Comparison between Surface Electrode and Monopolar Needle Electrode in the Determination of the Nerve Conduction Studies of the Radial Nerve

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ABSTRACT

Objective. This cross-sectional study aims to determine the accuracy of using a surface electrode compared with using a needle electrode in the determination of the latency, amplitude, and duration of the compound motor action potential and nerve conduction velocity of the radial nerve.

Methods. A cohort of 42 males and 30 females consisting of patients from the Philippine General Hospital referred for electrodiagnostic studies of the upper extremity and healthy volunteers were included in the study. The compound motor action potential of the radial nerve in each participant was determined using the surface electrode technique and the monopolar needle technique, and the results were compared. The main outcome measures were: compound motor action potential amplitude, latency, duration, and nerve conduction velocity; sensitivity; specificity; and agreement between the two techniques under investigation.

Results. When all parameters in the nerve conduction studies were considered, the sensitivity of the surface electrode compared with the monopolar needle electrode in determining radial nerve abnormalities was 46.14% (95% Confidence Interval (CI) 0.27 – 0.65), with a specificity of 82.61% (95% CI 0.72 – 0.94) and an overall diagnostic accuracy of 69.44%. When the parameters were taken individually, analysis of the latency showed sensitivity of 60% (95% CI 0.17 – 1.03), and specificity of 100%, with overall diagnostic accuracy of 97.22%. The test for amplitude yielded sensitivity of 50% (95% CI 0.1 – 0.90) and specificity of 100%. The overall diagnostic accuracy was 95.83%. Analysis of the duration showed a sensitivity of 71.43% (95% CI 0.38 – 1.05) and specificity of 100%, with overall diagnostic accuracy of 97.22%. The nerve conduction velocity alone showed sensitivity of 55% (95% CI 0.33 - 0.77), specificity of 84.61% (95% CI 0.75 – 0.94), and overall diagnostic accuracy of 76.39%. The kappa test revealed a fair association or agreement when all the parameters of the compound motor action potential were taken into consideration (k=0.30), moderate association between the surface and the needle electrode in nerve conduction velocity (k=0.40), a substantial association in amplitude (k=0.65) and latency (k=0.74), and a high association between the two techniques for the duration (k=0.81).

Conclusions. In the comparison of the surface electrode and the monopolar needle electrode techniques in the determination of the compound motor action potential of the radial nerve, the parameters have high specificity and a high probability of a negative test in individuals who are disease-free. The kappa test indicated a fair association between the two techniques. When the parameters of compound motor action potential are taken separately, the latency, amplitude, duration and nerve conduction velocity of the radial nerve have a high probability of positive test results in people with disease and a high probability of negative test results in people with no disease. The study showed that the surface electrode technique is a fair to good alternative to the needle electrode when conducting a radial motor nerve study.

Key Words: rehabilitation medicine, electrodiagnosis, nerve conduction studies, radial nerve, surface electrode, needle electrode

Introduction

The radial nerve is the direct continuation of the posterior cord of the brachial plexus. It supplies the triceps and the twelve muscles of the posterior osteofascial compartment of the forearm. There has been an increasing number of upper extremity neuropathies and peripheral nerve injuries caused by various accidents, including injuries of the radial nerve. At present, 75% of electromyography-nerve conduction velocity study (EMG-NCV) cases seen in the Department of Rehabilitation Medicine, Philippine General Hospital (PGH) are peripheral nerve injuries. Radial nerve compression injuries such as crutch palsy and Saturday night palsy are also becoming more common.

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However, the accuracy of the procedure in determining the parameters—namely, nerve conduction velocity (NCV), amplitude and duration of the compound motor action potential (CMAP) of the radial nerve—have been debated.

The recommended practice for radial nerve studies is to use a needle electrode, placed on the extensor indicis propius (EIP) muscle.[1,2] The practice of using a surface electrode has become quite common since it is noninvasive and it does not cause much discomfort. However, the deep location of the EIP muscle has led to questions regarding the accuracy of using the surface electrode.

