CARPAL TUNNEL SYNDROME AND CUBITAL TUNNEL SYNDROME

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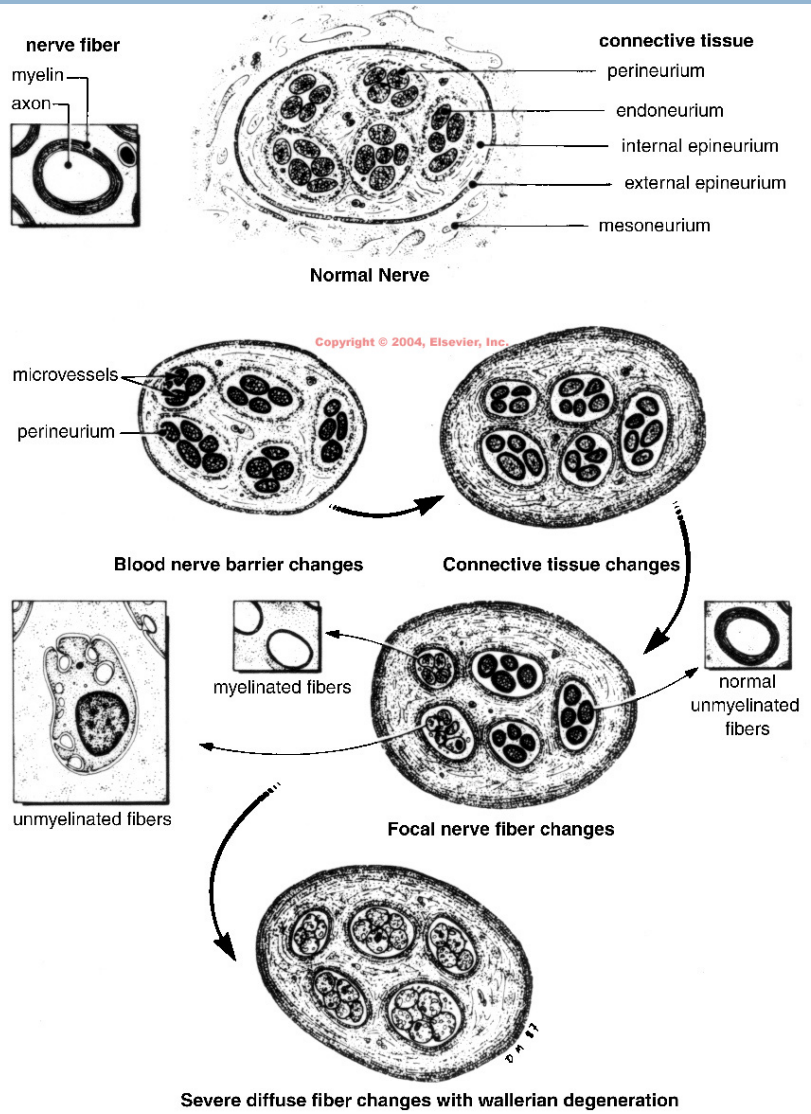
Chronic Nerve Compression

- Injury to blood-nerve barrier → subperineurial edema
- Thickening of external & internal epineurium
- Renaut's bodies seen in areas of compression following traction or repetitive motion
- Large myelinated fibers demonstrate segmental demyelination & unmyelinated fibers progressively degenerate
- With long-standing compression, wallerian degeneration may occur
- Clinically, patients at this point experience muscle atrophy & severe loss of sensation



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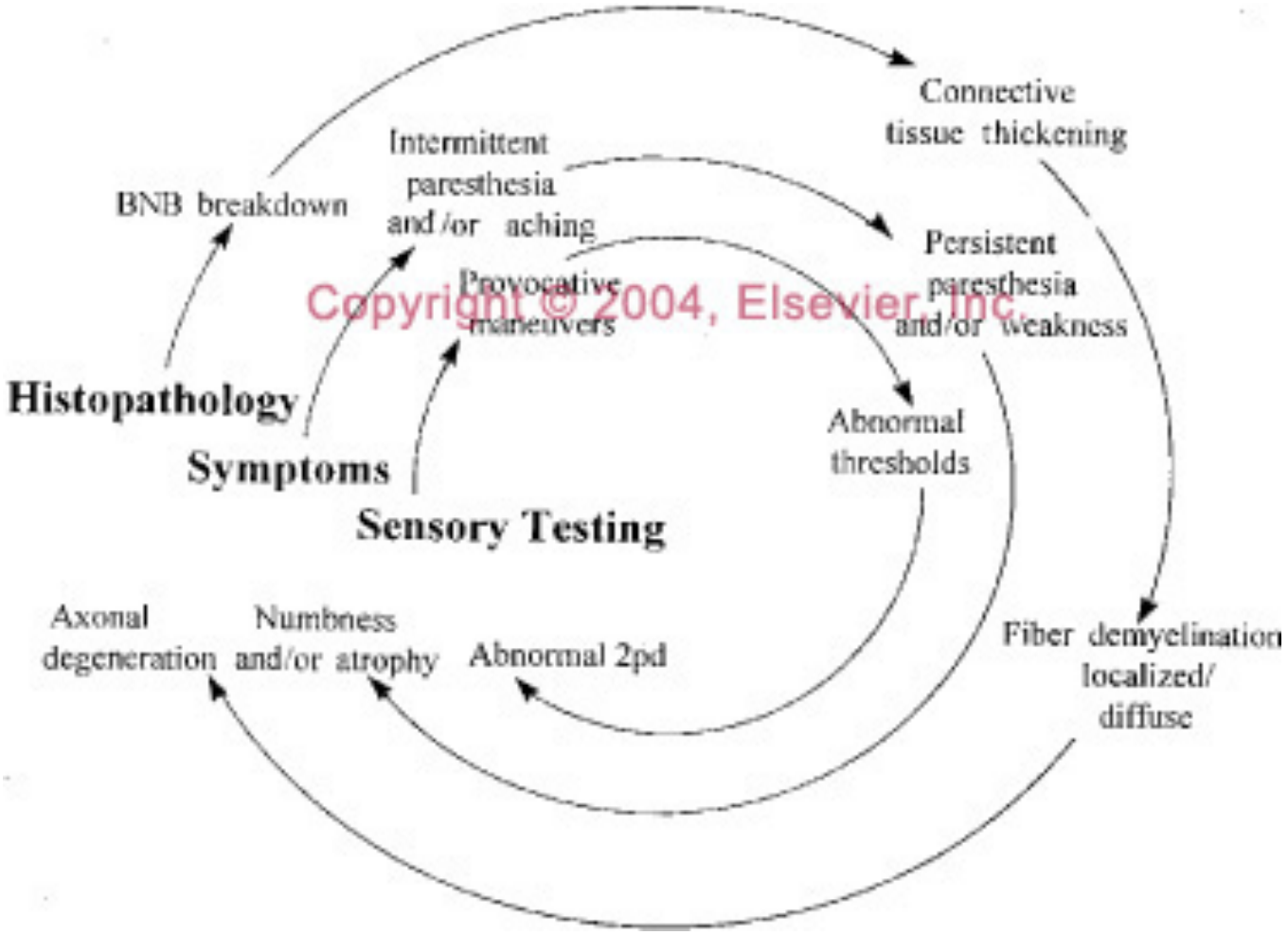


