

Neural Complications of Common Upper Extremity Orthopedic Injuries

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Conflicts of Interest

- ▶ I have no conflicts of interest to disclose.
- ▶ The views and contents of this presentation are mine.

Learning Outcomes

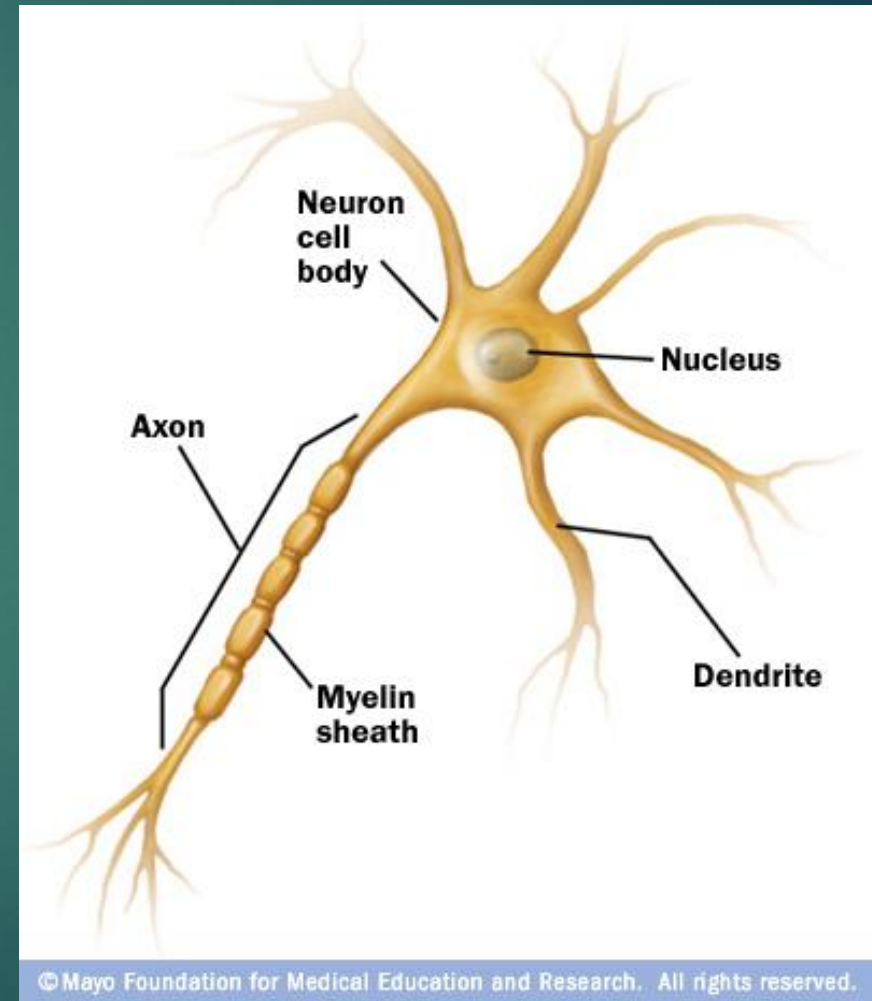
- ▶ 1. Attendees will be able to differentiate the peripheral nerves that can be involved for various upper extremity injuries.
- ▶ 2. Attendees will practice the best assessment technique to rule out neurological involvement for each injury presented.
- ▶ 3. Attendees will select specific treatment techniques or exercises to address the neurologic deficit for each common upper extremity orthopedic injury.

Outline

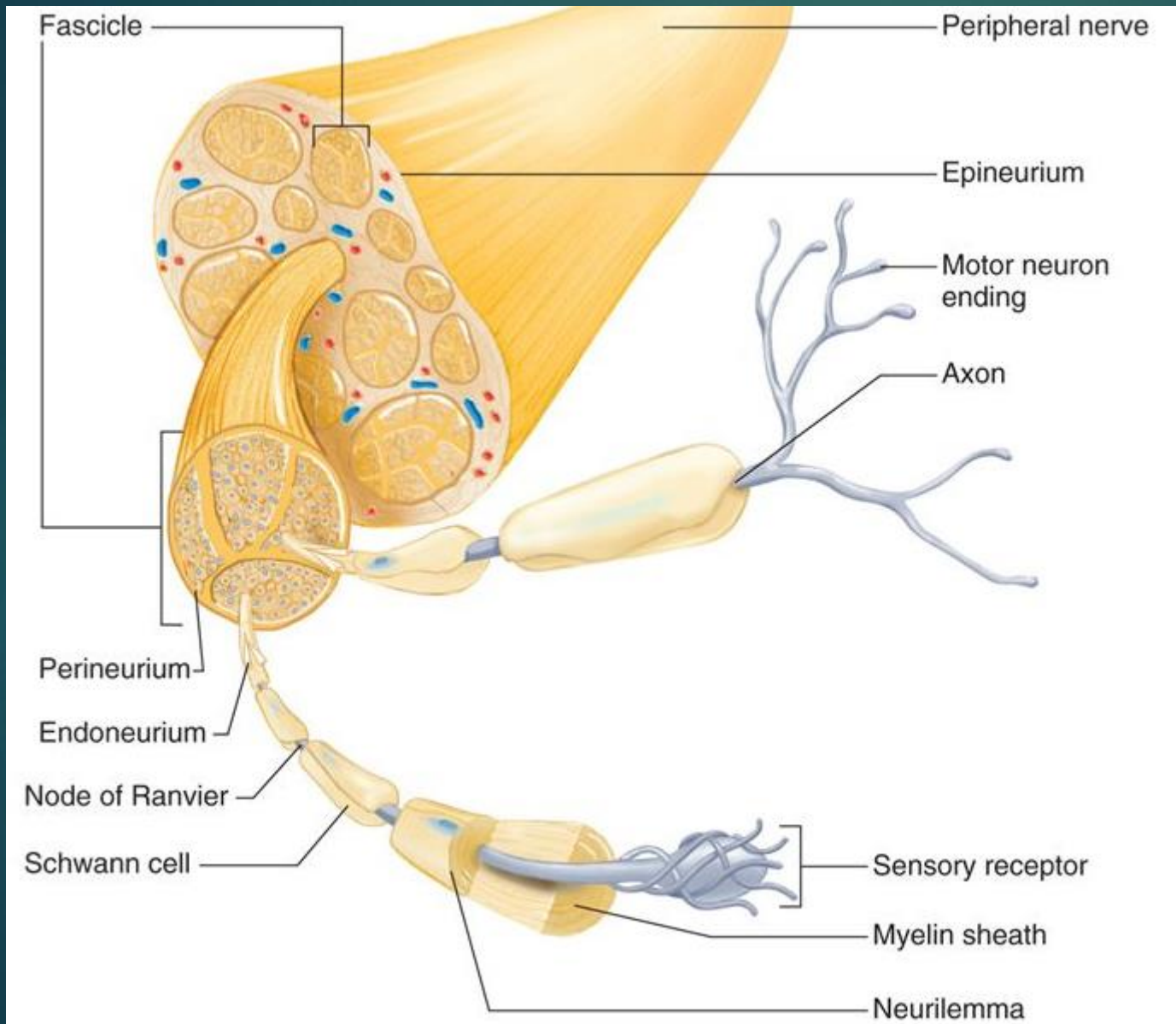
- ▶ UE peripheral nerve anatomy
- ▶ UE nerve pathology
- ▶ Assessment and treatment techniques for peripheral nerves
- ▶ Neuro complications of common orthopedic injuries
 - ▶ Shoulder pain
 - ▶ Elbow pain/medial and lateral epicondylitis
 - ▶ Wrist pain/carpal tunnel syndrome
- ▶ Case study #1- 10 min
- ▶ Case study #2- 10 min

Anatomy of a Peripheral Nerve

- ▶ Neuron
- ▶ Cell nucleus
- ▶ Dendrite
- ▶ Axon
- ▶ Myelin sheath

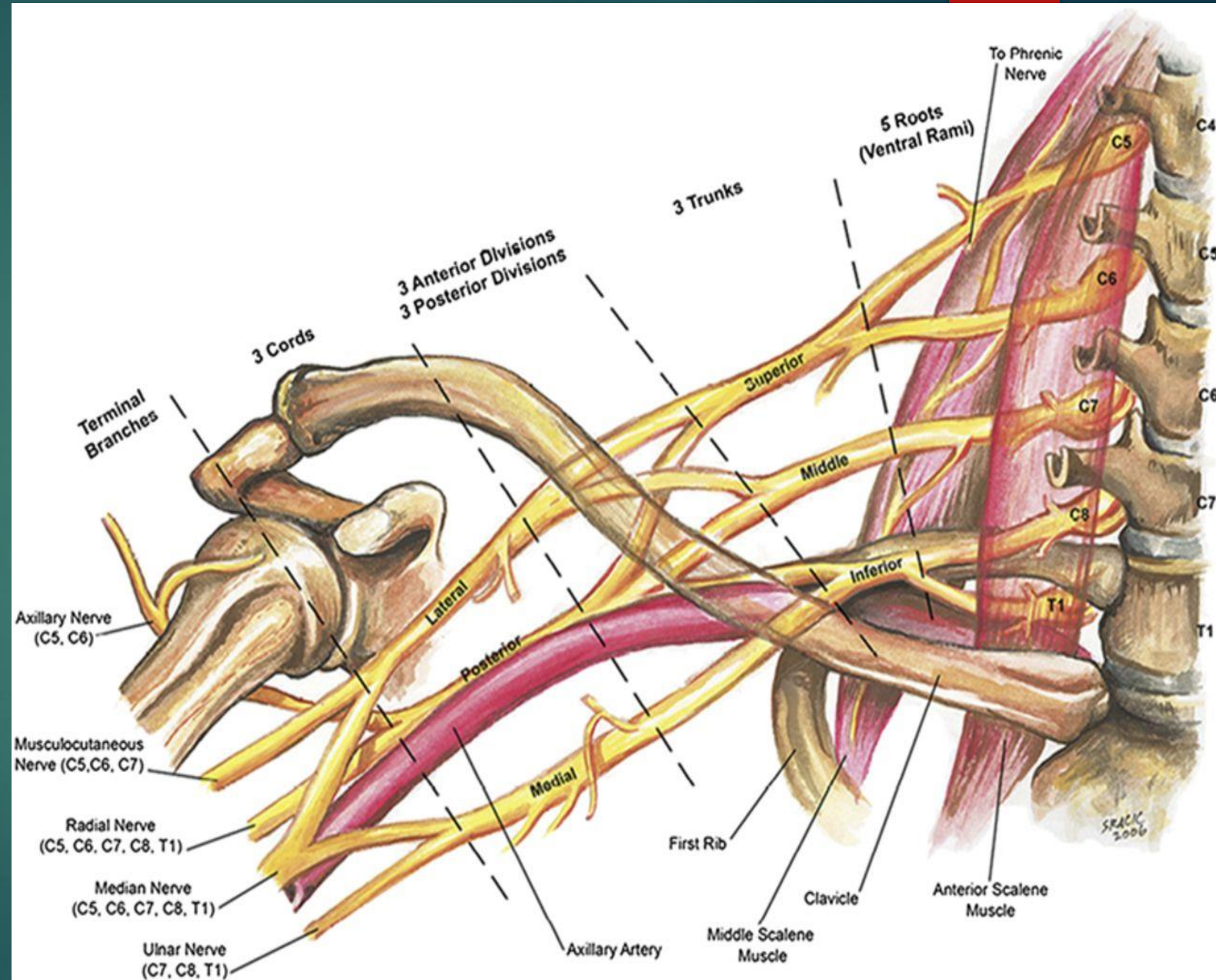


Requirements of Healthy Nerves

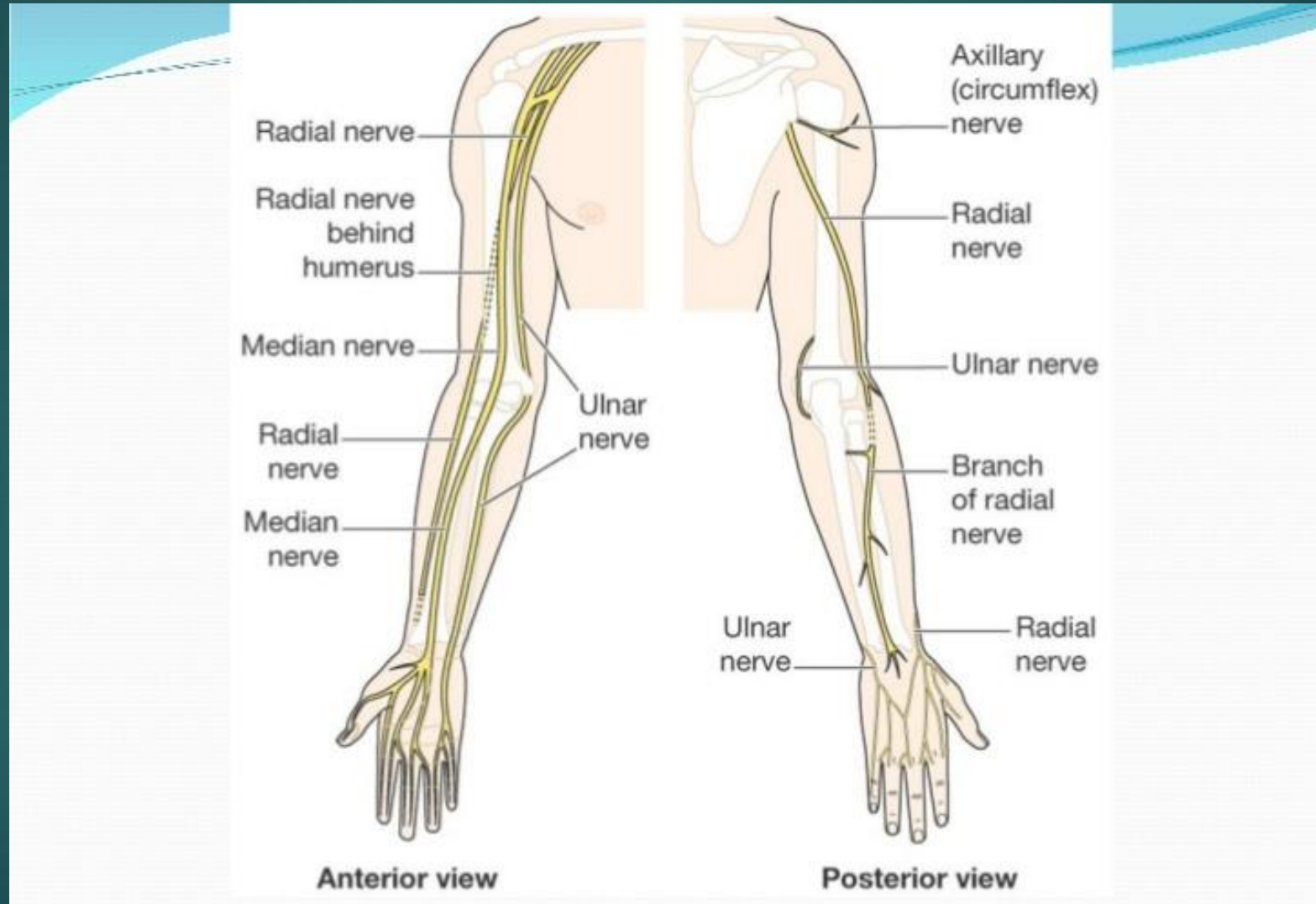


- ▶ Blood flow
- ▶ Space
- ▶ Homeostasis of surrounding tissue
 - ▶ pH
 - ▶ Lack of inflammatory substrates
- ▶ Mobility

