Relationship Between Work Activities and Carpal Tunnel Syndrome

Super EMG *Plus* 2012
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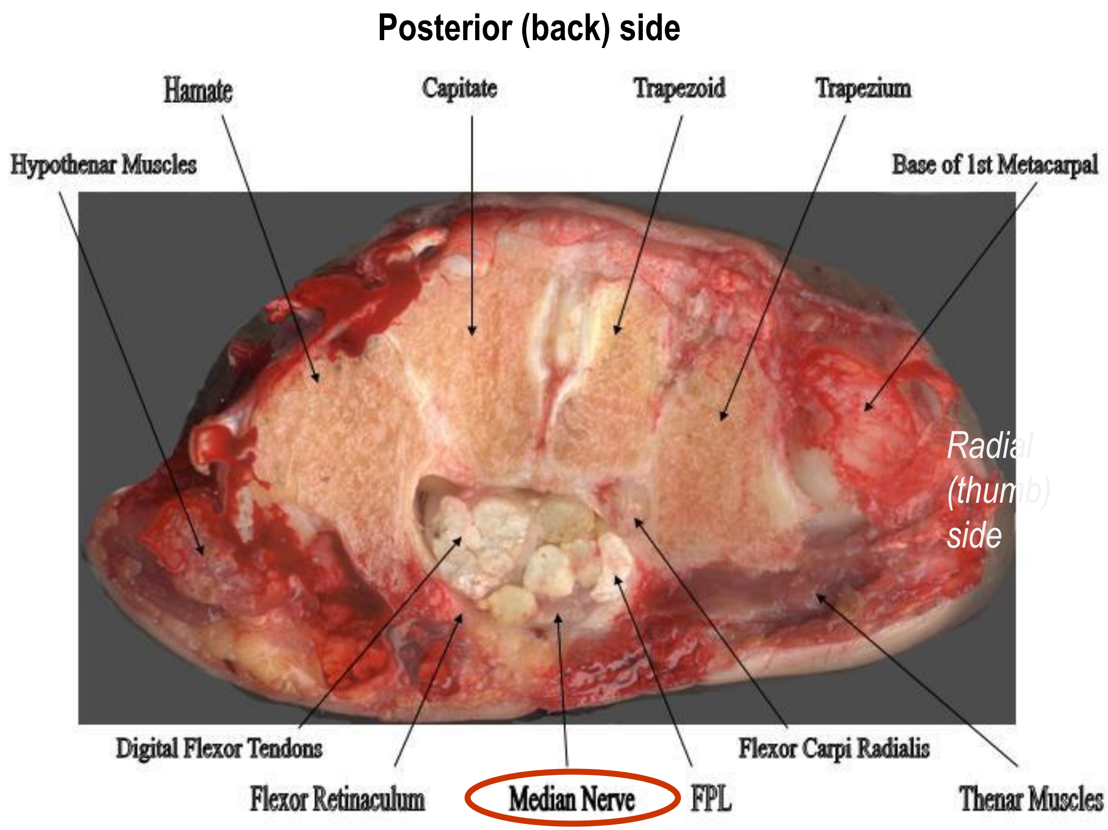
Carpal Anatomy

- Carpal tunnel syndrome results from localized compression of the median nerve within the carpal tunnel.
- It is the most commonly encountered peripheral neuropathy.



Cross-sectional view

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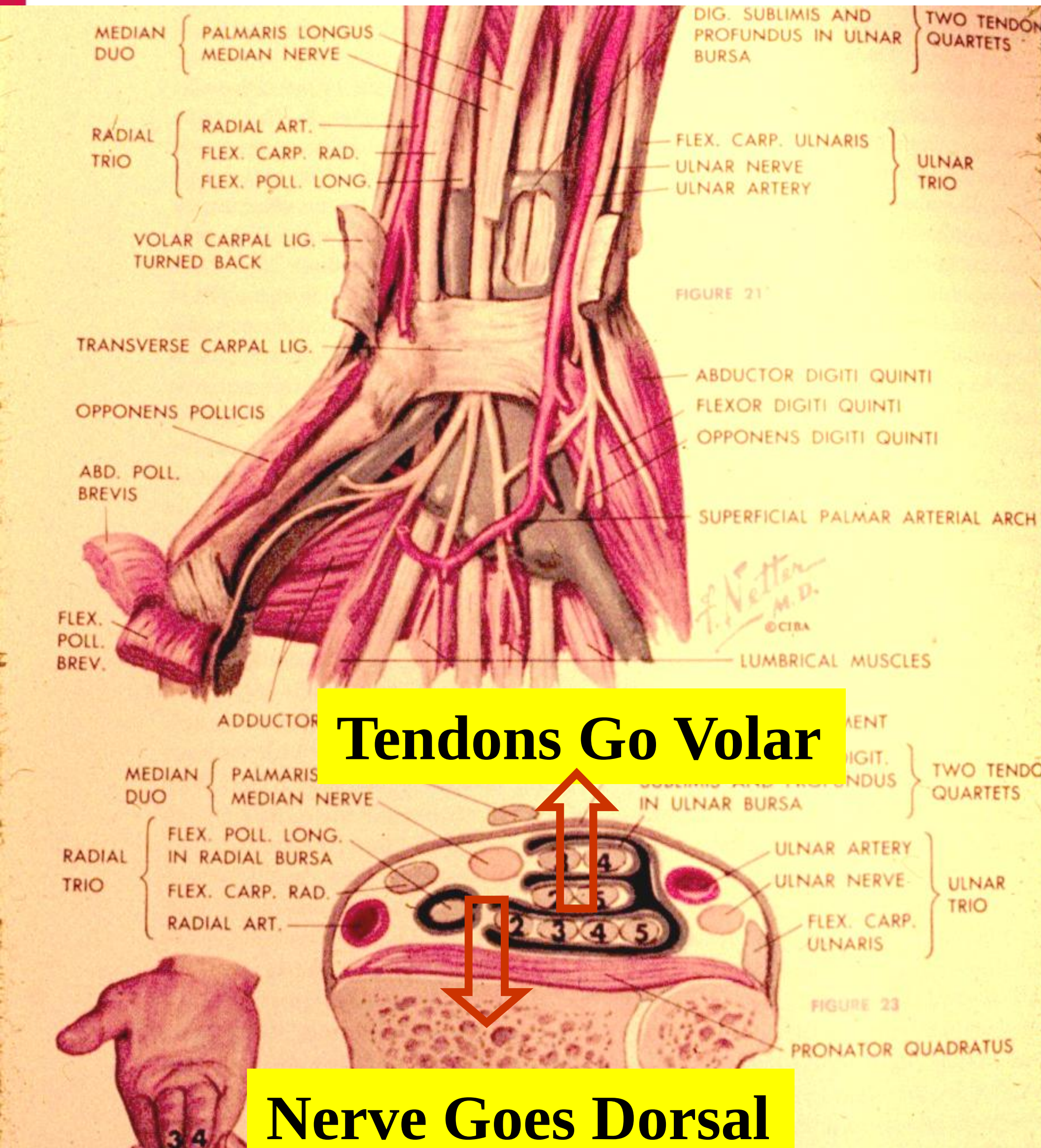
(Falkiner & Myers, 2002; Werner & Andary, 2002; picture credit: Gray's Anatomy)

