Objectives

- Discuss the basic anatomy and physiology of the nervous system
- Identify varying surgical techniques for common nerve compression injuries
- Apply assessment tools to evaluate peripheral nerve compression
- Apply evidence-based intervention to treatment of common nerve compression conditions
- Identify common brachial plexus injuries
- Analyze proximal nerve symptoms to guide with treatment
- Demonstrate cervical screening to rule in/out spinal nerve root injury
- Implement treatment strategies for cervical nerve root compression
- Evaluate and implement therapeutic techniques for Thoracic Outlet (TOS)
The Nervous System

Structurally
- Central Nervous System (CNS)
  - Brain and spinal cord
- Peripheral Nervous System (PNS)
  - Nerve fibers and cell bodies

Functionally
- Somatic Nervous System
  - Voluntary: Sensory carries sensations and position sense from skin and joints. Motor carries impulses to muscles.
- Autonomic Nervous System
  - Involuntary/visceral: walls of blood vessels, sweat glands, viscera (internal organs), body cavity (heart, stomach, bladder, etc.)

Central Nervous System (CNS)
- Structure: Brain & Spinal Cord
- Function: Control Center & Integrative

Peripheral Nervous System (PNS)
- Structure: Cranial & Spinal Nerves
- Function: Communicates between CNS and the rest of the body

Sensory
- Structure: Somatic & visceral fiber
- Function: Connects impulses from receptors to the CNS

Motor
- Structure: Motor nerve fibers
- Function: Conducts impulses from CNS to muscles & glands

Spinal cord relays information to and from the brain through the spinal tracts through the thalamus and finally to the cortex.
Peripheral Nerve

- Peripheral nerves connect information to the central nervous system
- Consist of cell body, dendrite send messages to cell body and axon send message out
- Efferent: motor
- Afferent: sensory
- Interneurons: connect neurons within a specific region (sensory or motor) to the central nervous system. Play a role in reflexes.

Spinal Nerves Mixed Fibers

- Part of Peripheral Nervous System
- 8 pairs of cervical nerves
- 12 pairs of thoracic nerves
- 5 pairs of lumbar nerves
- 5 pairs of sacral nerves
- 1 pair of coccygeal nerves

- Axons: receives information
- Dendrite: relays information
- All peripheral nerve fibers have a sheath cell and a Schwann cell. Larger nerve fibers have a fatty (myelin) sheath in addition to the Schwann cell
- Presence of myelin speeds conduction
- Nodes of Ranvier: constrictions separating successive segments of myelin
- Nerve impulses "leap" from node to node
- Farther apart=faster conduction
Peripheral Nerve Communication

- Nerves have **three** connective tissue layers to protect
  - **Endoneurium**: inner most nerve fiber or axons; protects against transmission of substances across the membrane
  - **Perineurium**: surrounds fascicles of nerve axons controls substances bi-directionally, diffusion barrier
  - **Epi-neurium**: outer most connective tissue that is highly vascularized

Sensory Receptors

- **Mechanoreceptors/Pressure, Proprioception**
  - Meissner corpuscles: light touch
  - Merkel cells: light touch (abundant in fingertips)
  - Ruffini (Bulbous Corpuscle): skin stretch, temperature, contribute to proprioception
  - Pacinian corpuscle: vibrations
  - Free nerve endings: pain
    - fast adapting (A delta I)
    - slow adapting (A delta I and C fibers)

[Sensory Receptors of Muscle & Tendon](http://www.bayareapainmedical.com/nerve.html)

- **Muscle Spindles**: detect changes in length, protects muscle length with the stretch reflex.
- **Golgi tendon reflex** (*inhibitory*): detects muscle tension changes, protects muscle force to help maintain steady levels of tension and stable joints to counteract effects that reduce muscle force such as fatigue.
Nerve Injury Classification

**Mononeuropathy**
- Traumatic or non-traumatic
- Compression syndromes
- Can result in ischemic changes, edema injury to myelin
- Can result in demyelination, axonal degeneration, or both
- Nerve lacerations/compression
- Motor & sensory Deficits in nerve distribution
- Weakness is dependent on the motor units damaged
- Sensory loss is distal to injury site

**Poly Neuropathy**
- Metabolic
- Nutritional
- Hereditary
- Immunologically Mediated
- Infectious Disease
- Neoplastic
- Bilateral & Symmetrical
- Affects large fibers distally first
- Sensory loss precedes motor loss
- Sensory loss at feet followed by hands (distal)

Peripheral Nerve Injury
- Macrophages and phagocyte remove myelin and axonal debris. Schwann cells signal to turn on pro-growth genes.
- The proximal end forms a growth cone that secretes growth hormone to be guided back to its target nerve if the cell body is intact and Schwann cells have made contact in the endoneurial tube
- Schwann cells then proliferate and migrate to regenerating axon

Nerve Injury Seddon Classification

<table>
<thead>
<tr>
<th>Seddon</th>
<th>Axon</th>
<th>Endoneural Tube</th>
<th>Perineurium</th>
<th>Epineurium</th>
<th>Wallerian Degeneration</th>
<th>Nerve conduction distal to injury/Prognosis</th>
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</tr>
<tr>
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<td>Absent/Reversible</td>
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<td>-</td>
<td>-</td>
<td>+/- ?</td>
<td>Yes</td>
<td>Absent/Irreversible</td>
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</table>
Nerve Injury Classification Sunderland

<table>
<thead>
<tr>
<th>Nerve Injury</th>
<th>Classification</th>
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</thead>
<tbody>
<tr>
<td>Neurapraxia</td>
<td>1st Degree: Observation, Wallerian degeneration, preservation of endoneurium and epineurium</td>
</tr>
<tr>
<td>Axonotmesis</td>
<td>2nd Degree: Loss of continuity of the axon, Wallerian degeneration, preservation of endoneurium and epineurium</td>
</tr>
<tr>
<td>Neurotmesis</td>
<td>3rd Degree: Neurapraxia, Wallerian degeneration, loss of nerve trunk, surgical intervention necessary</td>
</tr>
</tbody>
</table>

Medical Treatment

- **Neurapraxia** - Observation
- **Axonotmesis** - Surgical intervention may be required
- **Neurotmesis** - Loss of nerve trunk, surgical intervention necessary

Nerve Mechano-sensitivity Proximal Injuries Referring Distally

**Sensitivity of Regenerating Axon Sprouts**

- Micro-neuromas (sprouting nerve cells) form around the damaged nerve
- New cells fire causing severe electrical burning and shooting pain

[http://www.bayareapainmedical.com/nrvpain2.html](http://www.bayareapainmedical.com/nrvpain2.html)
Nerve Mechano-sensitivity Proximal Injuries Referring Distally

Nervi Nervorum (unmyelinated or poorly myelinated fibers in peripheral nerve sheaths)
- Participate in the transmission of evoked sensory information
- Neuropeptide release leading to edema due to poor lymphatic drainage. Distorts the endoneurium and epineurum due to pressure.
- Inflammatory mediators spread distal likely related to poor lymphatic drainage
- Nerve becomes more sensitive

Histopathology of Chronic Nerve Compression

Double Crush Syndrome Axoplasmatic Flow Disruption

Alterations of Axoplasmic Flow
- Possible alterations with a proximal lesion affecting distal compression sites
- Possible alterations with a distal lesion affecting proximal lesion sites
- Alterations to neural transmission (axoplasmic flow), but each site in isolation may not reproduce patient symptoms when tested
Double Crush Syndrome Possible Posture