Brachial Plexus



Upper Extremity Peripheral Nerves



UE Dermatomes

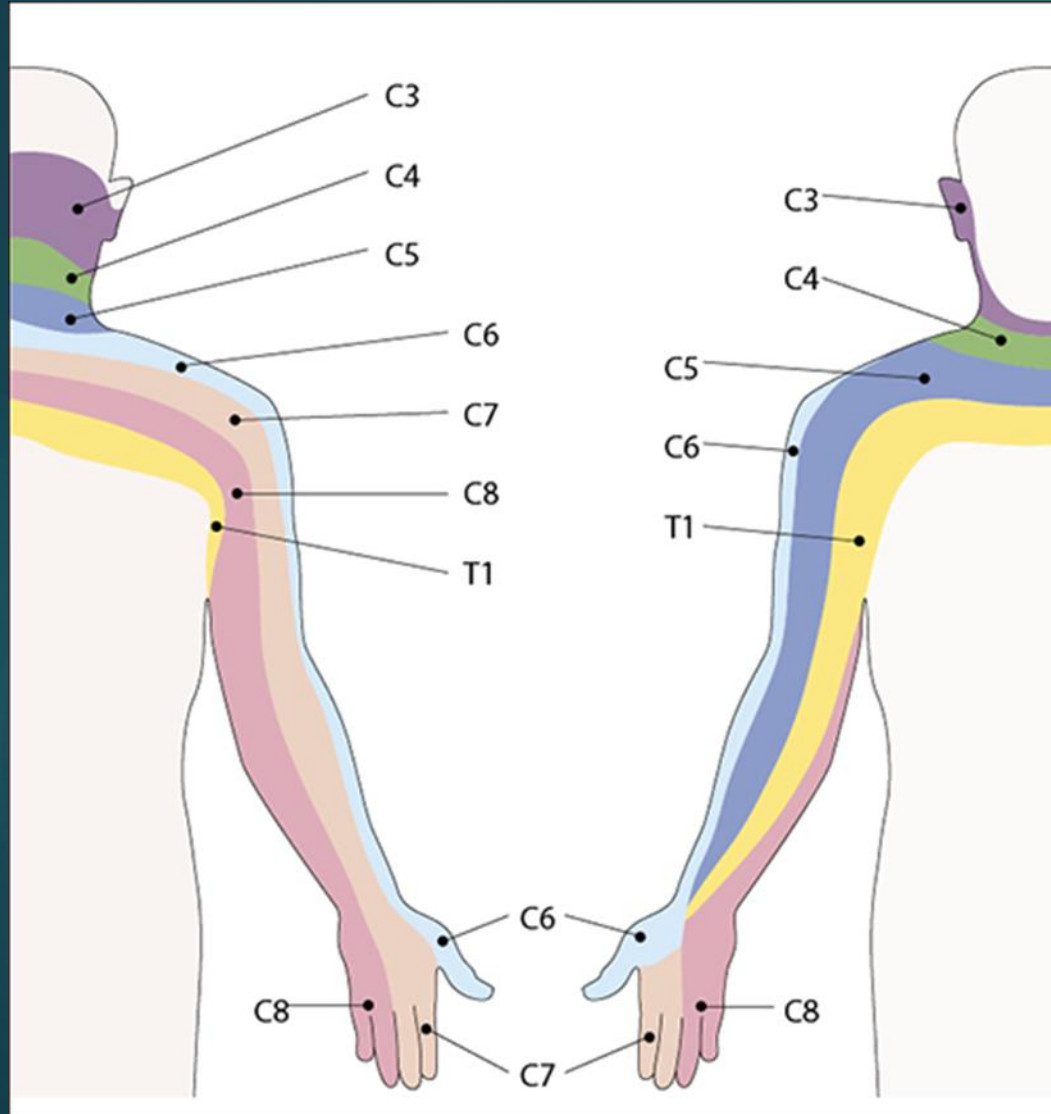
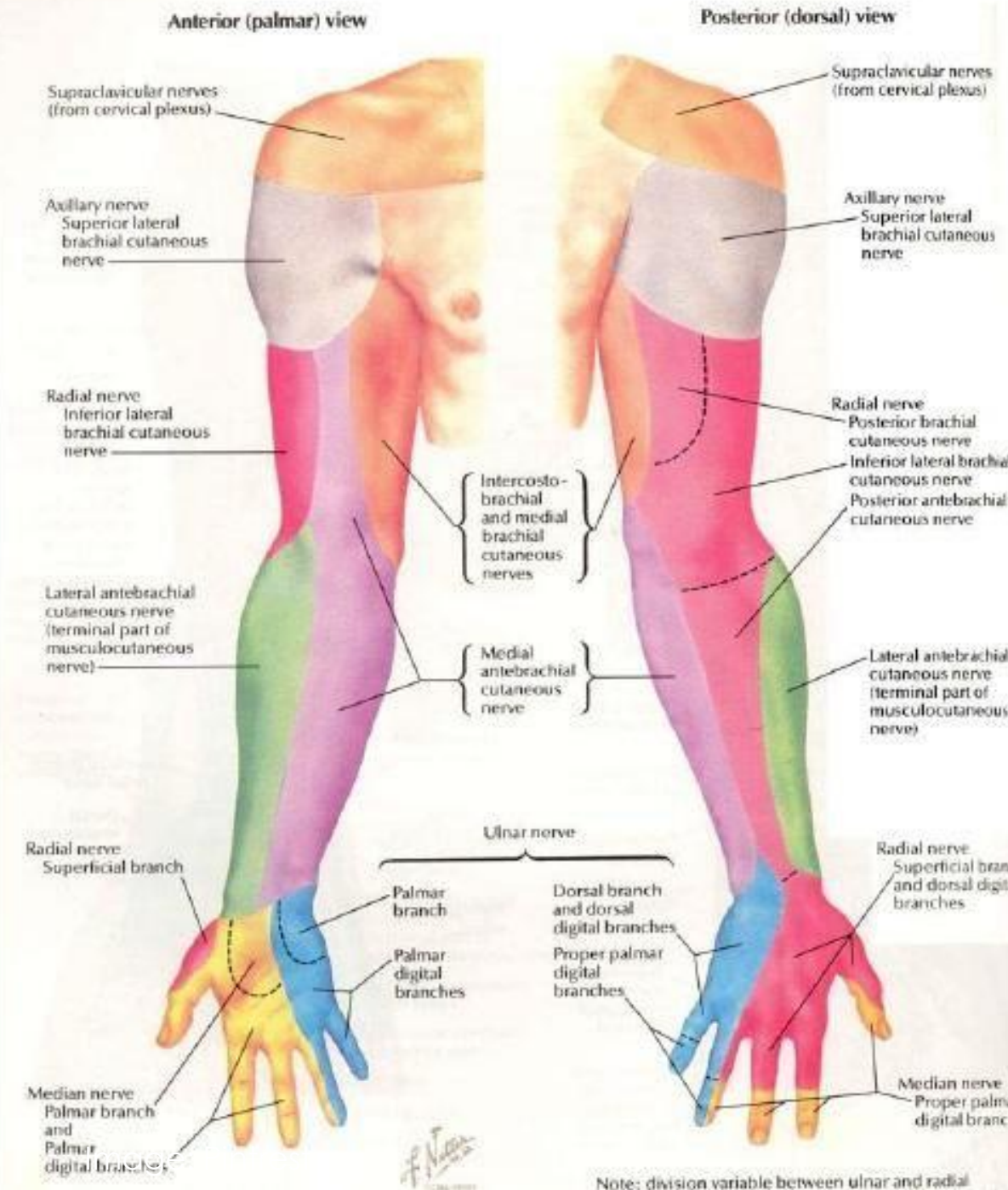


Image: cmej.org



UE Neuro Review: Myotomes & Reflexes

Myotomes

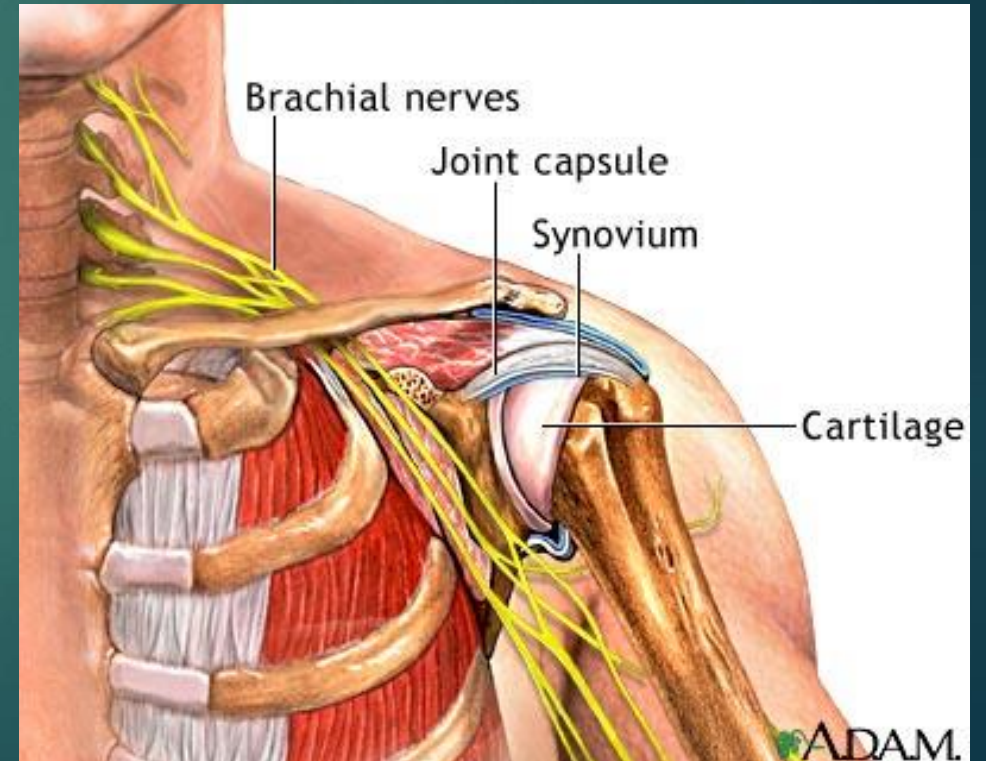
- ▶ **Deltoid and shoulder ER's: C5**
- ▶ Biceps: C5-6
- ▶ **Wrist extensors: C6**
- ▶ **Wrist flexors: C7**
- ▶ Triceps: C7-8
- ▶ **Thumb extensor and finger flexors: C8**
- ▶ Finger extension: C7-8
- ▶ **Finger abduction: T1**

Reflexes

- ▶ **Biceps: C5**
- ▶ **Brachioradialis: C6**
- ▶ **Triceps: C7**

Nerve Injuries

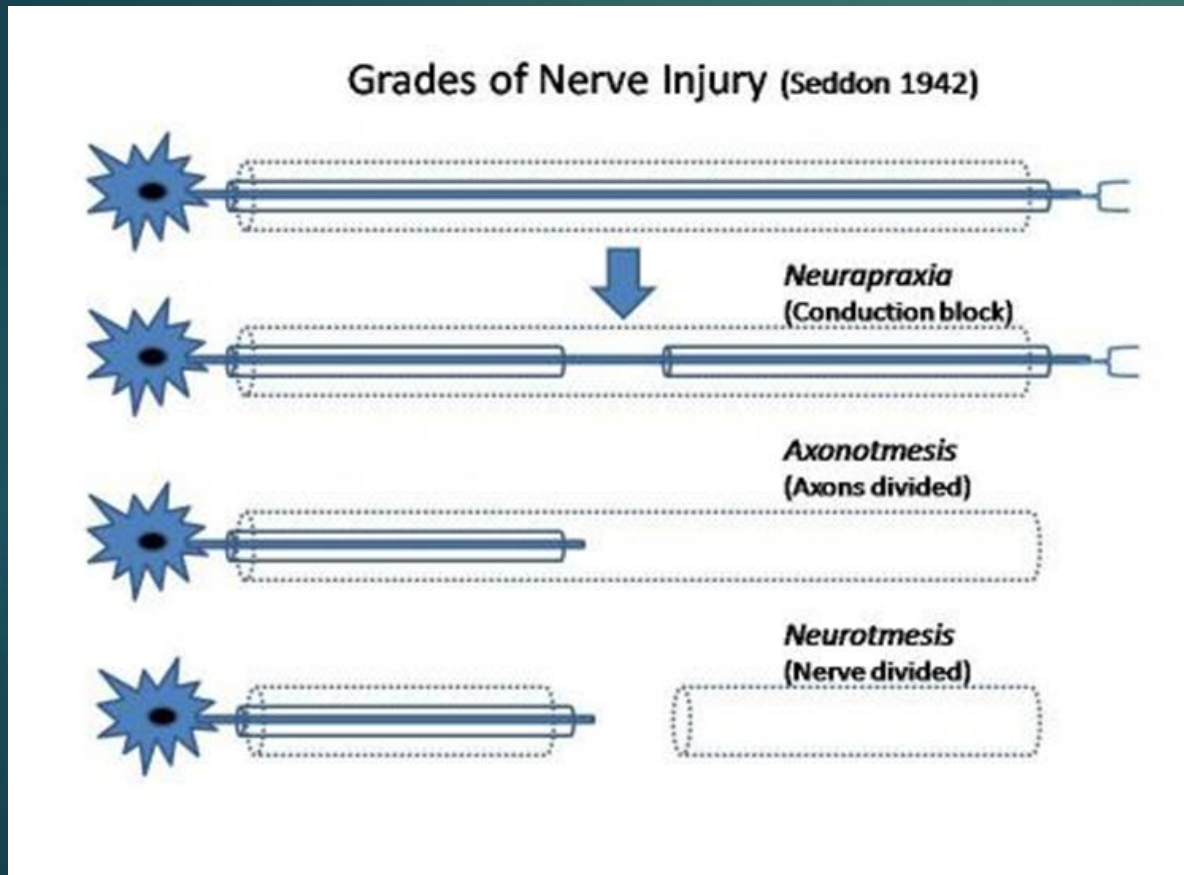
- ▶ Chemical irritation
- ▶ Changes in pressure/space in nerve tunnels
- ▶ Mechanical/friction compression
 - ▶ Constant
 - ▶ Intermittent/positional
- ▶ Excessive or repetitive stretch
- ▶ Severed
 - ▶ Partial or complete
 - ▶ Sharp or blunt



Classification of Nerve Injuries

Seddon's Classification	Sunderland's Classification	Tissue(s) Damaged
Neurapraxia	Grade I	Myelin
Axonotmesis	Grade II	Myelin, axon
Neurotmesis	Grade III: Axon disrupted with loss of endoneurial tubes; perineurium intact	Myelin, axon, endoneurium
	Grade IV: Nerve fascicle damaged, sheath intact	Myelin, axon, endoneurium, perineurium
	Grade V: Substantial perineurial hemorrhage & scarring	Myelin, axon, endoneurium, perineurium, epineurium

Variables that Impact Nerve Healing



- ▶ Severity
- ▶ Location
- ▶ Surrounding tissue health
- ▶ Age of patient
- ▶ Delay in repair/length of compression
- ▶ Blood flow
 - ▶ Diabetes
 - ▶ Smoking

