Nerve conduction study in cervical radiculopathy

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ABSTRACT

Background: Cervical radiculopathy is a common neurological condition characterized by pain, paresthesia, or weakness in the upper limb due to nerve root compression. While clinical examination and imaging are crucial, nerve conduction studies (NCS) provide objective evidence of functional impairment. This study aimed to evaluate motor, sensory, and F-wave conduction parameters in patients with cervical radiculopathy and to correlate electrophysiological findings with clinical severity.

Material and Methods: A cross-sectional observational study was conducted on 60 patients with clinically suspected cervical radiculopathy. All subjects underwent motor, sensory, and F-wave conduction studies of the median, ulnar, and radial nerves using standard surface electrodes. Demographic and clinical data were collected, and electrophysiological findings were analyzed with respect to disease severity. Statistical significance was set at $p < 0.05$.

Results: The mean age of participants was 44.8 ± 9.6 years, with a male-to-female ratio of 1.5:1. The most frequent symptom was neck pain (100%), followed by radiating arm pain (91.7%) and paresthesia (70%). Motor studies showed mean distal latency of 4.8 ± 0.7 ms (median nerve) and 3.1 ± 0.5 ms (ulnar nerve). Sensory conduction revealed reduced SNAP amplitudes, particularly in the median nerve (13.6 ± 4.1 µV). Prolonged F-wave latencies were detected in 30% of patients for the median nerve and 25% for the ulnar nerve. A significant association was observed between clinical severity and NCS abnormalities, with severe cases showing abnormal motor conduction in 91.7%, sensory abnormalities in 83.3%, and prolonged F-wave latency in 66.7%.

Conclusion: Nerve conduction abnormalities are common in cervical radiculopathy and strongly correlate with clinical severity. NCS serves as a useful adjunct to clinical assessment, aiding in diagnosis, severity grading, and management planning.

Key words: Cervical radiculopathy, Nerve conduction study, Motor conduction, Sensory conduction, F-wave latency

INTRODUCTION

Cervical radiculopathy (CR) results from dysfunction of a cervical spinal nerve root and commonly presents with neck pain radiating to the upper limb, sensory disturbances, and variable motor deficits [1,2]. Degenerative changes—disc herniation and foraminal stenosis—are typical etiologies in adults; the natural history is often favorable but a subset of patients experience persistent pain or progressive neurological deficit requiring intervention [2,3].

Accurate diagnosis of CR relies on an integrated approach that includes a focused history, directed neurological examination, imaging and electrodiagnostic testing. Magnetic resonance imaging (MRI) provides structural detail about foraminal compromise and root compression, but imaging findings may not correlate perfectly with symptoms or functional impairment [2]. Electrodiagnostic studies—needle electromyography (EMG) and nerve conduction studies (NCS)—therefore play an important complementary role by providing objective functional assessment of the peripheral nervous system and by helping to exclude coexisting peripheral neuropathies or entrapment syndromes that mimic radicular disease [1,4].

Needle EMG is regarded as the most sensitive electrophysiologic test to confirm radiculopathy because it can demonstrate denervation in paraspinal and limb muscles innervated by the affected root; reported sensitivities for EMG in appropriately selected patients range from approximately 50% to 72% depending on the cohort and criteria used [1,5]. Conventional nerve conduction studies are often normal in pure radiculopathy because the lesion is proximal to the dorsal root ganglion; however, motor and sensory NCS and late responses (including F-waves) can provide valuable complementary information — for instance, to detect axon loss, quantify severity, and identify distal entrapment neuropathies or polyneuropathy [1,4,5].

F-wave and other late-response parameters have been evaluated as adjuncts in the electrodiagnostic evaluation of cervical root lesions. While studies report modest sensitivity when F-wave measures are used alone, combining multiple late-response metrics (minimum latency, chronodispersion, persistence, and side-to-side differences) improves detection and can add information beyond needle EMG and routine NCS [3,6]. Despite these utilities, the diagnostic yield of different NCS parameters and their correlation with clinical severity remain variable across studies, underscoring the need for continued evaluation of NCS profiles in well-characterized clinical cohorts [3,5].

Given the complementary but sometimes limited sensitivity of individual electrodiagnostic measures, systematic reporting of motor, sensory, and late-response (F-wave) parameters in patients with clinically suspected cervical radiculopathy is useful both for diagnostic confirmation and for severity assessment. The present study was therefore designed to document NCS findings (motor, sensory and F-wave) in a consecutive cohort of patients with clinically suspected cervical radiculopathy and to examine the relationship between electrophysiological abnormalities and clinical severity.

MATERIAL AND METHODS

Study Design and Setting: This was a cross-sectional observational study conducted at a tertiary care teaching college and hospital over a period of 12 months.

Study Population and Sample Size: A total of 60 patients clinically diagnosed with cervical radiculopathy were recruited. The sample size was determined considering feasibility, patient flow in the neurology outpatient clinic, and comparison with similar published studies.

Inclusion Criteria

- Patients aged 18–65 years presenting with neck pain radiating to the upper limb with or without paresthesia.