Contribution

• Movement patterns and posture can be effected with a nerve compression
• Muscle imbalances can occur

Thoracic Outlet (TOS)

Potential Compression Sites

- Interscalene triangle
  Anterior and middle scalenes
- Costoclavicular space
  Between clavicle and 1st rib
- Thoraco-coraco-pectoral space
  Pectoralis minor

Compartment of Potential Compression

<table>
<thead>
<tr>
<th>Borders</th>
<th>Contents</th>
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<tbody>
<tr>
<td>Interscalene triangle</td>
<td>Anterior: anterior scalene</td>
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<tr>
<td></td>
<td>Posterior: middle scalene</td>
</tr>
<tr>
<td></td>
<td>Inferior: 1st rib</td>
</tr>
<tr>
<td>Costoclavicular space</td>
<td>Anterior: subclavus</td>
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<tr>
<td></td>
<td>Interscalene: 1st rib and</td>
</tr>
<tr>
<td></td>
<td>anterior scalene</td>
</tr>
<tr>
<td></td>
<td>Superior: clavicle</td>
</tr>
<tr>
<td>Sub-coracoid space</td>
<td>Anterior: pectoralis minor</td>
</tr>
<tr>
<td></td>
<td>Posterior: ribs 2-4</td>
</tr>
<tr>
<td></td>
<td>Superior: coracoid</td>
</tr>
</tbody>
</table>

Double Crush

“Local damage to a nerve at one site along its course may sufficiently impair the overall functioning of the nerve cells that they become more susceptible than would normally be the case to trauma at other sites.”

• 53 cases of ulnar nerve anterior subcutaneous transposition, 7 had TOS. 44/50 had resolved symptoms at 12-74 months post-op. 5/7 had persistent subjective symptoms and objective motor dysfunction.

Neurogenic TOS Estimated 95% of Cases

<table>
<thead>
<tr>
<th>True Compressor</th>
<th>Disputed Releaser</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Paresthesia am &amp; pm</td>
<td>• Paresthesia awaken often pm</td>
</tr>
<tr>
<td>• Compressors day pain &gt; night pain</td>
<td>• Releasers pm pain &gt; day pain</td>
</tr>
<tr>
<td>• Confirmation with neurophysiological tests</td>
<td>• No confirmation with neurophysiological test</td>
</tr>
<tr>
<td></td>
<td>• Estimated to be 95-99% of all neurogenic types and is bilateral</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>LR+</th>
<th>LR-</th>
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<tbody>
<tr>
<td>Supraclavicular Pressure (Nord et al 2008)</td>
<td>NT</td>
<td>85-98</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Cervical Rotation Lateral Flexion (Gilbert et al 2004)</td>
<td>0.42-1.8</td>
<td>100</td>
<td>NT</td>
<td>NA</td>
</tr>
<tr>
<td>Cyriax Release (Nord et al 2008)</td>
<td>NT</td>
<td>77-97</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Upper limb tension (Brisme et al 2004)</td>
<td>93</td>
<td>38</td>
<td>1.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Roos Elevated Arm Stress (Rayan &amp; Jensen 1995)</td>
<td>52-84</td>
<td>50-100</td>
<td>1.2</td>
<td>0.8-0.18</td>
</tr>
<tr>
<td>Costoclavicular Maneuver (Bertilson, Grunesio &amp; Strender, 2003)</td>
<td>NT</td>
<td>59-100</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Wright’s (Gillard et al 2001)</td>
<td>70-90</td>
<td>29-53</td>
<td>1.27-1.48</td>
<td>0.34-0.37</td>
</tr>
</tbody>
</table>
Clinical Tests: Cervical Rotation Lateral Flexion

Client must have at least 20% of lateral flexion to perform test

Testing right side

Patient is seated and the examiner is behind the patient. The examiner blocks the side being tested with their forearm. The examiner rotates the head away from the tested side and gently flexes the neck. Is lateral flexion limited? Bony end block?

Positive Test: Notably decreased forward flexion and a hard end feel. Compare sides.

Clinical Tests: Upper Limb Tension Test (ULLT) or Elvey Test

Suspected positive test for Neurogenic TOS

- Position 1
  - #1: Arms abduction to 90°
  - #2: Extend wrists
- Position 2
  - #3: Tilt head to side

Positive Test: pain and/or paresthesia in the hand or around the elbow

+ test which position provoked symptoms

Clinical Tests for Thoracic Outlet

- Rule Out Negative Tests: Highest Sensitivity (2 negative tests)
  - Cervical Rotation Lateral Flexion
  - Roo’s Elevated Stress Test
  - Upper limb tension testing
  - Wrights

- Rule In Positive Tests: Highest Specificity (5 positive tests)
  - Supraclavicular pressure
  - Cervical Flexion Lateral Rotation
  - Cyriax Release Test
  - Roo’s Elevated Stress Test
  - Costoclavicular Maneuver
  - Wright’s Test
Posture: Scalenes Length & 1st Rib Mobility

<table>
<thead>
<tr>
<th>Suspected Compression Site</th>
<th>Clinical Reasoning</th>
<th>Restriction</th>
<th>Treatment Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior &amp; Middle Scalenes</td>
<td>Supraclavicular Pressure test +</td>
<td>Soft tissue shortness</td>
<td>Scalenes mobilization &amp; stretching</td>
</tr>
<tr>
<td></td>
<td>Cervical lateral flexion test +</td>
<td>Elevated 1st rib</td>
<td>Neuromuscular re-education</td>
</tr>
<tr>
<td></td>
<td>Elvey test +</td>
<td>Hypomobility of 1st rib</td>
<td>Diaphragmatic breathing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1st rib mobilization</td>
</tr>
</tbody>
</table>

Teach Diaphragmatic Breathing

- Teach diaphragmatic breathing
- Scalenes release
- Stretch scalenes
- 1st rib mobility

Soft Tissue Mobilization Technique #1:
Scalenes Soft Tissue Release

Client is sitting with therapist standing behind client. Therapist places index and/or long digits on anterior scalenes with moderate caudal pressure. Client moves slowly towards slight lateral flexion to uninvolved side and rotation to involved side. Perform 5 to 10 reps.
Promote 1st Rib Mobility

- Clinician places radial hand on the 1st rib while using the other hand to stabilize the shoulder.
- The patient turns their head towards the treatment side.
- Clinician provides a glide to the 1st rib towards the opposite hip and slightly anterior.

Promote 1st Rib Mobility Home Program

Self 1st Rib Mobility
The patient is in sitting with cervical spine retracted. The client sits on a sheet/towel and places the sheet 1 inch lateral to the transverse process of T1. The patient uses their own hand to pull on the sheet in a contralateral caudal (opposite hip) direction. Adding a head rotation will stretch the scalenes.

