Upper Extremity
Compression Neuropathies
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Carpal Tunnel Syndrome – Most common nerve entrapment

Risk Factors
• Obesity
• Hypothyroidism
• Diabetes (14–30%)
• Pregnancy (50%)
• Renal disease
• Inflammatory arthritis
• Mucopolysaccharidoses
• Gender (3:1, women: men)
• Advanced age (> 50 yrs)
• Genetic factors

Work Causation
• Work causation issue is controversial
• Increased incidence in dental hygienists, beef packers, assembly line workers
• Positional, mechanical & repetitive stress
• Hand-held vibrating tools are causative
• Keyboarding is not causative
• Work may not be the “prevailing factor”

CTS: Study of Carpal Canal Pressures
Gelberman et al., JBJS 1981, 63-A: 380–3
• Intracarpal canal pressures by wick catheter
• 15 patient w/CTS; 12 control subjects
• Wrist in neutral: 32 mmHg vs. 2.5 in controls
• VF: 94 vs. 31 mmHg; DF: 110 vs. 30 mmHg
• Canal pressure reduced w/CTR

Clinical Diagnosis
• Median nerve compression in carpal tunnel
• Median paresthesia aggravated by grasping
• Nocturnal paresthesia, morning numbness
• Symptoms relieved by shaking the hand
• Grip weakness, fatigue (thenar intrinsics)

Physical Findings
• Sensory tests (Semmes–Weinstein, 2 PD)
• Provocative tests (Phalen’s, Tinel’s, Durkan’s)
• Motor tests (FPB strength, thenar atrophy)
9 EMG/NCS is Confirmatory
  • Quantifies disease severity
  • Serves as a preoperative baseline
  • In early CTS or in dynamic CTS, nerve conduction may be normal
  • In late CTS, electromyogram shows fibrillation potentials, abn MUPs

10 Methods of Carpal Tunnel Release
  • Standard open
  • Mini-open (Indianatome)
  • Percutaneous, ultrasound guided
  • Endoscopic (one or two incision)

11 Open Carpal Tunnel Release – Surgical Technique
  • Local anesthesia, no tourniquet
  • Loupe magnification (2.5x – 4.5x)
  • Incision 3 cm mid-palm in line w/ radial ring
  • Divide entire TCL under direct vision
  • Inspect for anomalies, nerve pathology
  • Subcutaneous closure, splint

12 WALANT Technique – Use Local w/ Epinephrine, No Tourniquet
  • Popularized by Don Lalonde (President, AAHS)
  • Used for wide variety of hand cases
  • Permits active motion (tendon repair, transfer)
  • Avoids tourniquet pain, need for sedation
  • 1% lidocaine w/ epi 1:100,000 (< 7mg/kg)
  • Injection using the tumescent concept

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15 Not Required in Carpal Tunnel Release
  • Release Guyon’s canal
  • Step-cut lengthening TCL
  • Flexor tenosynovectomy
  • External epineurotomy
  • Internal neurolysis
  • Preserve subcutaneous nerves

16 Postoperative Protocol
  • Immediate digital motion
• Wrist motion in 2–3 days
• Doctor–patient therapy
• Hand therapy if needed
• Full activity 6–8 weeks

17 Current ASSH Practice Patterns
Results of Member Survey (2012 vs 1987)
• 85% obtain preop EMG/NCS
• More preop splinting, injections
• Most use local anesthetic (47% w/epinephrine)
• Most common technique is mini-open
• Concomitant procedures are rare
• 40% use postop splints (vs 80% in 1987)

18 Treatment Complications
• Nerve injection
• Artery, nerve, tendon injury
• Incomplete decompression
• Hematoma
• Hypertrophic / painful scar
• Perineural scar
• Bowstringing flexors
• Persistent / recurrent symptoms
• Complex Regional Pain Syndrome

19 Revision CTR
• Longer incision
• Repeat TCL release
• Dissect from normal to abnormal
• Epineurotomy (external)
• Neuroma turn back
• Protect nerve from new scar

20 Cubital Tunnel Syndrome – 2nd most common nerve entrapment

21 Cubital Tunnel Anatomy
• Medial epicondyle
• Olecranon
• Floor – elbow, UCL
• Roof – retinaculum

22 Osborne’s Ligament
O’Driscoll’s Classification
• Type 0 – Absent
• Type 1A – Tight in full flexion
• Type 1B – Tight in 90–120 deg arc
• Type 2 – anconeus epitrochlearis

23 Five Potential Points of Ulnar Nerve Compression
• Arcade of Struthers
• Medial IM septum
• Medial epicondyle
• Osborne’s ligament
• Osborne’s fascia
24 Changes in Ulnar Nerve Pressure & Cubital Tunnel Area with Elbow Flexion  
Gelberman et al., JBJS 1998, 80A: 492–501  
- Cadaveric study measuring pressures, area  
- Cross-sectional area cubital tunnel decreased  
- Intraneural pressure increased > extraneural  
- Traction causes increase intraneural pressure

