The Biological Significance of Clinical Symptom Scales of Carpal Tunnel Syndrome (CTS)

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Overview

This study examined the severity of symptoms in CTS in relation to nerve conduction measures of the median nerve.

Significant relationships identified among the clinical scales and nerve conduction measures resulted in a dichotomous symptom classification scheme into primary and secondary symptoms in association with nerve injury.

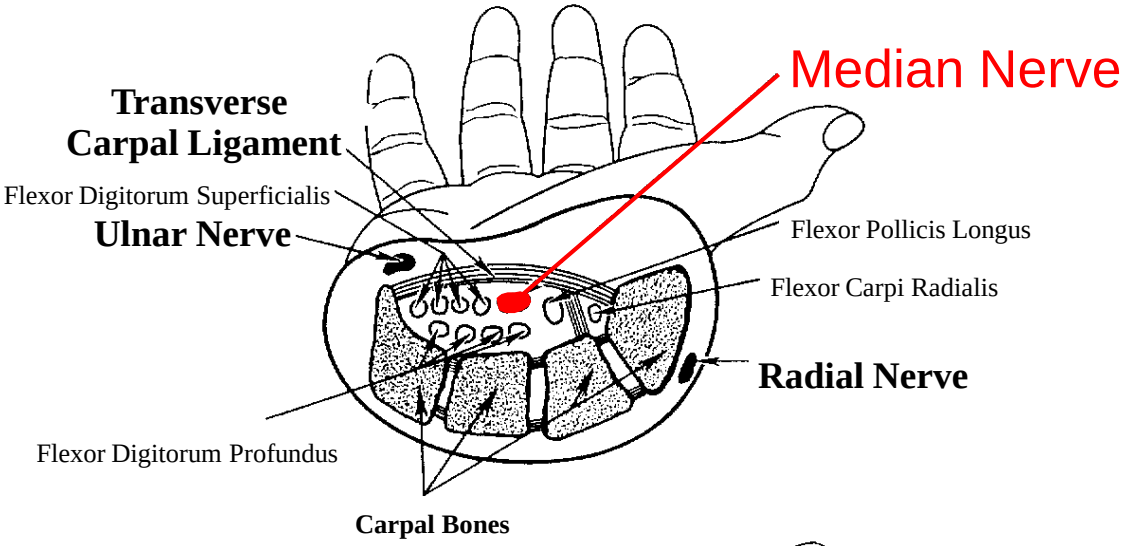
These findings on the biological significance of the clinical scales support their potential utility.

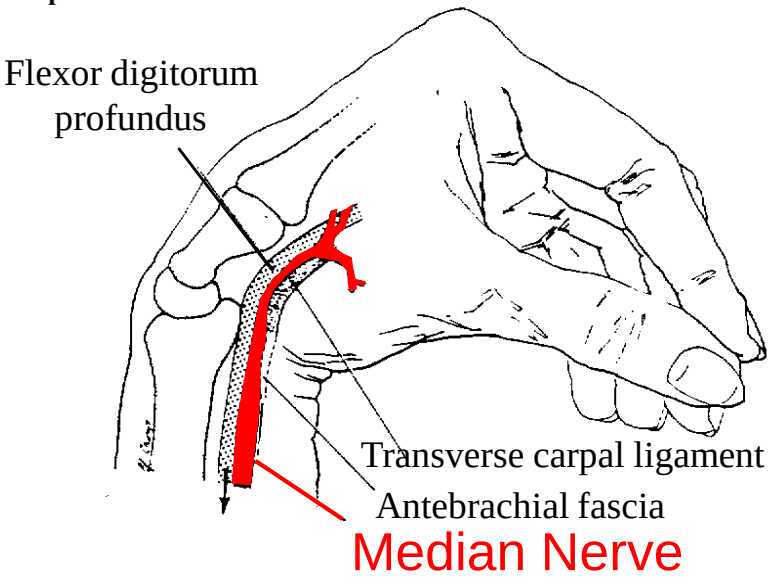
Agenda

- **Introduction**
  - Carpal Tunnel Syndrome
  - Motivation
  - Objectives
- **Methods**
  - Patient Recruitment
  - Electrodiagnostic Studies
  - Symptom Severity Questionnaire
- **Results**
- **Conclusions**

Carpal Tunnel Syndrome

Peripheral neuropathy due to localized compression to the median nerve within the carpal tunnel at the wrist.