<table>
<thead>
<tr>
<th>Suspected Compression Site</th>
<th>Clinical Reasoning</th>
<th>Restriction at Scapula</th>
<th>Treatment Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costoclavicular between clavicle and 1st rib</td>
<td>• Poor posture&lt;br&gt;• Depressed and/or downwardly rotated scapula observed&lt;br&gt;• Scapular Correction Test +</td>
<td>• Depression: poor muscular recruitment to achieve scapular upward rotation and/or muscular tightness at shoulder depressors (latissimus dorsi, pectoralis major/minor)&lt;br&gt;• Downward Rotation: same as above except muscle tightness possibly at scapular downward rotators (levator scapulae and rhomboidei)&lt;br&gt;• Poor movement patterns between scapula and humerus</td>
<td>• Diaphragmatic breathing&lt;br&gt;• Stretch tight muscles (latissimus and pectorals)&lt;br&gt;• Neuromuscular retraining (taping) scapula upward rotators&lt;br&gt;• Strengthening scapula upward rotators (lower trapezius and serratus anterior)&lt;br&gt;• Scapula mobilization&lt;br&gt;• Disassociate scapula and humerus motion</td>
</tr>
<tr>
<td>Suspected Compression Site</td>
<td>Clinical Reasoning</td>
<td>Restriction Scapula or Glenohumeral Joint</td>
<td>Treatment Strategy</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------</td>
<td>------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Costoclavicular space and/or beneath pectoralis minor</td>
<td>Palpation Observations of poor posture Scapula correction test + Anterior tilted scapula Short pectoralis minor muscle Joint specific test + for humerus</td>
<td>Poor scapula posture and recruitment: Anterior tilted and/or downward rotation due to muscular shortness or poor muscular recruitment patterns Poor glenohumeral motion: posterior capsule tightness; unable to dissociate scapular from glenohumeral motions</td>
<td>Diaphragmatic breathing Depression Stretch tight muscles (latissimus and pectoralis) Neuromuscular retraining (taping) Scapula upward rotators Strengthening scapula upward rotators (lower trapezius and serratus anterior) Scapula mobilization Disassociate scapula and humerus motion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Suspected Compression Site</th>
<th>Clinical Reasoning</th>
<th>Restriction</th>
<th>Treatment Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costoclavicular space between clavicle and 1st rib</td>
<td>Cervical lateral flexion test +</td>
<td>Soft tissue shortness scalenes Elevated 1st rib Hypomobility of 1st rib</td>
<td>Scalenus mobilization &amp; stretching Neuromuscular re-education Diaphragmatic breathing 1st rib mobilization</td>
</tr>
<tr>
<td>Costoclavicular space between clavicle and 1st rib</td>
<td>Joint specific test suggest poor clavicle mobility</td>
<td>Hypo-mobility of clavicle acromioclavicular (AC) and/or sternoclavicular (SC) joints</td>
<td>AC and SC mobilizations</td>
</tr>
</tbody>
</table>

Lab/Treatment Strategies for: Depressed Scapula affecting Costoclavicular Space AC & SC Mobility
- Mobilize clavicle
- Correct scapular restrictions
- Dissociate glenohumeral from scapula motions
- Correct glenohumeral capsular restrictions
- Thoracic mobility
- Progress to strengthening
Assessing Scapula by Observation Static

Downward Rotation
- Inferior border of scapula is closer to the spine as compared to superior border

Depressed Scapula
- Inferior border protrudes from thorax
  - One arm longer than the other

Anterior Tilt
- Inferior border protrudes from thorax

Test: Muscle length of latissimus dorsi, pectoralis clavicular and sternal fibers

- Shortness exists when the patient is unable to reach arms overhead to the mat.
- Short clavicular fibers exist when the arm can not abduct/drop down to the mat at 90° abduction
- Short muscle fiber exists when horizontally abduction at 120° to 140° does not drop down to the mat.

Testing: Posture Observations and Muscle Length

- Perform muscle length test for pectoralis minor.
  - Client lies supine with external rotation (palms up).
  - Check for asymmetry. Is the posterior acromion higher off the mat on one side.
  - Tightness at pectoralis minor will contribute to scapular anterior tilt causing the acromion to be higher on the right side.
Treatment: Pectoralis Muscles

Stretching pectoralis minor with client on a foam roller and therapist manually stretching. Therapist’s hands are on the coracoid process stretching dorsal and lateral.

Stretching pectoralis minor and major with client on a foam roller. Therapist’s one hand on unilateral coracoid process stretching dorsal and lateral. The other hand supports the arm.

Treatment Strategies: Scapular Restrictions

- Mobilize clavicle
- Correct scapular restrictions
  - Lengthen short muscles
  - Scapula Mobilizations
  - Neuromuscular Re-education
- Correct glenohumeral capsular restrictions
- Disassociate glenohumeral capsular restrictions from scapula
- Thoracic mobility
- Progress to strengthening

Treatment Strategies: Stabilize scapula with pectoralis minor in a lengthened position

The client is supine. Client is instructed to flex at knees and hips. A roller or towel is placed lengthwise down spine. Humerus supported. The client stabilizes scapula while performing external rotation exercises. Perform 5 to 10 reps.
**Treatment: Mobilize Clavicle**

- One hand on the scapula
- Thenar eminence of the other hand on the medial clavicle providing an inferior and posterior glide.

- One hand stabilizes the AC joint
- The thumb of the other hand is placed on the posterior acromion
- Provide a posterior glide to the posterior acromion while stabilizing with the other hand.

---

**Treatment: Neuromuscular Re-education**

**Scapula Downward Rotation/Depression/Anterior Tilt**

- Exercises to promote scapular upward rotation
- Taping to promote upward rotation

- Wall slides for upward rotation. Ulnar forearm on wall. Slide towards a teardrop position. 5 to 10 reps. Progress to resisted scaption exercises. (Hooper, Denton, McGalliard, Brismee & Sizer, 2010)

*As symptoms improve exercises can progress. Position #1*

---

**Evaluation**

**Peripheral Nerve Compression**

- Observations
- Motor
- Sensory
  - Light Moving Touch
  - Vibration Thresholds
  - Cutaneous Pressure Thresholds
  - 2 Point Discrimination
- Pain Evaluation
- Palpation, Potential Compression Sites & Clinical Provocative Tests
- Evaluating Cervical
Observations (distal)

<table>
<thead>
<tr>
<th></th>
<th>Early</th>
<th>Late</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vasomotor (temp.,</td>
<td>Skin rosy</td>
<td>Skin mottled</td>
</tr>
<tr>
<td>color, edema, cold</td>
<td>Skin warm</td>
<td>Skin cold</td>
</tr>
<tr>
<td></td>
<td>Dry skin</td>
<td>Dry or overly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>moist skin</td>
</tr>
<tr>
<td>Sudomotor (sweat</td>
<td></td>
<td></td>
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<td>patterns)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pilomotor (“goose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>flesh”)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tropic (skin</td>
<td>Finger blemish</td>
<td>Curved</td>
</tr>
<tr>
<td>texture, atrophy to</td>
<td>longer &amp; fine</td>
<td>longer &amp; fine</td>
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<tr>
<td>digit pulps, nail</td>
<td>hair growth</td>
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<td>changes)</td>
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<td>smooth/non-</td>
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<tr>
<td></td>
<td></td>
<td>elastic</td>
</tr>
</tbody>
</table>

Evaluation: Differentiating Nerve Lesions

- Combine clinical findings of reflex, sensory and strength testing
- Motor
  - Nerve Root: Myotome
  - Peripheral: Peripheral Nerve Innervation
- Sensory
  - Nerve Root: Dermatomes
  - Peripheral: Peripheral Nerve Cutaneous Distribution
- Deep Tendon Reflexes
  - Interpreted with sensory and strength findings to determine nerve root versus peripheral nerve lesion:
    - Hypotonia involving lower motor neurons (nerve root, neuromuscular junction or muscle)
    - Hypertonia involving upper motor neurons


Nerve Root Myotome Associations
- C5 – Shoulder abduction
- C6 – Elbow flexion, Wrist extension
- C7 – Elbow extension, Wrist flexion
- C8 – Finger flexion
- T1 – Finger abduction

Clinical Hints:
- T1 Intrinsic
- C5 Supinator
- C5 shoulder abduction, extension and external rotation
- C7 & 8 almost all others

Peripheral Nerve Associations
- Muscles innervated by each nerve
  - Median
  - Ulnar
  - Radial
  - Musculocutaneous
  - Axillary
SENSORY EVALUATION: Patient Subjective Symptoms

Nerve Root
- Spinal segment representation of dermatome (sensory) and myotome (motor) patterns

Peripheral Nerve
- Decreased sensation and strength in the peripheral distribution pattern

Quick Scan of Motor Scan for Peripheral Nerve

- Resist palmar abduction for median nerve
- Resist thumb dorsal retropulsion for radial nerve
- Resist index finger abduction and palpate 1st dorsal interossei for ulnar nerve

SENSORY EVALUATION: Moving Light Touch

Ten Test is a screen for large A-Beta fibers (testing moving fibers Meissner and Pacini quick adapting receptors)
- Moving touch contra-lateral unaffected digit identifying normal sensation at 10/10
- Touch the same area on the involved side and patient rates the normal sensation compared to the contra-lateral side.

