Seeing the Light at the End of the Carpal Tunnel
Prevention & Treatment Strategies

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CTS statistics
- High incidence:
  - 0.1 % to 10% of general population
  - most common nerve compression
- Direct medical costs: > 1 billion per year
- >500,000 surgeries per year in U. S.
  (NY Times article, 7-14-2013)

Patterson & Simmons, 2002
O'Connor et al, 2009

Economic Burden
- Higher in CT than UE fracture
  - Washington State Dept. of Labor & Industries
  - Median days off per worker's comp claim
    - 138 for CT
    - 46 days for fracture
  - Earnings post-injury >30 % less with CTS


Light provided for CTS
- Describe the pathophysiology & diagnosis
- Identify the most likely risk factors
- Highlight prevention techniques
- Conservative management
- When is surgery necessary?
- When is therapy needed after surgery?
- Prognosis for recovery and return to work
Clinical Practice Guideline for Conservative Management of CTS

Severe CTS
- Loss of:
  - muscle at base of thumb
  - ability to pick up small objects, button, etc.

Pathology in CTS
- Tunnel formed by:
  - Transverse Carpal Ligament
  - Carpal bones
- Contents of tunnel:
  - 9 Flexor tendons
  - Median nerve
- Tight compartment:
  - Thickened tendons
  - Swelling
  - Enlarged bone
- Increased pressure chokes blood supply to nerve

Symptoms of CTS
- Numbness, tingling, pins & needles
  - median nerve distribution
  - many times whole hand
  - frequently drop objects
- Pain:
  - hand & palm side of wrist
  - occasionally up to shoulder
- Symptoms usually worse at night and disturb sleep

Diagnosis: Symptoms
Katz Hand Diagram
- Patients asked to fill out hand diagram with symptoms
- Rated only on numbness & tingling (not pain)
- Classic=sx in at least 2 digits in median n. distrib. but not palm
- Unlikely: none of these digits

From: Katz et al 1990
**Diagnosis: Symptoms**  
*Boston Carpal Tunnel Scale*

- Self-report questionnaire  
- Symptom Severity Scale  
  - Sample questions: severity of pain, numbness/tingling  
  - Scaled 1-5  
    - 1 = none – very severe  
- Functional Severity Scale  
  - Sample questions: writing, buttoning, grip telephone  
  - Scaled 1-5  
    - 1 = no problem-unable to perform

**Diagnosis: Provocative tests**

- Tinel's sign  
  - occurs in an area of nerve injury--protective covering (myelin) removed  
  - electrical sensation when percussed

**Diagnosis: Rule Out**

- Cervical  
- Other nerve problem  
- Thoracic outlet  
- Cubital tunnel  
- OA of thumb

**Diagnosis: Sensory Examination**

- Semmes Weinstein Monofilaments

**Diagnosis: Provocative tests**

- Mechanism of Action:  
  - produce further vascular compromise to an already impaired median nerve – reproduces sx
  - Pressure elevation within the CT with wrist posturing  
  - Direct mechanical deformation

**Diagnosis: Sensory Examination**

- Phalen's Test  
- Compression Test
Diagnosis: Sensory Examination

Two Point Discrimination

Support for Employer Argument
Personal Predisposing Factors
> doubles risk

Diabetes
Women
Rheumatoid Arthritis
Previous m-s problem
1st degree relative
Thyroid disease

Obesity: BMI over 25 kg/m2
Age: over 50

"Square wrist" = larger wrist ratio = depth/width > 0.70

"Short wide hand" = Smaller hand ratio
= hand length/palm width

Is it work related?