Carpal Tunnel Syndrome

Epidemiology

- Most common entrapment neuropathy
- Incidence: 125:100,000
- Affects1% in general population
  - Usually people who use their hands extensively in their jobs or daily activities – repetitive movements
- F:M 2.5:1
- >50% between ages 40 & 60
- Dominant hand most often affected
  - Bilateral in10% of patients

Clinical Presentation: History

- Insidious onset
- Numbness, tingling, or aching in radial half of hand & lateral 3 ½ digits
  - Entire hand may be involved
- Waking in the middle of the night w/ paresthesias & numbness – patient must shake or rub hand to obtain relief – characteristic
  - ? Hypotonia results in venous stasis
- Clumsiness or weakness of the involved hand
- Symptoms usually aggravated by activity / repeated wrist flexion
- May occasionally present w/ forearm, arm, & shoulder pain radiating from wrist

Clinical Presentation: Physical Exam

- Advanced disease:
  - Decreased sensation to pain or light touch in radial half of hand & lateral 3 ½ digits
  - Thenar muscle atrophy & weakness, esp APB
  - Phalen sign may be absent in patient w/ profound sensory loss

- Phalen sign: 60% sensitivity, 80% specificity
- Tinel sign: 49% sensitivity, 55% specificity
- Durkan test: 89% sensitivity

- +ve Phalen & Tinel signs + objective sensory findings in median nerve distribution – 85% diagnostic

Pathophysiology

- Any condition that increases volume of contents of carpal tunnel & thereby compresses median nerve may produce CTS

Associated Conditions

- Metabolic
  - Diabetes mellitus
  - Hypothyroidism
  - Vitamin B6 deficiency
  - Acromegaly
  - Renal failure/dialysis
  - Gout
  - Pregnancy / lactation
- Traumatic
  - Malunion of Colles / carpal fracture
  - Unreduced dislocation of wrist
  - Compression by cast
  - Improper immobilization of wrist
  - Burns at wrist
- Neoplastic / Mass Lesions
  - Ganglion cyst
  - Hemangioma
  - Lipoma
  - Xanthoma
  - Neurofibroma
  - Schwannoma
- Infectious
  - Septic arthritis
  - Palmar space infections
  - Lyme disease
  - Tuberculosis
  - Tenosynovitis
  - Histoplasmosis
- Systemic
  - Rheumatoid arthritis
  - Amyloidosis
  - Obesity
  - Mucolipidoses
  - Chondrocalcinosis
  - Multiple myeloma
  - Hemophilia
  - Alcoholism
  - Sarcoidosis
- Congenital
  - Narrow carpal canal
- Anatomical
  - Persistent medial artery: thrombosed
  - Persistent median artery w/ AVM
  - Anomalous tendons or muscles
  - Aberrant muscles (palmaris profundus)
- Acquired
  - Repetitive wrist motion (e.g. Typing, knitting, scrubbing

Diagnostic Tests

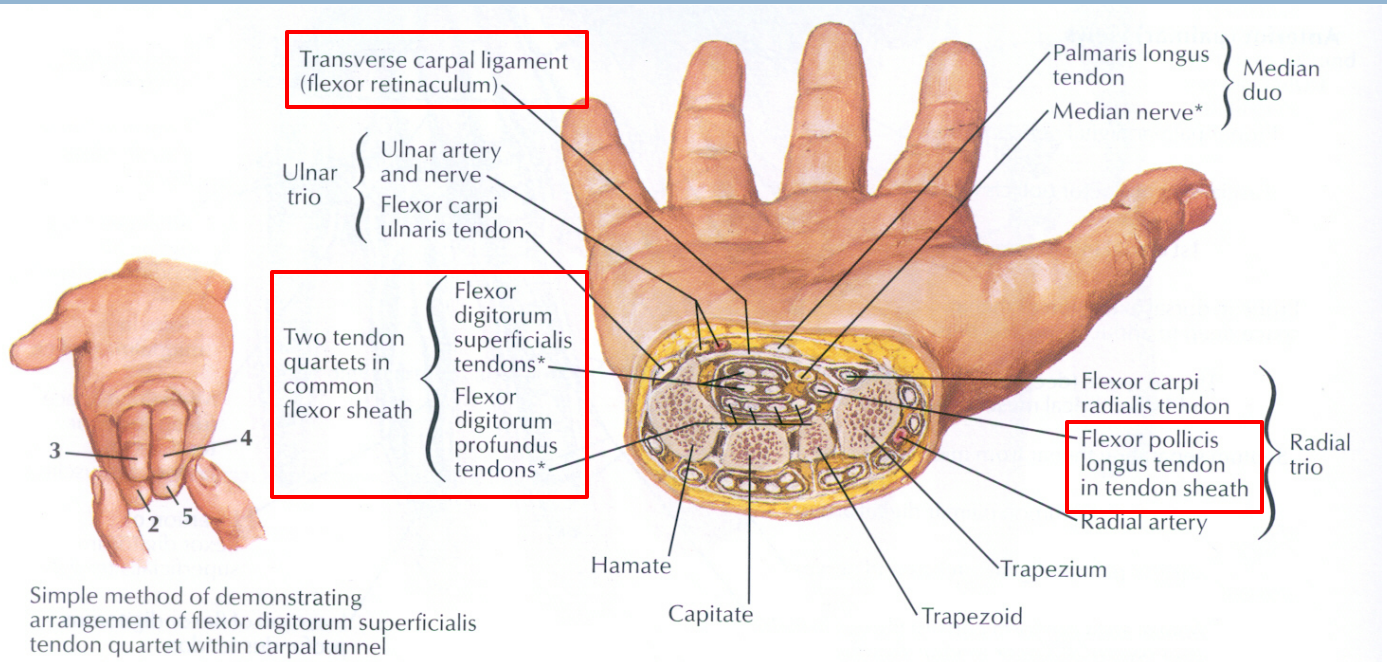
- Confirm CTS
- Rule out other neuropathies

- Electrodiagnostic studies: sensitivities 49% to 90%
- Nerve conduction studies: conduction block or slowing
  - Sensory evoked response – earliest & most sensitive
    - Prolonged distal sensory latency – decreased amplitude or absence
    - May be influenced by various factors e.g. age, obesity, edema, & temperature
  - Motor latency across carpal tunnel of >4 msec diagnostic
- EMG can help differentiate CTS from high median neuropathies, C6-C7 radiculopathies, or brachial plexus lesions
  - Advanced cases: loss of motor units & denervation potentials (fibrillations & positive sharp waves) in thenar muscles