- Clinical suspicion of cervical radiculopathy based on neurological examination (motor weakness, sensory changes, reflex asymmetry).
- Patients providing informed written consent.

Exclusion Criteria

- History of peripheral neuropathy due to diabetes, alcohol, or toxins.
- Previous cervical spine surgery or trauma.
- Coexisting neurological disorders (e.g., multiple sclerosis, motor neuron disease).
- Patients on neurotoxic medications.

Nerve Conduction Study (NCS) Procedure

All patients underwent detailed electrophysiological evaluation using a standard electromyography and nerve conduction system machine. The following parameters were recorded:

- Motor nerve conduction: Median and ulnar nerves were assessed for distal latency, amplitude, and conduction velocity.
- Sensory nerve conduction: Median, ulnar, and radial nerves were studied for sensory nerve action potentials (SNAPs) and conduction velocity.
- F-wave latency was obtained for the median and ulnar nerves.

The procedure was carried out in a temperature-controlled room (maintained at 23–25°C). Standardized skin temperature (≥32°C) was ensured before testing. Surface electrodes were used for stimulation and recording, following standard guidelines of the American Association of Neuromuscular & Electrodiagnostic Medicine (AANEM).

Data Collection and Statistical Analysis

Clinical data and NCS parameters were systematically recorded in a structured proforma. Data analysis was performed using SPSS version 25.0. Descriptive statistics were applied for demographic variables. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. The electrophysiological findings were correlated with clinical severity using appropriate statistical tests (Chi-square for categorical data, Student's t-test/ANOVA for continuous data). A *p* value of <0.05 was considered statistically significant.

RESULTS

A total of 60 patients with clinically suspected cervical radiculopathy were included in the study. The mean age of participants was 44.8 ± 9.6 years, with a male predominance (60% males vs. 40% females). The mean duration of symptoms was 4.6 ± 2.3 months. The majority of patients presented with neck pain (100%), followed by radiating arm pain (91.7%), paresthesia (70%), and limb weakness (46.7%). Right-sided involvement (63.3%) was more frequent than left-sided involvement (36.7%) (Table 1).

The mean distal latency of the median motor nerve was 4.8 ± 0.7 ms, and the mean amplitude was 6.2 ± 1.4 mV, with a conduction velocity of 49.6 ± 3.2 m/s. For the ulnar motor nerve, distal latency averaged 3.1 ± 0.5 ms, amplitude 7.1 ± 1.6 mV, and conduction velocity 53.2 ± 2.9 m/s. A significant proportion of patients demonstrated reduced amplitudes and slowed conduction velocities, particularly in those with moderate to severe clinical symptoms (Table 2).

In the sensory studies, the mean SNAP amplitude was 13.6 ± 4.1 µV for the median nerve, 15.1 ± 3.8 µV for the ulnar nerve, and 18.4 ± 4.6 µV for the radial nerve. Corresponding mean conduction velocities were 47.2 ± 3.4 m/s, 49.5 ± 3.1 m/s, and 52.7 ± 2.8 m/s, respectively. Patients with higher clinical severity demonstrated greater reductions in sensory amplitudes and velocities (Table 3).

The mean F-wave latency was 28.4 ± 2.1 ms for the median nerve and 27.1 ± 2.3 ms for the ulnar nerve. Prolonged F-wave responses were observed in 30% of patients for the median nerve and 25% for the ulnar nerve (Table 4).

Abnormalities in NCS parameters increased with the severity of clinical symptoms. Among patients with mild disease, abnormal motor conduction was detected in 36.4%, abnormal sensory conduction in 27.3%, and prolonged F-wave latency in 18.2%. In contrast, patients with severe disease demonstrated abnormalities in 91.7% for motor conduction, 83.3% for sensory conduction, and 66.7% for F-wave latency (Table 5). This correlation between clinical severity and electrophysiological findings was statistically significant ($p < 0.05$).

Table 1. Demographic and Clinical Profile of Patients (n = 60)

Variable	Frequency (%) / Mean ± SD
Age (years)	44.8 ± 9.6
Sex (Male:Female)	36 (60%) : 24 (40%)
Duration of symptoms (months)	4.6 ± 2.3
Affected side (Right:Left)	38 (63.3%) : 22 (36.7%)
Common symptoms	
– Neck pain	60 (100%)
– Radiating arm pain	55 (91.7%)
– Paresthesia	42 (70%)
– Weakness	28 (46.7%)

Table 2. Motor Nerve Conduction Parameters

Nerve	Distal Latency (ms)	Amplitude (mV)	Conduction Velocity (m/s)
Median	4.8 ± 0.7	6.2 ± 1.4	49.6 ± 3.2
Ulnar	3.1 ± 0.5	7.1 ± 1.6	53.2 ± 2.9

Table 3. Sensory Nerve Conduction Parameters

Nerve	SNAP Amplitude (µV)	Conduction Velocity (m/s)
Median	13.6 ± 4.1	47.2 ± 3.4
Ulnar	15.1 ± 3.8	49.5 ± 3.1
Radial	18.4 ± 4.6	52.7 ± 2.8