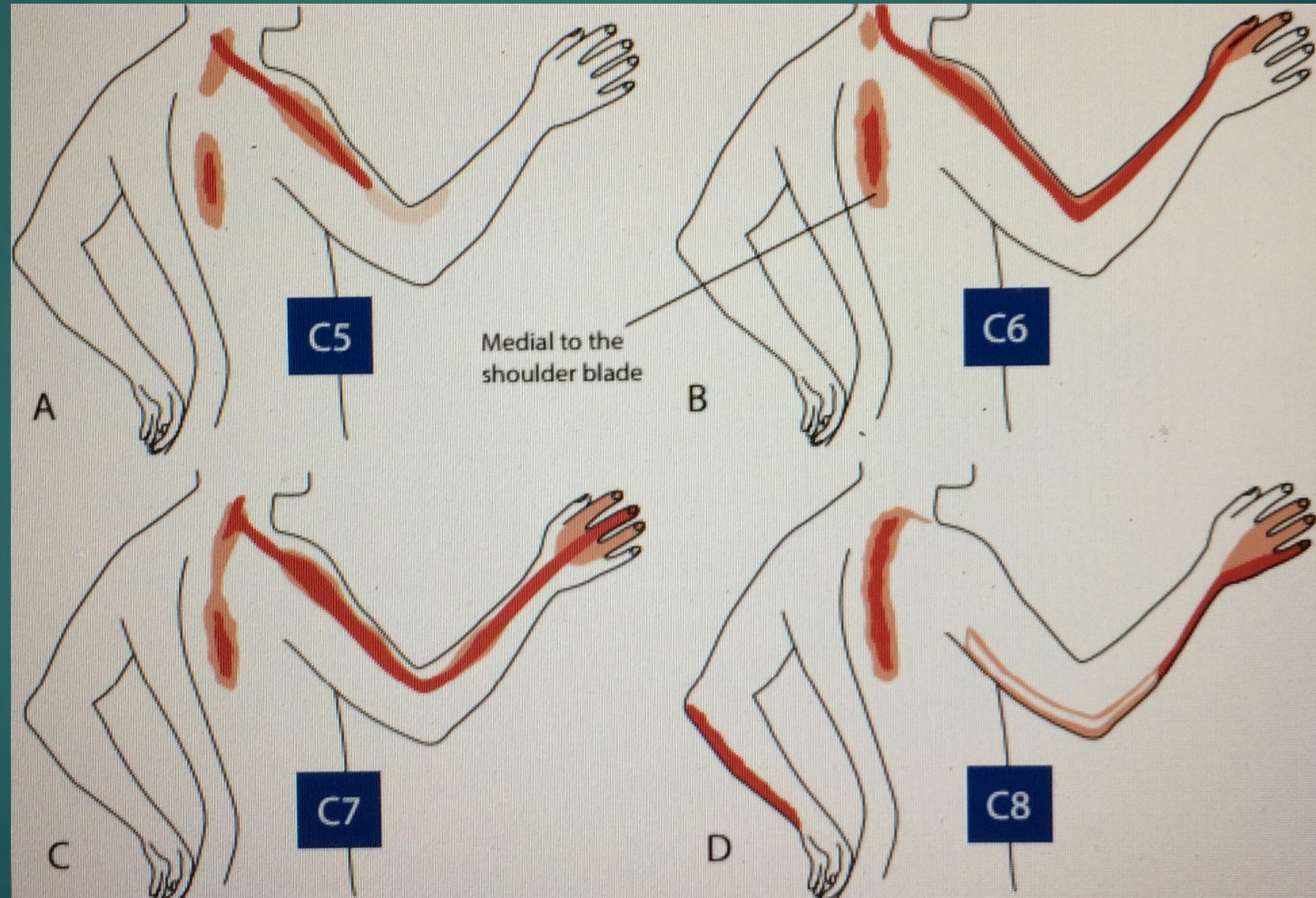
Cervical Radiculopathy Signs/Sxs

(Mogere et al 2013)

- ▶ Pain referred distal from neck
- ▶ Reflex loss
- ▶ Pain in dermatomal pattern typically
- ▶ Shoulder pain: C5, C6, or C7 radiculopathy
- ▶ C5: pain stops at the elbow
- ▶ C6-8: pain extends down to forearm and hand
- ▶ Sensory changes in dermatomal distribution
- ▶ C6: supplies thumb
- ▶ C7: index and middle fingers
- ▶ C8: little finger
- ▶ Muscle wasting is late finding

Cervical Radiculopathy Signs/Sxs

(Mogere et al 2013)



Common Areas of UE Nerve Entrapment

- ▶ Disc or stenosis in cervical spine neural foramina
- ▶ Scalene muscle tightness
- ▶ Space between posterior 1st rib and clavicle
- ▶ Space between anterior GH jt capsule and pec minor
- ▶ Biceps or triceps muscle tightness
- ▶ Lateral scapula border
- ▶ Ulnar tunnel (funny bone)
- ▶ Radial tunnel (3-4 cm distal & ant to lat epicondyle)
- ▶ Carpal tunnel
- ▶ Guyon's canal (ulnar tunnel)

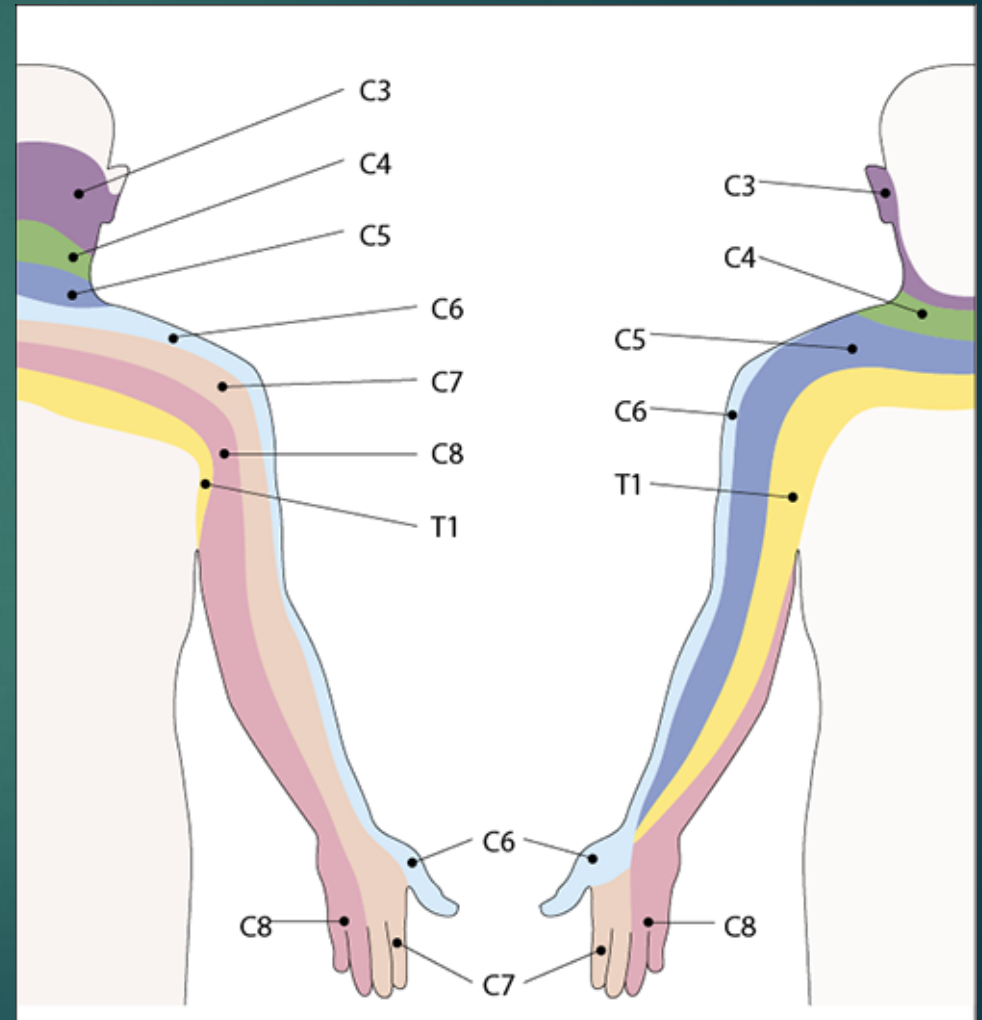
Signs and Sxs of Neuro Involvement

▶ Signs

- ▶ Weakness/neural fatigue
- ▶ Sensory loss
- ▶ Reflex loss
- ▶ Functional loss

▶ Sxs

- ▶ Pain intensity and quality
- ▶ Paresthesia
- ▶ Temperature change
- ▶ Swelling in atypical pattern



Signs & Sxs of Neuro Involvement

- ▶ Sxs at rest more than with movement
- ▶ Traveling and changing Sxs = very likely neuro involvement
- ▶ Pain quality
 - ▶ Toothache
 - ▶ Burning
 - ▶ Gnawing/Ischemic
 - ▶ Tingling
 - ▶ Numbness



Image: healthtap.com

Travell and Simon's Trigger Point Theory

- ▶ Myofascial pain syndrome: hyperirritability in muscle influences CNS functions
- ▶ Hyperirritable spots/Knots
- ▶ Areas of trapped metabolic wastes??
- ▶ Refer pain in typical referral patterns
- ▶ Can twitch upon palpation
- ▶ Palpation reproduces pain/Sxs
- ▶ Pain pattern not explained by neuro patterns
- ▶ Taut areas evident on MR (MR elastography) and in MS-US

Travell and Simon's Trigger Points: Scalene

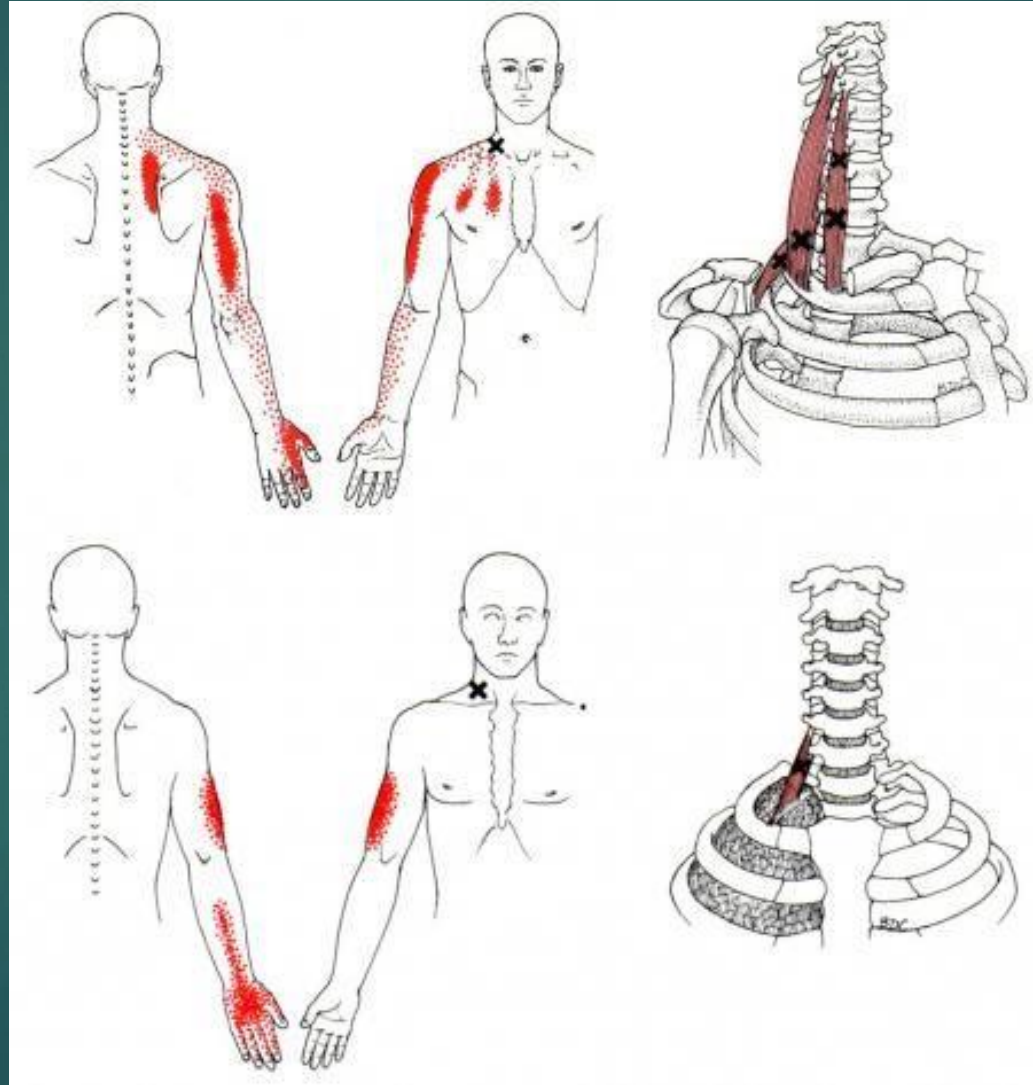


Image: Pinterest.com

Travell and Simon's Trigger Points: Rhomboid

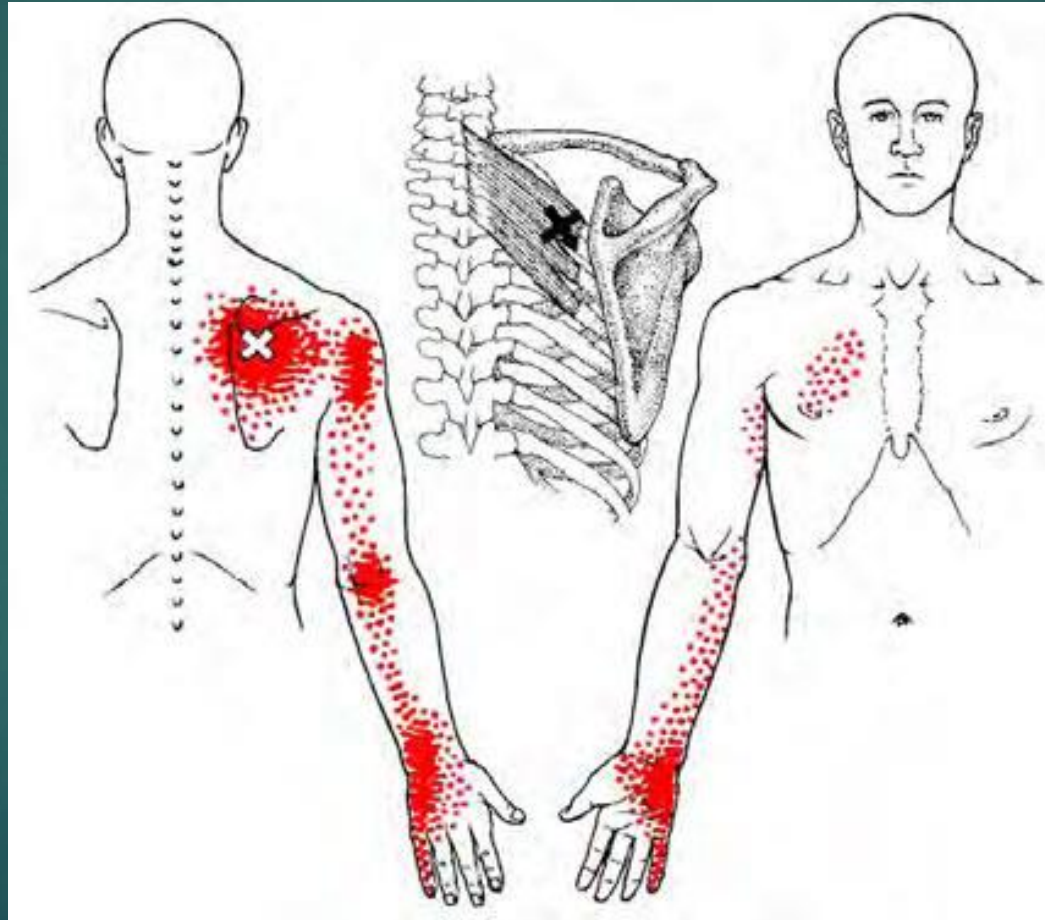
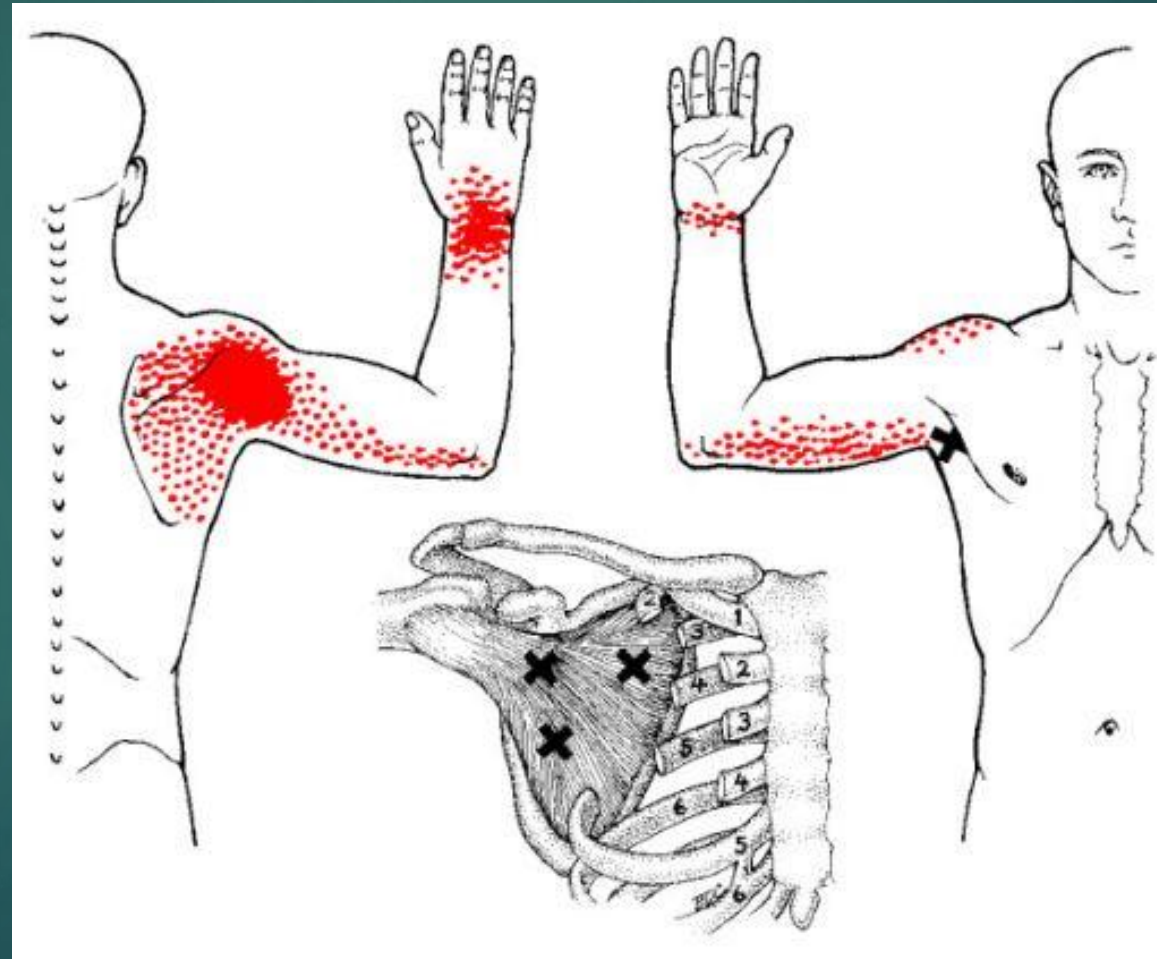