“Kinesiology” of the Median Nerve



- Yes, the nerve <u>moves</u> when the tendons move
- Muscle contraction pulls the tendons taut against the transverse carpal ligament
- Nerve is pushed, roughly, to a posterior position

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US Bureau of Labor Statistics Data on CTS

- Lost work days claimed in 2004:
  - 28 days - median for CTS cases
    - This is higher than for any other work claim type
  - 7 days - median for all lost time injuries & illnesses
  - 390 k -525 k days - Total estimated lost work days due to CTS
  - Approx. 16,000 cases w lost time

Passionate Debate
“Not Caused by Work”

- variation in opinion on the matter, ranging from ‘‘almost never’’ to up to 90% of cases being caused by workplace activities
- Routine occupational activities sometimes may unmask rather than actually cause carpal tunnel syndrome.
- many—if not most—cases of carpal tunnel syndrome occur with no clear-cut cause or association

Derebery J. Clin Occup Environ Med 2006, 5 (2) 353– 367

Risk Factors for CTS

- Physical factors[1]
  - Force
  - Repetition
  - Posture
  - External pressure
  - Vibration
  - Combinations of force and posture or force and repetition

- Personal factors[2]
  - Gender
  - Age
  - Obesity
  - Reduced fitness
  - Arthritis and trauma
  - Alcohol and caffeine use
  - Diabetes
  - Renal disease
  - Thyroid disease
  - Pregnancy
  - Lactation
  - Sports participation
  - Genetics

[1] Bernard (1997), Viikari-Juntura & Silverstein (1999); [2] Falkiner & Myers (2002), Hakim et al. (2002)

CTS Lost Time Cases

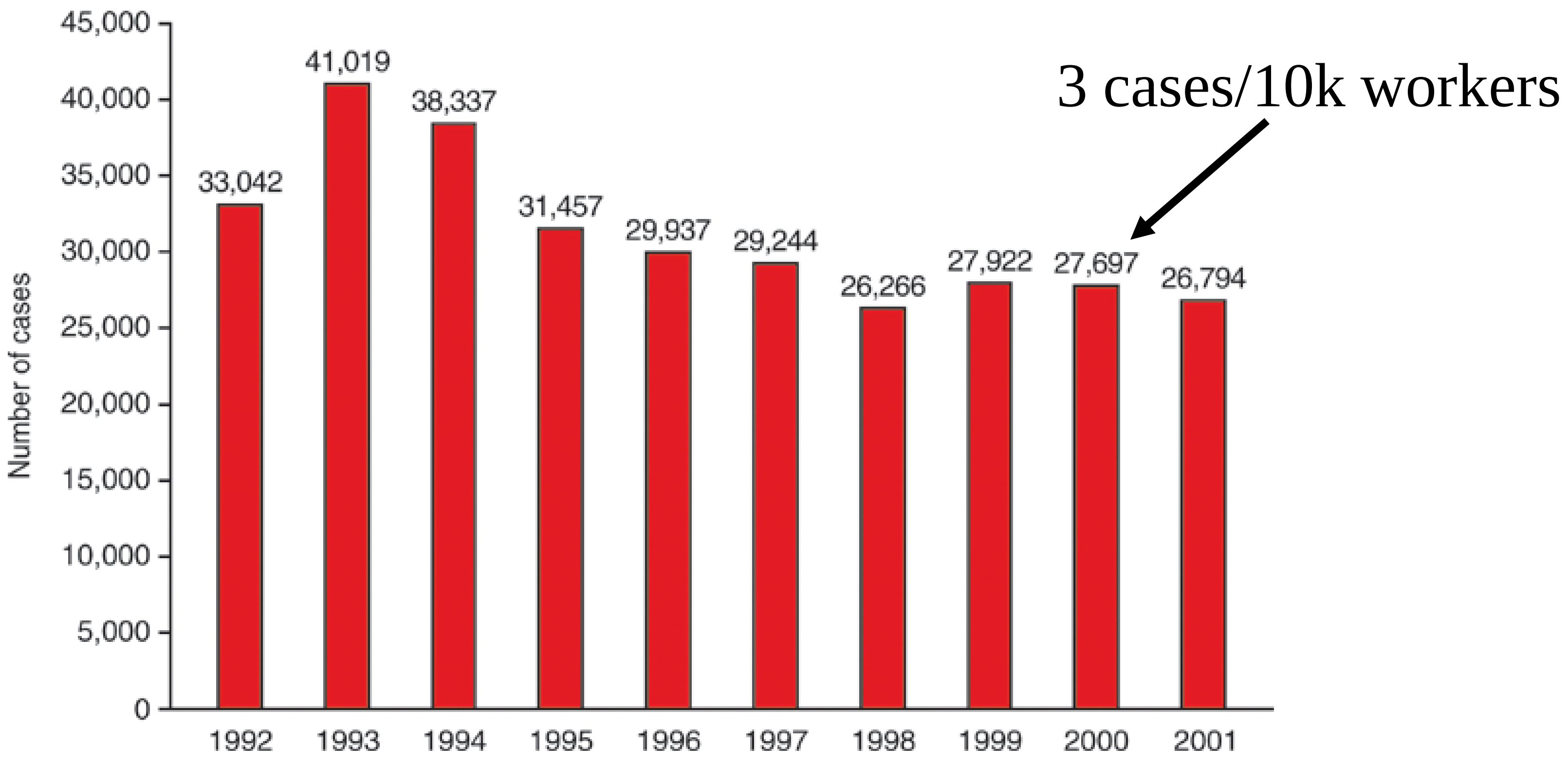

Figure 2-45. Number of CTS cases involving days away from work in private industry, 1992-2001. NIOSH

Risk Factors for CTS

- Physical factors[1]
  - Force
  - Repetition
  - Posture
  - External pressure
  - Vibration
  - Combinations of force and posture or force and repetition

A persistent question - Is CTS a work-related disorder? Debates continue.

