“What’s New in Orthopaedics?”

Carpal Tunnel Syndrome

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14 May, 2019

Objectives

- Anatomy of the carpal tunnel and median nerve
- Clinical diagnosis and examination techniques
- Decision-making for electrodiagnostic testing
- Nonoperative and Operative treatment strategies
  - Based on the 2016 Clinical Practice Guidelines from the American Academy of Orthopaedic Surgeons
Disclosures

- None financial

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  - Several provided are referenced with their source material.
  - Other images used are publicly available on the internet and have been cited accordingly.

The Median nerve

- Sensation to the radialmost 3.5 digits

- Motor function to the thumb and 2 radial lumbricals:
  - Abductor pollicis brevis
  - Opponens pollicis
  - Flexor pollicis brevis (superficial head)

- More proximally, the median nerve innervates
  - Pronator teres
  - Flexor carpi radialis
  - Flexor digitorum superficialis
  - Palmaris longus
  - Anterior Interosseous Nerve
    - Flexor pollicis longus
    - Flexor digitorum profundus – Index/Long
    - Pronator Quadratus
**Anatomy of the Carpal Tunnel**

- The Median Nerve enters carpal tunnel along with 9 other structures
  - FPL tendon
  - 4 FDS tendons
  - 4 FDP tendons
- Roof - Transverse Carpal Ligament
- Floor – Carpal bones

**The Transverse Carpal Ligament**

- 28.5 mm in length longitudinally, range 22-36 mm
- Widest at the proximal-distal ends, narrowest at the hook of the hamate
- Thickness of approximately 2.2 mm ± 0.32 mm

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https://commons.wikimedia.org/wiki/File:Gray422.png

Recurrent Motor Branch of the Median Nerve

- Provides motor innervation to thenar musculature
- Structure at potential risk during carpal tunnel release surgery
- Variability in anatomic course reported
  - Subligamentous – 31%
  - Extraligamentous – 46%
  - Transligamentous – 23%
  - Ulnar takeoff


Carpal Tunnel Syndrome

- Entrapment neuropathy of the median nerve at the carpal tunnel
- Characterized by numbness/tingling in the thumb through ring fingers
- Volar wrist pain that can radiate proximally
- Fine motor weakness and/or atrophy
  - Clumsiness with small objects like coins or buttons
- Often symptomatic at night
  - Can disturb sleep quality in as much as 80% of patients with CTS


Carpal Tunnel Syndrome

- Incidence of clinically significant CTS
  - 104-496:100,000 person-years
- Prevalence of 7.8% in US working population
- Estimated 500,000 carpal tunnel release surgeries performed annually in US
- Age-dependent increase may exist in males
- Bimodal distribution shown in females

Risk Factors

- Strong evidence
  - High repetition rate of hand use
  - BMI
- Moderate evidence
  - See List
- Limited evidence
  - Dialysis
  - Fibromyalgia
  - Varicosis
  - Distal radius fracture


**Occupational Risk Factors**

- **Strong** – Repetitive/Forceful exertion
- **Moderate** – Use of vibrational tools
- No direct relationship shown that typing or keyboard use increases risk for CTS

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**Women’s Health Considerations**

- **Moderate evidence**
  - No increased/decreased risk of CTS associated with use of oral contraceptives or female hormone replacement therapy
  - ~28% of females without prior symptoms will have symptoms of CTS in their 3rd trimester of pregnancy
  - Majority resolve by 6 weeks postpartum
  - Those with symptoms at 3 months postpartum often have persistent and/or worsening symptoms

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Mora AN, Bizar PE, Tapicza BA, Rogers J, Economy K, Barp BE. Prospective evaluation of the incidence and persistence of gestational carpal tunnel syndrome. Presented at ASSH annual meeting, Boston, MA, September 14, 2018.
What about Diabetes?