(Nota: Las imágenes y las referencias a otros textos se han resumido para facilitar la comprensión del contenido.)
Muscle Reflexes

<table>
<thead>
<tr>
<th>Grade</th>
<th>Response</th>
<th>Interpretation</th>
<th>Clinical Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No response</td>
<td>Always abnormal</td>
<td>Lower neuron</td>
</tr>
<tr>
<td>1+</td>
<td>Slight, muscle contraction but there is no joint movement</td>
<td>May or may not be normal</td>
<td>Lower neuron</td>
</tr>
<tr>
<td>2+</td>
<td>Brisk response</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>3+</td>
<td>Very brisk response</td>
<td>May or may not be normal</td>
<td>Upper motor neuron</td>
</tr>
<tr>
<td>4+</td>
<td>Clonus</td>
<td>Always abnormal</td>
<td>Upper motor neuron</td>
</tr>
</tbody>
</table>

Deep Tendon Reflexes

<table>
<thead>
<tr>
<th>Spinal Level</th>
<th>Reflex</th>
<th>Peripheral Nerve</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5</td>
<td>Biceps</td>
<td>Musculocutaneous</td>
</tr>
<tr>
<td>C5-6</td>
<td>Brachioradialis</td>
<td>Radial Nerve</td>
</tr>
<tr>
<td>C7</td>
<td>Triceps</td>
<td>Radial Nerve</td>
</tr>
</tbody>
</table>

Hypotonic reflex: suspect lower motor neurons/cervical radiculopathy; individuals with carpal tunnel likely will not cause changes with reflexes due to a distal compression.

SENSORY EVALUATION: Vibration Thresholds

Testing sensory return: 30 cps vibration to affected area (testing Merkel & Ruffini low frequency quick adapting receptors)

Testing for early neural changes: 256 cps to digit pulp of involved followed by a comparison of sensation intensity to the uninvolved (testing Pacini and Meissner high frequency quickly adapting receptors)

High adapting fibers are thought to be affected first in chronic nerve compression

256 cps best for testing in chronic injury because they are the first affected
SENSORY EVALUATION: Cutaneous Pressure Thresholds

Testing sensory return of fine tactile & discriminative location:
Semmes Weinstein testing screens for threshold (testing slow adapting Merkel receptors)

SENSORY EVALUATION: Two Point Discrimination (pd)

Testing quantity of innervated sensory receptor

<table>
<thead>
<tr>
<th>Static Two-Point Discrimination</th>
<th>pd</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 mm</td>
<td>Normal</td>
</tr>
<tr>
<td>6-10 mm</td>
<td>Fair</td>
</tr>
<tr>
<td>11-15 mm</td>
<td>Poor</td>
</tr>
<tr>
<td>Only one point perceived</td>
<td>Protective sensation only</td>
</tr>
<tr>
<td>No point perceived</td>
<td>Anesthetic</td>
</tr>
</tbody>
</table>

Pain Evaluation

• Pain during varying activities (work, home, sleep, etc.)
• Pain scales (visual analog scale)
• Pain descriptors
• Body diagram chart
• How is client coping with pain? Mechanisms such as medications
• Would the client benefit from psychological counseling? Will pain hinder the progress in therapy?
Visceral Referral Pain Patterns

General characteristics of pain due to visceral pathology:
1. Is poorly localized with referral to somatic structures
2. Produces nonspecific regional or whole-body motor responses
3. Produces strong autonomic responses
4. Leads to sensitization of somatic tissues
5. Produces strong affective responses (Sikandar & Dickenson, 2012)

Palpation, Potential Compression Sites & Clinical Tests

- Creates nerve tension and compression at nerve sites
- Assist with determining compression site
- Helpful identifying area of compression in the early stages when there may not be symptoms of sensory changes
- Tinels and provocative tests performed from proximal to distal for clinical signs of double crush syndrome. (Novak & Mackinnon, 2005)

Nerve Pathways & Palpation: Median Nerve Path Proximally C5,6,7,8,T1

- Lateral root arises from lateral cord; medial root arises from medial cord
- Follows the brachial artery; medial at elbow
- Passes through two heads of pronator; deep to biceps aponeurosis
- Passes b/w FDS and FCR
- Emerges distally b/w FPL & FDS
- Enters carpal tunnel
Median Nerve Possible Compression Sites

<table>
<thead>
<tr>
<th>Carpal Tunnel</th>
<th>Pronator Syndrome (PS)</th>
<th>Anterior Interosseus Nerve (AIN) Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpal tunnel</td>
<td>Supracondylar process (spurs)?</td>
<td>Edge of deep pronator</td>
</tr>
<tr>
<td></td>
<td>Ligament of Struthers</td>
<td>FDS arch</td>
</tr>
<tr>
<td></td>
<td>Bicipital aponeurosis</td>
<td>Accessory head FPL Gantzers</td>
</tr>
<tr>
<td></td>
<td>B/w ulnar and humeral heads of pronator teres</td>
<td>Accessory muscle from FDS to FDP</td>
</tr>
</tbody>
</table>
|               | FDS arch | |}

Carpal Tunnel vs. Cervical Radiculopathy Symptoms

<table>
<thead>
<tr>
<th>Carpal Tunnel</th>
<th>Cervical Radiculopathy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paresthesia in digits #1-2 &amp; radial side #3</td>
<td>Sensory deficit at lateral arm and digits #1-3</td>
</tr>
<tr>
<td>Waking due to night pain</td>
<td></td>
</tr>
<tr>
<td>Hand weakness, clumsy</td>
<td>Arm and hand weakness</td>
</tr>
<tr>
<td>Upper extremity pain</td>
<td>Pain at neck, scapula and upper extremity</td>
</tr>
</tbody>
</table>

Provocative Tests:

Carpal Tunnel Testing

CLINICAL TESTS
- Carpal compression test
- Phalens
- Tinel's
- Median nerve tension test
Clinical Tests Pronator Syndrome versus Anterior Interossei Nerve Compression tests

<table>
<thead>
<tr>
<th>Pronator Teres Syndrome</th>
<th>AIN Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resisted pronation with elbow extended (pronator teres)</td>
<td>Weak pronation tested with elbow flexed? Weakness of thumb IP and IF DIP. Weak grip/pinch Unable to make OK sign</td>
</tr>
<tr>
<td>Resisted contraction to long finger FDS (FDS compression)</td>
<td></td>
</tr>
</tbody>
</table>