Protective Factors

Decreased risk
Taller stature
Regular physical activity


Diagnosis
Clinical Criteria (CTS-6)
- Numbness & tingling median n. distribution
- Nocturnal numbness
- Weakness &/or atrophy of thenar m.
- Tinel’s sign
- Phalen’s test
- Loss of 2 Point discrimination
- Clinical diagnosis is adequate
  - Value added with electrodiagnostic testing is small
  - Many authors suggests if surgery planned to r/o cervical or other problem

Graham et al, 1985

"Square wrist" = larger wrist ratio = depth/width > 0.70

39.36 mm/54.02 mm = 0.73

“Short wide hand” = Smaller hand ratio
= hand length/palm width

Support for Employee Argument
Occupational Factors: > double risk

<table>
<thead>
<tr>
<th>Risk Factor</th>
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</thead>
<tbody>
<tr>
<td>Vibration exposure (power tools, saws)</td>
</tr>
<tr>
<td>Forceful exertions of hand/wrist</td>
</tr>
<tr>
<td>Repetitive movements of hand/wrist</td>
</tr>
<tr>
<td>Non-neutral positions of hand/wrist</td>
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<tr>
<td>Blue collar work: OR: 76.5 meat &amp; fish processing; 11.4 electronic assembly</td>
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Key references: You 2014, Barcenila 2012, van Rijen 2009

Occupational Risk Factors: Conflicting Evidence

- Duration of Employment
- Psychosocial variables: dislike supervisor, non-supportive co-workers
- Computer work

Promote Wellness

- **Aerobic Exercise**
  - Improve circulation to nerve, Prevent adhesions, improves NCV
  - Increases neurotransmitter serotonin, known to improve psychological health & pain
  - Lose weight/control diabetes

- **Healthy Weight**
  - Obesity known risk factor
  - Control diabetes
  - Healthy weight Advantage

Both Win!!

Now what can do we do about it?

Reduce Vibration

- Reduce force
- Spring-loaded
- Sharp scissors and knives
- Bigger & textured handles take less grip force

Promote Wellness

- Aerobic Exercise
- Healthy Weight

Reduce forceful exertions of hand & wrist

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Now what can do we do about it?
Eliminate non-neutral wrist

Carpal tunnel pressures increase the further from the neutral wrist position

Eliminate non-neutral wrist

Send the tool not the wrist

Factors ↑ chance for CTS computer users

- Non-neutral wrist
- More daily hours & more years on the computer
- Keyboard further from edge of the desk

Stable base with good posture
- Raise/lower chair or desk to obtain neutral wrist
- 0-20° below horizontal line of sight (slightly below eye level)
- Screen should be free of glare and should fit and given
- Upper Back
- 0° SP
- 90° SP
- 180° SP
- 270° SP
- Lower Back (support lumbar curve)
- Sitting Bones (distributed pressure)
- Thigh Behind the Knee (not touching seat pan)
One size does NOT fit all

Apple Adjustable
- CT & tendonitis pts.
- Compared to regular keyboard
- 6 mos. use

Microsoft Natural
- Best at numbness & pain

Adjustable
- Chair
- Work surfaces

Tittiramonga et al, 1999

• CT & tendonitis pts.
• Compared to regular keyboard
• 6 mos. use

Keyboarding Techniques
- Relaxed fingers
- Minimum pressure to depress keys
- Use wrist rest only at rest

Special Mouse?
- Not enough evidence to support or refute; all increase CT pressure

Effects of obesity on wrist position
Mouse techniques
- Wrist neutral
- Use whole arm
- No reaching
- No squeezing
- Don’t hold finger up

Effectiveness of Ergonomics Program
Honeywell-Torrance, CA
- Eliminated or modified highest risk tasks
- Cost of program: $355,000 (equipment & fees)
- Results:
  - ↑ employee satisfaction & productivity
  - ↓ Worker's comp & labor cost
  - Return on investment 1,675%

Source: Wade C. Applied Biomechanics & Ergonomics, Inc.