- Personal factors[2]
  - Gender
  - Age
  - Obesity
  - Reduced fitness
  - Smoking
  - Alcohol and caffeine use
  - Diabetes
  - Renal disease
  - Thyroid disease
  - Pregnancy
  - Lactation
  - Sports participation
  - Genetics

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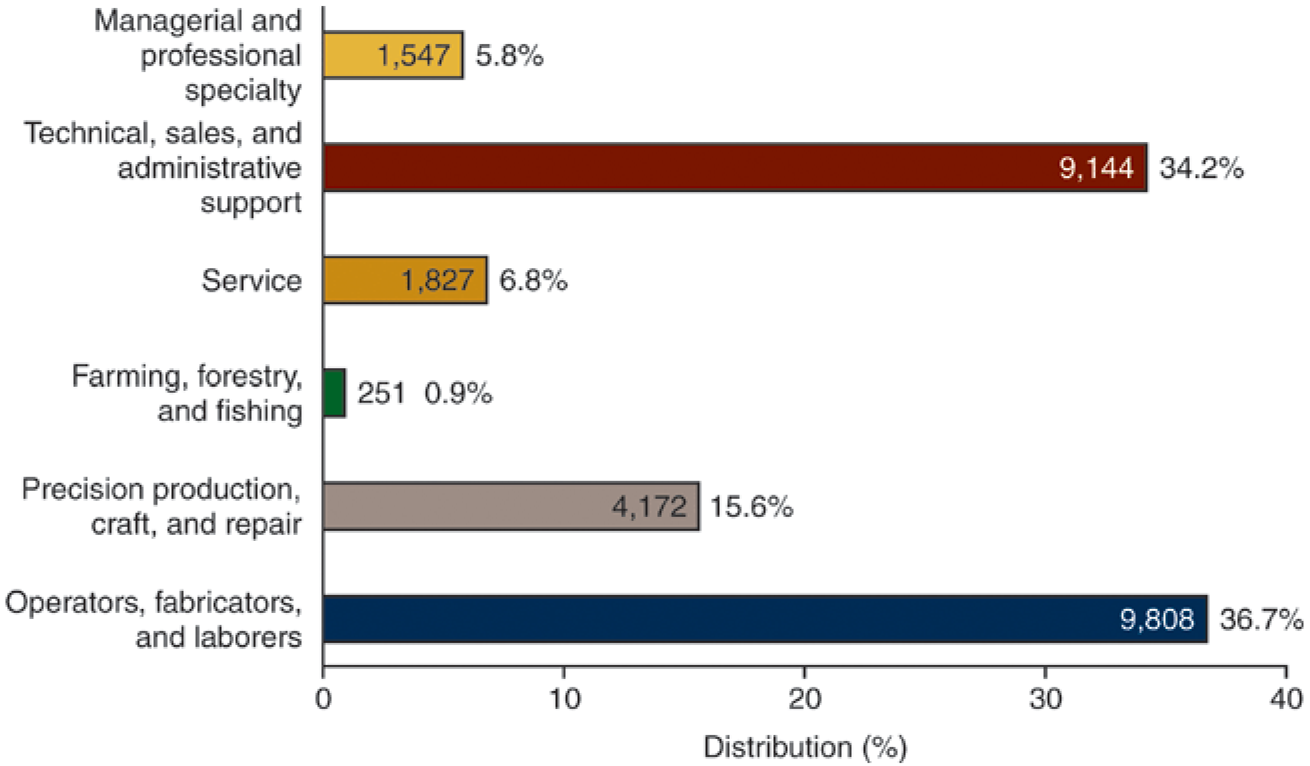
[1] Bernard (1997), Viikari-Juntura & Silverstein (1999); [2] Falkiner & Myers (2002), Hakim et al. (2002)

Is CTS Work-Caused?

- Dr. Phalen stated his belief that it is NOT caused by work*
  - “EBM” when I started medicine.
    “Eminence-Based Medicine”
- Cause & Effect is not the same is an association of increased risk

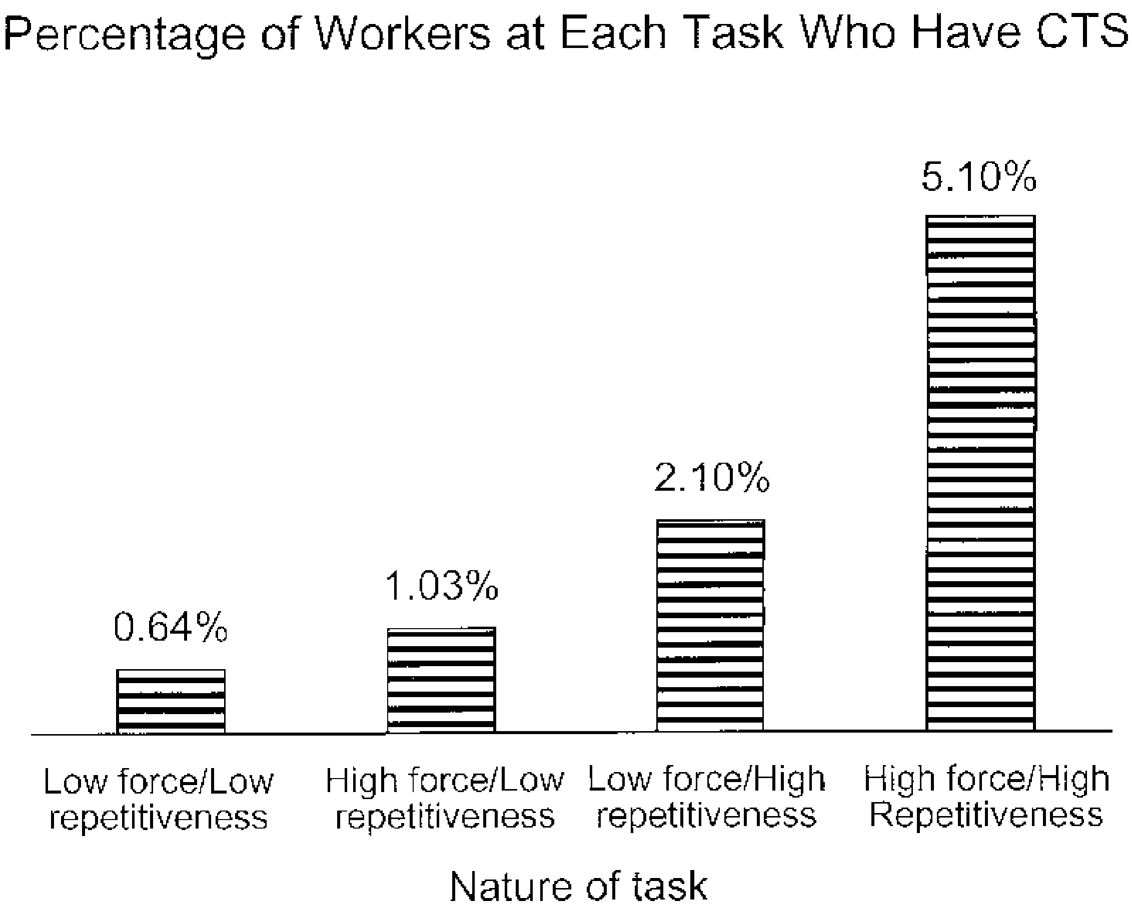
* Phalen. JBJS 1966: 211

CTS Cases by Occupation-NIOSH



2001-Distribution and number of CTS cases involving days away from work in private industry by occupation.