CTS as an Occupational Disorder

CTS has been a **major problem in hand-intensive industries** due to:

1. Work-relatedness
   - ✓ Adverse work conditions to the hand increase the risk of CTS.
2. Common occurrence
   - ✓ Industry-wide incidence rate (IR): 1.74/1000 full time workers (FTWs) (Franklin et al., 1991).
   - ✓ Meat-packing industry IR: 18~26/1000 FTWs (Silverstein et al., 1996).
3. High cost
   - ✓ Surgical treatment: $5,000 to $20,000/case (Cobb et al., 1996)
   - ✓ Production loss
   - ✓ Rehabilitation expense

Diagnosis of CTS

- Clinical Symptoms

  Patient reports of (1) wrist **pain**, (2) **weakness** (grip strength decrease), (3) **clumsiness** (restricted hand function), (4) **tingling**, (5) **numbness**, or (6) **nocturnal symptom aggravation**.

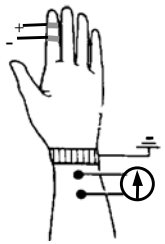
- Physical Signs

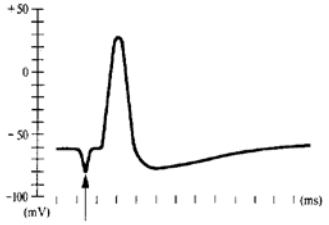
  ✓ **Tinel's signs:** Percussion over the median nerve.

  ✓ **Phalen's maneuvers:** Flexion of wrists dorsum-to-dorsum.

- Nerve Conduction Abnormalities

  Electrophysiologic testing of nerve conduction integrity. Employed to confirm the clinical diagnosis.





Stimulus applied to axon

Motivation

- Application of Assessment of the Severity of Symptoms

  Useful in evaluating the outcome of treatment and developing an exposure-severity relationship for CTS.

- Lack of Standardization of Symptom Severity Assessment

  No tool quantifying the severity of symptoms has been standardized so far.

$\Rightarrow$ Need a symptom assessment tool having biological significance (reflecting the integrity of the median nerve).

Objectives

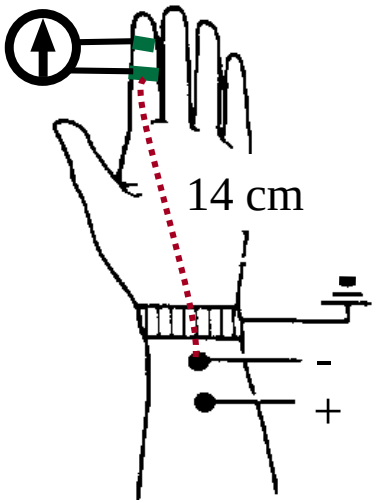
- Examine the relationships between clinical symptoms and electrodiagnostic measures in CTS.
- Develop a symptom assessment tool that reflects the integrity of the median nerve, and thus has biological significance.

Patient Recruitment

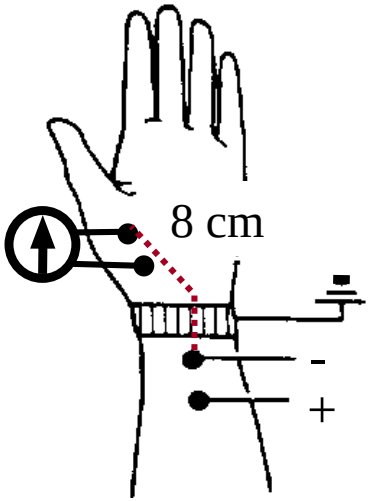
- Patients diagnosed with unilateral or bilateral CTS at EMG lab, Hershey Medical Center, were asked to participate in the study immediately after their nerve conduction studies.
- Selection Criteria
  - ✓ Clinical symptoms in one or both upper extremities,
  - ✓ Age ≥ 18 years,
  - ✓ Currently employed,
  - ✓ Working at the current job for at least one year,
  - ✓ No surgery for CTS on the involved limb(s).
- Approved by IRB at Penn State Univ.

