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# Practice parameter: Electrodiagnostic studies in carpal tunnel syndrome

## Report of the American Association of Electrodiagnostic Medicine, American Academy of Neurology, and the American Academy of Physical Medicine and Rehabilitation

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Carpal tunnel syndrome (CTS) is a common clinical problem and frequently requires surgical therapy. The results of electrodiagnostic (EDX) studies have been found to be highly sensitive and specific for the diagnosis of CTS. This document defines the standards, guidelines, and options for EDX studies of CTS based on a critical review of the literature published in 1993<sup>1</sup> and recently updated by a review of the literature through the year 2000.<sup>2</sup> The reader is referred to the updated review<sup>2</sup> for a detailed discussion of the literature and the EDX techniques for the assessment of CTS that are summarized here. Both reviews addressed the following key clinical questions:

1. In patients clinically suspected of having CTS, what are the best EDX studies to confirm the diagnosis?
2. How can future clinical research studies be improved to evaluate the usefulness of laboratory studies, including EDX studies, to confirm the diagnosis of CTS?

**Description of the review process.** The source of the articles for the first CTS Literature Review<sup>1</sup> published in 1993 was a Medline search for literature in English from January 1, 1986 through May 1991. The Medical Subject Headings searched were

1) wrist injuries or wrist joint, 2) nerve compression syndrome, and 3) carpal tunnel syndrome. The search identified 488 articles. Based on a review of the abstracts, 81 articles describing EDX studies were chosen for this review. An additional 78 reports were identified from the bibliographies of these 81 articles and American Academy of Electrodiagnostic Medicine (AAEM) consultants recommended six others. Of the total of 165 articles reviewed, 20 were classified as background references.

The source of the articles for the second CTS Literature Review<sup>2</sup> was a Medline search for literature in English through December 2000. The Medical Subject Headings (MeSH) searched were 1) carpal tunnel syndrome and diagnosis or 2) carpal tunnel syndrome and neural conduction. The search generated 497 article titles with abstracts published since 1990. Based on a review of the abstracts, the AAEM CTS Task Force chose 92 articles for review. An additional five articles were identified from the bibliographies of the articles and 16 from AAEM members who have current research interests in CTS. Of the total of 113 articles reviewed, 24 were classified as background references.

**Description of the reviewers.** In 1997, the AAEM President appointed Charles K. Jablecki, MD,

**See also pages 1583, 1597, and 1603**

See the Appendix on page 1592 for a complete listing of the members of the American Association of Electrodiagnostic Medicine 2001 CTS Task Force, the Quality Standards Subcommittee of the American Academy of Neurology, and the American Academy of Physical Medicine and Rehabilitation Practice Guidelines Committee.

Approved by the American Academy of Electrodiagnostic Medicine Board of Directors on January 30, 2002. Approved by the American Academy of Neurology (AAN) Quality Standards Subcommittee on December 8, 2001. Approved by the AAN Board of Directors on February 23, 2002. Endorsed by the American Academy of Physical Medicine and Rehabilitation (AAPM&R) Practice Guidelines Committee on February 4, 2002. Endorsed by the AAPM&R Board of Governors on February 20, 2002.

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to Chair the AAEM CTS Task Force. The Chair selected the members of the AAEM CTS Task Force from the AAEM membership with the assistance of the AAEM staff and the AAEM President to include neurologists (Drs. Floeter, Jablecki, Wilson) and physiatrists (Drs. Andary, Quartly, Vennix) in both academic (Drs. Andary, Floeter, Quartly, Vennix) and clinical practice (Drs. Jablecki, Wilson) with interests in the use of EDX studies in CTS. The AAEM CTS Task Force included three members who authored the first CTS Literature Review published in 1993 (Drs. Jablecki, Andary, Wilson). In 1999, the AAEM President appointed Robert G. Miller, MD, to the AAEM CTS Task Force to provide an interface and full collaboration with the American Academy of Neurology (AAN) Quality Standards Subcommittee in the development of the second CTS Literature Review and the Summary Statement.

**Literature inclusion criteria.** In the fall of 1991, the AAEM Quality Assurance Committee adopted six literature inclusion criteria (LIC) of scientific methodology to evaluate CTS literature describing EDX procedures. The AAEM CTS Task Force used the same six AAEM CTS LIC when reviewing the literature. The first two criteria apply to all studies of diagnostic tests and deal with the quality of evidence and reducing bias; the remaining four criteria deal with technical and analytic issues that are critical to the use of nerve conduction studies (NCS) to document nerve pathology. All of these criteria are important for a study to determine whether or not an NCS is useful to diagnose CTS.