Likelihood of CTS



- Types of job tasks in relation to CTS diagnosis
- Injured worker (BWC) database
- Recognize the diagnostic criteria are not standard

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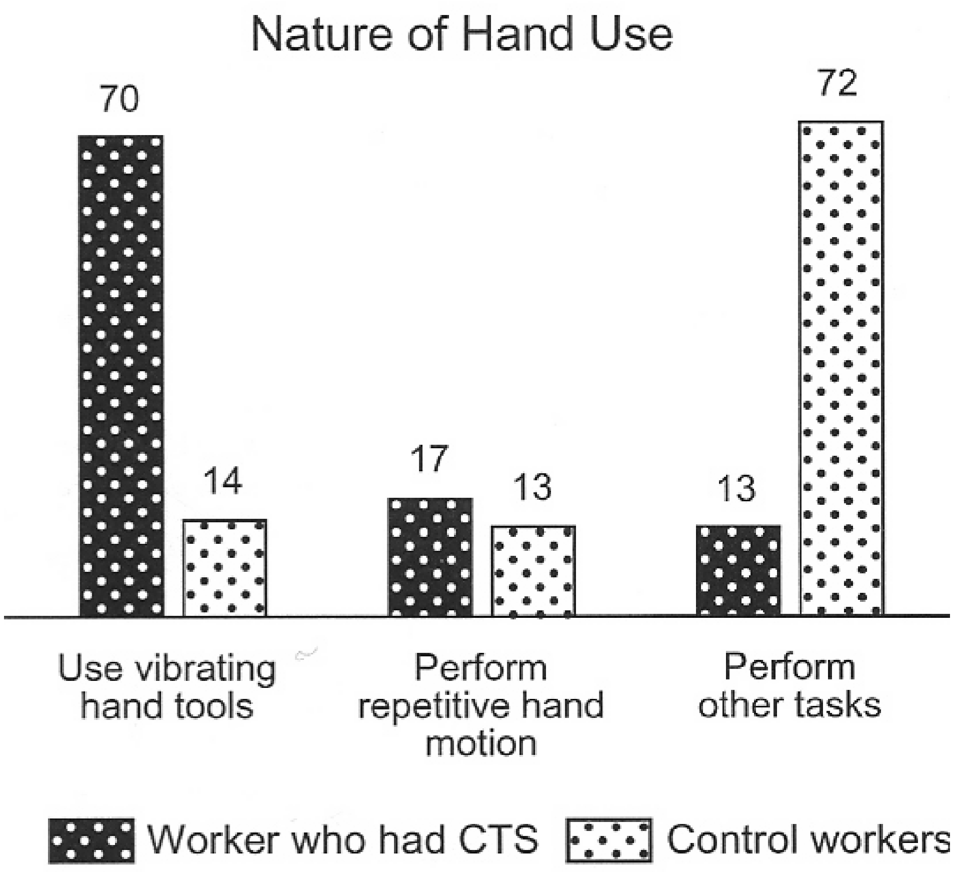
Vibration Risk also a Factor



- Vibration does aggravate the CTS risk-factors
- However, vibration can also cause vibration syndrome, a problem of small vessels and digital nerves (risk of misdiagnosis!)

Evidence for a Causal Relationship Between Work and CTS

- Examples:
  - Roquelaure et al., 1997:
  - Increased O.R.* for
  - pinch force > 1 kg,
  - operations requiring ≤ 10 s,
  - Breaks/changes in activity < 15% of the workday, no job rotation,
  - manual supply of the workstation,
  - increasing O.R. with increasing number of these risk factors.

*O.R. = Odds Ratio

Evidence for a Causal Relationship Between Work and CTS

- Examples:
  - Franklin et al., 1991: CTS cases/1000FTE differ by industry
    - examples:
      - Oyster, crab, clam packing 25.7
      - Carpentry 11.3
      - Plastic goods manufacturing 6.5
      - *All WA industries combined 1.7*

Work-related CTS: conclusions from epidemiological research

- Both work-related and non-work-related factors have been shown to be associated with CTS
- In order to determine if work (physical factors) alone can cause CTS, alternative research methods must be employed

Animal Models of CTS

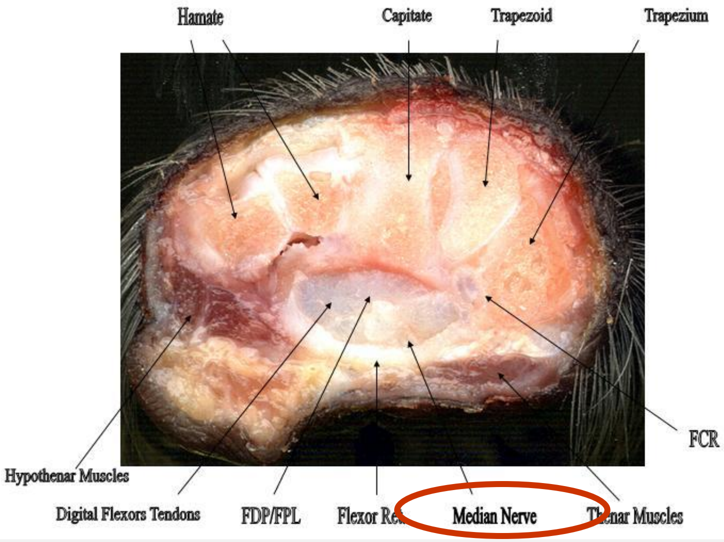
- Advantages:
  - Eliminate several personal risk factors
  - Afford control over physical exposures
  - Afford collection of baseline data
  - Afford longitudinal, experimental study of exposure (dose) effects