- 230 pts undergoing EMG and U/S for diagnosis of CTS
- Compared findings in pts with/without diabetes mellitus and with/without CTS
- 1 variable showed statistical significance
  - Action potential amplitudes in females with diabetes, $p < 0.001$
- Several differences identified in EMG findings between those with/without diabetes


Diagnosis

- 2-point tactile discrimination testing
- Tinel sign
- Phalen’s test
- Durkan’s median nerve compression test
- Thenar weakness/atrophy
- Wartenberg’s pinwheel

https://www.ncmedical.com/item_705.html
https://slideplayer.com/slide/4241124/
https://slideplayer.com/slide/26414
https://www.researchgate.net/figure/Test-de-Durkan-declenchant-les-paresthesies-par-compression-du-nerf-median-a-laide-des_fig1_236944568
https://en.wikipedia.org/wiki/Wartenberg_wheel
https://en.wikipedia.org/wiki/Carpal_tunnel_syndrome

Durkan’s Median Nerve Compression Test

- Described in case-control study of 46 EMG-positive hands vs 50 control hands
- Direct pressure applied for up to 30 seconds
- Sensitivity of 87%
- Specificity of 90%

Thenar atrophy

- Strong evidence
  - “Thenar atrophy is strongly associated with ruling-in CTS, but poorly associated with ruling-out CTS.”

https://en.wikipedia.org/wiki/Carpal_tunnel_syndrome

Diagnosis

- Strong and Moderate evidence supports the use of multiple physical examination tests to confirm diagnosis.
- Individually, tests are poor to rule in or out CTS.

Imaging?

- Radiographs can be helpful:
  - Carpal tunnel view
  - Often used for hook of hamate fractures
  - Can also identify radiopaque space-occupying lesions in carpal tunnel.
Imaging?

- Moderate evidence
  - MRI not routinely needed for diagnosis of CTS

- Limited evidence
  - Ultrasound not routinely needed for diagnosis of CTS

Growing role for Ultrasound

- Sensitivity of 91%; Specificity of 94%

- Severity of CTS symptoms associated with
  - Greater decrease in cross-sectional area of the median nerve over course of carpal tunnel
  - Thickness of the TCL


Electrodiagnostics

- Propagation of action potentials can be recorded using surface electrodes
  - CNAP - Combined nerve action potential
  - SNAP - Sensory nerve action potential
    - Pure sensory nerve
  - CMAP - Compound muscle action potential
- Can measure speed and amplitude of nerve signal, as well as help discern locations of compression

NCS/EMG in Carpal Tunnel Syndrome

- Opinions differ on utility of EMG testing for carpal tunnel syndrome
- Pros
  - Can add objective information to confirm diagnosis when diagnosis not clear
  - Different sites of compression?
  - Can serve as baseline into in case patient does not improve after surgery or if condition recurs
- Cons
  - Cost (Time and Finances)
  - Can be painful (needles involved)
  - May or may not change treatment plan

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How does EMG impact care?

- Population study of 62,894 pts undergoing EMG

- Pts undergoing EMG...
  - Waited 36% longer to undergo surgery, $p < 0.001$
  - Had an extra doctor’s visit, $p < 0.001$
  - Experienced overall average $996 greater cost$
  - Paid additional average $112 out of pocket

- Still...57% of hand surgeons in 1 study required EMG testing be performed prior to referral

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How powerful a test is EMG?

- Cited sensitivity of 91%, specificity of 83%

- Prospective cohort study of 40 hands undergoing EMG for reasons other than CTS

- 43% false-positive rate for EMG

- Compared to 27% false-positive rate for U/S

- Authors recommended U/S over EMG for confirmation of CTS diagnosis
Does EMG testing have prognostic value?

- Prospective study of 256 hands in 199 patients
- No correlation of electrodiagnostic severity with relief of symptoms after carpal tunnel release surgery

Should referring providers obtain EMG’s prior to referral?

- They can be helpful if obtained prior to initial hand surgery evaluation, but I don’t mandate them.
- If patients demonstrate active denervation on EMG testing, I generally recommend prompt surgery.
- Limited evidence
  - “hand-held nerve conduction study (NCS) device might be used for the diagnosis of carpal tunnel syndrome.”
- Moderate evidence
  - “diagnostic questionnaires and/or electrodiagnostic studies could be used to aid the diagnosis of carpal tunnel syndrome.”