1. Prospective study design.
2. Diagnosis of CTS in patient population based on clinical criteria independent of the EDX procedure under evaluation.
3. EDX procedure described in sufficient detail to permit replication of the procedure.
4. Limb temperature monitored (measured continuously) during nerve conduction procedures and minimum (or range) of limb temperatures reported for both CTS patients and the reference population.
5. Reference values for the EDX test obtained either:
  - a. with concomitant studies of a reference population, or
  - b. with previous studies of a reference population in the same laboratory.
6. Criteria for abnormal findings clearly stated and, if the measurement is a quantitative one, the abnormal value is defined in statistically computed terms, e.g., range and mean  $\pm$  2 SD, from data derived from the reference population.

**Review of electrodiagnostic studies.** A total of 22 of the 278 articles reviewed met all six AAEM CTS LIC. There were nine additional articles (eight using surface electrodes and one using needle electrodes) that studied median motor and sensory nerve conduction across the carpal tunnel (amplitude, la-

tency, and velocity) in normal subjects only and otherwise fulfilled the AAEM CTS LIC.

The first and second CTS Literature Reviews<sup>1,2</sup> provide convincing scientific evidence that median sensory and motor NCSs:

1. Are valid and reproducible clinical laboratory studies.
2. Confirm a clinical diagnosis of CTS with a high degree of sensitivity (>85%) and specificity (>95%).

The table provides a summary of pooled sensitivities and specificities from studies that met all six AAEM CTS LIC for EDX techniques used to diagnose CTS. In these studies, hand temperatures were monitored continuously and the majority of the studies maintained the hand temperature at 32 °C or greater. Details of techniques and the specific studies pooled are provided in the second CTS Literature review.<sup>2</sup>

**Recommendations regarding EDX studies to confirm a clinical diagnosis of CTS.** The recommendations below are identical to those made and endorsed in 1993 by the AAN,<sup>3</sup> the American Academy of Physical Medicine and Rehabilitation,<sup>4</sup> and the AAEM<sup>5</sup> with the clarification of recommendation 1 and 2a and the addition of 2c based on new evidence reviewed in the second CTS Literature Review.<sup>2</sup>

In patients with suspected CTS, the following EDX studies are recommended (see the table for sensitivity and specificity of Techniques A through K):

1. Perform a median sensory NCS across the wrist with a conduction distance of 13 to 14 cm (Technique G). If the result is abnormal, comparison of the result of the median sensory NCS to the result of a sensory NCS of one other adjacent sensory nerve in the symptomatic limb (**Standard**).

2. If the initial median sensory NCS across the wrist has a conduction distance greater than 8 cm and the result is normal, one of the following additional studies is recommended:

- a. Comparison of median sensory or mixed nerve conduction across the wrist over a short (7 to 8 cm) conduction distance (Technique C) with ulnar sensory nerve conduction across the wrist over the same short (7 to 8 cm) conduction distance (Technique D) (**Standard**), or

- b. Comparison of median sensory conduction across the wrist with radial or ulnar sensory conduction across the wrist in the same limb (Techniques B and F) (**Standard**), or

- c. Comparison of median sensory or mixed nerve conduction through the carpal tunnel to sensory or mixed NCSs of proximal (forearm) or distal (digit) segments of the median nerve in the same limb (Technique A) (**Standard**).

3. Motor conduction study of the median nerve recording from the thenar muscle (Technique H) and

**Table** Comparison of pooled sensitivities and specificities of electrodiagnostic (EDX) techniques to diagnose carpal tunnel syndrome (CTS)

Technique	Pooled sensitivity*	Pooled specificity*
A. Median sensory and mixed nerve conduction: wrist and palm segment compared with forearm or digit segment	0.85† (0.83, 0.88)	0.98† (0.94, 1.00)
B. Comparison of median and ulnar sensory conduction between wrist and ring finger	0.85 (0.80, 0.90)	0.97 (0.91, 0.99)
C. Median sensory and mixed nerve conduction between wrist and palm	0.74† (0.71, 0.76)	0.97† (0.95, 0.99)
D. Comparison of median and ulnar mixed nerve conduction between wrist and palm	0.71 (0.65, 0.77)	0.97 (0.91, 0.99)
E. Median motor nerve conduction between wrist and palm	0.69† (0.64, 0.74)	0.98† (0.93, 0.99)
F. Comparison of median and radial sensory conduction between wrist and thumb	0.65 (0.60, 0.71)	0.99 (0.96, 1.00)
G. Median sensory nerve conduction between wrist and digit	0.65† (0.63, 0.67)	0.98† (0.97, 0.99)
H. Median motor nerve distal latency	0.63† (0.61, 0.65)	0.98† (0.96, 0.99)
I. Median motor nerve terminal latency index	0.62† (0.54, 0.70)	0.94† (0.87, 0.97)
J. Comparison of median motor nerve distal latency (second lumbrical) to the ulnar motor nerve distal latency (second interossei)	0.56‡ (0.46, 0.66)	0.98‡ (0.90, 1.00)
K. Sympathetic skin response	0.04 (0.00, 0.08)	0.52 (0.44, 0.61)

\* For each EDX technique to summarize results across studies, sensitivities were pooled from individual studies by calculating a weighted average. In calculating the weighted average, studies enrolling more patients received more weight than studies enrolling fewer patients. Specificities were similarly pooled by calculating the weighted average. The data in the parentheses next to the sensitivity and specificity values represent the lower and upper 95% confidence limits of the weighted average, respectively. Data analysis courtesy of Dr. Gary Gronseth.