Image: [pinterest.com](https://www.pinterest.com)

Travell and Simon's Trigger Points: Subscapularis



Travell and Simon's Trigger Points: Infraspinatus

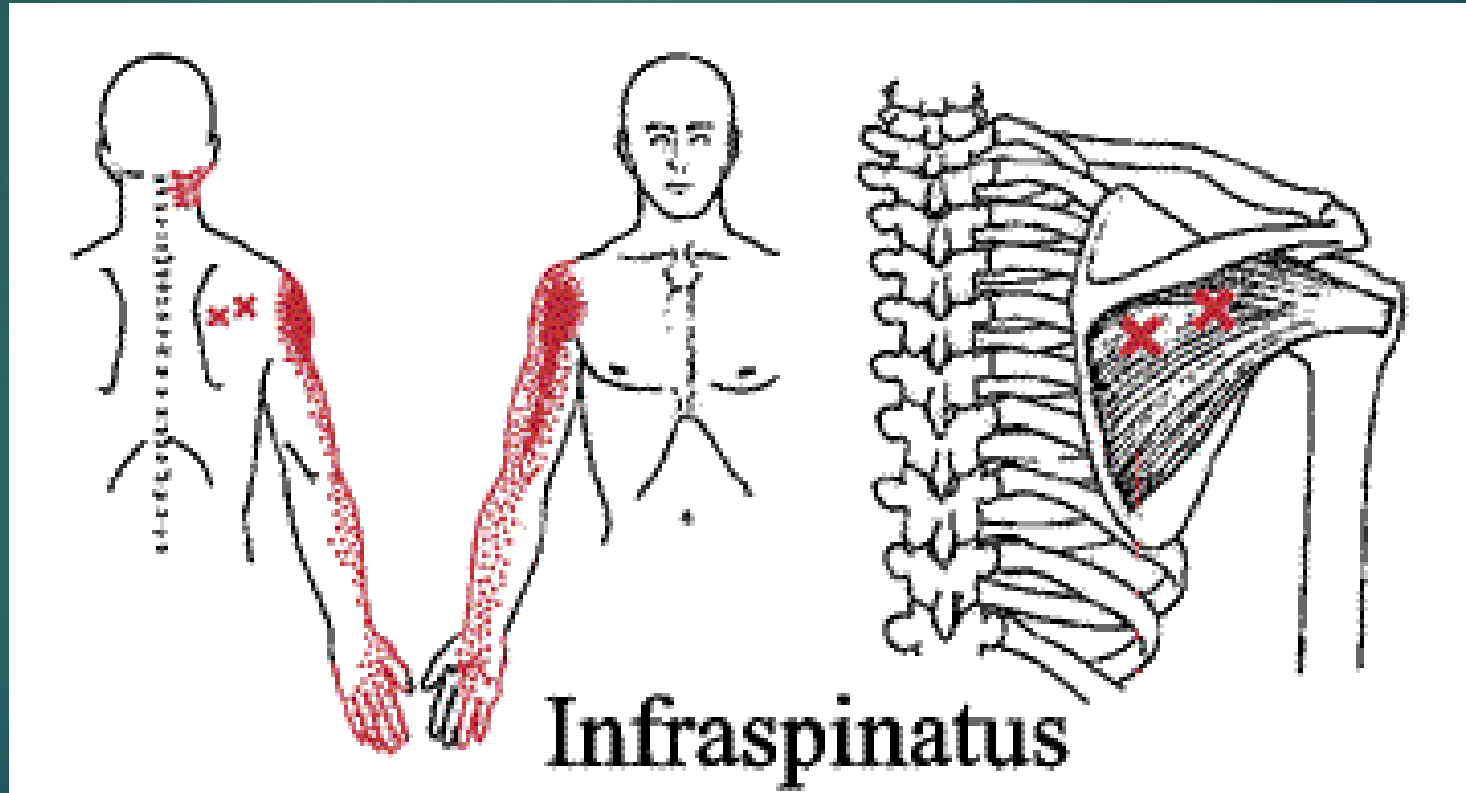


Image: liftbigatbig.wordpress.com

Travell and Simon's Trigger Points: Teres Minor & Levator

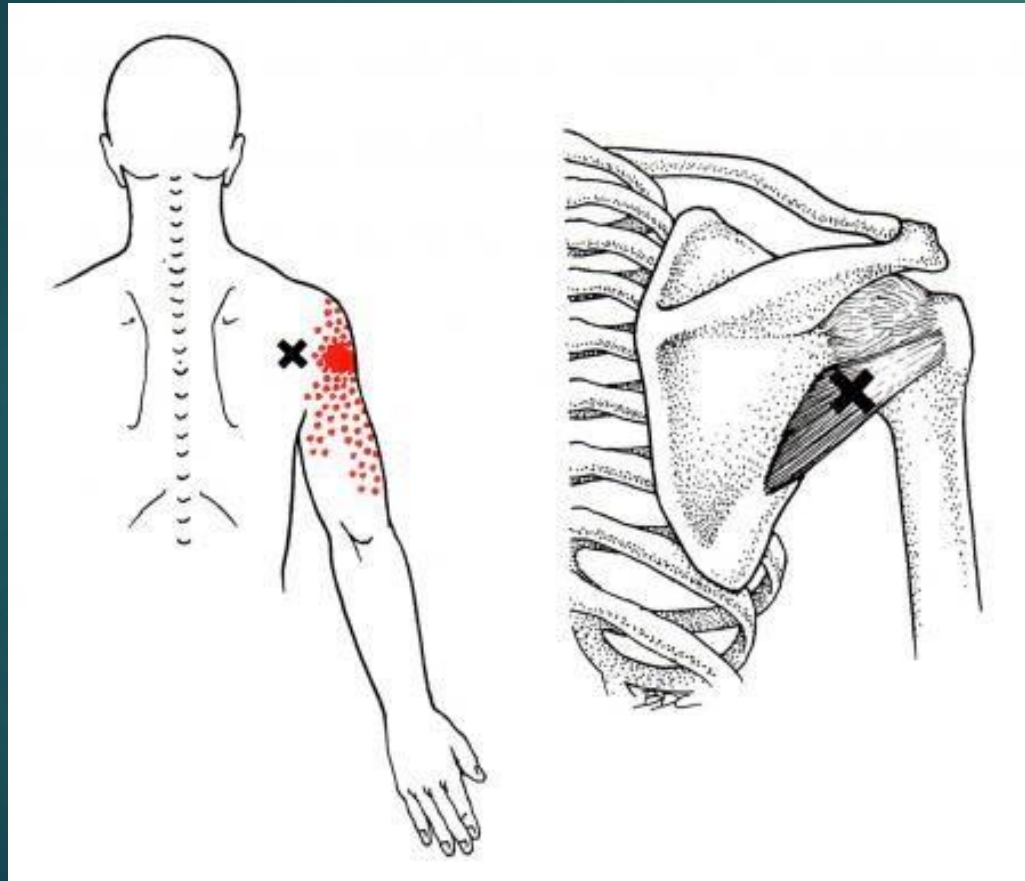


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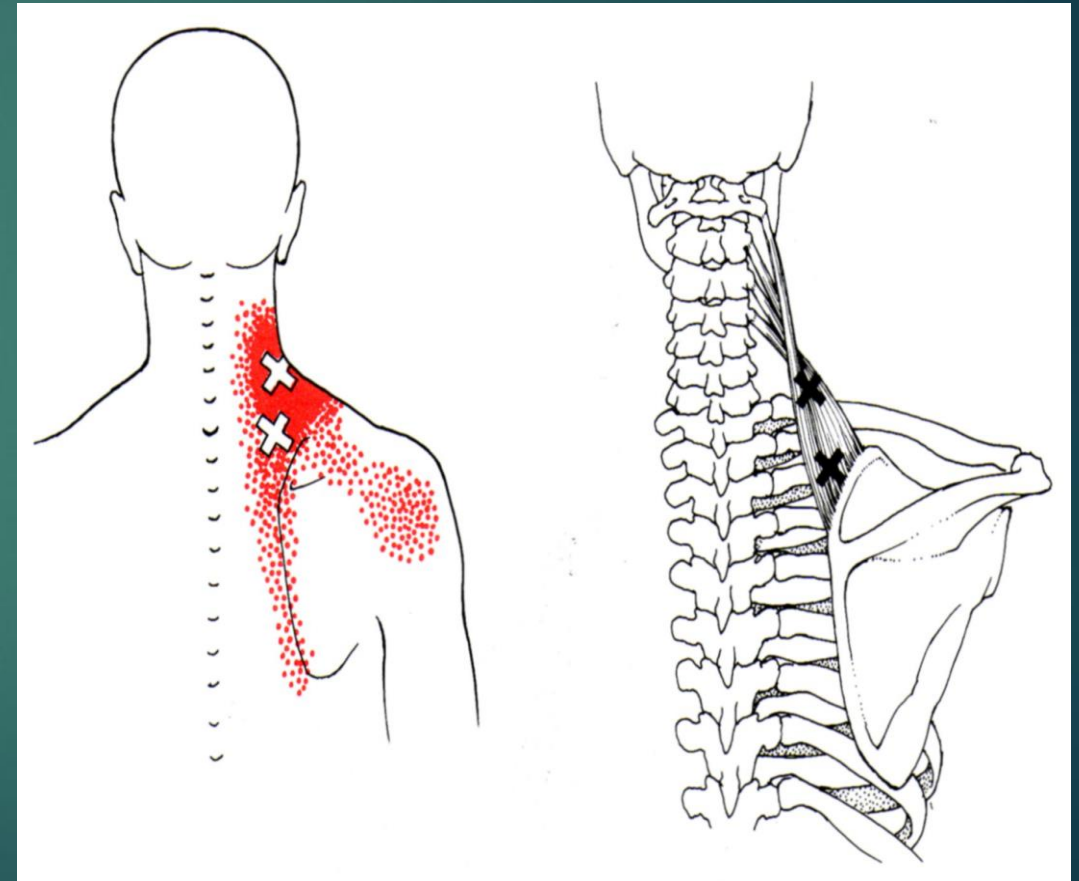