Treatment - Splinting

- First-line treatment typically includes a period of night splinting
- Splints in neutral wrist posture (rather than extension) optimize volume in carpal tunnel
- Strong evidence
  - Splinting “should improve patient-reported outcomes”

Steroid Injections

- Often considered at the time of initial presentation or after splinting has failed to relieve symptoms
- For pts with mild CTS
  - 93.7% note considerable improvement in their symptoms with improvement in nerve conduction and functional scores at 3 months post-injection
- For pts with more severe CTS (atrophy, weakness, symptoms > 1 year)
  - Only 22% symptom-free at mean 18 months post-injection

References:
- http://www.carpal-tunnel.net/treatments/splinting
Steroid Injections – Effect on Blood Glucose

- Steroid injections in the hand/wrist shown to elevate blood glucose measurements in the first 2 days
  - Mean increase of 43.1 mg/dL over baseline on post-injection day 1
  - Mean increase of 17.1 mg/dL over baseline on post-injection day 2
  - No statistical difference compared to baseline from post-injection day 3 on
- Greater likelihood of glucose elevation in type 1 diabetics and those taking insulin


Steroid Injections

- Strong evidence
  - “Use of steroid (methylprednisolone) injection should improve patient reported outcomes”

https://www.imagenesmy.com/imagenes/carpal-tunnel-injection-procedure-2e.html
Magnet therapy?

- Strong evidence
  - No benefit to magnet therapy for CTS


Oral agents?

- Moderate evidence
  - No benefit to
    - Diuretic
    - Gabapentin
    - Astaxanthin
    - NSAIDs
    - Pyridoxine

  - “Oral steroids could improve patient reported outcomes as compared to placebo.”

https://www.doctoroz.com/topic/pharmacy

**Surgical release**

- Indicated for patients who have had persistent symptoms refractory to nonoperative treatment
- Division of the transverse carpal ligament to relieve pressure on the median nerve
- Strong evidence
  - "surgical release of the transverse carpal ligament should relieve symptoms and improve function."
  - "...should have a greater treatment benefit at 6 and 12 months as compared to splinting, NSAIIDs/therapy, and a single steroid injection."

**Surgical techniques**

- Several available
  - Traditional open
  - Endoscopic
    - 1-incision
    - 2-incision
  - Mini-open
    - Longitudinal and Transverse incision options


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http://www.wheelessonline.com/ortho/incision_for_carpal_tunnel_release
http://www.eorthopod.com/endoscopic-carpal-tunnel-release/
https://www.spineorthopedicnm.com/sports-medicine/carpal-tunel-release/
Which technique is best?

Benefits of endoscopic cited in literature
- Same relief of symptoms in long-term
- Better recovery
- Earlier return to work
- Possibly better early satisfaction scores

Benefits of open
- Direct visualization of anatomic structures
- Generally costs less
- Lower complication rate
  - 0.1% vs 5%

http://www.wheelessonline.com/ortho/endoscopic_carpal_tunnel_release.html
http://compressionneuropathy.blogspot.com/2012/05/carpal-tunnel-syndrome-surgical-release.html


Which technique is best?

Limited evidence
- Surgeon “might consider using endoscopic carpal tunnel release based on possible short term benefits.”
Anesthesia and Setting?

- Cost savings and drive to improve efficiency and convenience for patients and physicians has led surgeons to consider
  - CTR in procedure room or clinic rather than OR
  - Local anesthesia rather than regional or general anesthetic
  - Limited evidence
  - Supports Local anesthesia over Bier block for possibly longer post-op pain control


Outcomes after open CTR

- Cohort of 1,049 pts
  - 93.8% had improvement at 6 months in functional outcome scores
  - 1.9% complication rate
  - Pts with more severe symptoms preop had better relief of symptoms post-op

Patients sleep better after surgery

- Cohort of 398 patients undergoing CTR
  - Statistically significant improvement in all 7 questions on the Insomnia Severity Index instrument at 2 weeks post-op
  - Improvement not related to severity on pre-op EMG
Depression may impact outcome