Animal Models of Chronic CTS

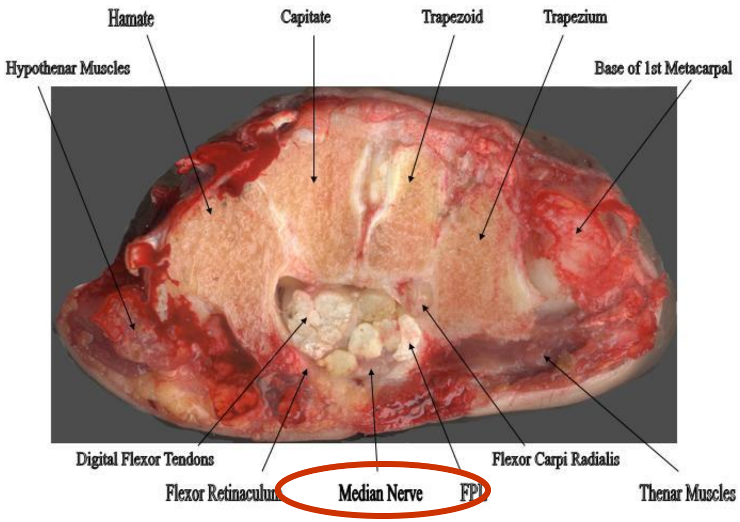
- <u>Rabbit models</u> (E-stim or compression)
  - Rempel, Diao et al. (2001, 2005)
  - High degree of control over exposure:
    - FDP m. is repeatedly stimulated to elicit a force of 15% MVC against a load cell
      - <u>Results</u>: Increased distal motor latency
    - Semi-permanent catheter inserted into the rabbit and inflated to a known pressure
      - <u>Results</u>: dose-response relationship between pressure and changes in median motor latency and histological changes
- <u>Rat model</u> Barr, Barbe, Clark et al. (2002, 2004)
  - Voluntary, repetitive reach & grasp task or reach, grasp & pull task
    - <u>Results</u>: decrements in task performance, nerve conduction velocity; histological changes in median nerve (including infiltrating macrophages, evidence of myelin degradation, fibrosis)

Research Void in Animal Models of CTS

- Exploration of a voluntary, non-human primate model for study of CTS has not been documented
  - The primary advantage of a non-human primate model over other animal models: extent of anatomical similarity with humans, including functional behavior



Macaca



Human


Dodd Hall Rehab Hospital @ OSUMC
The Park that vanished!!!!!!!!

Hypothesis

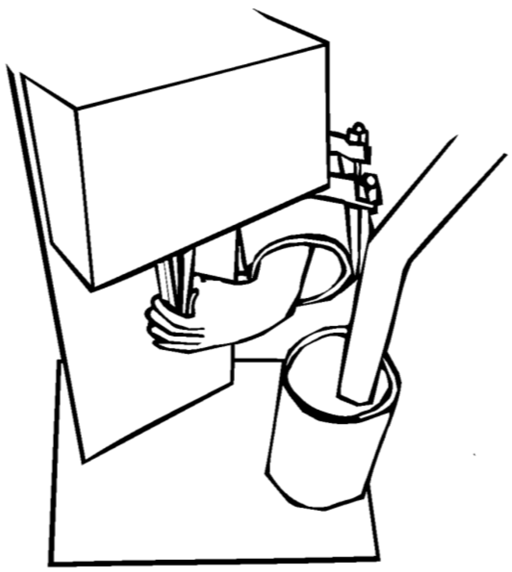
- Chronic median mononeuropathy at the wrist *(equivalent to CTS in humans)* will develop in a non-human primate as a direct result of exposure to a voluntary, repetitive manual task that requires moderately forceful exertions.

Research Methods

- Subjects
  - 4 adult female *Macaca fascicularis* monkeys; wt: 4 – 5.3 kg; age: 5 – 10 yr
  - *Experimental procedures were approved by the ILACUC of The Ohio State University and subject care was according to the NIH Guide for the Care and Use of Laboratory Animals*
- Training
  - 5-15 wk (varied by subject) to learn all aspects of task and reduce chance of acute response to increase in hand use

Task and Apparatus

- Posture: Palmar pinch and wrist flexed
- Force: 20% MVE*, *estimated*
- Hold time: 3 s
- Repetition limit: 6 rep/min
- Availability: 8 hr/d, 5 d/wk



- Customized LabView program controlled the task, provided food reward, and recorded performance data

*MVE = Maximum Voluntary Exertion

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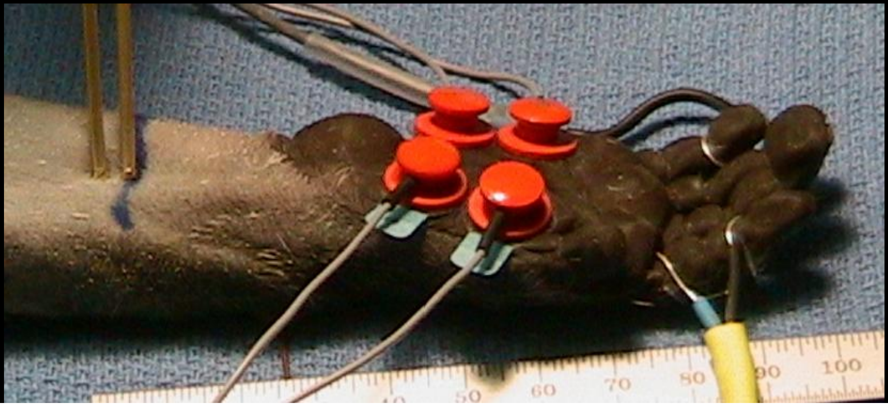
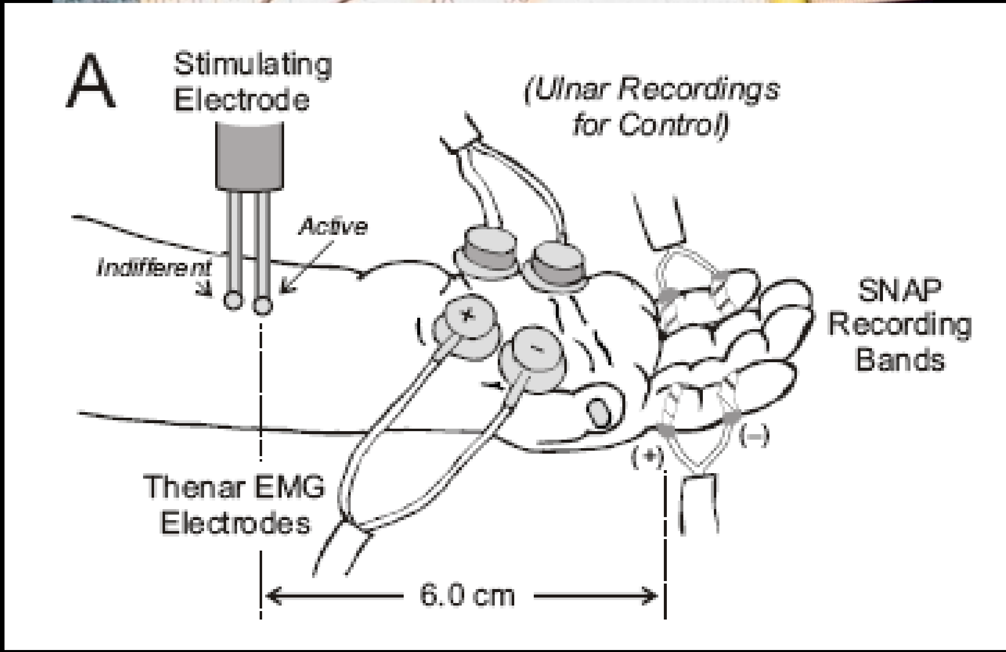
Bernard (1997), Viikari-Juntura & Silverstein (1999), Roquelaure et al. (1997)