25 Morphology of the Cubital Tunnel: An Anatomical and Biomechanical Study With Implications for Treatment of Ulnar Nerve Compression  
James et al., J Hand Surg 2011, 36A: 1988–95  
- 11 fresh frozen cadavers, optical & EM sensors  
- Ulnar nerve elongates with elbow flexion  
- Cubital tunnel retinaculum tightens with flexion  
- Tunnel cross-sectional area decreases w/flexion

26 Laxity of the Ulnar Nerve During Elbow Flexion and Extension  
- 11 fresh cadavers to assess ulnar nerve dynamics  
- No proximal–distal motion in cubital tunnel  
- Maximum nerve excursion proximal to elbow  
- Slack or laxity in nerve taken up with flexion

27 Ulnar Nerve at Elbow is Susceptible to Neuropathy  
- Five points of internal compression  
- Vulnerable to external compression  
- Elbow flexion increases traction  
- Flexion increases intraneural pressure

28 Etiology  
- Idiopathic  
- Intrinsic anomalies  
- Occupational  
- Trauma  
- Post–traumatic deformities  
- Elbow osteoarthritis  
- Ganglia, tumors, RA  
- Post–operative  
- Heterotopic ossification  
- Elbow UCL instability

29 Clinical Diagnosis  
- Intermittent ulnar paresthesia  
- Elbow flexion is provocative  
- Achiness medial elbow / forearm  
- Paresthesia progresses to constant  
- Loss of pinch & dexterity

30 Clinical Findings  
- Ulnar n. subluxation w/elbow flexion  
- Tinel’s sign is overly sensitive
- Passive elbow flexion test
- Elbow flexion w/digital pressure
- Prolonged static 2–PD
- Intrinsic muscle weakness, atrophy

31 Shoulder Internal Rotation Test
- Ochi, Japan, 2011
- Hold for 10 seconds
- Sensitivity = 80%
- Specificity = 100%
- Better than other tests
- Traction mechanism?

32 McGowan Grading Scale
- Grade I – Mild symptoms, intermittent paresthesia, no motor changes
- Grade II – Persistent paresthesia, mild intrinsic weakness, atrophy
- Grade III – Persistent sensory symptoms, marked intrinsic weakness, atrophy

33 EMG / NCS is Confirmatory
- > 50 m/sec is normal; < 50 m/sec, abnormal
- 15–25% reduction in velocity is diagnostic
- 40–50 m/sec range, often observe, serial exam
- < 40 m/sec, often require operative treatment
- Positive EMG indicates severe entrapment

34 Non–Operative Treatment
- Avoid provocative position, activity
- Pressure–absorbing elbow pad
- Figure–of–eight towel at night
- Night splint w/elbow flexed 45–60 deg
- 50% improve if entrapment is mild

35 Outcomes of Rigid Night Splinting and Activity Modification in the Treatment of Cubital Tunnel Syndrome
- 19 adults (25 limbs), mild entrapment
- 3–months night splinting, elbow 45 degrees
- At 2 years, 21 of 24 (88%) were not operated
- Mild or moderate CuTS are splinted x 3 mo

36 Surgical and Nonsurgical Treatment of Cubital Tunnel Syndrome in Pediatric and Adolescent Patients
Stutz et al., J Hand Surg 2012, 37A: 657–62
- 39 patients over 10–year period (rare)
- 25 of 30 (83%) failed conservative treatment
- 3 of 13 (23%) failed simple decompression
- Surgical treatment is effective in this group

37 Operative Indications
- Intermittent ulnar paresthesia, 6 months
- Constant ulnar paresthesia
- Symptomatic ulnar nerve subluxation
- Demonstrable ulnar motor weakness
- Prolonged static 2–PD, ulnar distribution
Positive EMG / NCS

38 Operative Techniques
- Simple in situ decompression
- Arthroscopic-assisted decompression
- Medial epicondylectomy (King & Morgan)
- Subcutaneous transposition (Curtis)
- Submuscular transposition (Learmonth)
- Intramuscular transposition (Adson)
- Transmuscular transposition (Dellon)

39 Incidence of Re–Operation and Subjective Outcome Following In Situ Decompression of the Ulnar Nerve at the Cubital Tunnel
- 56 adult patients (69 limbs), retrospective
- Nerve checked for stability, none transposed
- 5 of 69 (7%) failed in situ decompression
- All 5 improved w/revision submuscular rx

40 Intraneural Ulnar Nerve Pressure Related to Technique for Cubital Tunnel Decompression
- 50 fresh human cadavers
- Pressures measured at different nerve locations and in varying degrees elbow flexion
- All surgical techniques elevated pressure except anterior transmuscular transposition
- True for all sites in all positions of elbow flexion