- Study of 227 pts with 1-year post-op follow-up
- Pts with depression demonstrated higher pre-op/post-op Boston CTQ scores and post-op palmar pain scores compared to those without, p < 0.05
- Depression does not independently predict persistent symptoms after surgery
- Symptoms of depression decrease with CTS symptoms after surgery
- Correlation unclear

| Table 1. Baseline Characteristics of All Study Participants and a Comparison of These Characteristics Between Patients With and Without Depression at Baseline* |
|---------------------------------|-------------------------------|----------------|----------------|-------|
| Study Participants | No Depression at Baseline (n = 182) | Depression at Baseline (n = 29) | P Value | Missing Data |
| Participants | 227 | 162 | 25 | 0% |
| Preoperative CTQ-D Score | 2 (1-3) | 2 (1-3) | 2.7 (2.3-3.2) | <0.05 | 16 (57.1%) |
| Age (y) | 58 (46-71) | 58 (46-71) | 62 (42-66) | 0.14 | 0 |
| Sex (f/male) | 167 (74.9%) | 136 (74.8%) | 51 (65.2%) | 0.33 | 0 |
| Preoperative BCTQ Score | 2.7 (2.3-3.2) | 2.7 (2.3-3.2) | 3.3 (2.6-3.9) | <0.05 | 6 (20.7%) |
| Alcohol intake (current) | 2.6 (0.0-7.0) | 2.0 (0.0-7.0) | 1.0 (0.0-5.0) | 0.44 | 35 (16.6%) |
| Diabetes mellitus, present | 16 (7.2%) | 11 (6.1%) | 2 (6.9%) | 0.46 | 5 (2.2%) |
| NSI abnormality | 13 (5.7%) | 9 (5.4%) | 9 (9.1%) | 0.07 | 9 (4.0%) |
| Mild | 71 (32.0%) | 57 (32.6%) | 32 (51.6%) | 134 (99.9%) | 149 (92.3%) | 3 (1.6%) |
| Moderate | 71 (32.0%) | 57 (32.6%) | 32 (51.6%) | 134 (99.9%) | 149 (92.3%) | 3 (1.6%) |
| Severe | 34 (15.9%) | 28 (15.3%) | 6 (9.7%) | 8 (5.8%) | 10 (6.6%) |

*Continuous data are presented as median (25th-75th percentiles).

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Workers' compensation

- Systematic Review of CTR in work comp population
- WC pts returned to work almost 5 weeks later than non-WC pts
- WC pts “16% less likely to return to pre-injury vocation, and had lower SF-36 scores.”
- 3x increased complication rate
- Nearly 2x rate of persistent pain after surgery

| Table 2. Outcomes and Complications. |
|-------------------------------------|-------------------------------|----------------|----------------|-------|
| Outcome | WC | Non-WC | WC | Non-WC |
| Time to return to ADL | 4.9 | 4.9 | 6.5 | 6.5 |
| % return to work | 76% | 76% | 90% | 90% |
| Time to return to work | 61.5 | 61.5 | 61.5 | 61.5 |
| Continual pain | 40.0% | 40.0% | 40.0% | 40.0% |
| SF-36 score | 46.3 | 46.3 | 46.3 | 46.3 |
| % Improvement | 91.1% | 91.1% | 91.1% | 91.1% |
| % pain | 15.7% | 15.7% | 15.7% | 15.7% |
| % improvement | 45.6% | 45.6% | 45.6% | 45.6% |
| % Numbness | 16.7% | 16.7% | 16.7% | 16.7% |
| % return to work | 60.0% | 60.0% | 60.0% | 60.0% |
| P Value | <0.05 | <0.05 | <0.05 | <0.05 |

*Bold values indicate statistical significance (p < 0.05). **OR** = odds ratio; **P** = p-value; **WC** = workers compensation; **N** = non-compensated

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Risk factors for post-op infection

- Retrospective review of 454,987 Medicare pts
  - Infection rate of 0.32%
  - Independent risk factors
    - Younger age
    - Male sex
    - Obesity (BMI 30+)
    - Tobacco or Alcohol use
    - Medical comorbidities