Management Options

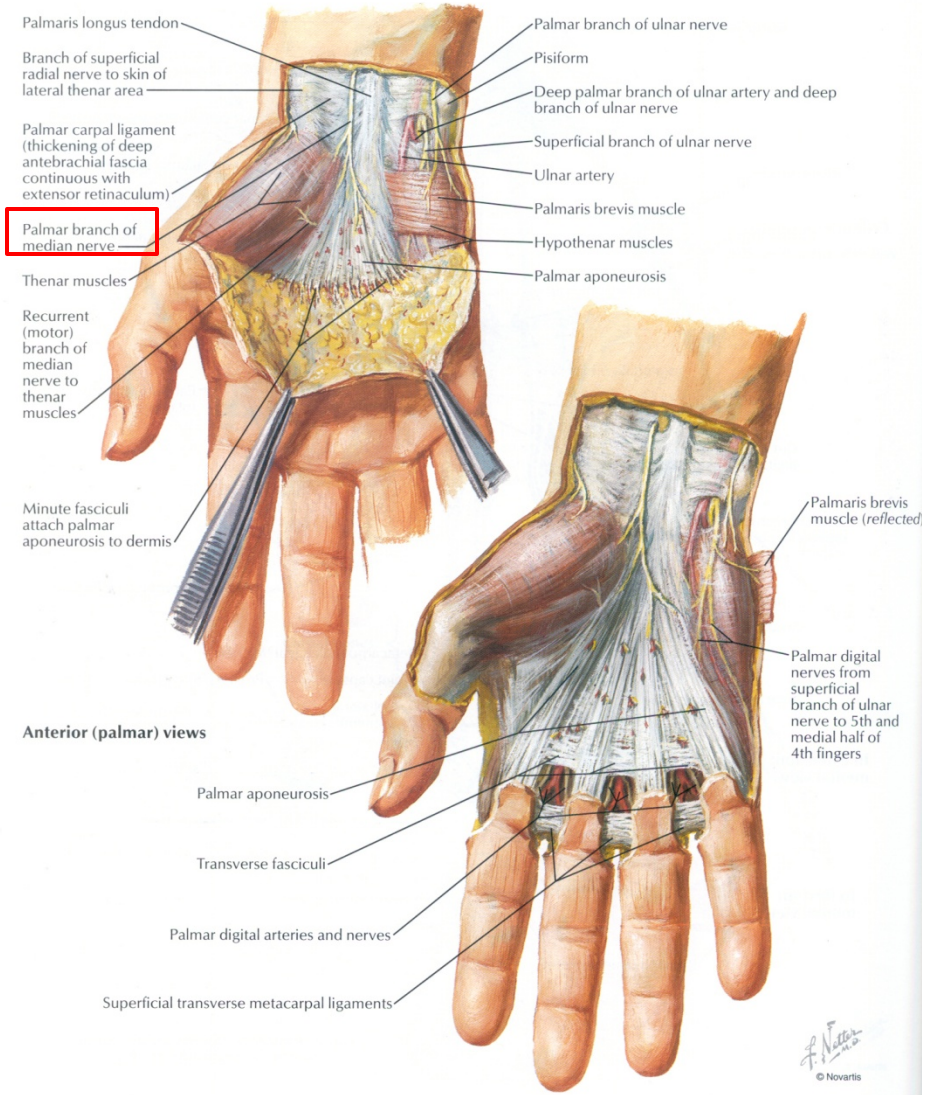
- Conservative
  - Activity modifications – avoidance of repetitive stressful motion of the hands
  - Splinting of wrist in neutral position
    - Relief in 80% of patients, however, symptoms may return once splints removed
  - Corticosteroid injections into carpal tunnel
  - Oral NSAIDs or steroids
- Surgical
  - Transverse carpal ligament release
    - Open
    - Endoscopic
  - Indications:
    - Failure of conservative management
    - History of progressive or unremitting sensory loss
    - Thenar muscle atrophy or weakness
    - Severe median neuropathy w/ electrophysiological evidence of axonal loss

Anatomy of the Carpal Tunnel



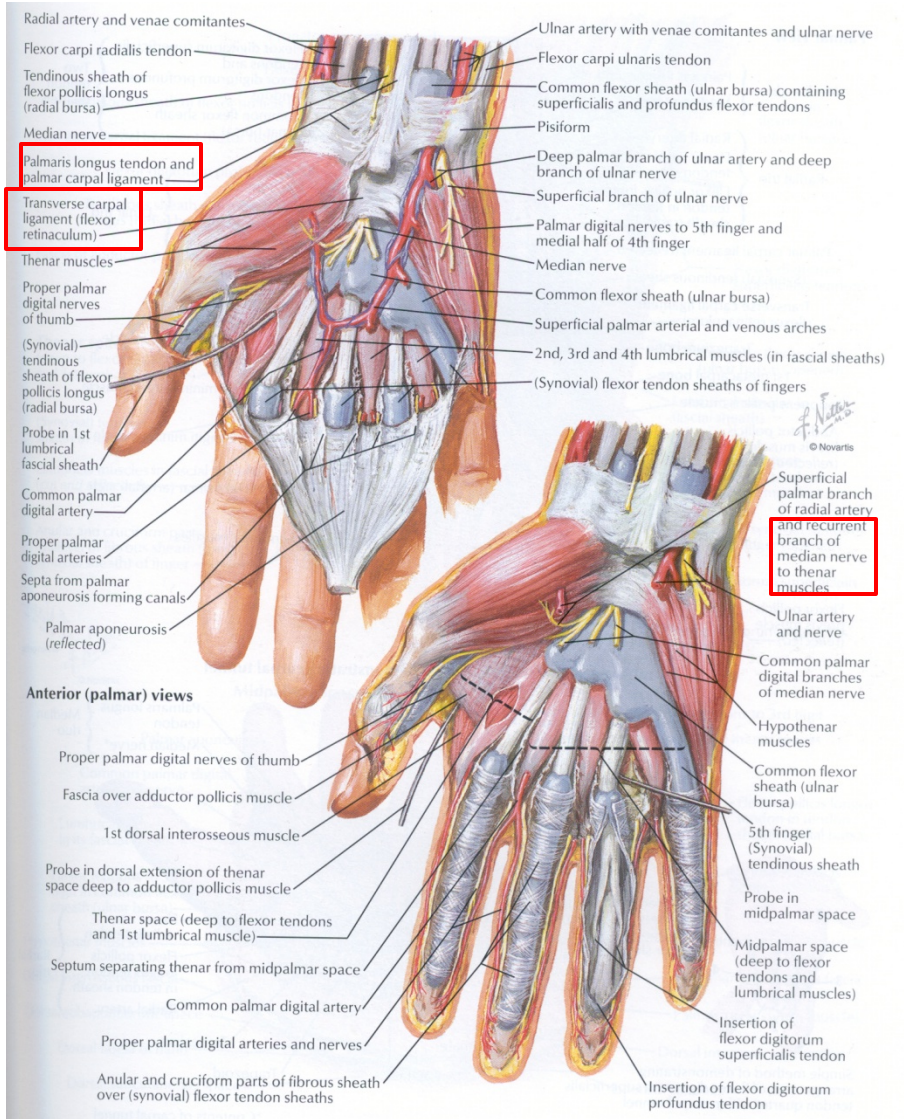
- Roof: transverse carpal ligament
  - Radial attachment: trapezium & scaphoid tuberosity
  - Ulnar attachment: pisiform & hook of the hamate
- Floor: volar radiocarpal ligament & ligaments between carpal bones
- Contents:
  - 9 flexor tendons – FPL, FDS x4, FDP x4
  - Median nerve – located radial to palmaris longus tendon

Palmar Cutaneous Branch of the Median Nerve



- Supplies sensation to base of thenar eminence
- Usually arises 2 cm proximal to TCL (or 3 to 4 cm proximal to distal wrist crease) & courses superficial to TCL, radial to palmaris longus tendon