Image: pinterest.com

Travell & Simon's Trigger Points: Deltoid

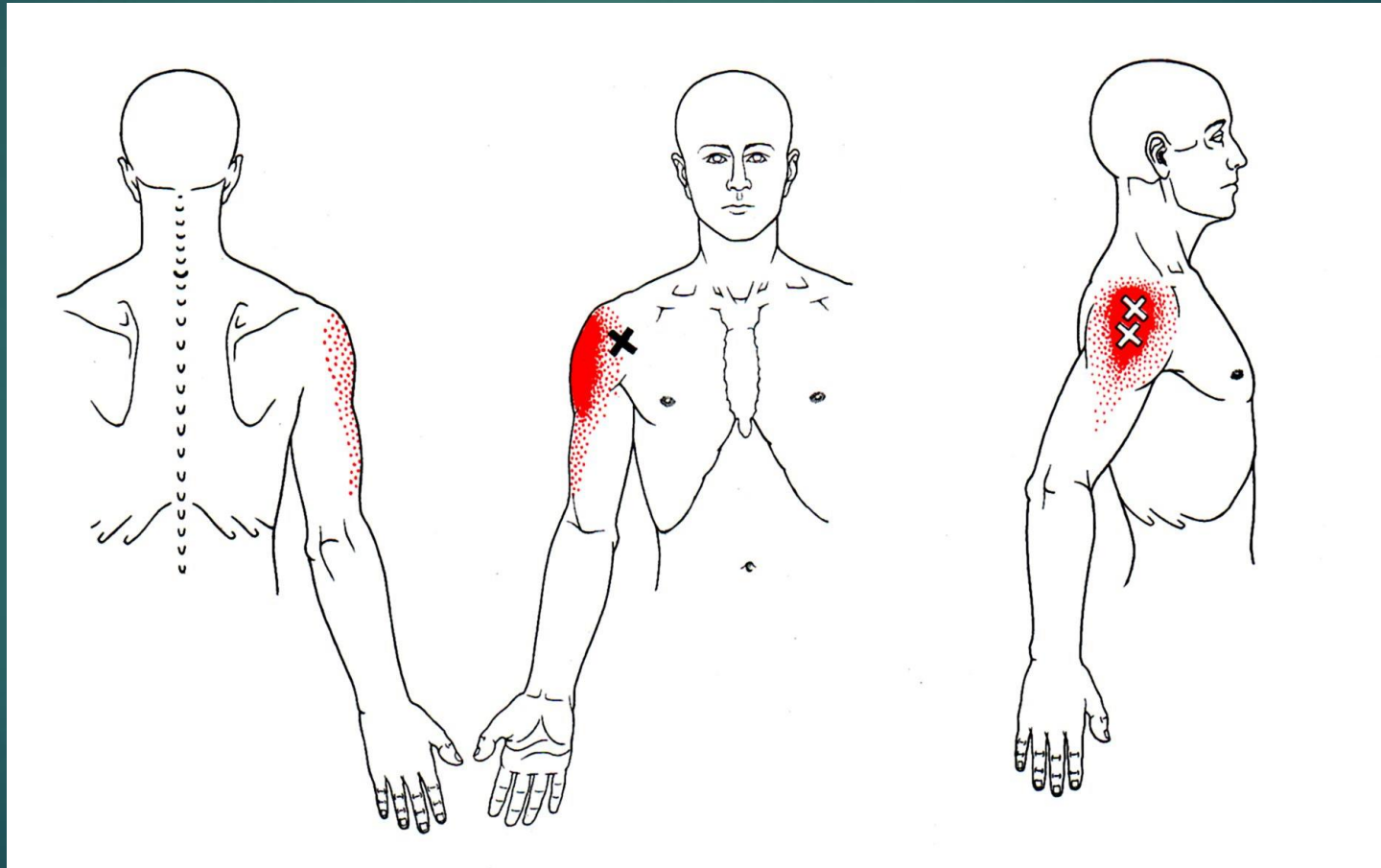
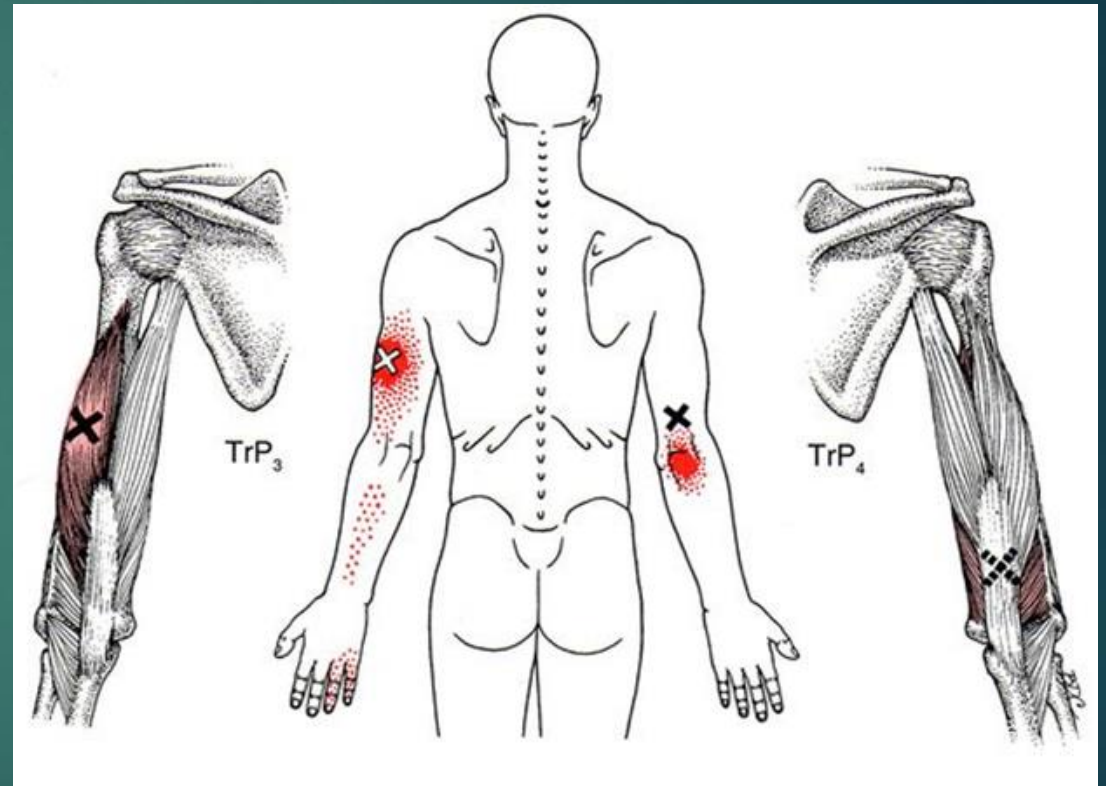
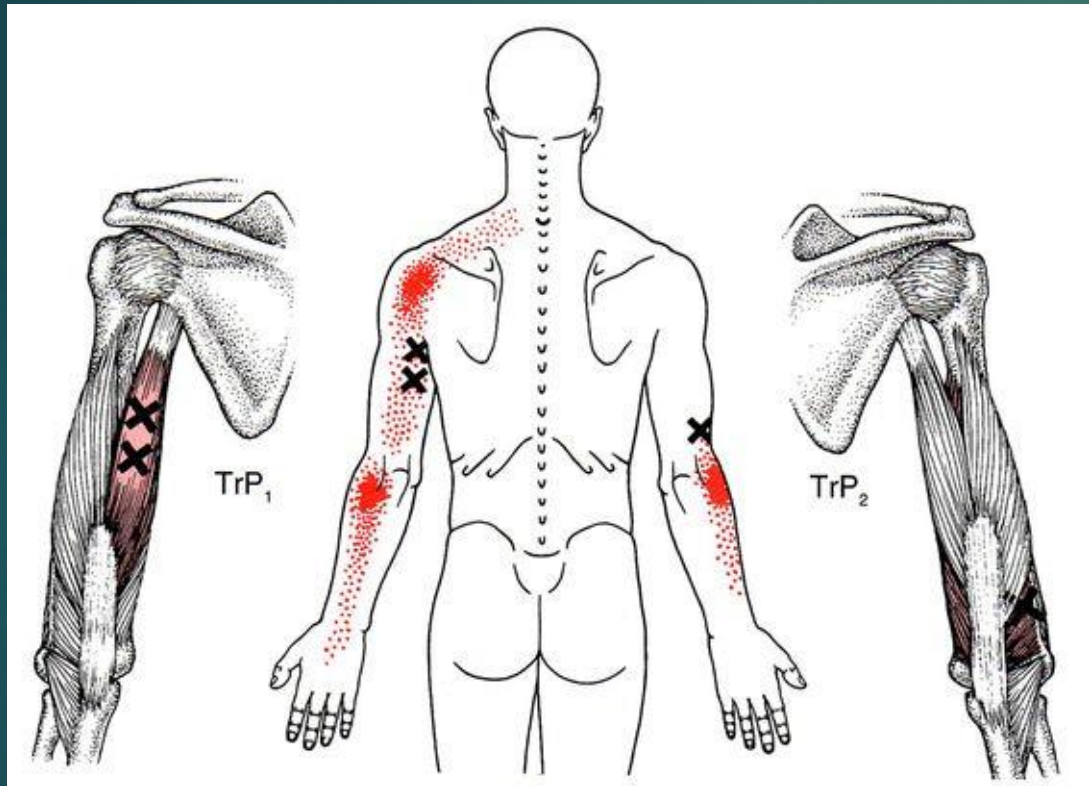


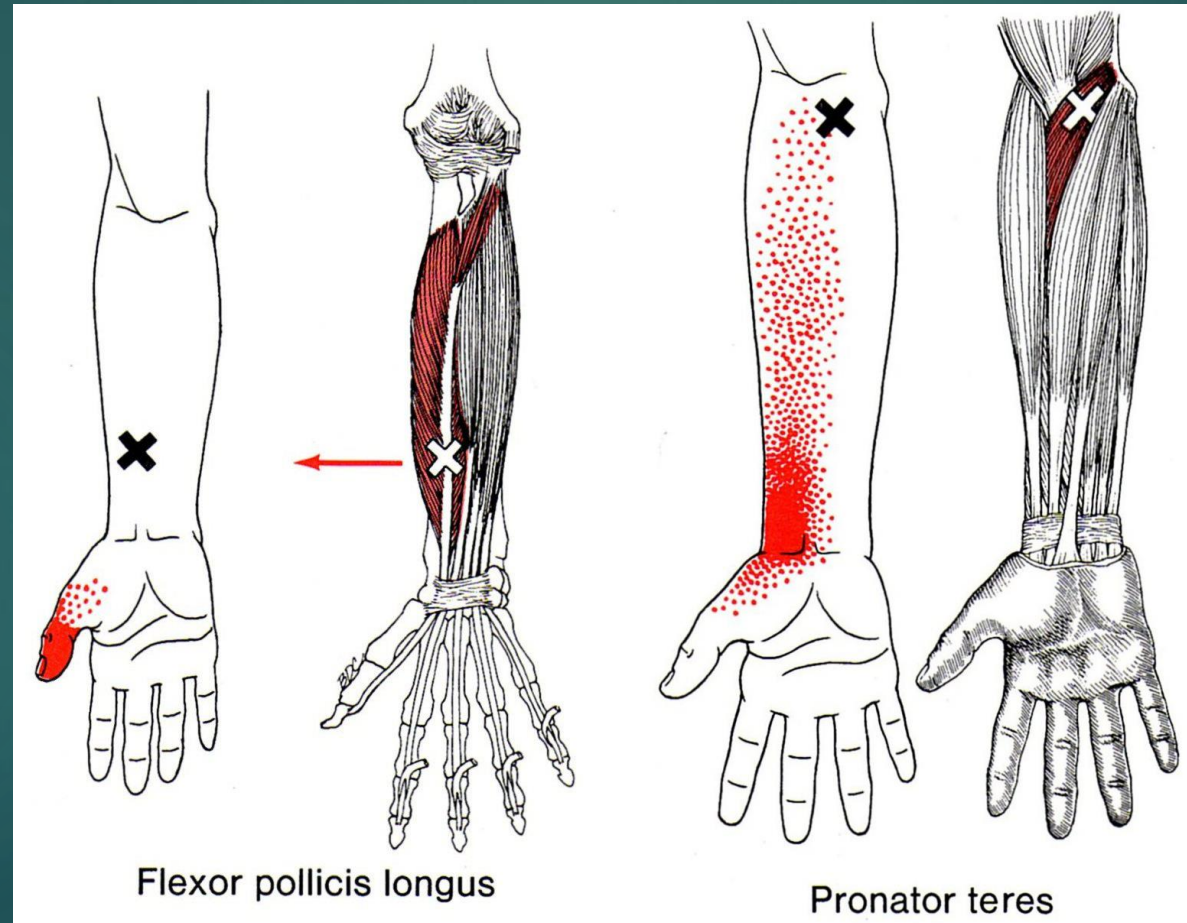
Image: [pinterest.com](https://www.pinterest.com)

Travell and Simon's Trigger Points: Triceps



Images: [pinterest.com](https://www.pinterest.com)

Travell and Simon's Trigger Points: Pronator Teres & Flexor Pollicis Longus



Travell and Simon's Trigger Points: Supinator

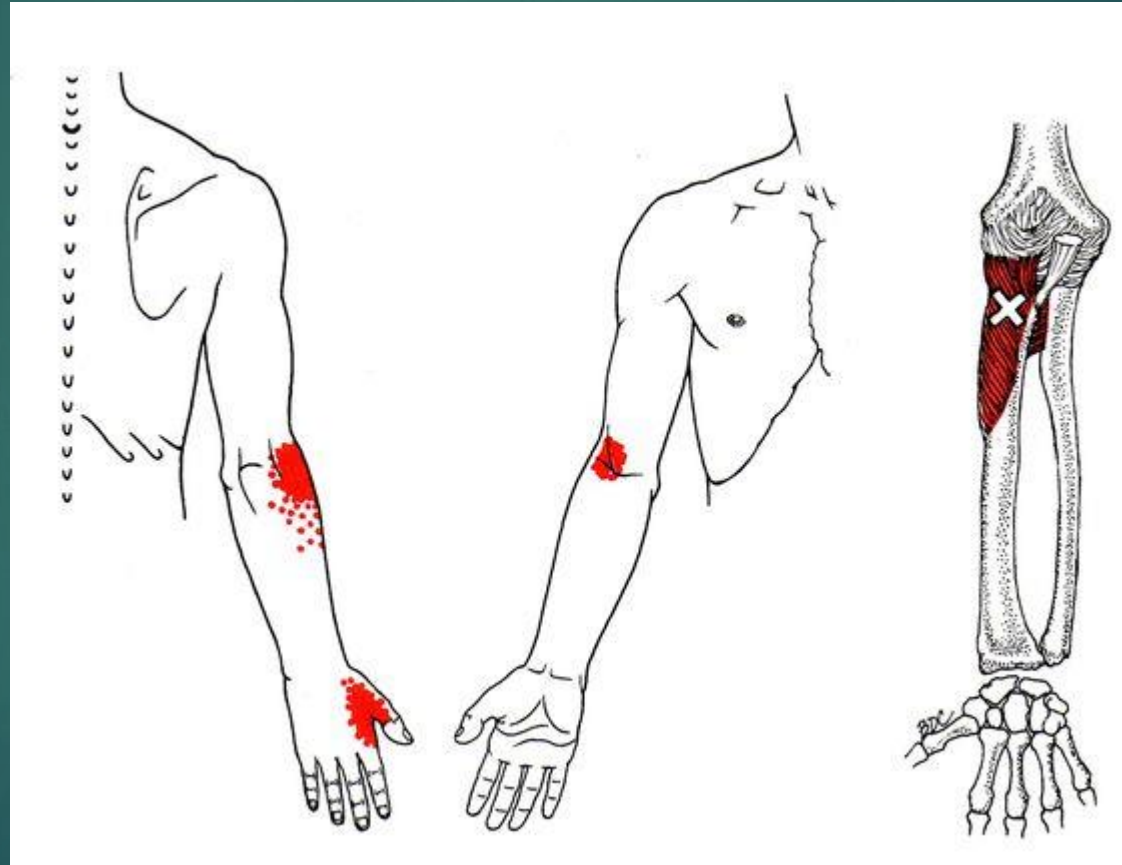
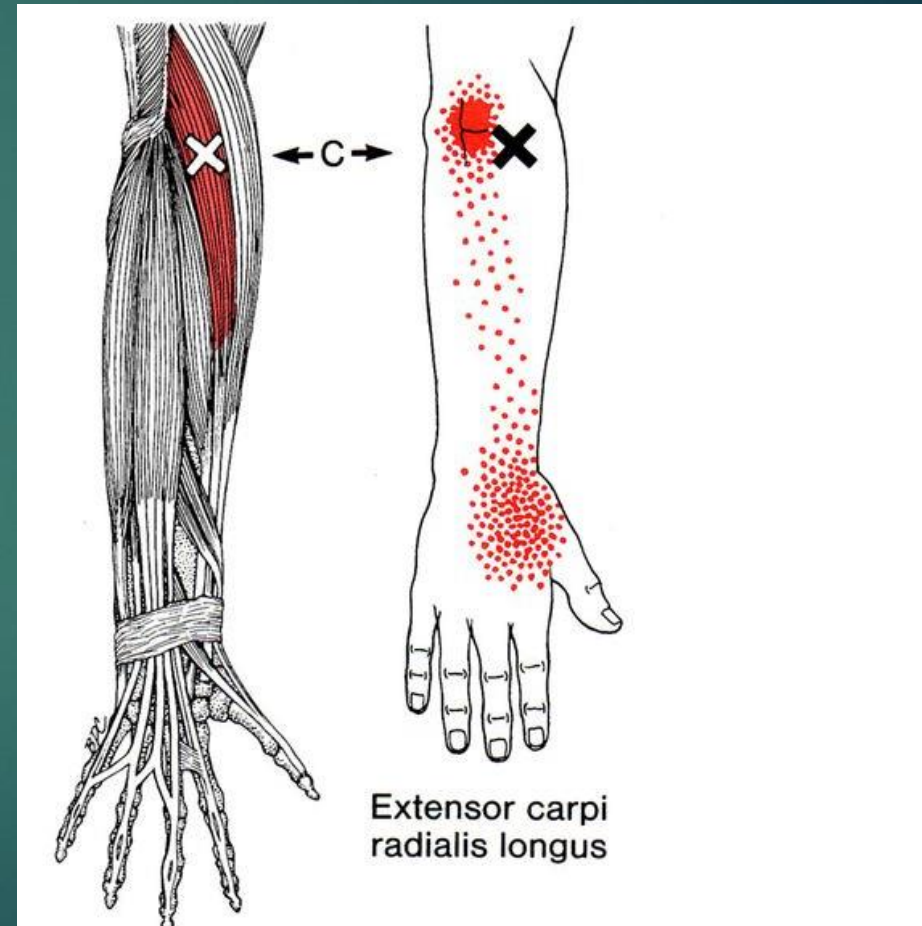
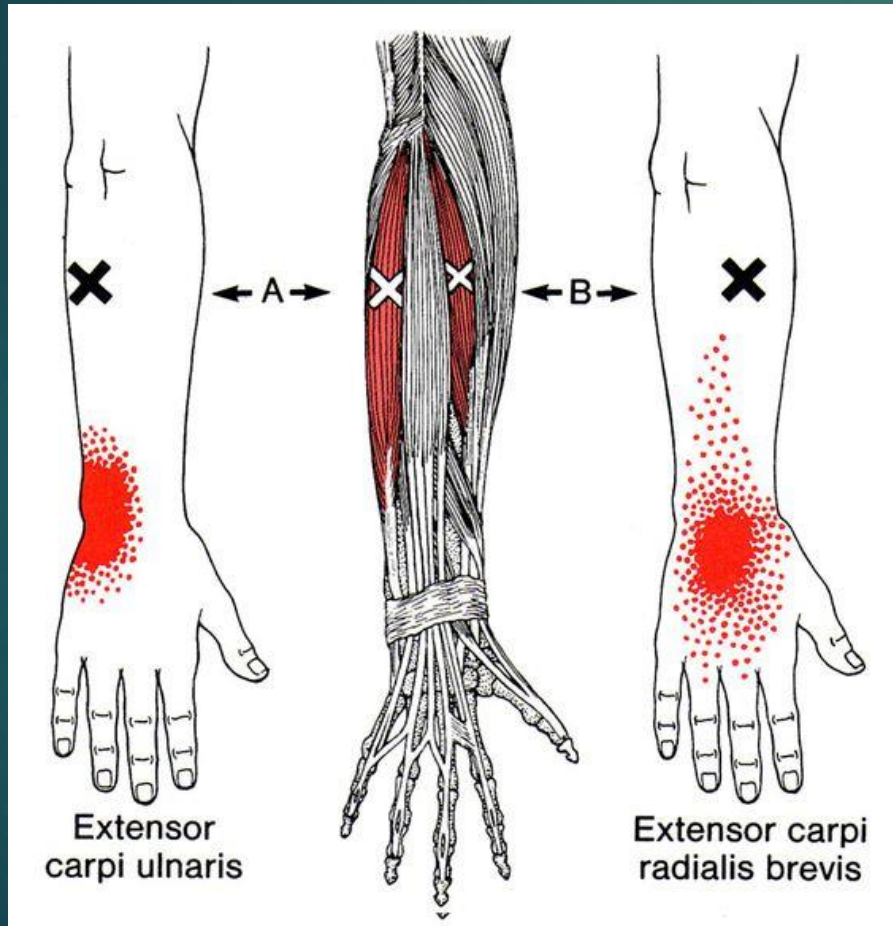


