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

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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 intracellular 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 (Dille & Bove, 2008, Dilley et al, 2013)
- Mechanical stress of stretch and/or compression
- Neuropraxia
Median Nerve Entrapment

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

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
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 Quadratus
- Flexor Digitorum Profundus
- 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%

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


- Inconclusive

Found improvement in subjective function, parasthesia 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

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

*Standing at patients head

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 than 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
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

<table>
<thead>
<tr>
<th>Location</th>
<th>Common Causes of Compression</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>Proximal to bifurcation of the nerve</td>
<td>Ganglia and hook of hamate fractures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed motor and sensory</td>
</tr>
<tr>
<td>Zone 2</td>
<td>Surrounds deep motor branch</td>
<td>Ganglia and hook of hamate fractures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motor only</td>
</tr>
<tr>
<td>Zone 3</td>
<td>Surrounds superficial sensory branch</td>
<td>Ulnar artery thrombosis or aneurysm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensory only</td>
</tr>
</tbody>
</table>
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, stabilize 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.

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

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
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

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
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!

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Greening J. Clinical implications for clinicians treating patients with non-specific arm pain, whiplash and carpal tunnel syndrome. Man Ther. 2006;11:171-2.