Video of Work Performance

"Routine" Motor and Sensory Nerve Conduction Monitoring

- Sensory NCVs calculated from distance/peak latency (Reliable)
- Median and ulnar motor and sensory data were collected q2 weeks
- Temp at 35ºC
- Ketamine sedation





Electrodiagnostic Testing

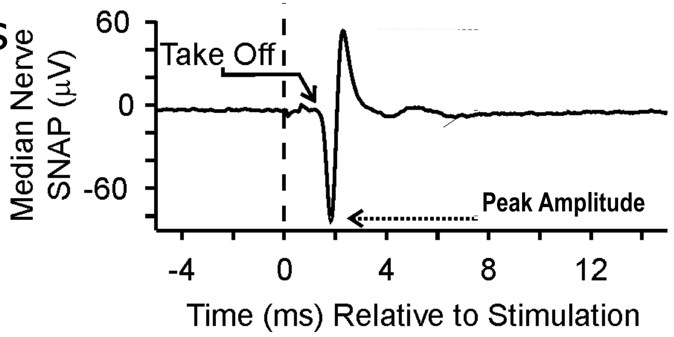
- Derivation of Sensory Nerve Conduction Velocity

• Determined latencies, from SNAP's onset and peak depolarization

• Averaged response to five stimuli at selected test current

• SNCV calculated from onset and peak latencies

• Peak is a more stable measure; Onset may be more sensitive



$$SNCV = \frac{(X_{\text{stimulus cathode}} - X_{\text{E1 recording electrode}})}{\text{latency}}$$

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Operational Definition of CTS

- 25% decrease in median SNCV derived from peak latency
  - ie, sensory lat increase from 3.2 to 4.0 ms in human equivalent
- Benchmarks, for comparison:
  - Human diagnostic testing: typically a 2 s.d. decline (~ 9-14% decline in SNCV from peak latency and 11-27% decline in SNCV from onset latency, from Jablecki et al., 2002).

Supplemental Measures and Analyses

- Magnetic Resonance Imaging
  - Bilateral
  - Baseline (n=1) and at point of peak nerve impairment (n=3 +1)
  - 4.7 Tesla unit; GEFI and RARE imaging
- Cytokines
  - IL-6 and TNF-α (important pro-inflammatory proteins, active at acute stage of response to trauma)
  - From serum
  - Baseline and every 2 wks after (n=1); at diagnosis (n=3)

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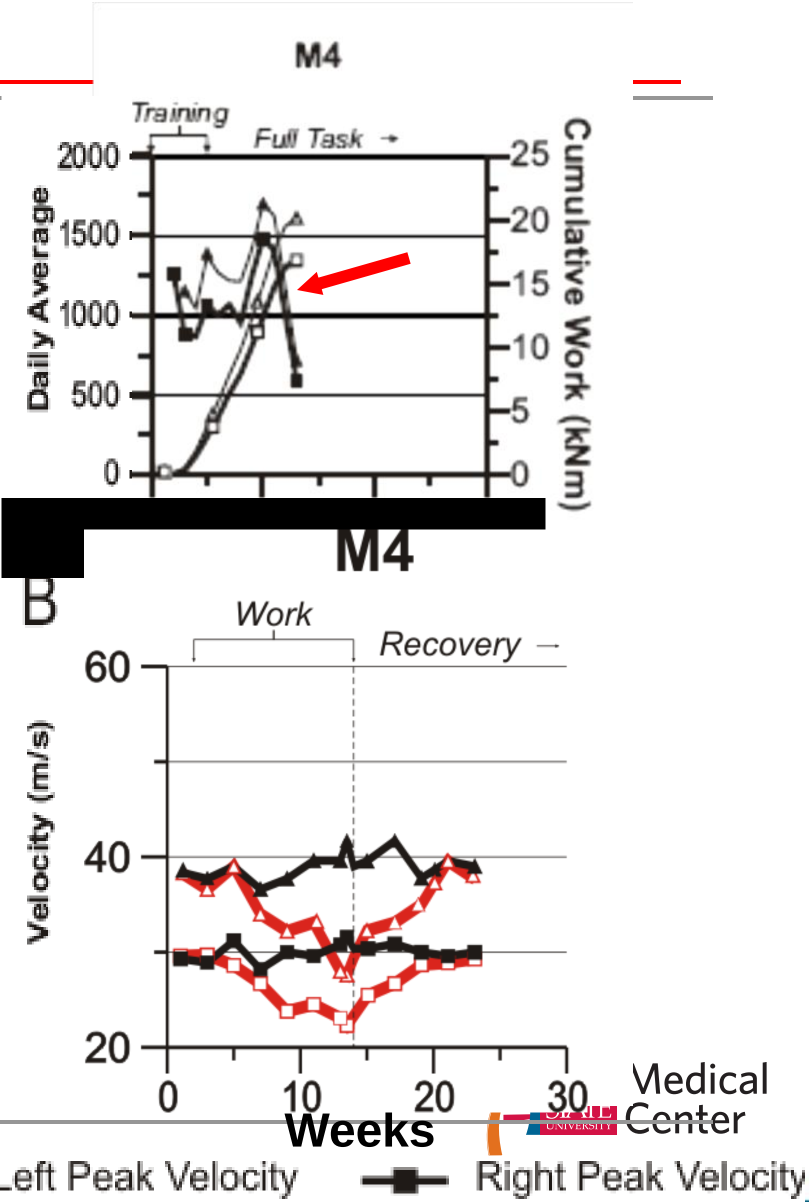
Work Effort and NCV Monkey M4