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Travell and Simon's Trigger Points: EC Ulnaris, Radialis Brevis, Radialis Longus



Assessment of Peripheral Nerve Involvement

- ▶ Rule out cervical radiculopathy
 - ▶ Spurling's test
 - ▶ MR imaging results
- ▶ Myotome strength testing
- ▶ Reflex testing
- ▶ Dermatome sensory exam
- ▶ Palpation
- ▶ Joint mobility in areas of entrapment
- ▶ UE Neural tension: ULTT's

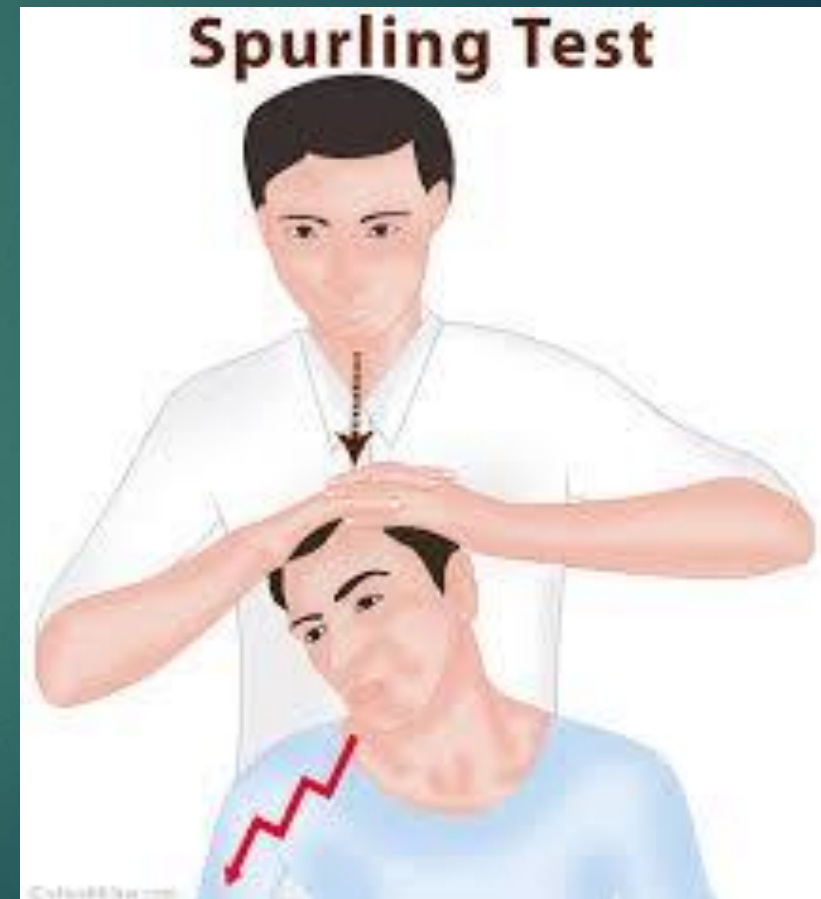


Image: ehealthstar.com

Heirarchical Scratch Collapse Test: Ulnar Nerve

- ▶ Pt is sitting; resisted UE ER at each area of potential ulnar nerve compression
 - ▶ Brachial plexus
 - ▶ Deep motor branch of ulnar nerve
 - ▶ Cubital tunnel
 - ▶ Guyan's canal
 - ▶ Arcade of Struthers
- ▶ To find a secondary area of compression, numb the primary compression area and repeat test
- ▶ For visual: https://www.youtube.com/watch?v=Y_pTgoVW-RA&t=3s

Assessment of Peripheral Nerve Involvement with High Res Ultrasound

- ▶ Peripheral nerve findings (Kerasnoudis & Tsivgoulis 2015)
 - ▶ Cross sectional area variability
 - ▶ Echogenicity
 - ▶ Vascularity
 - ▶ Mobility
- ▶ Entrapment neuropathy US findings (Kerasnoudis & Tsivgoulis 2015)
 - ▶ Increased cross sectional area
 - ▶ Hypervascularity

Upper Limb Tension Tests

(Elvey, Brachial Plexus Tension tests)

- ▶ What are you testing?
 - ▶ UE neural tension
 - ▶ Does NOT disclose WHAT is creating the excessive neural tension
- ▶ Positive test per Physiopedia.com
 - ▶ Symptom reproduction
 - ▶ 10 degrees or more side to side difference in ROM during test
- ▶ ULTT #1: Median Nerve bias at 90 degrees shoulder abduction
- ▶ ULTT #2a: Median Nerve bias at 0 degrees shoulder abd
- ▶ ULTT #2b: Radial Nerve bias
- ▶ ULTT #3: Ulnar Nerve bias

Upper Limb Tension Tests Lab:

ULTT 1: Median Nerve

- ▶ Patient supine; neck side bent to opposite side
- ▶ Scap depression
- ▶ Shoulder abd to 110 deg
- ▶ Elbow extension
- ▶ Forearm supination
- ▶ Wrist extension
- ▶ Finger extension



Upper Limb Tension Tests Lab:

ULTT2a: Median Nerve

- ▶ Patient supine; neck side bent to opposite side
- ▶ Scap depression
- ▶ Shoulder abd to 10 deg
- ▶ Elbow extension
- ▶ Forearm supination
- ▶ Wrist extension
- ▶ Finger extension
- ▶ Shoulder external rotation



Upper Limb Tension Tests Lab:

ULTT2b: Radial Nerve

- ▶ Patient supine; neck side bent to opposite side
- ▶ Scap depression
- ▶ Shoulder abd to 10 deg
- ▶ Elbow extension
- ▶ Forearm pronation
- ▶ Wrist flexion
- ▶ Finger flexion
- ▶ Shoulder internal rotation



Upper Limb Tension Tests Lab:

ULTT3: Ulnar Nerve

- ▶ Patient supine; neck side bent to opposite side
- ▶ Scap depression
- ▶ Shoulder abd to 90 deg, hand to ear
- ▶ Elbow flexion
- ▶ Forearm supination
- ▶ Wrist extension
- ▶ Finger extension
- ▶ Shoulder external rotation



Treatment of Peripheral Nerve Pathology

- ▶ Surgical
 - ▶ Repair
 - ▶ Removal of mechanical compression
- ▶ Pharmacological
 - ▶ Analgesics and Anesthetics
 - ▶ Narcotics
 - ▶ TCA's and SSRI/SNRI's
 - ▶ Anti-epileptics



Image: americanprestigecare.com

Treatment of Peripheral Nerve Pathology

- ▶ Goals of rehab
 - ▶ Removal of compression/maximize space
 - ▶ Restore health of surrounding tissue
 - ▶ Enhance blood flow
 - ▶ Reduce inflammatory substrates
 - ▶ Restore sensation
 - ▶ Improve neural tension/length
 - ▶ Return kinesthetic awareness
 - ▶ Stabilize area



Image:recsports.ufl.edu

Treatment of Peripheral Nerve Pathology



- ▶ Rehab techniques
 - ▶ Edema reduction
 - ▶ Soft tissue mobilization
 - ▶ Joint/rib mobilization
 - ▶ Stretching muscle and fascia
 - ▶ Mobilization/lengthening/flossing of neural tissue
 - ▶ Proprioceptive and kinesthetic awareness training
 - ▶ De-sensitization/re-sensitization
 - ▶ Strengthening/stabilization/neuromuscular re-ed
 - ▶ Posture re-ed/ergonomic analysis

Treatment of Peripheral Nerve Pathology

- ▶ Adjunctive treatment options
 - ▶ B vitamins
 - ▶ Pain treatments: TENS, acupuncture
 - ▶ Advanced pain treatments
 - ▶ Injections
 - ▶ Implanted stimulators
 - ▶ Implanted pain pumps
 - ▶ Radiofrequency ablation



Image: iconexperience.com

Shoulder Pain: Differential Diagnosis



Image: hongkongsportsclinic.com

- ▶ Impingement
- ▶ Rotator cuff tendonitis/tenosynovitis
- ▶ Rotator cuff tendon partial tear/tear
- ▶ Rotator cuff strain
- ▶ Labral tears
- ▶ Sub-acromial bursitis
- ▶ Multi-directional instability
- ▶ Biceps strain, tear, tendonitis
- ▶ Myofascial pain syndrome

Shoulder Pain: Neuro/Myofascial Signs/Symptoms

- ▶ Large, nebulous area of pain
- ▶ Myofascial involvement
- ▶ Pain extends down the arm
- ▶ Any paresthesia
- ▶ Weakness in a neural fatigue pattern
- ▶ AROM is better than PROM
- ▶ Pain is 10/10
- ▶ Pain quality: burning, gnawing, hot, poker-like, tingling
- ▶ Sensory loss
- ▶ Large range of pain throughout the day not associated with movement
- ▶ More pain at rest than with movement
- ▶ Placing arm above the head relieves pain

Shoulder Pain: TOS/ First Rib Dysfunction/Brachial Plexus

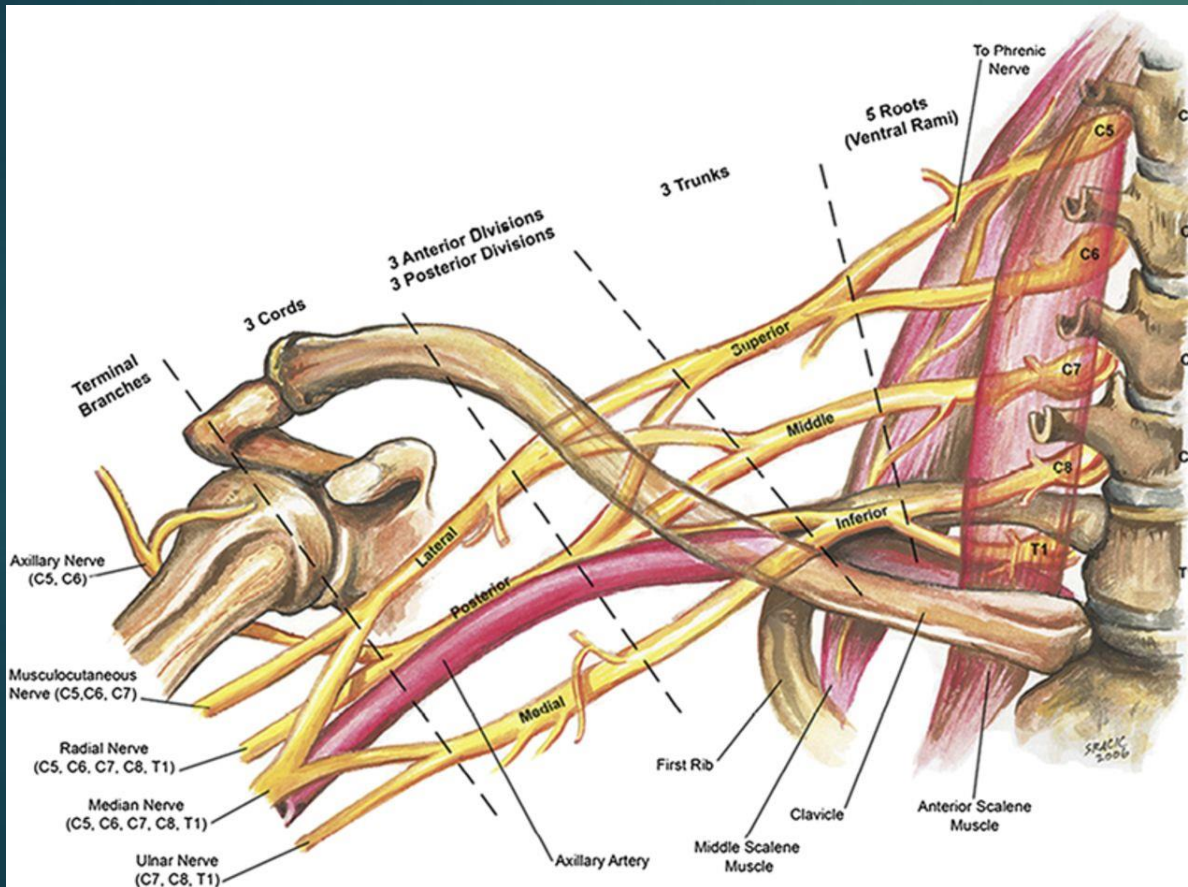


Image: Jbjs.org

- ▶ Elevated posterior 1st rib
- ▶ Myofascial restrictions
 - ▶ Scalene, upper trap, levator
 - ▶ Pec minor
- ▶ Thoracic spine hypomobility
- ▶ Postural issues
- ▶ Scapular stabilizer weakness
- ▶ Glenohumeral impingement
- ▶ SC, AC joint restrictions
- ▶ RTC weakness

