

## Summary of Electrodiagnostic Testing in Clinical Chiropractic Practice

Electrodiagnosis is an integral component of clinical chiropractic practice. Valid and reliable electrodiagnostic methods currently used by doctors of chiropractic include: electromyography (EMG); nerve conduction velocity testing (NCV); somatosensory/dermatomal evoked potentials (SEP/DSEP); H-reflex; F-waves; and quantitative sensory testing-current perception threshold (CPT-neurometer).

Testing peripheral nerves is germane and within the scope of chiropractic practice since it helps differentiate peripheral neuropathy from spinal radiculopathy. The spinal nerve roots contribute to all peripheral nerves (i.e., ulnar nerve = C8/T1). Electrodiagnostic testing methods are all rated "type A-level 1" (which signifies the strongest rating of being established and valid) by the Guidelines for Chiropractic Quality Assurance and Practice Parameters (Mercy guidelines).

### Electromyography

Needle electromyography (EMG) is used to help detect loss of neurons innervating a muscle, which may be seen in cases of nerve root compression, disc herniation, foraminal encroachment and peripheral nerve injury all leading to axonal degeneration. EMG is an extension of the history and clinical exam and must be correlated with those findings. EMG is a motor test that can help differentiate proximal and distal lesions, peripheral versus root dysfunction, as well as myopathy and neuropathy.

An abnormal EMG for radiculopathy should include fibrillation potentials and positive waves in a myotomal distribution with abnormal paraspinal findings and extremity abnormalities. The presence of fibrillation potentials in a root distribution with paraspinal findings is the most reliable evidence of radiculopathy. There should be findings from two or more muscles receiving innervation from the same root, preferably via different peripheral nerves, with normal findings in an adjacent nerve root (i.e., in C7 radiculopathy, denervation should be seen in the triceps (C7/8) and pronator teres (C6/7), but not the extensor indices (C8/T1).

EMG should be done no sooner than three weeks post-injury/trauma, because it takes about three weeks for denervation changes to occur.

An abnormal EMG for radiculopathy would include fibrillation potentials, spontaneous activity at rest, and positive waves in a myotomal distribution with paraspinal findings. Fibrillation potentials in a root distribution with the paraspinal findings is reliable evidence of radiculopathy. There should be findings from two or more muscles receiving innervation from the same root, preferably via different nerves, with normal findings in the adjacent root. For example, in a C7 radiculopathy, denervation changes should be seen in the triceps (C7/8) and the pronator teres (C6/7), but not the extensor indices (C8/T1).

### Nerve Conduction Velocities (NCV --Motor, Sensory, H-Waves, F-Waves)

Motor and Sensory NCV

NCVs are used to differentiate types of neuropathy. NCVs are typically normal in radiculopathy. Waveforms, latencies and amplitudes must be recorded. Sensory NCVs record the sensory nerve action potential (SNAP), when peripheral sensory nerves are stimulated. Motor NCVs record compound muscle action potentials (CMAP) when peripheral motor nerves are stimulated.

Motor conduction velocities and amplitudes must be recorded and tabulated. Conduction velocities are measured by supramaximal stimulation at two different points of the same nerve trunk. The velocity is calculated by  $D/T$ , where D equals the distance between the two sites and T equals the latency time between the two points. Typically the ulnar, median, tibial and peroneal nerves are studied in both sensory and motor NCV exams. NCVs are clinically appropriate tests to differentially diagnose carpal tunnel syndrome, tarsal tunnel syndrome, ulnar neuropathies, peroneal neuropathies, radiculopathy, polyneuropathy and plexopathy. Amplitude abnormalities are suggestive of axonal loss, while conduction abnormalities are suggestive of focal demyelination.

NCVs are usually normal in radiculopathy because the lesions are proximal to the dorsal root ganglion. However, with axonal degeneration of the roots, CMAP amplitudes may be reduced within seven days post-injury (i.e., C8/T1 radiculopathy will show decreased amplitude in the ipsilateral ulnar or median nerve CMAPs). As such, NCVs may be performed if medically indicated after one week post-injury or trauma.

#### F-Waves

Considered a "late response" due to a second CMAP for the proximal potential. It is used to detect proximal nerve lesions such as in radiculopathy and thoracic outlet syndrome or brachial plexopathies. The shortest latency is selected when the nerve is stimulated 10-20 times. It is then compared with the opposite side or normal database.

F-waves measure motor nerves only. It is a complementary test and should be used with motor and sensory NCV findings.

#### H-Reflex

H-reflex is a late response as well. It is easily and reliably recorded most from the tibial nerve (90% sensitivity). Therefore, it is used most commonly to diagnose S1 radiculopathy. A positive H-reflex is when the latency on the symptomatic side is delayed when compared to the normal side, absent, or reduced in amplitude. H-reflexes have also been used on the flexor carpi radialis (C6/7).

#### Somatosensory/Dermatome Evoked Potentials (SEP/DSEP)

SEPs test the integrity of the somatosensory pathways. DSEPs help localize functional segmental level abnormalities thus allowing the treating doctor of chiropractic to be selective on levels of care.