In a study by Chang and Oh on the standardization technique in sensory nerve conduction studies of the radial nerve, the authors concluded that study of the superficial radial nerve can be easily performed and that the findings were consistent when taken in the forearm.[3]

Young et al. reported that a side-by-side comparison using the surface electrode in the determination of the radial motor nerve conduction studies revealed consistent amplitude results when the surface recording is at the extensor digitorum communis measured 8 cm from the distal stimulation site.[4]

After an extensive literature search in both Medline (Pubmed) and Cochrane review databases, no published studies comparing the use of the surface electrode with the use of the needle electrode in radial motor nerve studies were found. This study was undertaken to determine the comparability of the use of the surface electrode and the use of the needle electrode in obtaining the latency, NCV, amplitude and duration of the CMAP of the radial nerve. The study attempts to validate the accuracy of an alternative method to the invasive needle electrode technique. The technique using the surface electrode is inexpensive, safe and relatively easy to perform. It is also more acceptable to patients who are apprehensive of needles and to electromyographers seeking a valid alternative method for examining the radial nerve.

Methods

The study recruited 72 participants to estimate sensitivity and specificity with a margin of error of 10% at 95% confidence level. Participants aged 18 to 55 years were included in the study and were randomized by recruiting every other participant with various diagnoses referred for upper extremity nerve conduction studies at the Electrodiagnostic Laboratory of the Department of Rehabilitation Medicine, PGH, from September 2008 to November 2008. Pilot testing on 20 participants two months prior to the actual study was conducted to familiarize the investigator with the procedure's technique. The principal investigator conducted all the procedures under the direct supervision of the Electrodiagnosis Consultant of the Department.

The participants, after signing an informed consent form, underwent two procedures using the Cadwell 6200A electrodiagnostic machine to obtain the radial NCV, latency, amplitude and duration of the CMAP. The body temperature of the participants was checked using a mercurial thermometer prior to the start of the procedures and was recorded. The participants were examined using the surface electrode procedure followed by the needle electrode procedure.

Surface Electrode Procedure

Each participant was instructed to move the index finger, using the EIP muscle (Figure 1). The surface bar electrode was placed 2 to 4 cm proximal to the ulnar styloid process on the dorsal aspect of the forearm, near the lateral edge of the ulnar bone (E1) (Figure 2). A supramaximal stimulus was applied at the forearm (distal) using a cathode placed 4 to 6 cm proximal to the E1 electrode along the lateral edge of the ulna (Figure 3). Stimulation was also done at the elbow (proximal) 5 to 6 cm proximal to the lateral epicondyle of the humerus between the biceps brachii and brachioradialis muscles (Figure 4). Using the Jebsen's technique, the distance between the distal and proximal sites was measured using a measuring tape[5,6] (Figure 5). The values of the parameters obtained and distances measured in centimeters were recorded in a data collection form.

Needle Electrode Procedure

The needle electrode procedure was performed on the same extremity as the surface electrode procedure. A topical anesthetic was applied over the needle insertion site 10 minutes prior to the procedure. Each participant was asked to move the index finger. Movement of the needle was observed to determine the location of the EIP muscle. A monopolar needle electrode was inserted at the EIP muscle 2 to 4 cm proximal to the ulnar styloid process on the dorsal aspect of the forearm, near the lateral edge of the ulnar bone (E1) (Figure 6). A supramaximal stimulus was applied at the forearm (distal) using a cathode placed 4 to 6 cm proximal to the E1 electrode along the lateral edge of the ulna (Figure 3). Stimulation was also done at the elbow (proximal) 5 to 6 cm proximal to the lateral epicondyle of the humerus between the biceps brachii and brachioradialis muscles (Figure 4). Using the Jebsen's technique, the distance between the distal and proximal sites was measured using a tape measure[5,6] (Figure 5). The values obtained and distances in centimeters were recorded in a data collection form.