Recurrent Motor Branch of the Median Nerve



- Supplies:
  - Abductor pollicis brevis
  - Opponens pollicis
  - Superficial head of flexor pollicis brevis
- Usually arises 3 cm distal to distal wrist crease
- Variants:
  - Extraligamentous & recurrent – 50%
  - Subligamentous – 30%
  - Transligamentous – 20%
  - Multiple accessory motor branches

TCL Release: Open

- Local anesthetic: 1% lidocaine w/ epinephrine
- Incision
  - 3 to 4 cm incision extending from distal wrist crease to a point in line w/ distal border of extended thumb, on ulnar side of palmaris longus tendon, in line w/ long axis of ring finger
  - Should be at ulnar edge of median nerve
- Layers divided: skin & subcutaneous fat → palmar fascia / palmar carpal ligament → transverse carpal ligament
  - Maximal point of entrapment 2 cm below level of distal wrist crease
  - Use mosquito to gently dissect under TCL & incise TCL w/ tonotomy scissors or scalpel – distally & then proximally
    - Distally – enter palmar fat space
    - Proximally – divide TCL 2 cm proximal to wrist crease – enter deep fascia of forearm
- Inspect median nerve ± explore carpal tunnel for tumor, ganglion cysts, muscle anomalies, or synovitis
- Hemostasis w/ bipolar coagulation
- Close skin w/ interrupted vertical mattress nylon sutures
- Apply protective bulky hand dressing
- Post-op instructions
  - Encourage finger movement
  - Restrict wrist movement x few days

Outcome

- Overall:
  - Good to excellent relief of symptoms in ~80%
  - Partial relief in ~10%
  - No change ~9%
  - Exacerbation of condition in <1%
- Patients w/ muscle atrophy & weakness pre-op:
  - 84% have return of normal function
  - 9% have some improvement
  - 7% show no improvement or become worse
- Sensory symptoms:
  - 78% have reduction in paresthesias & numbness post-op
  - 59% recover sensory function
- Pain & mild sensory symptoms usually resolve
- More severe manifestations partially improve post-op
  - Severe degree of axonal loss & nerve damage
- Conduction velocities improve in parallel to clinical response, over 8 to 12 weeks

Complications

- Inadequate release of ligament → persistence of symptoms
- Post-op fibrosis & scarring → return of symptoms
- Tender or hypertrophic scars
- Tender neuroma of palmar cutaneous branch of median nerve
- Section of recurrent motor branch of median nerve → complete denervation & atrophy of thenar muscles
- Reflex sympathetic dystrophy
- Bowstringing of flexor tendons
- Wound infection

Open vs. Endoscopic TCL Release

Systematic review of randomized clinical trials of surgical treatment for carpal tunnel syndrome

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Background: Carpal tunnel syndrome (CTS) is a common disorder for which several surgical treatment options are available. However, there is no consensus on the most effective method of treatment. The object of this systematic review is to compare the efficacy of the various surgical techniques in relieving the symptoms of CTS and promoting return to work and/or activities of daily living.

Methods: Computer-aided searches of Medline, EMBASE and the Cochrane Controlled Trials Register were conducted, together with reference checking. A rating system, based on the number of studies and their methodological quality and findings, was used to determine the strength of the available evidence for the efficacy of the treatment.

Results: Fourteen studies were included in the review. None of the alternatives to standard open carpal tunnel release (OCTR) seems to offer better relief of symptoms. There is conflicting evidence about whether endoscopic carpal tunnel release results in earlier return to work and/or activities of daily living.

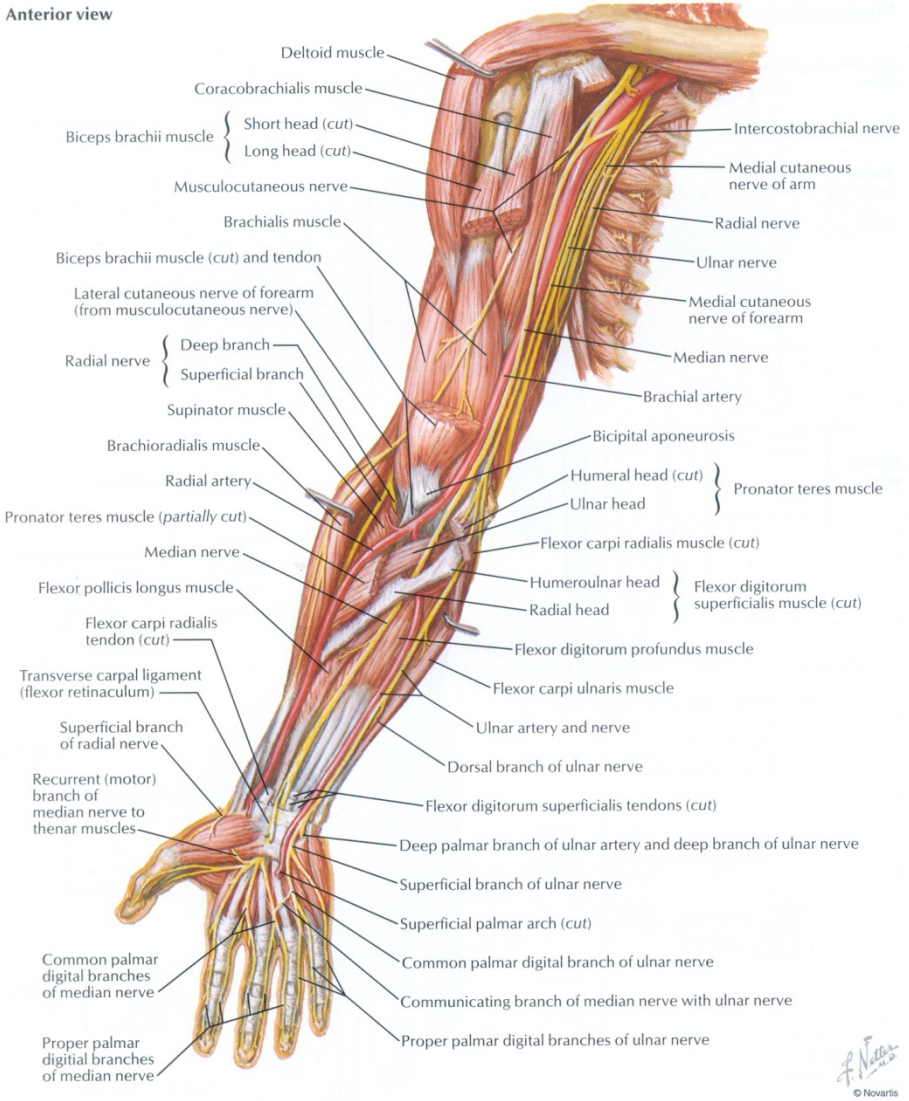
Conclusion: Standard OCTR is still the preferred method of treatment for CTS. It is just as effective as the alternatives, but is technically less demanding, so incurs a lower risk of complications and of added costs.