Table 4. F-wave Latency Findings

Nerve	Mean F-wave Latency (ms)	Prolonged Latency (%)
Median	28.4 ± 2.1	18 (30%)
Ulnar	27.1 ± 2.3	15 (25%)

Table 5. Correlation between Clinical Severity and Abnormal NCS Findings

Clinical Grade (n=60)	Abnormal Motor NCS (%)	Abnormal Sensory NCS (%)	Prolonged F-wave (%)
Mild (n=22)	8 (36.4%)	6 (27.3%)	4 (18.2%)
Moderate (n=26)	18 (69.2%)	15 (57.7%)	9 (34.6%)
Severe (n=12)	11 (91.7%)	10 (83.3%)	8 (66.7%)

DISCUSSION

In this hospital-based cohort of 60 patients with clinically suspected cervical radiculopathy, we found frequent electrophysiologic abnormalities on routine nerve conduction studies (reduced motor/sensory amplitudes, slowed conduction velocities) together with a substantial proportion of prolonged F-wave latencies (median: 30%; ulnar: 25%). Importantly, the frequency and magnitude of NCS abnormalities rose with clinical severity: patients classified as severe had motor abnormalities in 91.7%, sensory abnormalities in 83.3% and prolonged F-waves in 66.7%. These findings have several practical and pathophysiologic implications.

First, our observation that objective NCS abnormalities are more common in patients with greater clinical severity aligns with prior reports showing that electrophysiologic indices tend to reflect the extent of axonal involvement and functional loss. Electrophysiologic testing—especially when it demonstrates reduced compound motor action potential amplitudes or reduced sensory nerve action potentials—most commonly indicates axon loss and thus correlates better with motor deficits than with pain or purely sensory complaints. This relationship between degree of physiologic impairment and clinical severity is discussed in electrodiagnostic reviews and series which emphasize that EDX abnormalities are most likely when motor deficits or clear objective signs are present [7,8].

Second, although routine peripheral NCS (distal motor and sensory studies) are often normal in purely proximal root lesions, certain NCS parameters and late responses (F-waves and more detailed F-wave measures) can increase diagnostic yield and help quantify severity. Our finding of prolonged F-wave latencies in a meaningful subset of patients is consistent with studies showing that F-wave measures—while of limited sensitivity when used in isolation—can detect proximal conduction abnormalities or motor axon dysfunction when combined with other measures [for example, chronodispersion, persistence, amplitude metrics]. Recent work on late-response analysis (including objective characterization of repeater F-waves and discrimination from A-waves) highlights both the potential value of late-response metrics and the technical complexity of interpreting them; this explains why F-wave abnormalities are supportive but not definitive for radiculopathy [9].

Third, the variable diagnostic yield of different electrodiagnostic modalities must be emphasized. Needle EMG remains the most sensitive single EDX technique for demonstrating radiculopathy because it can directly show denervation changes in muscles innervated by the affected root; by contrast, routine surface NCS are primarily useful to exclude superimposed mononeuropathies or generalized polyneuropathy and to quantify axonal loss when present. Studies comparing EMG and MRI emphasize that EMG adds functional information and that combined use (clinical exam + imaging + EDX) improves diagnostic confidence and localization. Our study focused on NCS parameters (motor, sensory, F-wave) and therefore complements EMG-centered reports by documenting how commonly NCS abnormalities occur and how they relate to clinical grading [10].

Fourth, the strength of the correlation between subjective symptom burden and objective EDX measures is imperfect and variable across conditions and studies. Work in related peripheral nerve disorders (for example, carpal tunnel syndrome) demonstrates that electrodiagnostic severity does not always map neatly onto patient-reported disability or pain scores; conversely, moderate correlations are reported when objective strength or neurophysiologic loss is compared with validated clinical scales. These data caution clinicians against over-reliance on a single modality and support a multimodal evaluation—especially when management decisions (conservative versus surgical) depend on both symptoms and objective dysfunction. Our finding of stronger NCS

abnormalities in patients with marked objective deficits—but potential normal/near-normal results in milder or pain-predominant disease—mirrors these broader observations [11-13].

Limitations: First, this study is a single-center series with a modest sample size; the absolute percentages may differ in other populations. Second, although our protocol included motor, sensory and F-wave measurements, we did not present a comprehensive needle EMG dataset in the present report (EMG was performed selectively), which limits direct comparison with EMG-based sensitivity estimates reported elsewhere. Third, late-response interpretation (F-waves) is technically demanding and can be influenced by temperature, stimulation technique, and recording parameters; therefore, F-wave abnormalities should be interpreted in the larger clinical and electrodiagnostic context. Finally, the cross-sectional design precludes assessment of longitudinal change or prognostic value of the observed NCS abnormalities.

CONCLUSION

In this study, abnormalities in motor and sensory conduction parameters, as well as prolonged F-wave latencies, were frequently observed and showed a significant correlation with clinical severity. These findings highlight the role of electrophysiological assessment as a complementary diagnostic tool to clinical examination and imaging. Early use of NCS may aid in confirming the diagnosis, assessing disease severity, and guiding management strategies in patients with cervical radiculopathy.

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