TOS/First Rib Dysfunction Assessment: Possible Causes

- ▶ Poor posture habits
- ▶ Over-utilization of upper trap for overhead movements
- ▶ Compensation of upper trap for rotator cuff weakness
- ▶ Over-use of scalene for neck movements
- ▶ Weak scapular stabilizers
- ▶ Decreased activation of scap stabilizers due to T-spine hypomobility



Image: lifewire.com

TOS/First Rib Dysfunction Treatment

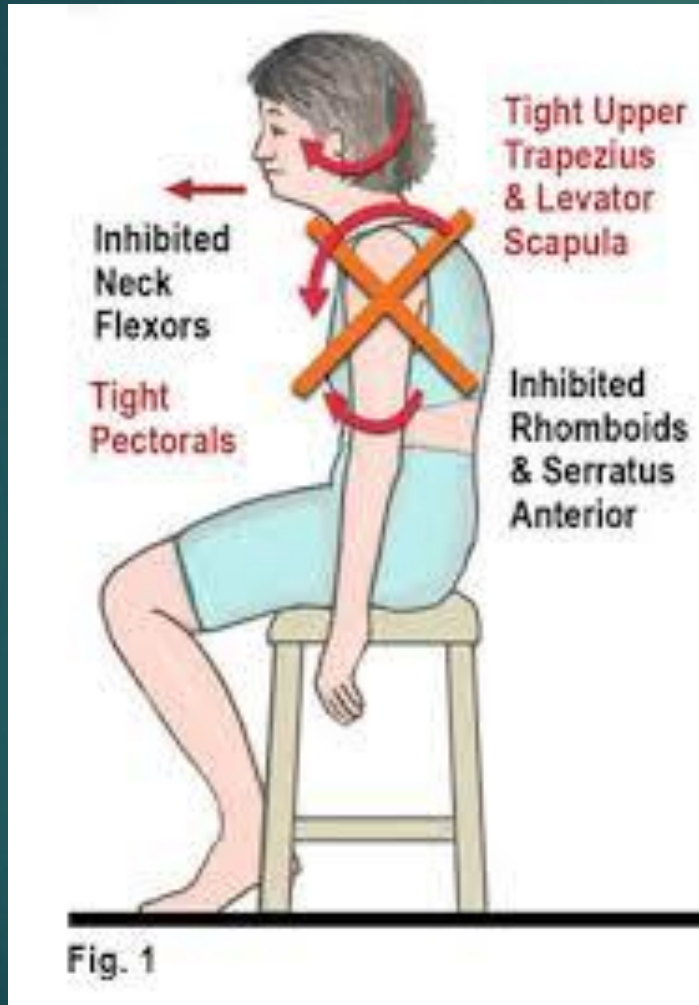


Image: daltonart.com

- ▶ Treat myofascial restrictions
 - ▶ Upper trap, levator, scalene
 - ▶ Pec minor
- ▶ Mobilize T-spine and rib hypomobility (Deschenes & Zafereo)
- ▶ Address postural issues
- ▶ Stretch muscles
- ▶ Mobilize nerves
- ▶ Activate/strengthen scapular stabilizers, RTC
- ▶ Mobilize other jts PRN

Posterior 1st Rib Mobility Assessment

- ▶ Posterior 1st rib spring test



Elevated Posterior 1st Rib Treatment

- ▶ Muscle energy/mobilization technique



T-spine Mobility Assessment

- ▶ Palpation of movement
- ▶ Spring testing



Hypomobile Upper T-spine Treatment

- ▶ Progressive mobilization with exhalation



Elbow Pain/Med & Lat Epicondylitis

- ▶ Are you finding the neural component?
- ▶ Berglund et al (2008) found 70% of subjects with lateral elbow pain also had pain in the C-T spine (compared to 16% of control group)
- ▶ Subjects with lateral elbow pain
 - ▶ Had a higher frequency of pain response to provocation tests of the C-T spine
 - ▶ Had increased pain response to radial nerve ULTT
 - ▶ Had reduced cervical flexion and extension AROM
- ▶ Assess C-T spine when patients have lateral (and medial) elbow pain!

Elbow Pain/Med & Lat Epicondylitis

- ▶ Lateral epicondylitis treatment approach (Drechsler et al, 1997)
 - ▶ Standard treatment
 - ▶ US common extensor tendon
 - ▶ Transverse friction massage to tendon
 - ▶ Stretching and strengthening of wrist extensors
 - ▶ Neural tension treatment group: Median nerve gliding HEP & mobilization of radial head PRN
 - ▶ Results
 - ▶ No long term improvement from standard treatment
 - ▶ Neural tension group improved over time

Neural Mobilization

- ▶ Names for neural mobilization
 - ▶ Tensioner
 - ▶ Flossing
 - ▶ Lengthener
 - ▶ Stretching
 - ▶ Gliding
 - ▶ Restoring neural dynamics
 - ▶ Neural manipulation
- ▶ Neural dynamics
 - ▶ “Integrated biomechanics, physiological, and morphological functions of the nervous system” (Ellis & Hing, 2008)



Neural Mobilization

- ▶ Nerves must (Ellis & Hing 2008):
 - ▶ Elongate
 - ▶ Slide
 - ▶ Change in cross-sectional area
 - ▶ Angulate
 - ▶ Compress
- ▶ Causes of altered neurodynamics (Ellis & Hing 2008):
 - ▶ Edema
 - ▶ Ischemia
 - ▶ Fibrosis
 - ▶ Hypoxia

Neural Mobilization

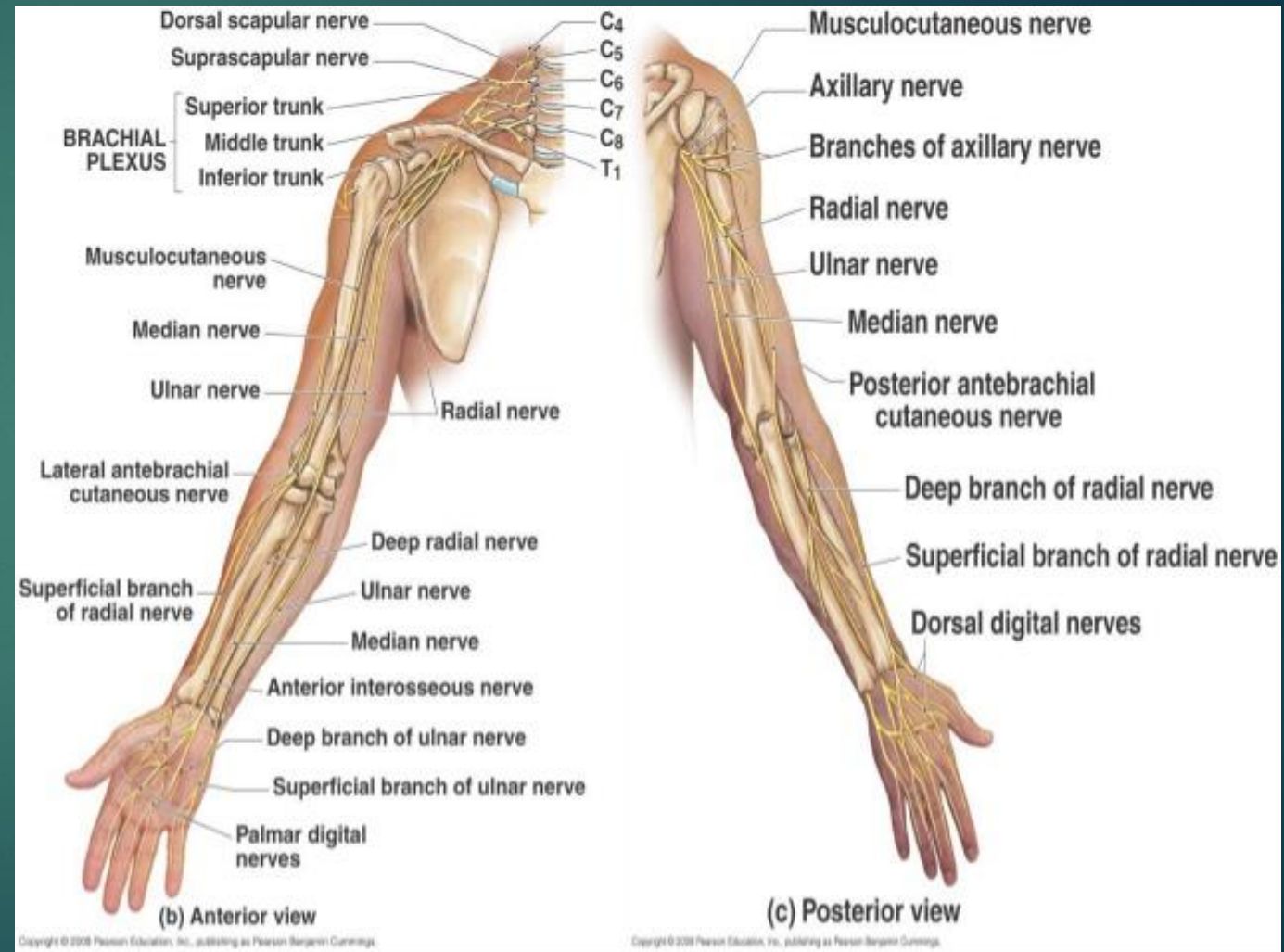
- ▶ Neural mobilization (Ellis & Hing 2008):
 - ▶ Improves nerve gliding
 - ▶ Reduces nerve adherence
 - ▶ Boosts neural vascularity
 - ▶ Enhances axoplasmic flow
- ▶ Causes of altered neurodynamics (Ellis & Hing 2008):
 - ▶ Edema
 - ▶ Ischemia
 - ▶ Fibrosis
 - ▶ Hypoxia

Neural Mobilization

- ▶ Ellis & Hing (2008) review of neural mobilization
 - ▶ Neural mobilization positively impacts altered neural dynamics (8 of 11)
 - ▶ Limited evidence supports the use of...
 - ▶ Active nerve and flexor tendon gliding exercises of the forearm
 - ▶ Cervical contralateral glides
 - ▶ Median nerve mobilization in ULTT position 2
 - ▶ Inconclusive evidence for remaining techniques as of 2008

Neural Mobilization Exercises

- ▶ Types of nerve mobilization
 - ▶ Tensioner
 - ▶ Flossing
 - ▶ Lengthener
- ▶ Median Nerve flossing
 - ▶ At 0 degrees abduction
 - ▶ At 90 degrees abduction
- ▶ Radial Nerve flossing
- ▶ Ulnar Nerve flossing
- ▶ 10x, 2x/day

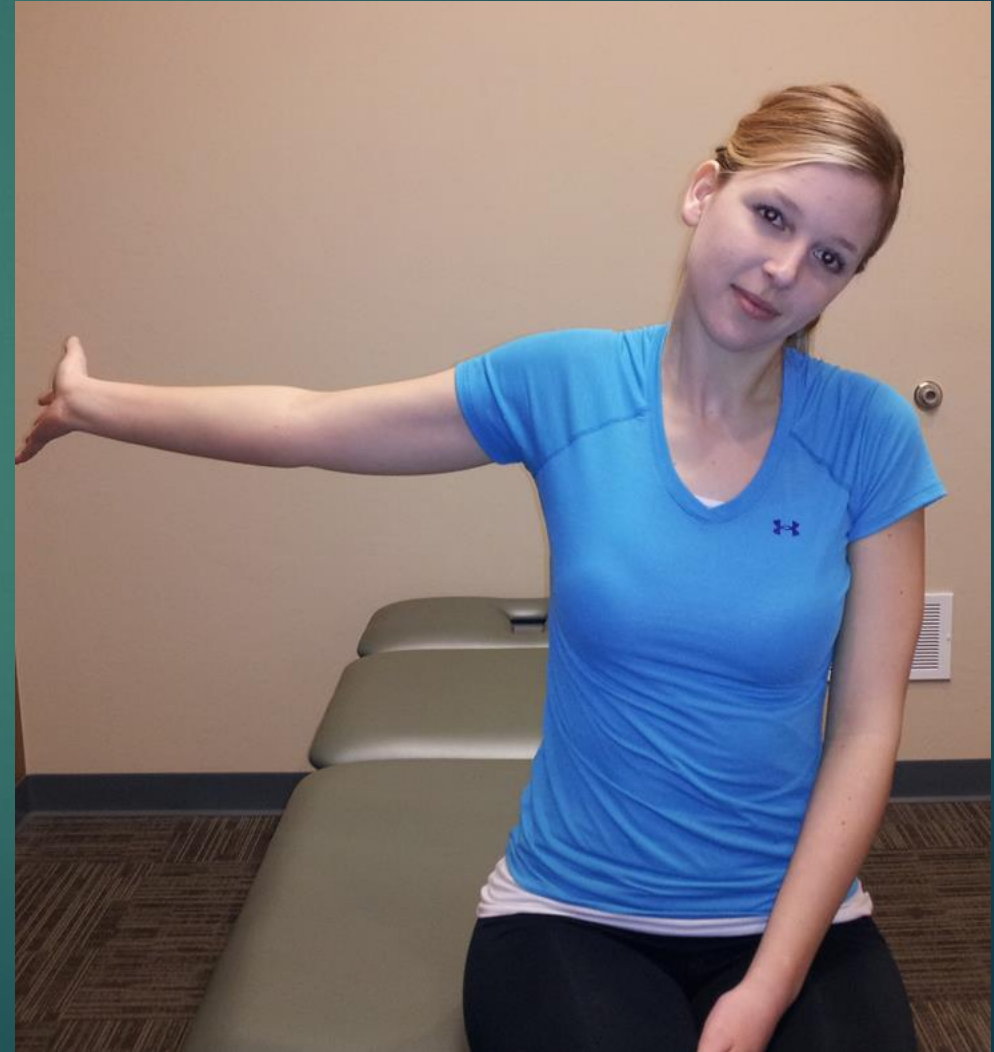


Median Nerve Flossing

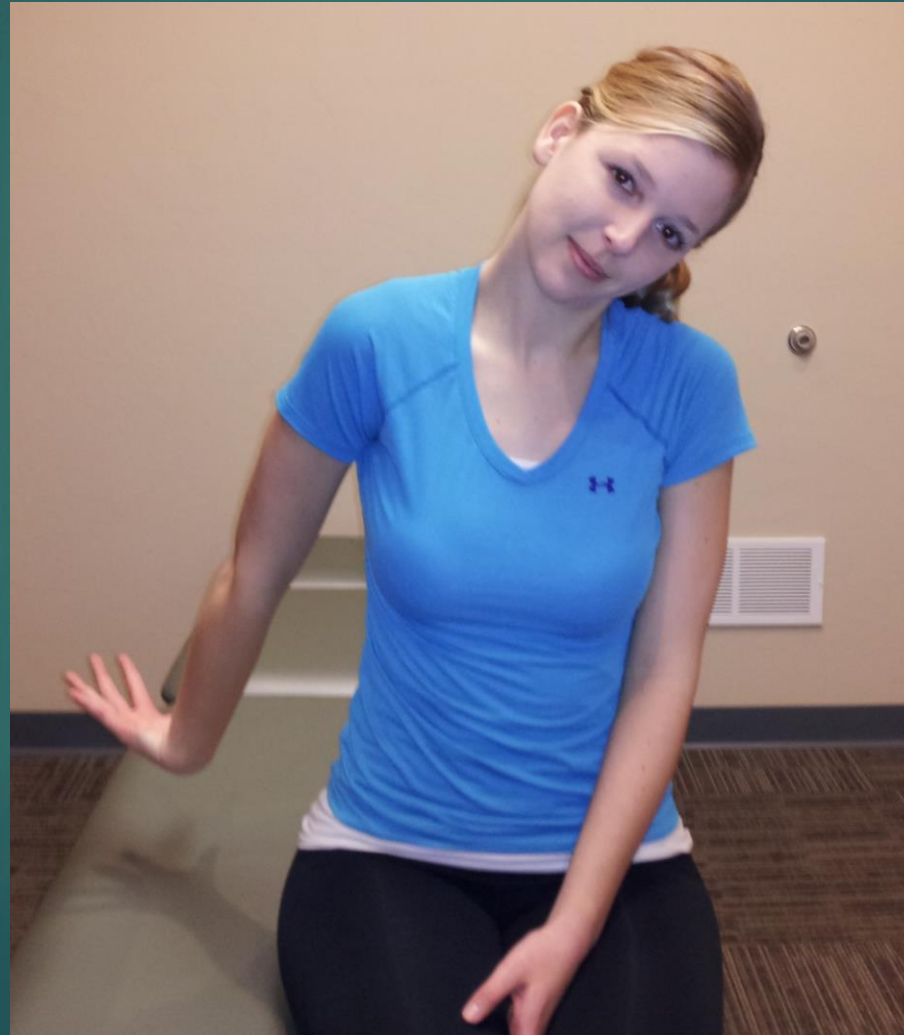
▶ At 10 degrees abduction



▶ At 90 degrees abduction



Radial Nerve Flossing



Ulnar Nerve Flossing



Carpal Tunnel Syndrome

- ▶ Median nerve entrapment in the carpal tunnel
- ▶ Diagnostic EMG results vary
- ▶ Numbness/tingling when sleeping are hallmark
- ▶ Treatment ideas- Cochrane review of 16 studies (Page et al, 2012)
 - ▶ No significant difference b/t treatment with carpal bone mobilization vs median nerve mobilization, but both treatments are better than none
 - ▶ Nerve gliding exercises with splint and activity modification are more effective than splint and activity modification alone

Carpal Tunnel Syndrome

- ▶ Seror (2005) reported 100 upper limbs with mild to moderate CTS with + clinical & electrodiagnostic tests for CTS
 - ▶ 68 paresthesia in the whole hand
 - ▶ 58 pain in forearm
 - ▶ 29 pain in shoulder
 - ▶ 52 upper trap tenderness
 - ▶ 45 pain at Erb point
 - ▶ 14 Roo's test –could not continue test
 - ▶ 58 Roo's test with paresthesia
- ▶ Conclusion?