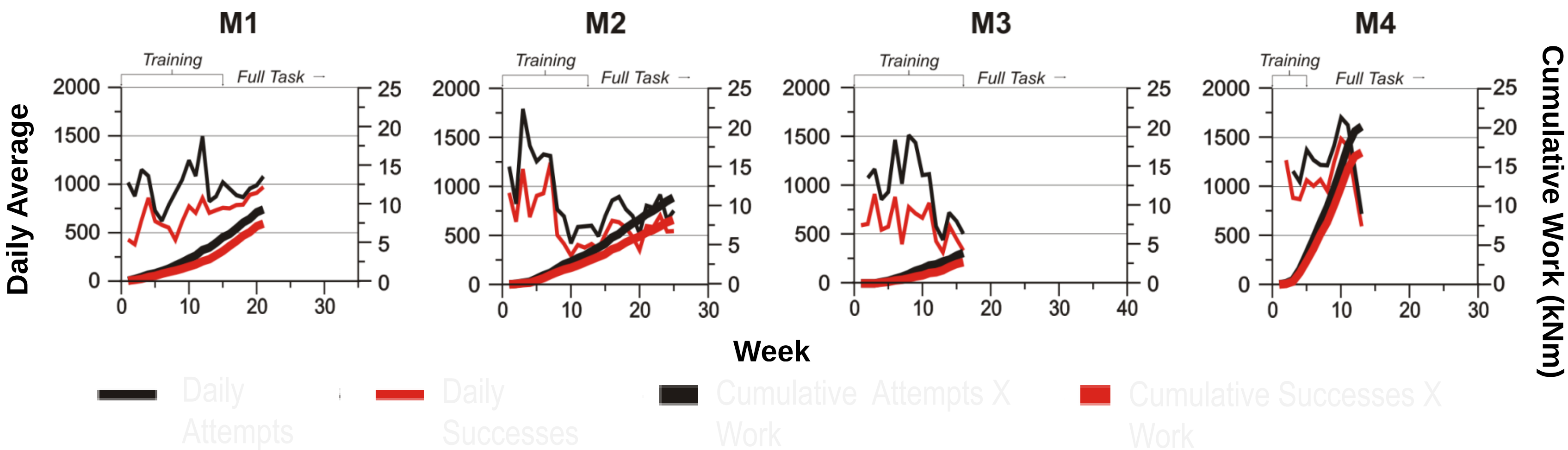
Top-Sudden decline in work output and pinch force (→)

- *Coincides with NCV slowing (lower) of 25%*
- *Red lines-affected (Left) hand*
- *Black lines-right hand, no exposure to work*
- *Work exposure ended wk 14, and NCV recovers (=to right side)*
- *Peak lat. Increase 2ms to 2.6ms*



Results

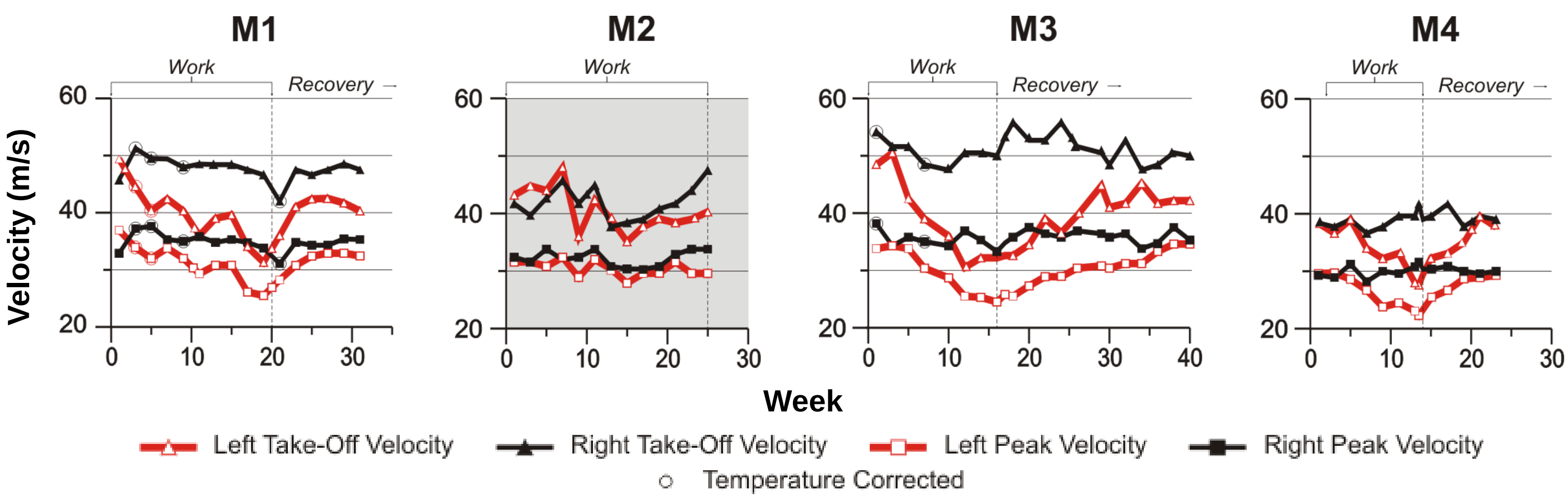
- Daily and cumulative performance data



- Reduction in performance is seen prior to diagnosis for M3 and M4.