41 Lateral Decubitus Position
- General anesthesia
- Bean bag stabilization
- Padded arm support
- Sterile tourniquet
- 2.5 x loupes
- Surgeon standing

42 Advantages of Lateral Decubitus
- Familiar position
- Front door to elbow
- Frees first assistant
- Avoids MABC
- Best view ulnar nerve
- Allows open CTR

43 Postoperative Protocol
- Drain removed 3 days postop
- Neoprene compression sleeve
- Early active elbow ROM
- OT for strengthening 4–6 weeks
- Full activity at 2–3 months

44 Simple Decompression Can Lead to Subluxation
- Subluxation accounts for 33% of my cases
• If preop subluxation, rx w/transposition
• If intraop subluxation, rx w/transposition
• Especially important in younger patients

45 Operative Findings in Reoperations for Cubital Tunnel Syndrome
Mackinnon & Novak; Hand 2007; 2: 137–43
• Retrospective study 100 pts (1995–2001)
• New ulnar nerve symptoms (55%)
• New pain in MABC distribution (55%)
• Ulnar nerve distal kinking at FCU (57%)
• MABC neuromas (73%)

46 Sound Surgical Principles Lead to Good Outcomes
• If transposition, avoid new compression
• If decompression, avoid destabilizing
• For all procedures, protect MABC nerve
• For all procedures, early mobilization

47 Uncommon Upper Extremity Nerve Entrapments

48 Ulnar Tunnel Syndrome – Ulnar nerve entrapment in Guyon’s canal
• Ganglia (triquetrohamate joint)
• Anomalous muscles
• Ulnar artery thrombosis
• Pseudoaneurysms
• Fractures hook of hamate
• Ulnar nerve subluxation

49 Guyon’s Canal Decompression
• Volar carpal ligament
• Pisohamate ligament
• Fibrous arch hypothenars
• Hook of hamate

50 Pronator Syndrome
• Clinical diagnosis
• Compression test at pronator teres
• Resisted forearm pronation is provocative
• Decreased senation at thenar eminence
• Electrodiagnostics are not helpful
• XR may show supracondylar process

51 Five Potential Points of Median Nerve Compression
• Ligament of Struthers
• Bicipital Aponeurosis
• Lacertus Fibrosis
• Pronator Teres
• Proximal FDS Arch

52 AIN Syndrome
• Weakness index FDP, FPL, PQ
• Difficulty writing, clumsiness
• If associated with pain, observe
• If tumor or trauma, decompress
• Unable to make “OK” sign
• EMG/NCS is confirmatory

53 Possible Anatomic Causes
• Deep head PT
• FDS leading edge
• Gantzer’s accessory FPL
• Variant muscles
• Aberrant vessels

54 Nonsurgical Treatment – Pronator or AIN Syndrome
• Activity modification
• NSAIDs
• Corticosteroid injection
• Minimum 3–month trial
• Highly effective

55 Surgical Decompression – AIN Syndrome
• Surgeon at patient’s head
• Release all compression points
• Bloodless dissection
• Light, compressive dressing
• Early elbow & wrist motion
• Activity modification 4–6 weeks

56 Radial Tunnel Syndrome
• Controversial diagnosis
• Lateral proximal forearm pain
• Distinguish from lateral epicondylosis
• ECRB tendinous origin implicated
• Electrodiagnostics not helpful
• Injection may confirm diagnosis

57 PIN Syndrome
• Motor deficit (no sensory loss)
• Weakness wrist & digital extension
• Wrist radial deviation on extension
• Positive compression test at supinator
• Causes: Trauma, inflammation, mass, entrapment, iatrogenic

58 Potential Points of Radial Nerve Compression
• Fascia anterior to radiocapitellar joint
• Leash of Henry (radial recurrent branches)
• Fibrous origin or leading edge of ECRB
• Arcade of Froshe (leading edge supinator)
• Trailing edge of supinator

59 Nonsurgical Treatment – PIN Syndrome
• Activity modification
• Stretching
• NSAIDs
• Corticosteroid injection
• 3 months observation

60 Surgical Decompression – PIN Syndrome
• Transmuscular (BR-splitting)
• BR–ECRL (Mackinnon)
• Posterior (Thompson)
• Anterior (modified Henry)

61 Anterior Approach – PIN Syndrome
• Surgeon sits in axilla
• Find SRN beneath BR and dissect proximally
• Find PIN and release all compression points
• Arcade of Froshe (leading edge supinator)
• Compression dressing, early motion
• Activity modification 4–6 weeks

62 Wartenberg’s Syndrome
• Cheiralgia paresthetica
• Direct compression SRN between BR and ECRL
• SRN compressed in pronation
• Distinguish from deQuervain’s
• Differentiate from LABC

63 Radial Sensory Nerve Release
• Divide forearm fascia
• Window BR tendon
• Release SRN proximal & distal