Clinical Tests Pronator Syndrome

- Pronator Compression Tests: Pressure for 30 seconds at PT (1.5 in distal flexion crease) muscle belly recreates symptoms (PT compression)
- + Tinel's at proximal forearm; pronator compression
- Symptoms reproduced with resisted pronation (wrist neutral) passively extending elbow (PT compression)
- Resist elbow flexion between 120-130 degrees with supination recreates symptoms. (Bicipital aponeurosis compression)

Nerve Pathways & Palpation:
Radial Nerve Path Proximally C6,7,8,T1

- Exits triangular interval
- Posterior between long head of triceps and humerus
- Through spiral groove
- Lateral intermuscular septa (l/w brachialis and brachioradialis anterior to lateral epicondyle)

**Compression Sites Proximal to the Elbow: TRIANGULAR INTERVAL (TI) & SPIRAL GROOVE**

**Triangular Interval (TI)**
- TI contains radial nerve and profunda artery
- TI compressions can occur from:
  - Posture: humeral adduction and scapular protraction
  - Hypertrophy of teres major
  - Adaptive shortening of internal rotators
  - Fibrous arch at the long head of triceps

**Spiral Groove**
- Compression distal triceps

---

**Mechanism of Injury**

<table>
<thead>
<tr>
<th>Triangular Interval</th>
<th>Spiral Groove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertrophy at teres major and medial triceps</td>
<td>Compression from leaning on a hard surface “Saturday Night Palsy”</td>
</tr>
<tr>
<td>Fibrous bands at teres major and medial triceps</td>
<td>Radial shaft fractures</td>
</tr>
<tr>
<td>Shortened teres major</td>
<td></td>
</tr>
<tr>
<td>Sports with forceful shoulder extension</td>
<td></td>
</tr>
<tr>
<td>Symptoms reproduced with external rotation combined abduction</td>
<td></td>
</tr>
</tbody>
</table>

---

**Presentation Sites Radial Nerve**

<table>
<thead>
<tr>
<th>Motor Presentation</th>
<th>Triangular Interval</th>
<th>Spiral Groove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weakness in all muscles innervated by radial nerve</td>
<td>Triceps spared. Weakness at all muscles innervated by radial nerve distal to triceps</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensory Presentation</th>
<th>Triangular Interval</th>
<th>Spiral Groove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior cutaneous nerve of arm</td>
<td>Lower lateral cutaneous nerve of arm</td>
<td></td>
</tr>
<tr>
<td>Posterior cutaneous nerve of forearm</td>
<td>Superficial radial nerve</td>
<td></td>
</tr>
</tbody>
</table>
Compression Sites Radial Nerve Distal to Elbow
Two conditions: Some compression sites

- Posterior Interossei Nerve (PIN)
- Radial Tunnel

<table>
<thead>
<tr>
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<th>Radial Tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibrous bands at radiocapitellar joint</td>
<td>Lateral proximal forearm pain, tenderness at supinator muscle, pain with supination with extended elbow, pain with resisted long finger</td>
</tr>
<tr>
<td>Leash of Henry</td>
<td>• No motor weakness</td>
</tr>
<tr>
<td>Medial edge of ECRB</td>
<td>Awakens nocturnally due to forearm pain</td>
</tr>
<tr>
<td>Proximal edge of supinator (Arcade of Frohse)</td>
<td>Pronation, elbow ext and wrist flex ↑ symptoms</td>
</tr>
<tr>
<td>Distal edge of the supinator</td>
<td>Rule out tennis elbow, may have lateral elbow tenderness</td>
</tr>
</tbody>
</table>

Clinical Presentation: Radial Nerve

- PIN Weakness and/or paralysis to: ECRB, supinator, ECU, EDC, EDM, APL, EPL, EPB, EI
- Radial Tunnel Weakness and/or paralysis to: ECRB, supinator, ECU, EDC, EDM, APL, EPL, EPB, EI

<table>
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<th>Radial Tunnel</th>
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<td>Weakness and/or paralysis</td>
<td>Lateral proximal forearm pain, tenderness at supinator muscle, pain with supination with extended elbow, pain with resisted long finger</td>
</tr>
<tr>
<td>to: ECRB, supinator, ECU, EDC, EDM, APL, EPL, EPB, EI</td>
<td>• No motor weakness</td>
</tr>
<tr>
<td>Radial Tunnel Weakness and/or paralysis</td>
<td>Awakens nocturnally due to forearm pain</td>
</tr>
<tr>
<td>to: ECRB, supinator, ECU, EDC, EDM, APL, EPL, EPB, EI</td>
<td>Pronation, elbow ext and wrist flex ↑ symptoms</td>
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<td></td>
<td>Rule out tennis elbow, may have lateral elbow tenderness</td>
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Provocative Tests Radial Nerve
Posterior Interossei versus Radial Tunnel

<table>
<thead>
<tr>
<th>Posterior Interossei</th>
<th>Radial Tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>resisted supination recreates pain.</td>
<td>Tenderness 3-5 cm distal lateral epicondyle</td>
</tr>
<tr>
<td>Test for weakness of MP extension and wrist weakness. Observe wrist extension for a bias towards radial deviation.</td>
<td>Resisted supination with the elbow and wrist extended reproduces pain.</td>
</tr>
<tr>
<td></td>
<td>Positive pain with long finger extension test.</td>
</tr>
<tr>
<td></td>
<td>Passive pronation with wrist flexion reproduces pain</td>
</tr>
</tbody>
</table>
Nerve Pathways & Palpation: Ulnar Nerve Path C8, T1

- Arises from the medial cord
- Descends distally and medially at the arm
- 1/3 distal arm pierces intermuscular septumTraveling posterior
- Crosses elbow posterior in supracondylar area
- Enters forearm b/w medial epicondyle and olecranon
- Deep to FCU in forearm
- In hand, lateral to pisiform and hook of hamate
- Ulnar nerve superficial branch (cutaneous) and deep (motor) within Guyon’s canal

Compression Sites Ulnar Nerve

<table>
<thead>
<tr>
<th>High Lesions</th>
<th>Low Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cubital Tunnel</td>
<td>Distal to FCU and FDP motor branches</td>
</tr>
<tr>
<td>Medial Intermuscular Septum</td>
<td>Guyon's canal</td>
</tr>
<tr>
<td>Arcade of Struthers</td>
<td>Flexor carpi ulnaris (FCU)</td>
</tr>
</tbody>
</table>

Ulnar Nerve Clinical Presentation

High Lesions
- All extrinsics and intrinsics affected (weak wrist flexors)
- Sensory loss over palmar and dorsal aspect of small digit and ulnar half of ring digit

Low Lesions
- Deep intrinsics affected (wrist flexors intact)
- No sensory loss over proximal and middle phalanx of dorsal small and ring digits due to dorsal cutaneous nerve branch being spared
## Provocative Tests for Ulnar Nerve

**Guyon's Canal versus Cubital Tunnel**

### Clinical Tests Cubital Tunnel
- Tinels at cubital tunnel and Guyon's canal
- Modified Shoulder Internal Rotation Test
- Elbow Flexion Test
- Scratch Collapse

### Clinical Test for Guyon's Canal
- Sensory testing at dorsal ulnar digits normal but, volar ulnar digits impaired

---

### Clinical Tests: Cubital Tunnel Syndrome

<table>
<thead>
<tr>
<th>Test</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tinels</td>
<td>54% to 70%</td>
<td></td>
</tr>
<tr>
<td>Modified Shoulder Internal Rotation Test</td>
<td>87% (5 second)</td>
<td>97%</td>
</tr>
<tr>
<td>Elbow Flexion Test</td>
<td>46% to 75% (1 to 3 min.)</td>
<td></td>
</tr>
</tbody>
</table>

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### CERVICAL SCREENING

Cervical Spondylosis: Non-specific term

Cervical Radiculopathy Type I
Cervical nerve roots compression and inflammation of the nerve root or roots at or near the cervical foramen. Symptoms are pain radiating into the arm corresponding to the dermatome of the involved cervical nerve root.