The values of the parameters of the radial CMAP were compared with the international standard values[1] as there are no standard values for the Filipino population. The data was analyzed by computing the sensitivity and specificity.[7] The association between the surface electrode and monopolar needle electrode techniques was analyzed using the kappa test.[7,8]

Figure 1. Measurement for placement of electrodes

Figure 2. Radial nerve test using the surface bar electrode

Figure 3. Radial nerve distal stimulation to get the CMAP

Figure 4. Radial nerve proximal stimulation to get the CMAP

Figure 5. Measurement of distance between distal and proximal stimulation areas for radial nerve NCV determination

Figure 6. Radial nerve test using the monopolar needle electrode

Results

A total of 72 participants were included in the study with mean age of 37.92 years and age range of 18 to 55 years. There were 42 males and 30 females. Sixty-two (62) out of 72 participants (86.11%) were right-handed. The average weight of the participants was 60 kilograms.

The computed sensitivity using the surface electrode compared with the monopolar needle electrode in determining CMAP was 46.15% (95% Confidence Interval (CI) 0.27 – 0.65) and the computed specificity was 82.61% (95% CI 0.72 – 0.94). Among participants with neuropathies detected with the needle electrode, the surface electrode yielded a positive predictive value (PPV) of 60% (95% CI 0.39 – 0.81) among those with disease. In contrast among patients without neuropathy by needle electrode, the negative predictive value (NPV) of the test was 73.08% (95% CI 0.61 – 0.85). An overall diagnostic accuracy of 69.44% was computed (Table 1).

Table 1. The overall sensitivity and specificity of surface electrode examination compared with a monopolar needle electrode examination in the detection of radial neuropathy

	Needle Electrode		
Surface Electrode	**Disease**	**No Disease**	**Total**
Positive Test	12 (16.67%)	8 (11.11%)	20
Negative Test	14 (19.44%)	38 (52.78%)	52
Total	26	46	72

When latency was analyzed as a separate parameter in the comparison of the surface electrode and the monopolar needle electrode, sensitivity was 60% (95% CI 0.17 – 1.03) and specificity was 100%. Among patients with neuropathies as detected by the needle electrode, all patients were found to have radial neuropathy by using the surface electrode. The computed PPV was 100%. In patients without neuropathies as confirmed by the needle electrode, NPV of the test was 97.1% (95% CI 0.93 – 1.01). An overall diagnostic accuracy of 97.22% was computed (Table 2).

Table 2. Sensitivity and specificity of surface electrode examination compared with a monopolar needle electrode examination in the detection of abnormalities in latency of the radial nerve

	Needle Electrode		
Surface Electrode	**Disease**	**No Disease**	**Total**
Positive Test	3 (4.17%)	0	3
Negative Test	2 (2.78%)	67 (93.06%)	69
Total	5	67	72

Analysis of the amplitude when taken separately from the other parameters of the CMAP showed sensitivity of 50% (95% CI 0.10 – 0.90) and specificity of 100%. A PPV of 100% among patients with neuropathies and a NPV of 95.65% (95% CI 0.91 – 1.00) among patients without neuropathies were computed. There was an overall clinical accuracy of 95.83% (Table 3).

Table 3. Sensitivity and specificity of surface electrode examination compared with needle electrode examination in the detection of abnormalities in amplitude of the radial nerve

	Needle Electrode		
Surface Electrode	**Disease**	**No Disease**	**Total**
Positive Test	3 (4.17%)	0	3
Negative Test	3 (4.17%)	66 (91.67%)	69
Total	6	66	72

The duration parameter of the CMAP has a clinical sensitivity of 71.43% (95% CI 0.38 – 1.05) and a specificity of 100%. Among patients diagnosed with neuropathy by needle electrode, the surface electrode tested as positive in 100%, while among participants without disease as manifested by the needle electrode, the surface electrode tested negative in 97.01% (95% CI 0.93 – 1.01) of participants. Among the 72 participants, an overall diagnostic accuracy level of 97.22% was computed (Table 4).