Electrodiagnostic Studies

- Median Nerve Study Techniques
  - ✓ Skin temperature ≥ 32°C.
  - ✓ Stimulation with a supramaximal surface impulse at the wrist



Sensory Studies



Motor Studies

Electrodiagnostic Measures

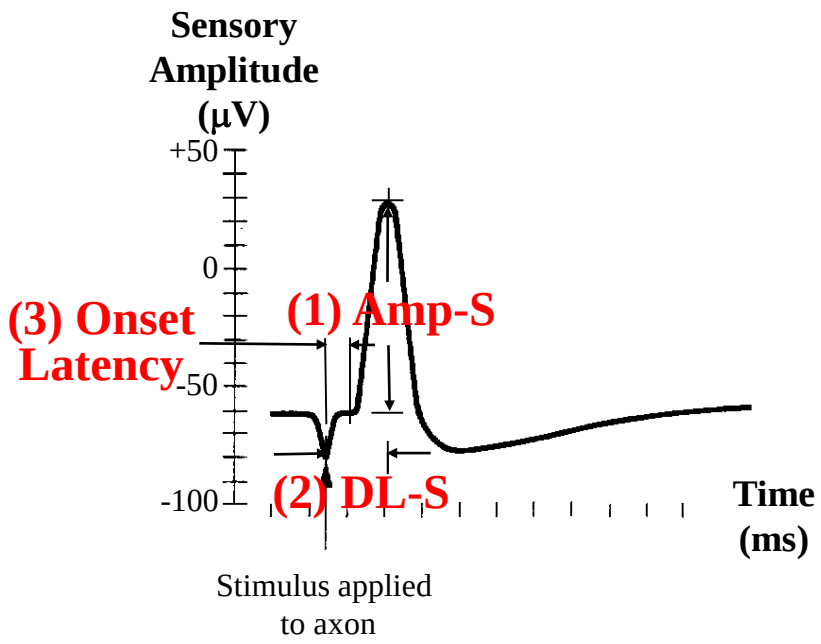
(1) Sensory Amplitude (Amp-S)

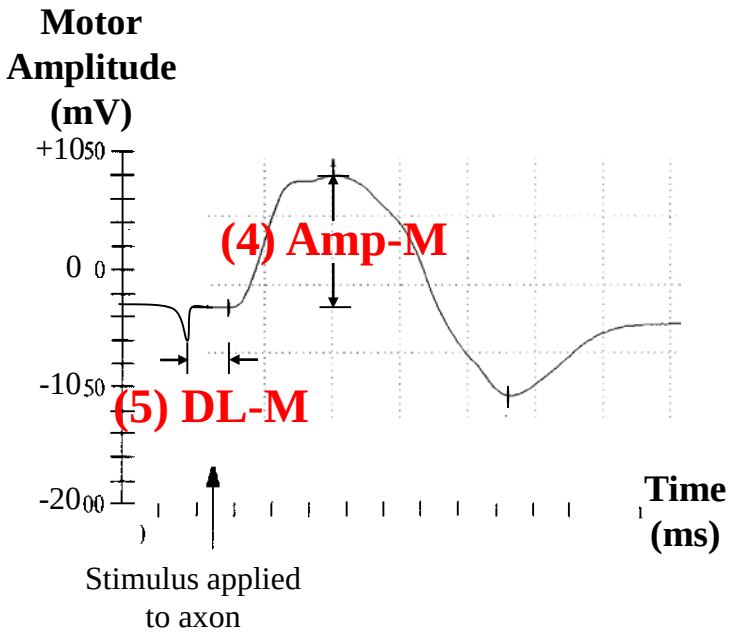
(2) Sensory Peak Latency (DL-S)

(3) Sensory Conduction Velocity (CV-S) = $\frac{\text{Conduction Distance (14 cm)}}{\text{Onset Latency}}$

(4) Motor Amplitude (Amp-M)

(5) Motor Onset Latency (DL-M)





Diagnosis Criteria of CTS

- CTS was defined as being present when median nerve studies met one of the following criteria:

Nerve Conduction Measures	Diagnosis Criteria for CTS
Sensory Amplitude (Amp-S)	Not Used
Sensory Peak Latency (DL-S)	> 3.7 msec
Sensory Conduction Velocity (CV-S)	< 49 m/sec
Motor Amplitude (Amp-M)	Not Used
Motor Onset Latency (DL-M)	> 4.4 msec

Symptom Severity Questionnaire

- 11-item questionnaire developed by Levine et al. (1993) was utilized to evaluate the severity of each of six common CTS symptoms in terms of magnitude (M), frequency (F), or duration (D).

