervical rotation <60 degrees to the affected side

Wainner RS, Irrgang JJ, Boninger ML, Delitto A, Allison S. Reliability and diagnostic accuracy of the clinical examination and patient self-report measures for cervical radiculopathy. Spine 2003;28(1):52-62.

Spurlings test

- The examiner turns the patient's head to the affected side while extending and applying downward pressure to the top of the patient's head
- Gradual build up and release
- 7 seconds



ULTT

0/5 Shoulder IR, elbow 90, arm across stomach, wrist and fingers neutral

1/5 Shoulder ER to neutral, elbow at 90, wrist and fingers neutral

2/5 Shoulder ABD 100, elbow 90, neutral rotation, wrist and fingers neutral, thumb in radial abduction

3/5 Shoulder in ABD 100 ER 90, elbow at 90, forearm in supination, fingers neutral, thumb radial abduction

4/5 Shoulder in ABD 100 ER 90, elbow at 10, forearm in supination, fingers neutral, thumb radial abduction

5/5 Shoulder ABD 100 ER 90, elbow 0, forearm supination, wrist extension, fingers neutral, thumb radial abduction

- Do not depress the shoulder
- Do not drop the shoulder into extension
- Change grip at 45 degrees of ABD
- Watch for the eyebrow sign

Questions??????












Thank You!

Lconway@selectmedical.com

References

- Bove GM, Focal nerve inflammation induces neuronal signs consistent with symptoms of complex regional pain syndromes. Exp Neurol. 2009;219(1):223-7.
- Bove GM, Ransil BJ, Lin HG, Leem JG. Inflammation induces ectopic mechanical sensitivity in axons of nociceptors innervating deep tissues. J Neurophyisol. 2003;90:1949-55. 3.
- Butler MB, Common shoulder diagnoses. In Cooper C, editor: Fundamentals of hand therapy 2nd of hand therapy 2 ed St Louis Mosby Elsevier 2014 nd ed., St. Louis, Mosby Elsevier, 2014.
- Butler DS, The Sensitive Nervous System. Noigroup Publications, Adelaide, Australia, 2000.
- Coppeiters MW, Hough AD, Dilley A. Different nerve-gliding exercises induce different magnitudes of median nerve longitudinal excursion: an in vivo study using dynamic ultrasound imaging. J Orthop Sports Phys Ther 2009;39(3):164-171.
- Dilley A, Bove GM. Disruption of Axoplasmic transport induces mechanical sensitivity in intact rat C-fibre nociceptor axons. J Physio. 2008;586(2):593- 604.

- Dilley A, Lynn B, Pang SJ. Pressure and stretch mechanosensitivity of peripheral nerve fibres following local inflammation of the nerve trunk. Pain 2005;117:462-472.
- Dilley A, Richards N, Pulman KG, Bove GM. Disruption of fast axonal transport in the rat induces behavioral changes consistent with neuropathic pain. J Pain 2013;14(11):1437-49.
- Elvey R, Physical evaluation of the peripheral nervous system in disorders of pain and dysfunction, J Hand Ther 10:122, 1997.
- Greening J. Clinical implications for clinicians treating patients with non- specific arm p , ain whiplash and carpal tunnel syndrome. Man Ther. 2006;11:171-2.