† There was heterogeneity between some of the studies (the 95% CI of the sensitivities and specificities do not overlap). This disparity may be related to differences in case definition of CTS, the use of different cut-points to define an abnormal value, and differences in the average severity of the CTS patients in the different studies.

‡ Results based on a single study.

of one other nerve in the symptomatic limb to include measurement of distal latency (**Guideline**).

4. Supplementary NCS: Comparison of the median motor nerve distal latency (second lumbrical) to the ulnar motor nerve distal latency (second interossei) (Technique J), median motor terminal latency index (Technique I), median motor nerve conduction between wrist and palm (Technique E), median motor nerve compound muscle action potential (CMAP) wrist to palm amplitude ratio to detect conduction block, median sensory nerve action potential (SNAP) wrist to palm amplitude ratio to detect conduction block, short segment (1 cm) incremental median sensory nerve conduction across the carpal tunnel (**Option**).

5. Needle electromyography of a sample of muscles innervated by the C5 to T1 spinal roots, including a thenar muscle innervated by the median nerve of the symptomatic limb (**Option**).

Based on the second AAEM CTS Literature Review,<sup>2</sup> the following EDX studies are not recommended to confirm a clinical diagnosis of CTS either because the EDX studies recommended above have greater sensitivity and specificity or the test is best described as investigational at this time.

1. Low sensitivity and specificity compared to other EDX studies: multiple median F wave parameters, median motor nerve residual latency, and sympathetic skin response (Technique K).
2. Investigational studies: evaluation of the effect on median NCS of limb ischemia, dynamic hand exercises, and brief or sustained wrist positioning.

**Definition of practice recommendation strengths.** The strength of a recommendation or conclusion is based on the quality and consistency of supporting evidence. The following rating system is used:

*Practice standards:* generally accepted principles for patient management that reflects a high degree of clinical certainty.

*Practice guidelines:* recommendations for patient management that reflect moderate clinical certainty.

*Practice options:* other strategies for patient management for which the clinical utility is uncertain.

**Recommendations for future research studies in CTS.** The AAEM recommends that future clinical research studies of the usefulness of EDX studies

to confirm the diagnosis of CTS meet three clinical study criteria:

1. Prospective study.
2. Clinical diagnosis of CTS independent of EDX studies. For example, a diagnosis of probable CTS as defined in the second CTS Literature Review,<sup>2</sup> which is based on a consensus recommendation by Rempel et al.<sup>6</sup>
3. A uniform protocol for data collection and measurement with the physicians performing and interpreting the EDX studies under investigation blinded to the clinical diagnosis of all the human subjects (normal, CTS, disease control) in the study at least until the data collection and measurements are completed.

The AAEM recommends that future clinical research studies of the usefulness of EDX studies to confirm the diagnosis of CTS meet four additional methodologic study criteria:

4. Description of EDX technique sufficient to permit replication of the study.
5. Monitor limb temperature continuously during the EDX study.
6. Normal values for EDX technique obtained with concomitant studies or with previous studies in the same laboratory.
7. Criteria of EDX abnormality obtained from normal population and defined in statistical terms.

The first and second AAEM CTS Literature Reviews<sup>1,2</sup> used six CTS LIC. The second CTS Literature Review<sup>2</sup> recommended 1) the addition of criterion 3, and 2) that future AAEM CTS Literature Reviews use all seven CTS LIC to review reports of the usefulness of EDX studies in the evaluation of patients with CTS. The second AAEM CTS Literature Review<sup>2</sup> also provided a set of specific criteria to make a clinical diagnosis of CTS based on expert opinion.

Both the first and second AAEM CTS Literature Reviews recommended that outcome studies should be performed to assess the harms, benefits, and costs of performing NCSs and needle electromyography in patients with symptoms suggestive of CTS.

The AAEM CTS Task Force has addressed future research principles over future research topics (except for outcome studies) because the Task Force concluded that future research studies need to meet these principles: 1) to provide reliable and reproducible data to evaluate the usefulness of EDX studies to confirm the clinical diagnosis of CTS, and 2) to permit comparison of the relative utility of different EDX studies for that purpose.

**Disclaimer.** This report is provided as an educational service of the AAEM, AAN, and American Academy of Physical Medicine and Rehabilitation (AAPM&R). It is based on an assessment of the current scientific and clinical information. It is not intended to include all possible proper methods of care for a particular clinical problem or all legitimate criteria for choosing to use a specific procedure. Neither is it intended to exclude any reasonable alternative methodologies. The AAEM, AAN, and AAPM&R recognize that specific patient care decisions are the prerogative of the patient and the physician caring for the patient, based on all of the circumstances involved.

## Appendix

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