Paper accepted 16 May 2001

British Journal of Surgery 2001, 88, 1285–1295

Cubital Tunnel Syndrome

Ulnar Nerve: Arm



- Terminal continuation of medial cord, derived from C8 & T1 roots
- Courses into upper medial arm anterior to latissimus dorsi tendon in a groove between coracobrachialis muscle laterally & long / medial heads of triceps muscle
- At middle of arm, pierces medial intermuscular septum & courses anteriorly along medial head of triceps muscle
- Approaches elbow posterior to medial intermuscular septum & in close association w/ insertion of medial head of triceps muscle
- Traverses arcade of Struthers (present in 70% of population) at ~8 cm above medial epicondyle as it descends from anterior into posterior compartment

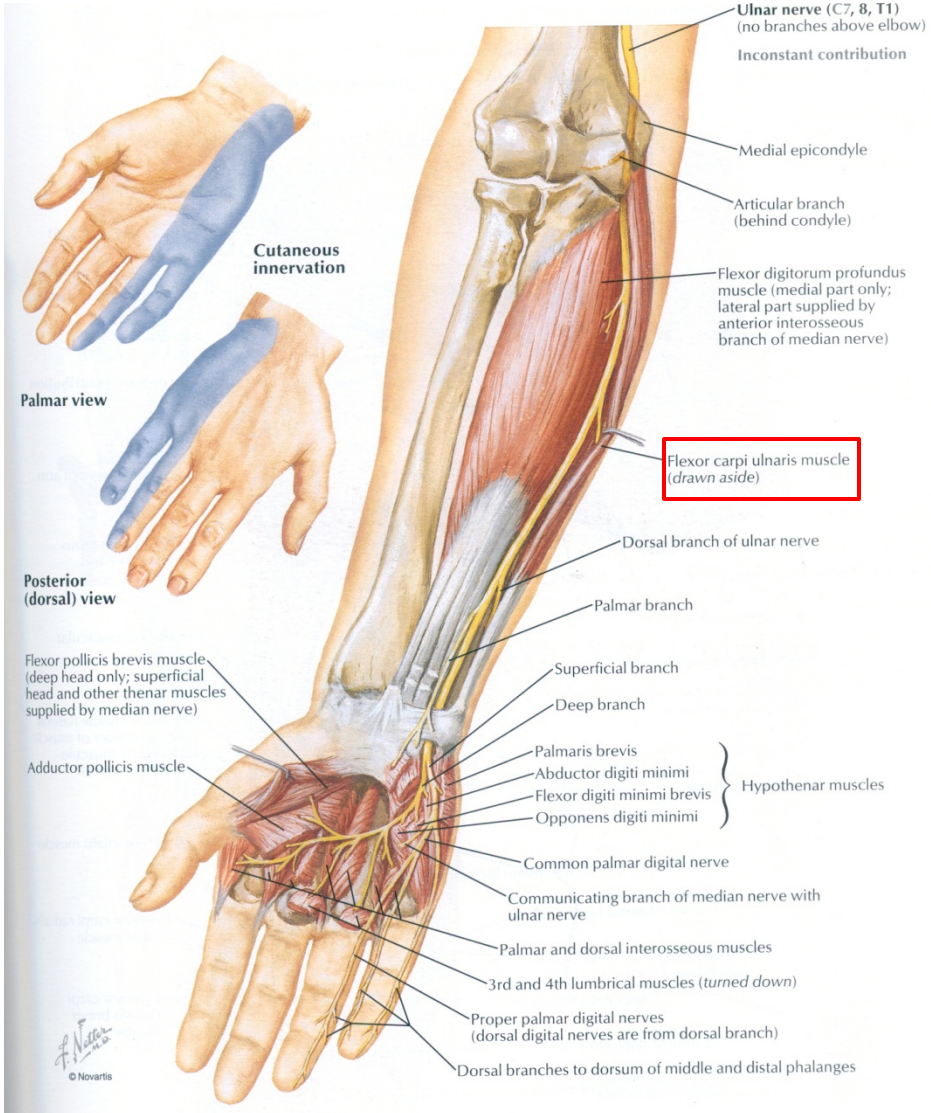
Ulnar Nerve: Elbow

- Lies in postcondylar groove on dorsum of medial epicondyle
- Gives off articular branches to elbow joint before entering cubital tunnel between medial epicondyle & olecranon
- In cubital tunnel, ulnar nerve covered by arcuate ligament, which extends from medial humeral epicondyle to tip of olecranon
  - Arcuate ligament connects 2 heads of FCU

- Cubital tunnel:
  - Roof – arcuate ligament
  - Floor – medial collateral ligament & elbow joint capsule
  - Walls – olecranon & medial epicondyle

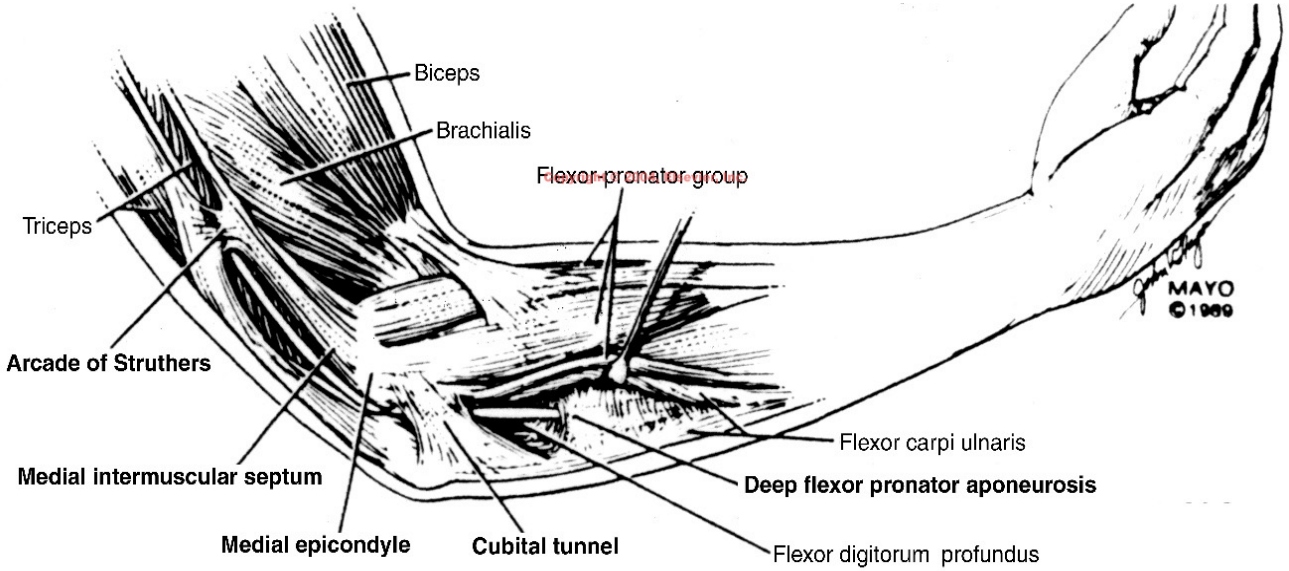
- Rare cause of compression: ancoeus epitrochleoanconeous muscle
  - Anomalous muscle extends from medial epicondyle to olecranon
  - Present in as many as 30% of patients

Ulnar Nerve: Forearm



- 1st muscular branch to FCU
- Enters forearm between humeral & ulnar heads of FCU
- Descends over medial side of forearm & FDP, covered by FCU