Cervical Myelopathy Type II
Compression of the cervical spinal cord related to degeneration of discs and bone spurs. Symptoms can include: weakness and numbness, loss of balance and coordination and neck pain. Rheumatoid arthritis can cause myelopathy due to synovium swelling destructing facet joints.

Axial Joint Pain Type III
Neck pain with pain radiation to one or more of the following: medial scapula, chest wall, shoulder area and head. Symptoms stem from the joints. Correlation between activity and pain. Pain is expected to improve with rest.

EXAMINATION

1. History
2. Pain Patterns & Scales
3. Inspection
4. AROM/PROM of upper limb & cervical
5. Palpation
6. Myotome scan
7. Dermatome scan
8. Vertebral Artery test
9. Provocative tests
10. Upper limb neural tension testing (median, ulnar, and radial nerves)

History

• Current condition and past condition
• Age
• Past medical information/surgeries
• Onset/history of current condition
• Medications
• Social history (past & present)
• Occupations and functional status
• Past location
• Pain Characteristics: patterns (dermatomal, mechanical, segmental distribution pattern, trigger point), aggravating activity, intensity, duration, location
Pain: Classification

<table>
<thead>
<tr>
<th>Central Sensitization</th>
<th>Denervation</th>
<th>Peripheral Nerve Sensitization</th>
<th>Musculoskeletal Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central nervous system centralization, dominance of allodynia and hyperalgesia</td>
<td>Significant axonal compromise but no central nervous system changes. Loss of nerve supply. Can be from injury, disorders or surgery.</td>
<td>Inflammation arising from nerve trunk or peripheral nerve without clinical evidence of significant denervation. Injury to the area produces a flare.</td>
<td>Pain is referred from non-neural structures.</td>
</tr>
</tbody>
</table>

Administer Laniss Pain scale
http://www.bayareaopmilical.com/htmadmin.html

Denervation
Significant axonal compromise but no central nervous system changes. Loss of nerve supply. Can be from injury, disorders or surgery.

Peripheral Nerve Sensitization
Inflammation arising from nerve trunk or peripheral nerve without clinical evidence of significant denervation. Injury to the area produces a flare.

Musculoskeletal Pain
Pain is referred from non-neural structures.

Posture

- Patient attempts to shorten anatomical distance over the course of the sensitized nerve when experiencing central sensitization
  - Elevated scapula, ipsilateral side cervical flexion and elbow flexed

- Patient may attempt to increase the available space surrounding the nerve roots when experiencing neuropathic pain related to denervation from compressed, stenotic nerve root

Inspection/Posture

Forward head posture, rounded shoulders, kyphosis
- Scapula protracted & internally rotated (IR) and glenohumeral IR or flat cervical spine
- Associated with headaches and interscapular pain
- Interscapular pain
- Overly extended cervical spine can cause overstretching and friction on nerve roots

- Asymmetry? Alignment of scapula? Scoliosis?
- Guarding
Inspection (cont.)

Forward Head Posture

Forward Head Posture Joint Mechanical Changes
- Excessive forces at mid cervical spine
- Increased forces on intervertebral disc & neural arches
- Degeneration of disc
  - Osteophytic spurs at posterior facet joints
  - Friction at cervical vertebrae due to repetitive extension & rotation causing friction on the nerve roots at the transverse processes

Vertebral Artery Testing

- Patient can be supine or sitting.
  - Extend, rotate and flex the cervical spine to the right when testing the left side (vice versa for testing the right side). Hold the position for approximately 30 seconds and ask the patient to count back from 20.
  - Signs of a positive test are:
    - Dizziness
    - Diplopia (double vision)
    - Dysarthria (poor motor speech)
    - Dysphagia (difficulty swallowing)
    - Drop attacks (short loss of consciousness)
    - Nausea and vomiting
    - Sensory changes
    - Nystagmus

Cervical AROM

Check for quality of movement, burning, sharp pain, numbness. Is there a correlation of adverse responses?

- Client actively flexes cervical spine
- Followed by active cervical extension with the mouth open to avoid tension of suprahyoid and infrahyoid muscles

Clinical Reasoning: Muscular, Ligament Strain/Sprain or Nerve Root

<table>
<thead>
<tr>
<th>Maneuver</th>
<th>Pain (soft tissue)</th>
<th>Pain (nerve root)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AROM</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>PROM</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Provocation of ligament or muscle or ligament</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Provocation of neural tissue</td>
<td>Yes</td>
<td>(paresthesia)</td>
</tr>
</tbody>
</table>


Cervical ROM (cont.)
Active motion first, followed by overpressure, if there was no pain actively.

- Flexion
- Extension
- Side-bending
- Rotation

Provocative Tests:
Testing Recreation of Symptoms

- AROM, if no pain
- Over pressure at end range, if no pain
- Compression/ Distraction, if no pain
- Spurlings
  - Arm squeeze test
    - Gumina, Carbone, Albino, Gurzi & Postacchini, 2013
- Determine cluster signs

Palpation

- Start with uninvolved side
- Palpation should be mild (blanch the nailbed of the palpating finger)
- Supra and infra-clavicular fossa associated with TOS involvement
- Distal nerve palpation to rule out peripheral nerve involvement

Upper and Middle Trunks
- Posterior to sternocleidomastoid (STM)
- Between the anterior and middle scalenes
Paresthesia & Sensory Loss: Myotome and Dermatome Scan
Referred Pain Patterns

- **MYOTOME**: muscles served by a single spinal nerve
- **DERMATOME**: spinal segment innervates skin
- **SCLEROTOMAL**: area of bone innervated from a single spinal segment

---

Myotome Scan: Testing Strength (cont.)
(Painless and weak suggestive of neurologic compromise).

- C2,3,4 scapular elevation
- C5 shoulder abduction
- C6 elbow flexion, wrist extension
- C7 elbow extension, wrist flexion
- C8 digit flexion
- T1 finger abduct/adduct
Dermatome Pain: Testing sensory (cont.)

- C4 supraclavicular area
- C5 lateral arm
- C6 dorsal lateral thumb
- C7 long finger
- C8 ulnar hand
- T1 medial forearm
- T2 apex axilla

Peripheral Nerve Management

PERIPHERAL NERVE MANAGEMENT

Post-op:
- Good MD Communication
- Protect surgical structures
- Manage edema and pain
- Sensory re-training techniques
- Cortical retraining activities can be helpful
- Maintain Mobility of uninvolved joints
- Orthosis as indicated

Non-Op Management:
- Improve tissue mobility
- Activity modification
- Improve nerve mobility
- Orthosis as needed
- Space, motion, and slack
Post-Surgical management

- Good Communication with MD is key
- Type of repair?
- Tension?
- Nerve Graft and nerve conduits?
- Nerve Transfer?

Sensory Re-education & Cortical Re-mapping

Sensory Re-education:
- Localization and Discrimination
- 4 to 6 months after repair

Cortical Re-mapping:
- Cortical Silent period
- Application EMLA cream
- Cutaneous anesthesia significantly improved distal sensation after 6 weeks
- Protect surgical structures

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Walbruch and Kalliainen retrospective study
- Established post-op standardization protocol
- Result suggest cortical reorganization improve sensory outcomes.