Ergonomic Assessment

Purdue Office Ergonomics Program
- Consisted of:
  - Educational website for staff on workstation set up & postures
  - On-site ergonomic assessment & equipment changes
  - Significant decrease in overall CTD incidence rate (63%)
  - 50% decrease in CTS
  - Lower WC claims paid
  - Fewer lost work days

Bidasse et al, 2010

Minimize Repetition

Let's stretch
Seradge Stretches

Seradge: Prospective study meat packing
Full set before & after work, ½ set during breaks (3x)
↓ 45% carpal tunnel syndrome

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Non-operative Treatment Options for CTS
- Therapy Management
  - Orthotics
  - Modalities
  - Exercise
  - Education
  - Hand Surgeon
  - Steroid injection

Orthotics (splints)
- Goal: keep wrist in neutral
- Full time wear no better than night alone

Therapy Modalities
- Heat
  - Heat wraps, paraffin
  - Effective for short term pain relief
- Ultrasound
  - Uses pulsed sound waves to improve circulation, decrease pain, promote nerve regeneration
  - Can add dexamethasone to gel (decrease edema, thin tissue)
  - 6 treatments

Interferential Electrical Current
- Better than TENS & wrist splint in sx & improving NCV
- Frequency 4000 Hz, modulation of 20 Hz
- 15, 20 min treatments
Other Treatments

- Laser: conflicting evidence (Tascioglu, 2012; Chang 2008; Ekim 2007)
- Magnets: ineffective (Celibert 2010)

Treatment: Education

- Modifiable risk factors
  - Lose weight
  - Neutral wrist
  - Computer set-up
  - Eliminate vibration
- Exercises
  - Stretching (Seradge/Yoga)
  - Core & Scapular strengthening
  - Aerobic exercise

Treatment Options for CTS

- Steroid injection
- Surgery

Effectiveness: Conservative vs. Surgery

- Therapy
  - Ligament stretching
  - Tendon gliding exercise
  - Splint use
  - Work modification
  - US offered if not improved
  - 79% had at least one visit
- Surgery stat. better in sx & function at 1 yr
- Clinical difference marginal
- 61% conservative avoided surgery

Predicting success with Conservative Rx

- 93% fail if 3 or more following:
  - > 50 y.o.
  - Sx present > 10 mos.
  - Constant paresthesias
  - Trigger finger
  - Phalens + less 10 sec.
- Discuss surgery with pt. if atrophy
- Boston Carpal Tunnel Sx Score
  - If less than 2.5 out of 5 will likely succeed with conservative

Success of steroid injections

- Better than placebo at 1 month
- Results are not maintained long term
- No better than splints + NSAIDs at 8 weeks

Kaplan et al, 1990
Ollivere et al, 2007
Steroid injection
Surgery
Huisstede et al, 2010
Systematic review
Surgery

- Release of transverse carpal ligament
  - Increases space in CT
  - Improves blood flow

Open vs. Endoscopic: results same
- Patient satisfaction, Boston CT score
- Grip & pinch strength
- Sensation return

Endoscopic
- Less scar pain short term
- Earlier return to work
- Increased chance of nerve injury (usually reversible)

Complications (most common)
- Scar pain & hypersensitivity to touch
- Laceration of palmar cutaneous branch of the median nerve
- Tendons stuck in scar
- "Pillar Pain"
  - Pain in thenar or hypothenar eminence
  - Nerve regeneration into the muscle
  - Surgery changes muscle position; soreness from trying to overcome new configuration
  - Adhesion of nerve/tendons/scar

Post-operative Therapy

Research
- Not routinely needed
- Those who received therapy
  - No difference in Boston CT scores
  - Quicker recovery
  - Returned to work 10 days sooner (32 vs. 42 days)

Home Program
- Wound care
- Edema control
- Massage
- Nerve and tendon glides
- Immobilization & splints not needed
- Those that wore bulky dressing and started motion immediately do better

Post Operative Therapy

- Edema control
- Retrograde massage (CPT 97124)
- Compression wrap/isotoner glove
- Contrast baths
- Paraffin with stretch (CPT 97018)