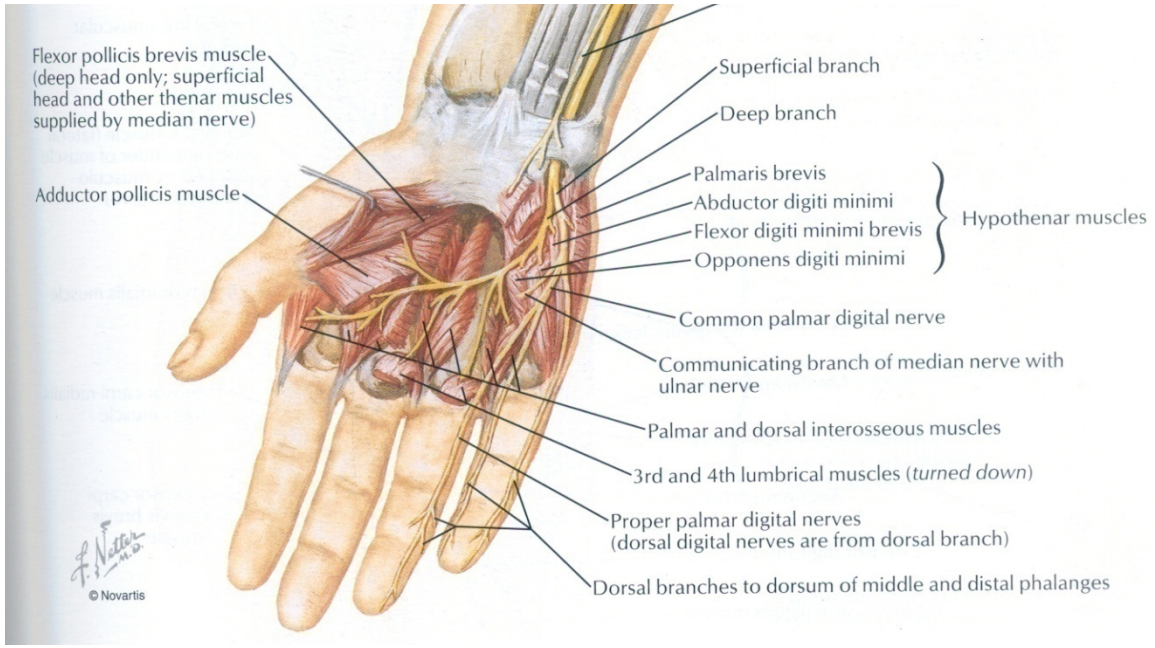
5 Potential Levels of Compression of Ulnar Nerve In Region of the Elbow



- Arcade of Struthers – thick fascial structure spanning from medial head of triceps to medial intermuscular septum, located ~8 cm proximal to medial epicondyle
- Medial intermuscular septum – after anterior transposition
- Medial epicondyle
- Cubital tunnel – 2 heads of FCU form arcuate ligament of Osborne
- Flexor-pronator aponeurosis
- Deep fascia within FCU – after anterior transposition

Ulnar Nerve: Wrist and Hand

- Proximal to wrist, dorsal sensory branch becomes subcutaneous ~5 cm proximal to pisiform
  - This branch supplies sensation to dorsal ulnar hand & ulnar 1 ½ digits proximal to DIPj
- As ulnar nerve traverses wrist, it lies on medial aspect of ulnar artery, beneath FCU tendon, & crosses radial to pisiform to enter Guyon canal
- Guyon canal:
  - Roof – volar (palmar) carpal ligament
  - Floor – transverse carpal ligament
  - Medial wall – pisiform
  - Lateral wall – hook of hamate



- 3 zones of distal ulnar tunnel:
  - Zone 1: proximal to bifurcation of ulnar nerve into sensory & motor branches – begins at proximal edge of volar carpal ligament & runs for 2 to 3 cm
  - Zone 2: envelops deep motor branch, which supplies the hypothenar muscles, 3rd & 4th lumbricales, adductor pollicis, deep head of FPB, all interossei muscles
  - Zone 3: surrounds superficial branch, which supplies palmaris brevis & palmar skin of small finger & ulnar ½ of ring finger

Ulnar Nerve Entrapment at the Elbow

- 2nd most common nerve entrapment syndrome of upper extremity

- Superficial location of ulnar nerve at the elbow renders it vulnerable to direct trauma during routine activities of daily living

Pathophysiology

- Compression & stretch
  - Area of cubital tunnel decreases up to 55% w/ elbow + wrist ulnar flexion – as result of stretching & tautness of arcuate ligament in flexion & active FCU contraction
  - Shallower groove on inferior surface of medial epicondyle raises floor of cubital tunnel during flexion
  - 600% increase in intraneural pressure in cubital tunnel w/ wrist extended, elbow flexed, & shoulder abducted
  - Ulnar nerve increases in length by 4.7 mm during elbow flexion
  - Fusiform enlargement of ulnar nerve behind medial epicondyle seen in ~50% of normal cadaveric ulnar nerves – thought to be due to increase in connective tissue
- Motion
  - Ulnar nerve slides ~10 mm proximally & 3 mm distally around elbow during flexion-extension maneuver

Clinical Presentation: History

- Insidious onset
- Early: paresthesias & numbness in ulnar nerve distribution – small and ring fingers
  - Aggravated by prolonged elbow flexion
- Late: weakness of intrinsic hand muscles
  - Clumsiness or impaired hand grip
  - Loss of fine motor skills in affected hand
- Aching pain in medial forearm or elbow

Clinical Presentation: Physical Exam

- Elbow flexion-pressure test w/ compression
  - Flex elbow w/ forearm in neutral position & apply pressure to ulnar nerve just proximal to cubital tunnel – +ve when symptoms reproduced within 1 min
  - Most sensitive & specific provocative test
- Decreased light touch & 2-pt discrimination
- Tinel sign
- Atrophy of intrinsic hand muscles & weakness most evident in 1st dorsal interosseous muscle
- Wartenberg sign
  - Involvement of 3rd palmar interosseous muscle (adductor) produces abduction of little finger
- Froment sign
  - Abnormal distal thumb flexion during attempted thumb adduction due to substitution of median innervated flexor pollicis longus for ulnar-innervated adductor pollicis
- Clawing of ring & little fingers
  - Lumbrical & interosseous tendons (ulnar supplied muscles) no longer work, which destabilizes MCP joints, resulting in wasting of the action of extensor tendons (radial supplied muscles) & allowing flexor tendons (median supplied muscles) to overpower extensor tendons

Subluxation of Ulnar Nerve

- 16% of normal population

- Childress classification
  - Type A: subluxation to tip of medial epicondyle
  - Type B: subluxation beyond medial epicondyle

- Assoc w/ ulnar neuropathy – increased susceptibility to trauma or frictional type injury
- Marked "snapping" of ulnar nerve may represent a subluxing, prominent, or hypermobile triceps muscle & may be related to ulnar nerve compression at the elbow
  - Portion of tendinous insertion of medial head of triceps should be resected