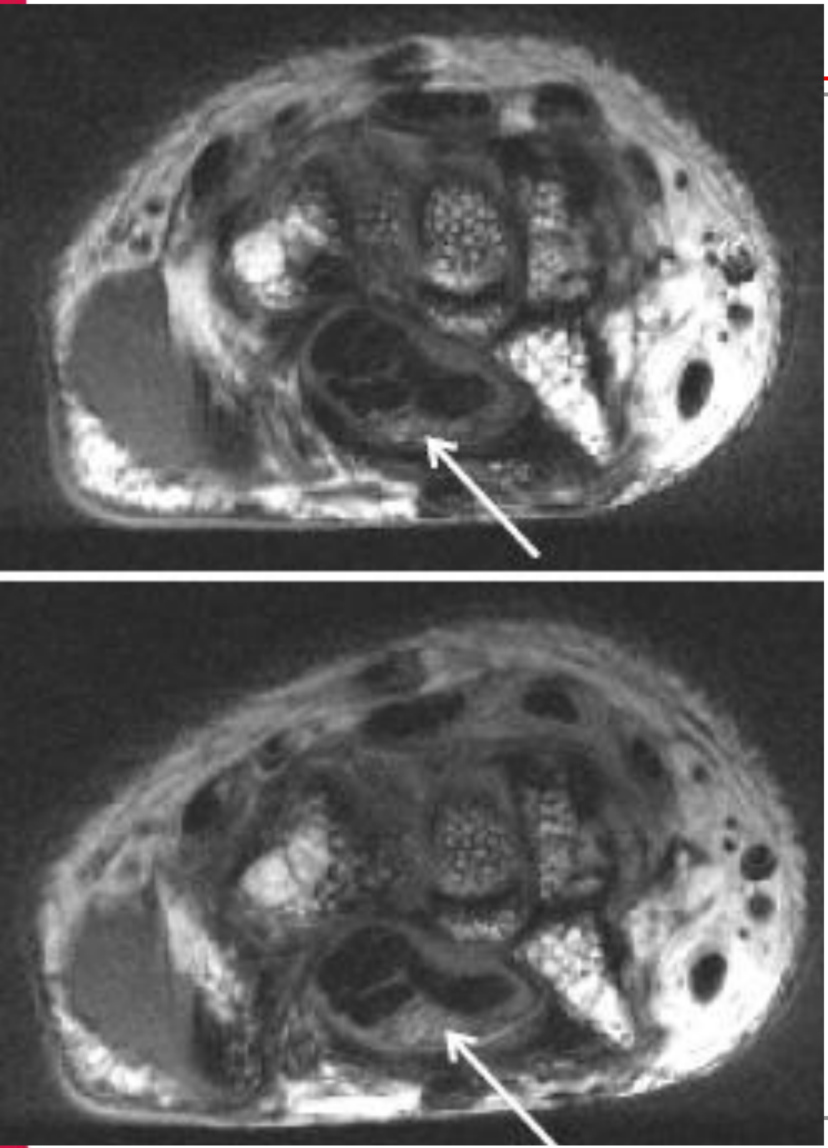
Results

- Sensory nerve conduction velocity



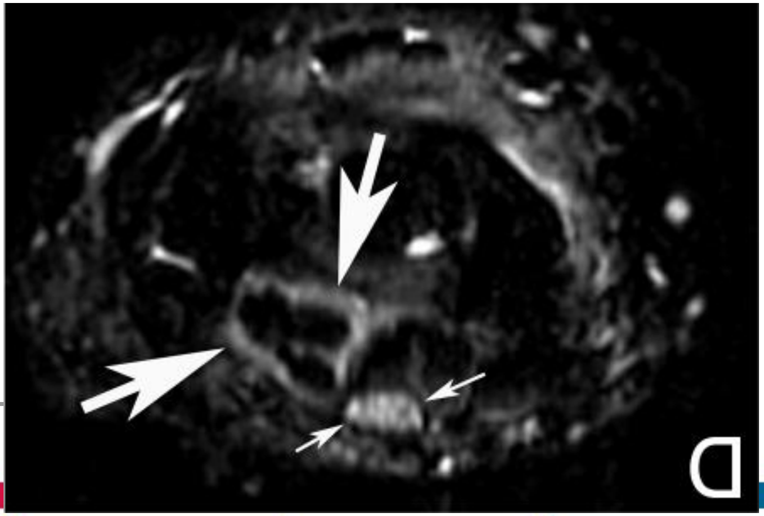
- M1, M3, and M4 met operational definition of CTS: 25% reduction in SNCV.
- All diagnosed subjects showed recovery in SNCV after task exposure ceased.

MRI Pre and Post CTS



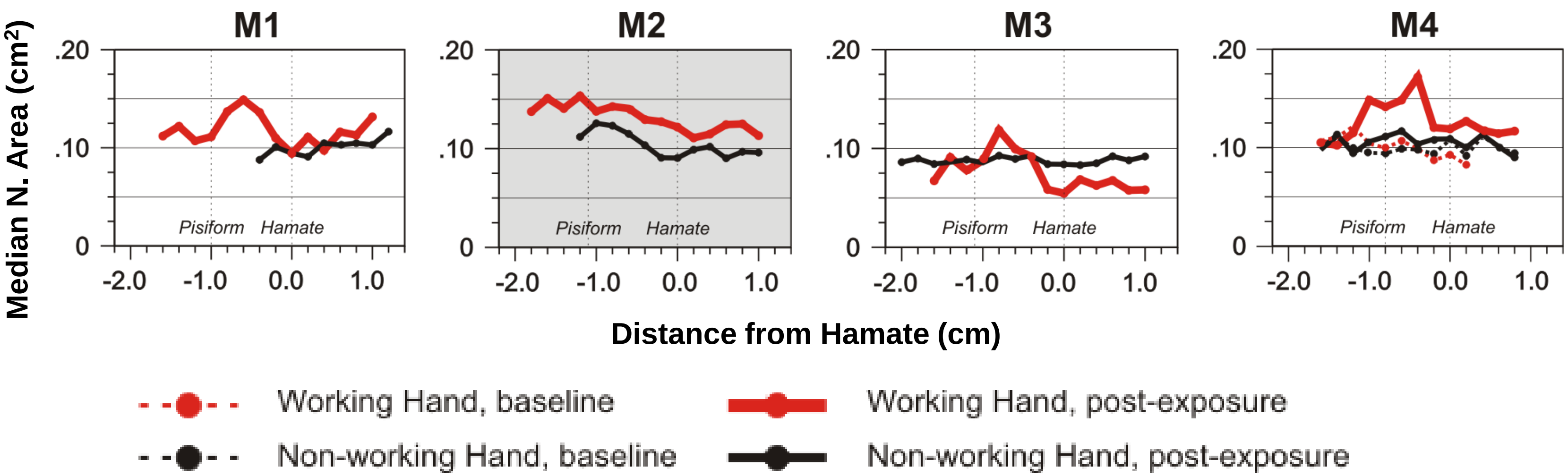
- *Wrist of M4-young female adult monkey*
- *Top-MRI before work exposure*
- *Lower-MRI after onset of NCV slowing*
- *Nerve swelling with edema/soft tissue thickening*

Human CTS w nerve enlarged



Results

- MRI - Area of median nerve



- Area of the median nerve within the carpal tunnel of the working hand is enlarged for M1, M3, and M4

Discussion

- Research hypothesis
  - This study showed that chronic median mononeuropathy at the wrist *(equivalent to CTS in humans)* will develop in a non-human primate as a direct result of exposure to a voluntary, repetitive manual task that requires moderately forceful exertions applied with a pinch grip.

Discussion

- Pattern of evidence
  - These results support the pattern of evidence provided by other animal models and human epidemiological studies regarding the likelihood that moderately forceful, repetitive manual work, alone, can impose stress on the median nerve that is sufficient to result in chronic median nerve impairment.

Summary-Monkey CTS

- *3 out of 4 monkeys developed neuropathy at the wrist in this trial*
- *All improved after cessation of work*
- *Reduced work output at peak of abnormal NCV suggests weakness, pain, etc.*
- *IL-6 or TNF-α serum levels did not show changes*
- *Trials now expanded to explore exposure "risks" and therapy times*
- *Published:* J Orthopaedic Res

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Is this CTS Work-Related?

- 1. Is affected hand work predominant?
- 2. Wrist movement > 2/min?
- 3. Finger tap > 2/min?
- 4. Activities 2 or 3 > 4 hr/d?
- 5. Grip firmly during 2 or 3?
- 6. Hold tools that vibrate most of day?
- Score=1 pt each: ≤2-low risk;
- 3-4= mod risk; ≥5=high risk

Kao SY. J Am Bd Fam Pr 2003; 16:533

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Ergonomic Keyboard

- Split keyboard improves wrist posture at computer.
- Best selling type of keyboard in 2006.

Some evidence of benefit-Cochrane Review

Questions?

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