Symptoms	Question No. (Metrics)
Pain	1 (M), 2 (F), 3 (D)
Weakness (grip strength decrease)	6 (M)
Clumsiness (overall functional status)	7 (M)
Numbness	8 (M)
Tingling (paresthesia)	9 (M)
Nocturnal symptoms	4 & 10 (M); 5 & 11 (F)

Symptom Severity Assessment

- Responses were converted to a scale of 1 (no symptoms) to 5 (most severe).

2. **How often** do you have hand or wrist **pain during the daytime**?

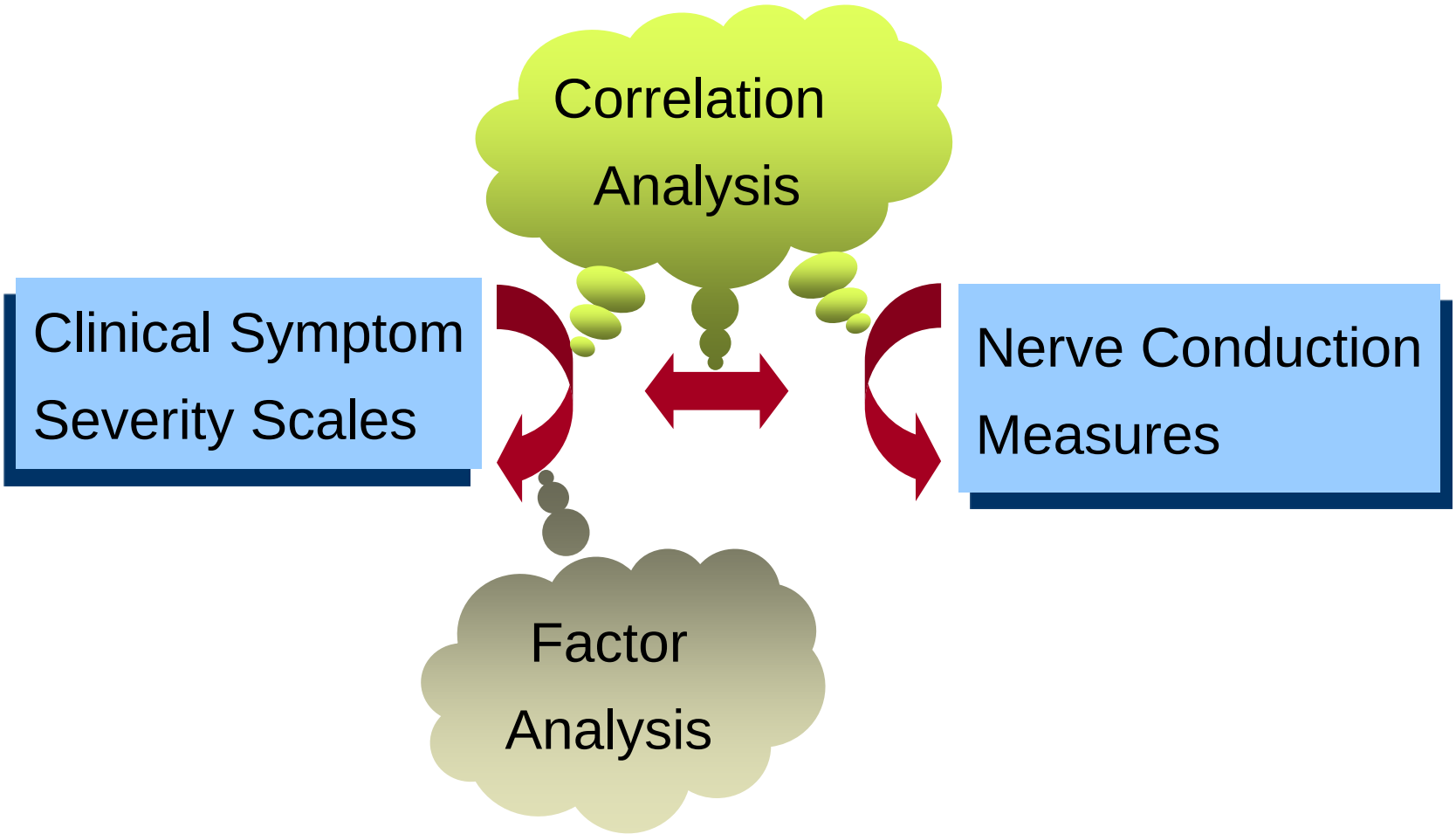
	Left	Right
• Never	❑	❑
• Once or twice a day	❑	❑
• Three to five times a day	❑	❑
• More than five times a day	❑	❑
• The pain is constant throughout the day	❑	❑

- **Averaging** was used to produce a single value for those symptoms having more than one more questions.