Differential Diagnosis

- Cervical disc
- Thoracic outlet syndrome
- Ulnar nerve compression at wrist

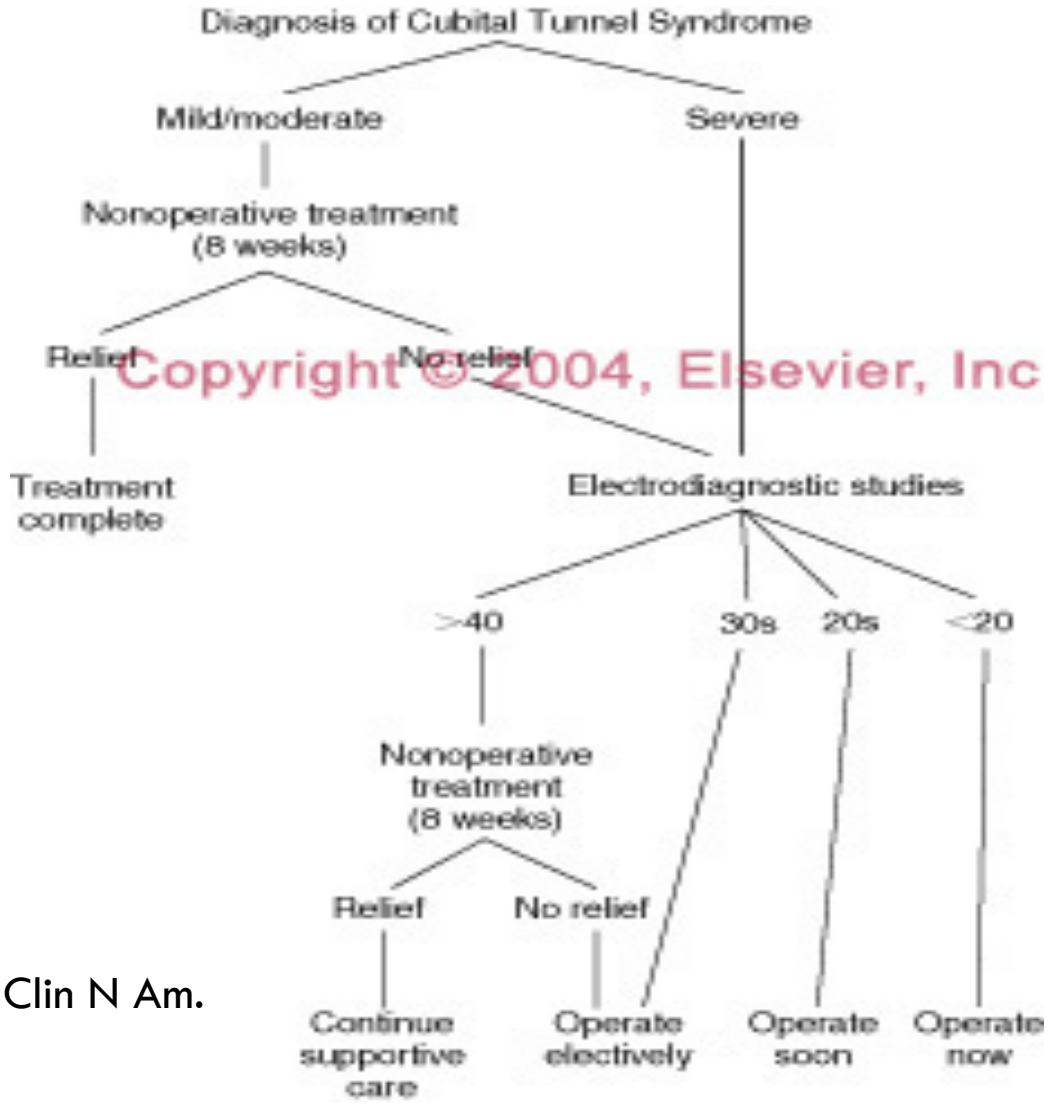
Diagnostic Tests

- Helpful to localize points of compression along course of ulnar nerve
- Nerve conduction studies – focal prolonged latency across elbow w/ normal distal forearm velocity
  - <50 m/s generally considered diagnostic
- EMG – may show signs of denervation (i.e. reduced voluntary motor unit potentials, fibrillations, increased insertional muscle activity)
- Imaging – elbow deformity, previous fracture, tumor or ganglion

Management Options

- Conservative
  - Activity modification
    - Avoid repetitive elbow flexion or leaning on flexed elbow
- Surgical
  - Indications
    - Failure of conservative management
    - Muscle weakness or atrophy
    - Severe ulnar neuropathy w/ electrophysiological evidence of axonal loss
  - Operate early to prevent further axonal degeneration & functional loss

Treatment Algorithm



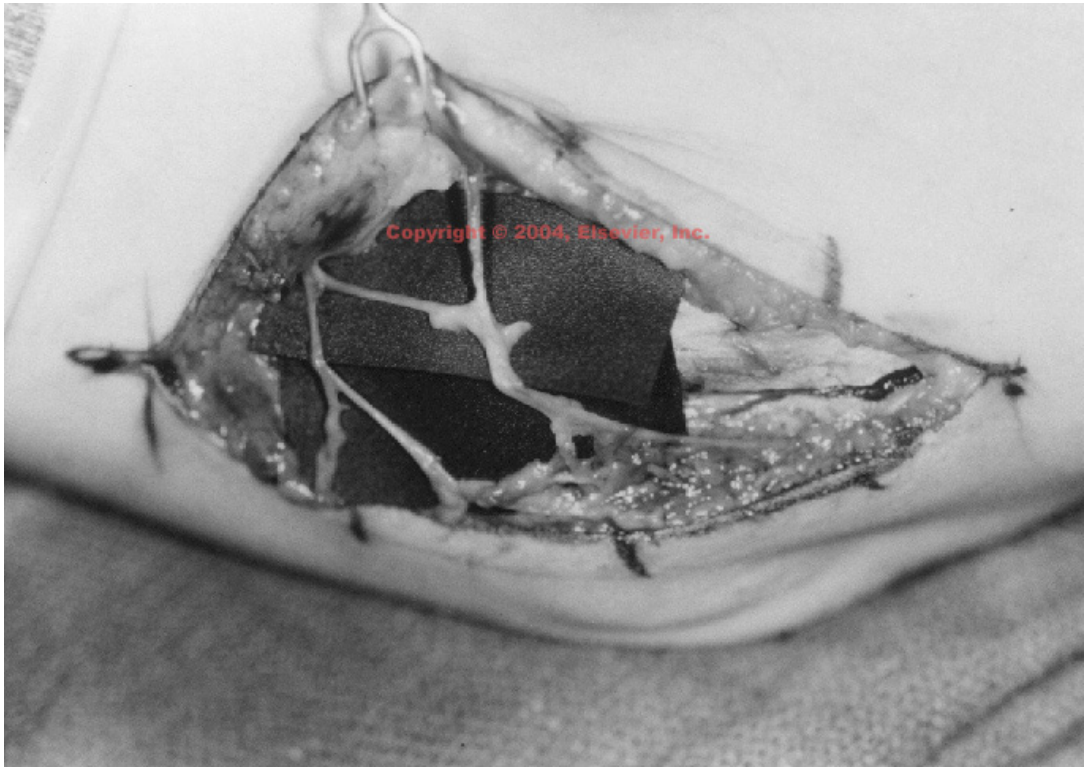
Lowe JB et al. Neurosurg Clin N Am. 12:267-284, 2001.