Median Nerve Flossing

▶ At 10 degrees abduction



▶ At 90 degrees abduction



UE Case Study #1

46 y old female dental hygienist with UE pain

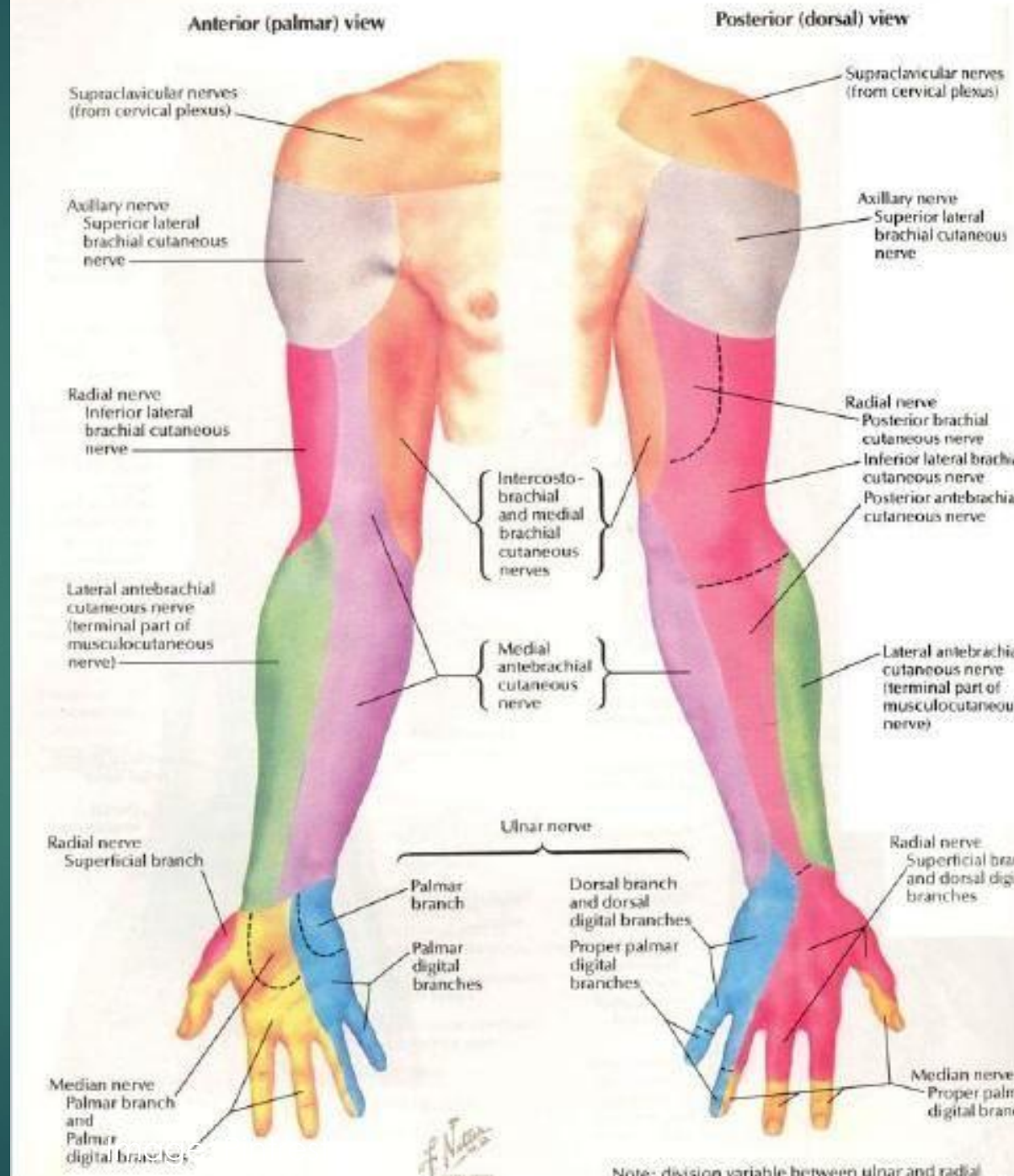
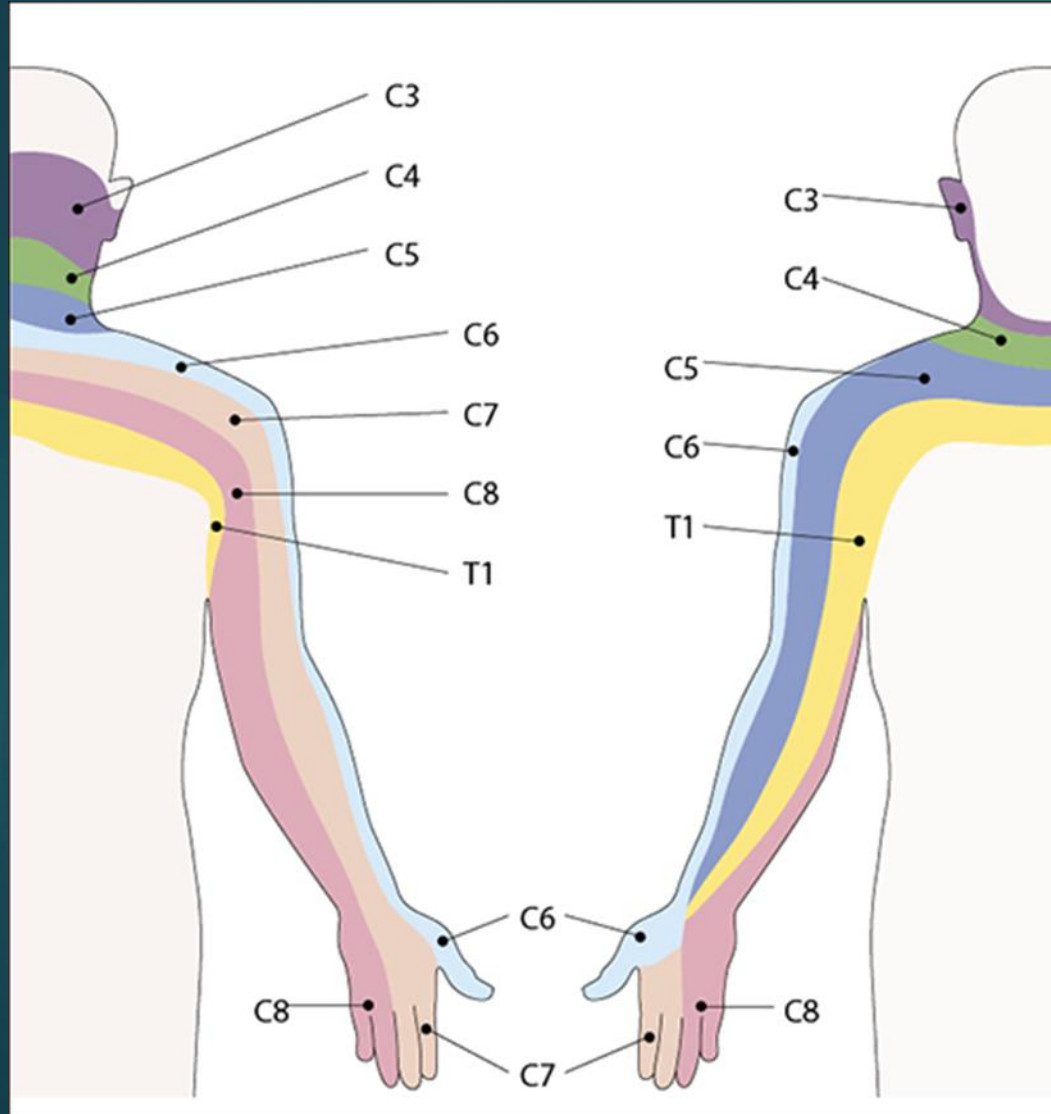


Image: medicalcareers101.com

▶ Subjective

- ▶ Dental hygienist returning to PT 1 wk s/p discharge with pain in the L (opposite) shoulder, upper arm, and distal R UE fine motor issues with the hand and fingers, nearly dropping instruments, with numbness/tingling in palm, 2nd and 3rd digits
- ▶ No traumatic event, recent family stress with in-laws in hospital

Dermatomes



UE Case Study #1

▶ Objective

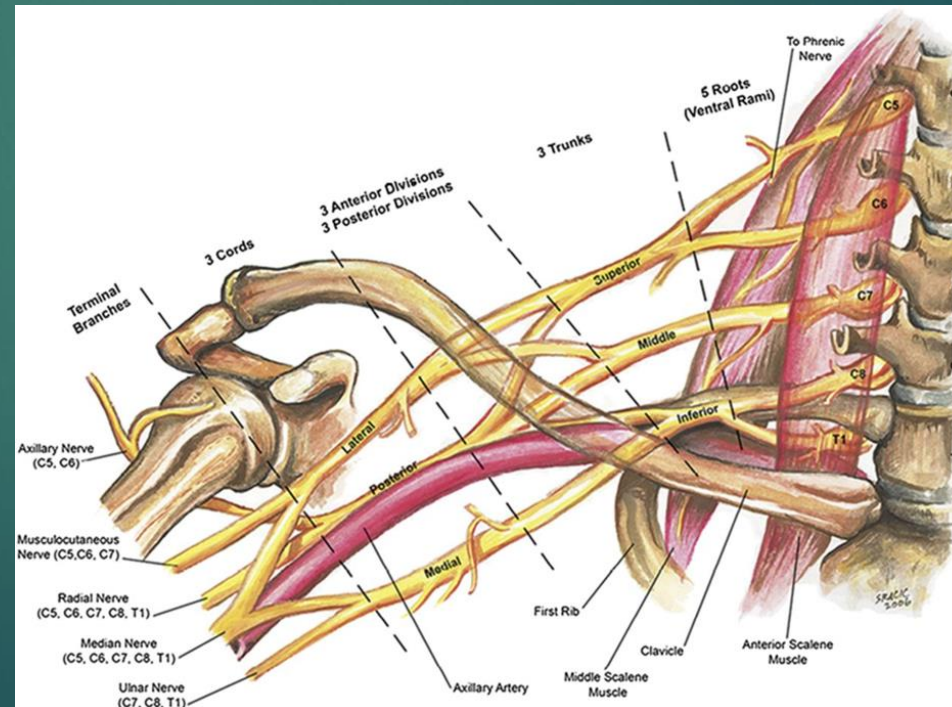
- ▶ Cervical AROM: limited ext and B Side bending
- ▶ B shoulder, elbow, wrist, and finger AROM WFL
- ▶ Mild reduction in R distal UE strength: lat and power grip, thumb ext, wrist flex
- ▶ Palpation: 3+ myofascial restrictions B upper traps, levators, full length L scalene, cervical pillars, sub-occipital muscles
- ▶ Decreased OA/cranial posterior glide
- ▶ Elevated left posterior 1st rib with decreased mobility into depression; L rotated T1-2, T2-3 with reduced extension and L side bending
- ▶ + L median>radial nerve ULTT's 1, 2a, 2b
- ▶ Negative Spurling's test

UE Case Study #1

▶ Assessment

- ▶ 3+ tight/tender L scalene along with FRS L @ T1-2 with elevated L>R post 1st rib decreasing foraminal opening for R brachial plexus

▶ Treatment plan?



UE Case Study #1 Treatment

- ▶ D2 Flexion Diagonal/Pulling out your sword functional mobility exercise
- ▶ Do 15x to each side; 2x/day



UE Case Study #1 Treatment

- ▶ Arm Circle in sidelying
- ▶ Do 10x to each side; 2x/day



UE Case Study #2

15 y old Level 10 Gymnast with Wrist Pain



- ▶ Subjective
 - ▶ Wrist pain with writing in school and computer work
 - ▶ Pain with gymnastics activities with end range wrist extension
 - ▶ Also c/o neck pain and headaches

UE Case Study #2

- ▶ Objective
 - ▶ 20 degree loss of end range wrist extension
 - ▶ 4+/5 wrist extensor strength with pain
 - ▶ 25% decreased cervical spine AROM with segmental C-T spine hypomobility and severely limited OA joint mobility in posterior glide
 - ▶ Decreased posterior 1st rib and carpal bone mobility
 - ▶ 3+ myofascial restrictions R>L cervical muscles including pec minor
 - ▶ + ULTT tests for median nerve in 0 and 90 degrees of abduction

UE Case Study #2

▶ Assessment

- ▶ OA hypomobility with mod to severe FHP along with 3+ cervicocranial myofascial restrictions and R>L upper quadrant and decreased C-T spine and posterior 1st rib mobility and increased median neural tension causing biomechanical motion loss in wrist extension

▶ Treatment

- ▶ STM/MFR for myofascial restrictions
- ▶ OA, C-T spine, rib and wrist mobilization
- ▶ Stretching muscles, median nerve flossing, deep ant neck flexor & scap stabilization, and T-spine and posterior 1st rib self mobilization

UE Case Study #2 Treatment

- ▶ Prone Prop extension stretch
- ▶ 5 minutes every day



UE Case Study #2 Treatment

- ▶ Lat dorsi/C-T extension stretch



Conclusions

- ▶ Discover the full story: you will not find what you do not look for
- ▶ If the client is not getting better, you are missing something!
- ▶ Find the source of the pain that explains ALL of the Sxs; think outside the box
- ▶ Develop a comprehensive POC to address each aspect contributing to the problem
- ▶ Instruct clients to maintain what they have learned
 - ▶ Stretching
 - ▶ Strengthening/stabilization
 - ▶ Posture changes
 - ▶ Neural mobilization
 - ▶ Self spine and rib mobilization

Questions?



THANK YOU FOR YOUR ATTENDANCE!
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