Participant Composition

- 64 hands with CTS from 45 patients
  - ✓ Gender: 11 males, 34 females.
  - ✓ Age: average = 46.7 years (s.d. = 10.2, range = 24 to 65).
  - ✓ Body mass index (BMI): average = 30.1 (s.d. = 6.4, range = 19.0 to 46.9); 'obese' level: BMI > 30.0 (Werner et al., 1994).
- Comparison of individual characteristics of the participants to those of 149 patients with CTS for the year 1997 diagnosed at the EMG lab.
  - ✓ Gender: $\chi^2(1) = 0.56$, $p = 0.46$.
  - ✓ Age: $t\ (73) = -0.32$, $p = 0.75$.
  - ✓ Body mass index (BMI): $t\ (69) = -0.36$, $p = 0.72$.
  - $\Rightarrow$ No significant difference at $\alpha = 0.05$.

Analysis Structure



Relationships between Symptom Severity Scales

- Strongly significant relationships ($p < 0.001$) within each of the following **two symptom groups**: (1) numbness, tingling, and nocturnal symptoms, and (2) pain, weakness, and clumsiness.

	Numbness	Tingling	Nocturnal Symptoms	Pain	Weakness	Clumsiness
Numbness	1					
Tingling	0.67 ‡	1				
Nocturnal Symptoms	0.51 ‡	0.49 ‡	1			
Pain	0.28 *	0.33 †	0.39 †	1		
Weakness	0.22	0.11	0.22	0.57 ‡	1	
Clumsiness	0.50 ‡	0.27 *	0.29 *	0.54 ‡	0.55 ‡	1

*: $p < .05$; † : $p < .01$; ‡ $p < .001$

Symptom Classification

- Factor analysis supports a dichotomous classification scheme for the six CTS symptom scales:
  - ✓ **Primary symptoms**: more **specific for nerve injury**.
  - ✓ **Secondary symptoms**: commonly found in **soft tissues and other musculoskeletal disorders**.

Variables	Factor Loadings		Communality
	Factor1	Factor2	
Numbness	0.86	0.23	0.79
Tingling	0.85	0.16	0.76
Nocturnal Symptoms	0.76	0.15	0.61
Weakness	0.23	0.79	0.68
Clumsiness	0.12	0.88	0.79
Pain	0.20	0.81	0.79
Variance explained	2.15	2.16	4.31
Percentage	36%	35%	71%

Relationships between Nerve Conduction Measures

- Strong correlations (|*r*| = 0.81 to 0.95) between sensory peak latency (DL-S), motor onset latency (DL-M), and sensory conduction velocity (CV-S), which are widely used for CTS electrodiagnosis.
- Relatively low correlations (|*r*| = 0.25 to 0.43) between motor amplitude (Amp-M) and the other nerve conduction measures implies restricted use of motor amplitude in the diagnosis of CTS.
- All the sensory and motor nerve fibers in the median nerve are usually impaired simultaneously.

Relationships between Symptom Scales and Nerve Conduction Measures

- The primary, secondary, and overall symptom scales were calculated as averages of the severity scores of the corresponding symptoms.
- The primary symptom scale is more closely related to the nerve conduction measures except motor amplitude than the secondary and the overall symptom scales.

	Primary	Secondary	Overall
correlation with nerve conduction measures (|r|)	0.47 to 0.58	0.10 to 0.34	0.41 to 0.53

- No symptom scales had a significant relationship at $\alpha = 0.05$ with motor amplitude.

Conclusions

- Significant relationships among the clinical scales resulted in a dichotomous classification scheme for symptoms of CTS with respect to nerve injury: primary and secondary symptoms.
- The significant relationship between the symptom scales and nerve conduction measures indicates that the symptom scales have biological significance, reflecting median nerve injury.

Conclusions

- Use of the primary symptoms would be more meaningful for developing a symptom assessment tool having biological significance than use of all the CTS symptoms.
  - ✓ Painless and easy to administer.
  - ✓ Screening tool for CTS in the workplace.
  - ✓ Study on exposure-severity relationships for CTS.
  - ✓ Evaluation of outcomes of CTS treatment.