The major clinical application of SEP/DSEP is in the detection of physiologic impairment through proximal parts of peripheral nerves, spinal nerve roots, the spinal cord and the brainstem. SEPs help localize the anatomic site of somatosensory pathway lesions and can identify impaired conduction from axonal loss (reduced amplitude or response) and/or demyelination (prolonged or absent cortical waveforms).

Numerous studies have shown that SEP/DSEP are useful, since EMG/NCV mostly detect motor radiculopathies. Since many radiculopathies seen in chiropractic practice are sensory type radiculopathies, SEP/DSEP is well suited to chiropractic practice.

In SEP testing, peripheral mixed sensory nerves are stimulated and studied for latency, amplitudes and interpeak latencies. In DSEP testing, the "signature" region for a particular dermatome (i.e., middle finger for C7) is stimulated, then cortical latencies and amplitudes are recorded. In the upper extremity, a minimum of a three channel montage recording setup is required (EEG-type gold electrodes at Erb's point, the spinous of C7 and the contralateral cortex). These three channels will pick up three common waveforms referred to as N9, N13 and N20. In the lower extremity, a similar three channel montage is utilized and consists of electrodes at the popliteal fossa, the lumbar spine and the contralateral cortex. Most typically, the cortical peaks are the waveforms reviewed (N37/P45).

DSEPs have been shown to be very useful in spinal stenosis and multiple root disease/compression (Snowden et al.), radiculopathy (Walk and Slimp), and thoracic outlet syndrome (Chodroff and BenEliyahu). DSEPs have also recently been shown to be helpful in thoracic/intercostal radiculopathies, since there are no other tests to reliably document an intercostal nerve root injury. Recently in Spine, DSEP was shown to be valuable in the diagnosis of cervical spondylitic myelopathy (CSM).

Abnormal SEP/DSEP findings should include:

1. delayed or absent cortical waveforms and potentials of the deviations from published normals);
2. side to side latency ratio >2.0 standard deviations;
3. decreased amplitudes >2.0 standard deviations below normal;
4. amplitude ratios from side to side >2.0 standard deviations.

SEP/DSEP is useful in clinical chiropractic due to its non-invasive nature and is often combined with NCV. Since most radiculopathies are sensory in nature, this test is appropriate in the chiropractic setting.

BAER -- Brainstem Auditory Evoked Potentials

BAER is a subtype of evoked potential testing. It measures the integrity of the of the auditory nerve and brainstem. The patient wears a set of headphones and hears a series of 60 decibel clicks. Recordings are made over the scalp with EEG electrodes. Several waveforms are recorded. In clinical chiropractic practice, BAER is useful in differentiating multiple sclerosis, post-concussion syndrome (PCS) and posterior fossa tumors.

Indications include posttraumatic dizziness or vertigo. PCS lesions will usually be seen in wave III. This test is not routinely done, ordered or necessary in clinical chiropractic practice.

VEP -- Visual Evoked Potentials

Electric waveforms are recorded over the cerebral cortex with EEG-type electrodes due to light stimuli seen on a reverse pattern checkerboard. The normal VEP response is at 100ms (P-100). This test helps detect a variety of neurological disorders and is not particularly useful or used in chiropractic practice. This test is not routinely performed in clinical practice either, but it is sometimes used to rule out multiple sclerosis.

CPT -- Current Perception Threshold/Neurometer

CPT is a quantitative sensory test (QST) which provides an objective and reproducible functional assessment of the peripheral nervous system. CPT is the minimum amount of transcutaneous applied current that an individual consistently perceives as evoking sensation. A standardized and computerized double-blind forced choice testing paradigm allows for objective testing preventing patient deception and examiner bias.

CPT may be utilized to differentiate polyneuropathy, focal compressive neuropathy and radiculopathy due to its neuroselective capabilities of stimulating at different frequencies (i.e., 5 hertz = C fibers, 250 hertz = A delta fibers).

All three frequencies must be tested. Data should be processed by the onboard computer, which compares patient data to a normal database. When evaluating for a radiculopathy, two different nerves should be tested abnormal in the same dermatome (i.e., superficial peroneal and saphenous nerves for the L4 dermatome).

When evaluating for a focal neuropathy (i.e., carpal tunnel syndrome), testing is done bilaterally and at the distal phalanx of the index finger. Isolated impairment of the median nerve with normal findings in the ipsilateral ulnar digital nerve and median nerve palmar branch is consistent with carpal tunnel syndrome. In a 1998 study, CPT was found to have an 80% sensitivity in radiculopathy.

Electrodiagnostic studies, including but not limited to EMG, NCV (motor and sensory), F-waves, H-reflex, SEP/DSEP and CPT are appropriate, reliable and valid diagnostic methods in clinical chiropractic practice. The tests should be medically necessary in so much as they help the clinician delineate and formulate a differential diagnosis, prognosis, and make clinical management decisions.

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