### Table 1. Significant Risk Factors for Infection After Open CTR

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>95% Confidence Interval</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age &lt; 65 y</td>
<td>1.82</td>
<td>1.64–2.02</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Male sex</td>
<td>1.62</td>
<td>1.48–1.77</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Body mass index 30–40</td>
<td>1.34</td>
<td>1.19–1.50</td>
<td>&lt; .001</td>
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<tr>
<td>Body mass index &gt;40</td>
<td>1.85</td>
<td>1.64–2.07</td>
<td>&lt; .001</td>
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<tr>
<td>Tobacco use</td>
<td>1.45</td>
<td>1.31–1.60</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Alcohol use</td>
<td>1.57</td>
<td>1.36–1.82</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Medical comorbidities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.17</td>
<td>1.06–1.29</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>0.91</td>
<td>0.81–1.03</td>
<td>.124</td>
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<tr>
<td>Hypertension</td>
<td>0.94</td>
<td>0.83–1.09</td>
<td>.416</td>
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<tr>
<td>Inflammatory arthritis</td>
<td>1.28</td>
<td>1.13–1.46</td>
<td>&lt; .001</td>
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<tr>
<td>Peripheral vascular disease</td>
<td>1.20</td>
<td>1.08–1.34</td>
<td>&lt; .001</td>
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<tr>
<td>Congestive heart failure</td>
<td>1.06</td>
<td>0.95–1.18</td>
<td>.291</td>
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<tr>
<td>Coronary artery disease</td>
<td>0.91</td>
<td>0.83–1.01</td>
<td>.080</td>
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<tr>
<td>Chronic Ven disease</td>
<td>1.27</td>
<td>1.12–1.45</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>1.16</td>
<td>1.03–1.30</td>
<td>.012</td>
</tr>
<tr>
<td>Chronic lung disease</td>
<td>1.13</td>
<td>1.02–1.24</td>
<td>.015</td>
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<tr>
<td>Depression</td>
<td>1.78</td>
<td>1.62–1.96</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Renal disease</td>
<td>1.06</td>
<td>0.87–1.30</td>
<td>.559</td>
</tr>
<tr>
<td>Hypersensitivity</td>
<td>1.11</td>
<td>0.92–1.32</td>
<td>.274</td>
</tr>
</tbody>
</table>

*P < .05 was considered statistically significant.


Diabetes mellitus

- Retrospective cohort of 1,144 open CTR procedures
  - 14 pts (1.2%) required secondary surgery for persistent symptoms, hematoma, or infection
  - Increased risk of secondary surgery associated with diabetes

- Retrospective cohort of 7,958 diabetic pts undergoing open CTR with Hgb a1C measurements within 3 months of CTR
  - Increased rate of surgical site infections in first year post-op above a Hgb a1C threshold between 7 and 8

Werner BC, Tanan VA, Conlinne J, Deal DN. The association of perioperative glycemic control with postoperative surgical site infection following open carpal tunnel release in patients with diabetes. Hand (N Y). 2017 Dec;1:1558944717433194. [Epub ahead of print]
Postoperative pain management

- Double-blind PRT comparing acetaminophen, ibuprofen, and oxycodone after CTR in 105 pts

- For open CTR, mean total pill consumption:
  - OXY – 3.7 pills
  - IBU – 5.1 pills
  - ACE – 4.2 pills

- No statistical difference in average daily pain scores

Return to work after CTR

- No clear guidelines exist, although a 2015 report from the UK provides general recommendations based on Level 5 evidence

- Supervisory/Managerial work: 1-2 weeks after surgery

- Light manual (clerical/secretarial): 2-4 weeks after surgery

- Medium manual (cleaner/carer/nurse): 4-6 weeks after surgery

- Heavy manual: 6-10 weeks after surgery

- Custodial/Rescue services: 6-10 weeks


Strength after CTR

- Prospective cohort study of 24 wrists before and after CTR
  - Pinch strength reached 96% of preop level at 6 weeks
  - Grip strength reached preop level at 3 months
  - Typing speed returns to preop level between 2 and 3 weeks after surgery
  - Mean improvement of 4 words per minute at 12 weeks post-op

Need for preoperative antibiotics?

- Multiple studies now support no routine need for preoperative antibiotics before clean, elective hand surgery.
- Not shown to affect postoperative infection rates
  - Even for pts with diabetes
- Limited evidence
  - “no benefit to routine use of prophylactic antibiotics prior to carpal tunnel release”

Do patients need therapy post-op?

- **Moderate evidence**

  - "no additional benefit to routine supervised therapy over home programs in the immediate postoperative period."

- **Cochrane review**

  - Overall limited and low-quality evidence in the literature to support any specific postoperative rehabilitation regimen

- **Strong evidence**

  - No need for routine post-op immobilization


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Thanks!

https://explorehealthcareers.org/career/occupational-therapy/occupational-therapist/


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