Procedure:
- 2 weeks post repair forearm rubbed with anaesthesia. Denervated area rubbed with varying textures (2x/wk/1 mo followed by 1x/wk/4 mo).
- Visual and auditory feedback
- Imagery activities: client described how things feel.
- Laminated cards with 10 action verbs read throughout the day and client visualized doing the activity
- Mirror therapy 1 to 2x daily using varying textures

Sensory Re-Education and Cortical Re-mapping

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Sensory Re-Education: Patient is able to identify vibration 30cps

**Phase II**

- Nerve is beginning to innervate
- Introduce traditional sensory training
  - Rice bins
  - Textures
  - Shapes
  - Tracing items with digits

Proprioceptive Activities

<table>
<thead>
<tr>
<th>Gentle Oscillations</th>
<th>Light Ball Toss</th>
<th>Scarf Juggling</th>
</tr>
</thead>
</table>

Non-operative Peripheral Nerve Management

- Goal is to create space, slack, and glide around the nerve
- Soft tissue mobilization
- Neuro mobilization/Nerve Glides (mobilize/glide)
- Orthosis (create slack)
- Taping (create space)
- Cupping? (create space)
Cupping Principles

• Primary objective to provide space along the nerve bed
• Compressive forces around the rim and distraction at center cup
• Combine with distraction to maximize tensile and distractive forces
• Static - sustained pressure/tissue distraction
• Evidence?
• Contraindications:
  • Can produce erythema and ecchymosis
  • Avoid DVT
  • Compromised skin

M. Butler (2019, May). Scrape, Cup & Glide: Neuro Mobilization for the UE. Presented at Select Physical Therapy Charlotte, NC

Median Nerve

<table>
<thead>
<tr>
<th>Pronator Syndrome</th>
<th>AIN Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest; orthosis to avoid rotation</td>
<td>Rest; orthosis with elbow flexion at 90 degrees (8-12 wks)</td>
</tr>
<tr>
<td>Nerve glides?</td>
<td>Nerve glides?</td>
</tr>
<tr>
<td>Taping?</td>
<td>Taping?</td>
</tr>
<tr>
<td>Soft Tissue Mobilization?</td>
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</tr>
<tr>
<td>Decompression surgery is indicated if symptoms remain.</td>
<td></td>
</tr>
</tbody>
</table>
### Carpal Tunnel vs. Cervical Radiculopathy: Symptoms

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Waer et al 2000

### Carpal Tunnel Interventions

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<tr>
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<tbody>
<tr>
<td>Nocturnal wrist orthosis</td>
</tr>
<tr>
<td>Carpal mobilization techniques</td>
</tr>
<tr>
<td>Nerve gliding</td>
</tr>
<tr>
<td>Tendon gliding</td>
</tr>
</tbody>
</table>

March 2018 Nerve Compression and Injuries

### Carpal Tunnel Treatment

Symptoms improved with wear of nocturnal and day wrist orthosis.

- 12 week follow-up supports full-time wear of orthosis for median motor distal latency deduction and improvement with median motor compound muscle action potential
Carpal & Nerve Mobilization

- Mobilization group compared to controls
- Therapy 3 days a week for 4 weeks
- Carpal mobilizations performed 3x for 30 seconds
- Neural mobilizations performed 15 reps/3x with oscillatory elbow flexion and extension
- Mobilization group improved with function status scale and improved motor latency

(Oskouei et al., 2015)

Carpal Tunnel Gliding: adding digit abd/add

- Traditional nerve gliding exercises resulted in minimal gliding at the carpal tunnel.
- Adding digit abduction increased median nerve glide at carpal tunnel.
- Positive numbers represent proximal gliding
- Negative numbers represent distal gliding

(Meng et al., 2015)

Median Nerve Gliding Occurs during Tendon Gliding Exercises

- Significant changes from hook to fist position
- Significant changes from straight to hook position
- Increased compression in controls and experimental group in fist position

(Finger, 2015; Ishiai, Yamaguchi, Tachibana & Sawada, 2008)
Carpal Tunnel Management

- Daily Orthosis Wear
- Carpal Mobilization techniques can be helpful
- Neuro mobilization with Finger Abduction
- Avoid Forceful Gripping

Ulnar Nerve

Compression Sites Ulnar Nerve

<table>
<thead>
<tr>
<th>High Lesions</th>
<th>Low Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arcade of Struthers</td>
<td>Distal to FCU and FDP motor branches</td>
</tr>
<tr>
<td>Medial Intermuscular</td>
<td>Guyon's canal</td>
</tr>
<tr>
<td>Septum</td>
<td></td>
</tr>
<tr>
<td>Cubital Tunnel</td>
<td></td>
</tr>
<tr>
<td>Flexor carpi ulnaris</td>
<td></td>
</tr>
</tbody>
</table>
**Interventions for Ulnar Nerve**

**Interventions for Cubital Tunnel**

- Rest/Orthosis: elbow flexion block nocturnally; heelblock during waking hours
- Activity Modification: Avoid elbow flexion and range, leaning on elbow and any repetitive elbow activity.
- Nerve Glides: Is this effective distally?

**Interventions for Guyon’s Canal**

- Wrist orthosis?
- Activity Modification: Avoid palmar compression and/or trial wear padded protective gloves
- Nerve Glides: Use with caution

**Interventions for Ulnar Nerve Cubital Tunnel Syndrome**

**Acute phase GOAL:** Decrease pain/paresthesia
- **Patient education:** Avoid elbow flexion and leaning on cubital tunnel.
- **Activity modification:** Avoid repetitive elbow motion, elbow flexion
- **Orthosis (elbow at 45 degrees flexion, wrist neutral, forearm slight supination) for 4-6 wks**
- **Modalities with caution**

**Conservative Guidelines Ulnar Cubital Tunnel Syndrome**

**Phase II GOAL:** Decrease pain/paresthesia
- Orthosis wear as needed
- Nerve gliding? Use with caution
- Progress to strengthening as symptoms resolve with emphasis on proximal strengthening.
Radial Nerve

Interventions

<table>
<thead>
<tr>
<th>Triangular Interval (rare condition)</th>
<th>Spiral Groove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid combined shoulder extension activities</td>
<td>Most common radial nerve compression</td>
</tr>
<tr>
<td>Transverse soft tissue mobilization of triceps and teres major</td>
<td>High rate of nerve return 60% to 92% (Grass, Kabir, Ohse, Rangger, Besch &amp; Mathiak, 2011)</td>
</tr>
<tr>
<td>Radial nerve gliding</td>
<td>Wrist &amp; digit orthosis (outrigger)</td>
</tr>
<tr>
<td></td>
<td>Neuromuscular re-training (NMES, taping, etc.)</td>
</tr>
</tbody>
</table>

Radial Nerve Distal to the elbow

<table>
<thead>
<tr>
<th>PIN</th>
<th>Radial Tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weakness and/or paralysis to: ECRB, supinator, ECU, EDC, EDM, APL, EPL, EPB, EI</td>
<td>Lateral proximal forearm pain, tenderness at supinator muscle, pain with supination with extended elbow, pain with resisted long finger</td>
</tr>
<tr>
<td></td>
<td>Awakens nocturnally due to forearm pain</td>
</tr>
<tr>
<td></td>
<td>Pronation, elbow ext and wrist flex symptoms</td>
</tr>
<tr>
<td></td>
<td>Rule out tennis elbow, may have lateral elbow tenderness</td>
</tr>
</tbody>
</table>
**Non-operative Management**