Indications for therapy f/u
- High Boston Carpal Tunnel score at 2 weeks post*
- Excessive hypersensitivity/pain
- Significant edema—leads more scar & stiffness
- Inability to make a full fist within 2 weeks
- Inability to RTW within 1 month
- Heavy or highly repetitive job

(*Mallick et al, 2007

Systematic Reviews
Zuo et al, 2015
Sayegh & Starch, 2015
Hu et al, 2016

Post-op Therapy: Exercises

Median nerve gliding
- Retrograde massage (CPT 97124)
- Compression wrap/isotoner glove
- Contrast baths
- Paraffin with stretch (CPT 97018)

Tendon gliding
Desensitization
Neuromuscular Re-education; CPT 97112
- Vibration
- Texture rubs/immersion
- Fluidotherapy (CPT 97022)

Pillar Pain/nerve pain
- Ultrasound (CPT 97035)
- Transcutaneous Electrical Nerve Stimulation (TENS; CPT 64550)
  - Effective in multiple studies in treating nerve pain

Scar Management
- Massage (CPT 97124)
  - Decrease hypersensitivity
  - Stretch fascial adhesions limiting nerve glide
  - Soft tissue elongation
- Myofascial Release (CPT 97140)

Therapeutic Exercise
- Thenar muscle strengthening
- Grip strengthening
  - (4 wks post-op)

Scar Management
- Silicone Gel (A6025)
  - Pad tender area
  - Smooth scar
- Gel Shell Splint

Return to work
- depends on:
  - Physician preference
  - Type of job
    - No forceful gripping for 3-4 weeks
  - Healing potential
    - Older, diabetic, smoker take longer
    - Inflammatory phase of healing: 4-7 days
    - More bleeding-more scar

Return to work
Less likely to RTW if:

**Work Factors**
- Greater time off work $^2,^3$
- Short duration working $^2,^5$
- Poor supervisor, dislike job $^4$
- Higher job stress $^6$
- No available modified work: 2x less likely $^7$

Politin et al.$^1$, Gallagher et al.$^1$, Hildebrandt et al.$^2$, Beissner et al.$^2$, Lancourt & Kettlehut$^4$, Feuerstein et al.$^2$, Bonzan$^1$

Less likely to RTW if:

**Psychological Factors**
- Depressed: Beck > 16, 84-86% not RTW $^1,^2$
- High hysteria $^3,^4$
- Pessimistic in recovery expectations: 30% less likely $^5$
- Doubt about RTW: 67% not RTW $^6$

Ash et al.$^1$, Politin et al.$^1$, Millhous et al.$^2$, Gallagher et al.$^1$, Cole et al.$^4$, Hildebrandt et al.$^1$

Less likely to RTW if:

**Other Factors**
- Disabled family member $^{15}$
- Attorney representation: (58% vs. 35%) $^{13}$, (73% vs. 32%) $^{14}$

Beissner et al.$^2$, Stutta & Kasden$^{15}$, Peterson$^{13}$

Work Conditioning

(CPT 97545 initial 2hrs; 97546 add1 hrs)
- UE chronic pain: 34% greater RTW $^1$
- Minimum: 3 days wk; 3-4 wks
- Key feature: Job simulation

Feuerstein et al.$^1$

Recovery following CTR

70-90% good-excellent outcomes

Kronlage, 2015
Turner, 2010

Predictors of Poor Outcomes

**Physical**
- Muscle wasting
- NCV normal pre-op
- Fragile health
- Alcohol consumption (> 2 drinks per day)
- Smoking
- Co-morbid condition
  - Diabetes: 26%
  - Thoracic Outlet: 80%
  - Cervical: 27%

**Other**
- Worker’s compensation
- 48-53% poor outcomes
- Slower return to work
- Attorney representation
Light at the end of the Talk & Carpal Tunnel

- Prevention
- Benefits Of Therapy
- When Surgery Needed
- Outcomes