Surgical Management

- Simple decompression ± medial epicondylectomy
- Anterior transposition – places ulnar nerve anterior to axis of elbow motion & decreases nerve tension during flexion
  - Subcutaneous
  - Submuscular
  - Intramuscular

Medial Antebrachial Cutaneous Nerve

- Terminal branch of medial cord of brachial plexus
- Anterior & posterior branches course both distal & proximal to medial epicondyle
  - Both at risk when incision made at elbow
- Persistent pain or hypesthesia post-op may be due to injury to branch MABC nerve
  - Neuroma



Simple Decompression

- 8 cm curvilinear incision overlying cubital tunnel
- Release of FCU fascia spanning olecranon & medial epicondyle

- Advantages
  - Easy to perform
  - Minimally traumatic – ulnar nerve branches & blood supply relatively undisturbed
- Disadvantages
  - Possibility of incomplete release of all compression points
  - Dislocation of ulnar nerve

- Outcome: good to excellent results in 75-90%

- Complication rates low
  - Failure to relieve symptoms as a result of incomplete release of all points of compression
  - Post-op scarring around nerve
  - Increase tendency for ulnar nerve subluxation

Medial Epicondylectomy

- Simple decompression followed by linear incision in the aponeurotic origin of pronator teres & flexor muscles of the forearm over the front of the medial epicondyle to allow subperiosteal dissection of fascia from bone
- Epicondyle & 2-5 cm of medial supracondylar ridge removed w/ drill or chisel
- Bone waxed & split aponeurosis sutured to provide a smooth surface for the nerve
- Outcome: good to excellent results in 72-90%
- Complications
  - Medial elbow instability – may be prevented by preserving medial collateral ligament & partial epicondylectomy
  - Elbow flexion contracture – may be related to improper reattachment of flexor-pronator muscle origin or prolonged post-op elbow immobilization

Anterior Transpositions

- Need longer incision compared to simple decompression
- Nerve must be free circumferentially at least 4 to 8 cm above & below elbow to permit transposition without tension
  - Always require section of the small ulnar articular branches at the elbow & branches to FCU may need to be lengthened by neurolysis
  - Circumferential nerve dissection increases chances of vascular compromise & ischemia of nerve as well as damage to FCU branches
- New points of compression may be created
  - Medial intermuscular septum
  - Deep flexor-pronator aponeurosis
  - Fascial sling
  - Flexor-pronator muscle mass

Subcutaneous Transposition

- Fasciodermal sling from flexor-pronator mass used to secure nerve in anterior position or can plicate subcutaneous layer directly to flexor-pronator fascia to prevent subluxation of ulnar nerve

- Outcome: good to excellent results in 83%

Which Procedure?

- No consensus on optimal surgical treatment for cubital tunnel syndrome
  - Most studies are flawed
- Simple decompression considered if ulnar nerve does not sublux
- Epicondylectomy rarely performed & reserved for patients who have bony deformity of the medial epicondyle
- Anterior transposition often used to create smooth linear & unencumbered course of ulnar nerve across elbow
  - Transposition type determined by patient's anatomy & surgeon's preference – subcutaneous preferred
  - Transposition assoc w/ more complications

Simple Decompression vs. Anterior Transposition

Anterior Transposition Compared with Simple Decompression for Treatment of Cubital Tunnel Syndrome

A Meta-Analysis of Randomized, Controlled Trials

By Michael Zlowodzki, MD, Simon Chan, MD, Mohit Bhandari, MD, MSc, Loree Kalliainen, MD, and Warren Schubert, MD

Investigation performed at the University of Minnesota, St. Paul, Minnesota

Background: There is currently no consensus on the optimal operative treatment for cubital tunnel syndrome. The objective of this meta-analysis of randomized, controlled trials was to evaluate the efficacy of simple decompression compared with that of anterior transposition of the ulnar nerve in the treatment of this condition.

Methods: Multiple databases were searched for randomized, controlled trials on the outcome of operative treatment of cubital tunnel syndrome in patients who had not previously sustained trauma or undergone a surgical procedure involving the elbow. Two reviewers abstracted baseline characteristics, clinical scores, and motor nerve-conduction velocities independently. Data were pooled across studies, standard mean differences in effect sizes weighted by study sample size were calculated, and heterogeneity across studies was assessed.

Results: We identified four randomized, controlled trials comparing simple decompression with anterior ulnar nerve transposition (two submuscular and two subcutaneous). In three studies that included a total of 261 patients, a clinical scoring system was used as the primary clinical outcome. There were no significant differences between simple decompression and anterior transposition in terms of the clinical scores in those studies (standard mean difference in effect size = −0.04 [95% confidence interval = −0.36 to 0.28], $p = 0.81$). We did not find significant heterogeneity across these studies ($I^2 = 34.2\%$, $p = 0.22$). Two reports, on a total of 100 patients, presented postoperative motor nerve-conduction velocities; they showed no significant differences between the procedures (standard mean difference in effect size = 0.24 [95% confidence interval −0.15 to 0.63] in favor of simple decompression, $p = 0.23$; $I^2 = 0\%$, $p = 0.9$).

Conclusions: The results of this meta-analysis suggest that there is no difference in motor nerve-conduction velocities or clinical outcome scores between simple decompression and ulnar nerve transposition for the treatment of ulnar nerve compression at the elbow in patients with no prior traumatic injuries or surgical procedures involving the affected elbow. Confidence intervals around the points of estimate were narrow, which probably exclude the possibility of clinically meaningful differences. These data suggest that simple decompression of the ulnar nerve is a reasonable alternative to anterior transposition for the surgical management of ulnar nerve compression at the elbow.

Level of Evidence: Therapeutic Level I. See Instructions to Authors for a complete description of levels of evidence.

J Bone Joint Surg Am. 2007;89:2591-8 • doi:10.2106/JBJS.G.00183

Post-op Care

- Arm in splint that immobilizes elbow flexed at 90 degrees w/ forearm in pronation & wrist in neutral
- Splint & dressing removed 2 to 3 days post-op
- Patient started on ROM exercises to prevent scarring
- Caution against heavy lifting & instruct patient to slowly stretch forearm into supination & elbow into extension

Outcome

- Nonselective series (various procedures)
  - Good to excellent outcome in 60%
  - Fair in 25%
  - Poor (no improvement or increase in symptoms) in 15%

- Factors that portend poor outcome
  - Traumatic causes
  - Symptoms persisting for >1 year pre-op
  - Severe pre-op atrophy, weakness, clawing, dysesthesia, or pain
  - Alcoholism
  - Absence of an evoked sensory potential & large numbers of fibrillations on EMG

References

Papers

- Gerritsen AAM, Uitdehaag BMJ, van Geldere D, Scholten RJPM, de Vet HCW, and Bouter LM. "Systematic review of randomized clinical trials of surgical treatment for carpal tunnel syndrome." British Journal of Surgery. 88:1285-1295, 2001.

- Zlowodzki M, Chan S, Bhandari M, Kalliainen L, and Schubert W. "Anterior transposition compared with simple decompression for treatment of cubital tunnel syndrome." J Bone Joint Surg Am. 89: 2591-8, 2007.

Books

- Netter's Atlas of Human Anatomy

- Surgery of Peripheral Nerves: A Case-Based Approach: Chapters 21, 22, 25, 26, & 27

- Youman's Neurological Surgery, 5th ed.: Chapters 255 & 256