<table>
<thead>
<tr>
<th>Posterior Interossei Nerve (PIN)</th>
<th>Radial Tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintain PROM</td>
<td>Orthosis to unload tension</td>
</tr>
<tr>
<td>Orthosis for positioning and function</td>
<td>Nerve gliding</td>
</tr>
<tr>
<td>Stretching wrist extensors and supinator?</td>
<td></td>
</tr>
<tr>
<td>Limit activities limiting pronation and elbow extension. Limit prolonged activities with wrist ext and pronation</td>
<td></td>
</tr>
</tbody>
</table>

**PERIPHERAL NERVE MANAGEMENT**

**Post-op:**
- Good MD Communication
- Protect surgical structures
- Manage edema and pain
- Sensory Re-training techniques
- Cortical Retraining activities can be helpful
- Maintain Mobility of uninvolved joints
- Orthosis as indicated

**Non-Op Management:**
- Improve Tissue mobility
- Activity Modification
- Improve nerve mobility
- Orthosis as needed
- Find a way to create Space, motion, and slack

**Lab: Nerve Tension Testing and Gliding**
- Slider: Tension off nerve
- Tensioner: Tension on nerve

Theraband demonstration: median, ulnar, radial nerves

Abnormal responses to gliding and/or tension of a nerve can result in:
- Impaired nerve mobility
- Decreased nerve conduction velocity
- Nerve damage
- Loss of function

**Goal of nerve gliding:** healthy blood profusion, axonal conduction and target tissue innervations
**Upper Limb Tension Testing Sitting**  
**Median Nerve**

- Place involved side in following position:
  - Abduction and external rotation with slight extension
  - Elbow extension with forearm supination
  - Wrist extension
  - Cervical side bending to uninvolved side

---

**Brachial Plexus Neurodynamic Test (BPNT): Grading Scale 0-5**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0/5</td>
<td>Supine, shoulders level with arm with arm resting on abdomen; shoulder lift and adducted and elbow at 90° flexion; wrist and fingers in neutral</td>
</tr>
<tr>
<td>1/5</td>
<td>Externally rotate shoulder to neutral; keep elbow at 90° flexion; the wrist and fingers remain neutral</td>
</tr>
<tr>
<td>2/5</td>
<td>The wrist and fingers remain in neutral, elbow 90° flexion; radial abduct the thumb; abduct shoulder to 110° in coronal plane while blocking scapula elevation; maintain forearm neutral rotation</td>
</tr>
<tr>
<td>3/5</td>
<td>Externally rotate the shoulder to 90° with the elbow remaining at 90° flexion; follow with supination while keeping the digits and wrist in neutral with thumb radial abducted</td>
</tr>
<tr>
<td>4/5</td>
<td>Keep the above position, but slowly extend the elbow</td>
</tr>
<tr>
<td>5/5</td>
<td>Same as above with elbow extended, slowly extend the wrist and digits</td>
</tr>
</tbody>
</table>

*(Butler, Karagiannopoulos & Galantino, 2019)*

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**Established Reliability and Accuracy**

- Beyond the grade but, < half-way to the next grade
- > half-way to the next level
Peripheral Nerve Glide Lab

- 5’ yellow Theratube with loop for neck and finger

  - Median Nerve Glide
    - Neck to long finger
  - Ulnar Nerve Glide
    - Neck, cubital tunnel, small finger
  - Radial Nerve Glide
    - Neck, under axilla, spiral groove to index finger

---

Median Nerve Gliding

- Median Nerve: Tension:
  - Shoulder abduction
  - Wrist/finger extension
  - Shoulder external rotation
  - Elbow extension
  - Cervical side-bending

  Thera-tube around long finger
  https://www.youtube.com/watch?v=Fv_EJV8q2E0

Median Nerve: Slider distally at wrist. Side bend neck to other side while flexing and extending the wrist.

Median Nerve: Slider proximally at the neck. Extend the wrist while moving the neck from side flexion to neutral or ipsilateral side flexion.

---

Upper Limb Tension Testing Sitting Radial Nerve

- Place involved side in following position:
  - Abduction and internal rotation with slight extension
  - Elbow extension with forearm pronation
  - Wrist flexion
  - Add cervical side bending to uninvolved side clinical clues
Upper Limb Tension Testing

**Radial Nerve**

- Patient is supine while the examiner fixes the scapula with body weight.
- **Position 1:** Shoulder girdle depression
- **Position 2:** Shoulder internal rotation & forearm pronation
- **Position 3:** Wrist & finger flexion
- **Position 4:** Shoulder abduction
- **Position 5:** Cervical side-bending

**Positive Tests:** Symptoms with tensioning of the nerve

Differentiate
- Release cervical side-bending
- Release shoulder depression
- Release wrist flexion

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Upper Limb Tension Testing Sitting **Ulnar Nerve**

- Place involved side in following position:
  - Abduction and external rotation
  - Elbow flexion with forearm pronation
  - Wrist flexion
  - Add cervical side bending to uninvolved side for clinical clues

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Upper Limb Tension Test

**Ulnar Nerve**

- Patient is supine while the examiner fixes the scapula with body weight.
- **Position 2:** Wrist/finger extension
- **Position 2:** Forearm pronation
- **Position 3:** Elbow flexion
- **Position 4:** Shoulder external rotation
- **Position 5:** Shoulder girdle depression
- **Position 6:** Shoulder abduction

**Positive Tests:** Symptoms with tensioning of the nerve

Differentiate
- Release cervical side-bending
- Release shoulder depression
- Release wrist extension

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Ulnar Nerve Gliding

Ulnar Nerve:
- Tensioner tube behind medial epicondyle
  - Wrist/finger extension
  - Forearm pronation
  - Elbow flexion
  - Shoulder external rotation
  - Shoulder girdle depression
  - Cervical side bending

Ulnar Nerve: Slider
- Slider at the elbow. Side bend neck to opposite side. Flex and extend elbow.

Ulnar Nerve: Slider
- Slider proximally. Flex elbow and side bend neck to neutral or opposite side. May need to modify elbow extension.

Radial Nerve Gliding

Radial Nerve:
- Tensioner wrap the tube around the humerus
  - Shoulder girdle depression
  - Shoulder internal rotation & forearm pronation
  - Shoulder abduction 45° & 20°
  - Cervical side bending

Radial Nerve: Slider
- Slider at the wrist. Side bend neck to opposite side while flex/extend wrist to tolerance.

Radial Nerve: Slider
- Slider proximally. Move neck to opposite side and back to neutral with the wrist extended.

Novel Median Nerve Gliding Techniques

- Exercise 1: ER & Abd. at shoulder, elbow extension, supination, wrist and digit extension while performing digit abd./add.
- Exercise 2: ER & Abd. at shoulder, elbow extension, supination, wrist and digit extension while performing forearm supination and pronation

https://www.youtube.com/watch?v=Hl0CIg8QwY4
Novel Median Nerve Gliding Techniques

• Exercise 3: ER & Abd. at shoulder, elbow extension, supination, wrist and digit extension while performing elbow flexion and extension
  Modify with sliding at cervical (side bend when elbow is extended)

• Exercise 4: ER & Abd. at shoulder, elbow extension, supination, wrist and digit extension while performing shoulder circumduction

• Exercise 5: ER & Abd. at shoulder, elbow extension, supination, wrist and digit extension while performing shoulder distraction with side cervical bending

References


Website References

- https://www.orthobullets.com/spine/2031/cervical-myopathy