Table 4. Sensitivity and specificity of surface electrode examination compared with needle electrode examination in the detection of abnormalities in duration of the radial nerve

	Needle Electrode		
Surface Electrode	**Disease**	**No Disease**	**Total**
Positive Test	5 (6.94%)	2 (2.78%)	5
Negative Test	0	65 (90.28%)	67
Total	7	65	72

The NCV has a sensitivity of 55% (95% CI 0.33 – 0.77) and a specificity of 84.62% (95% CI 0.75 – 0.94). Among the participants confirmed to have radial neuropathies as tested by the monopolar needle electrode, a PPV of 57.89% (95% CI 0.36 – 0.80) tested as positive with the surface electrode technique. Among patients without radial neuropathies as confirmed by the needle electrode, an NPV of 83.02% (95% CI 0.73 – 0.93) was deemed negative by the surface electrode. An overall diagnostic accuracy of 76.39% was reported (Table 5).

Table 5. Sensitivity and specificity of surface electrode examination compared with a monopolar needle electrode examination in the detection of abnormalities in nerve conduction velocity of the radial nerve

	Needle Electrode		
Surface Electrode	**Disease**	**No Disease**	**Total**
Positive Test	11 (15.28%)	8 (11.11%)	19
Negative Test	9 (12.5%)	44 (61.11%)	53
Total	20	52	72

The kappa test revealed a fair association or agreement for CMAP (k=0.30), moderate association between the surface and the needle electrode in nerve conduction velocity (k=0.40), a substantial association in amplitude (k=0.65) and latency (k=0.74), and a high association between the two techniques for the duration (k=0.81). (Table 6).

Table 6. Agreement between the surface electrode and the needle electrode using the kappa values

Parameter	**Kappa Values**	**Agreement**
CMAP*	0.30	Fair
Amplitude	0.65	Substantial
Latency	0.74	Substantial
Duration	0.81	Excellent
Nerve Conduction Velocity	0.40	Moderate

**CMAP: compound motor action potentials*

Discussion

Radial neuropathies can be detected by evaluating the CMAP and its parameters. This study compared the accuracy of using the surface electrode and monopolar needle electrode techniques.

This study with 72 participants showed that when all the parameters are taken as a whole (CMAP), the comparison showed high specificity, 82.61% (95% CI 0.72 – 0.94) where patients with no radial neuropathy showed negative results in both the monopolar needle electrode and surface electrode examinations. Among participants who tested positive for radial neuropathy using the needle electrode examination, 46.15% (95% CI 0.2 7 – 0.65) were found positive by surface electrode examination. Among those with radial neuropathy as detected by the needle electrode, 60% (95% CI 0.39 – 0.81) had a positive test using the surface electrode examination. On the other hand, among patients without radial neuropathies as confirmed by the monopolar needle electrode, 73% (95% CI 0.61 – 0.85) tested negative on surface electrode examination. A kappa test of 0.30 indicated a fair agreement between the surface electrode and the monopolar needle electrode.

When the parameters of the CMAP were taken individually in the comparison, analysis of the latency, amplitude and duration parameters revealed a high specificity and confirmed 100% of those tested negative for radial neuropathy using the monopolar needle electrode examination. Among those patients with radial neuropathy detected by monopolar needle electrode, 100% had a positive test when the surface electrode examination was used in the following parameters: latency, amplitude and duration. The abnormalities in latency could result from axonal neuropathy with the loss of fast conducting fibers.[5] On the other hand, when there is axonal injury or dysfunction, it may cause the abnormalities in the values of the amplitude.[5]

Analysis of the NCV study in the determination of the presence of demyelination showed that 84.62% (95% CI 0.75 – 0.94) of those tested negative for radial neuropathy using the monopolar needle electrode examination were found to have negative test using the surface electrode examinations. Among patients without radial neuropathy as confirmed by the monopolar needle electrode, 83.02% (95% CI 0.73 – 0.93) showed negative test when the surface electrode was used.

The individual parameters revealed different degrees of association as evidenced by the values on the kappa test, the amplitude and latency; kappa values ranging from 0.61 to 0.80 indicate a substantial agreement between the surface electrode and the monopolar needle electrode examinations. Nerve conduction velocity studies showed a kappa value of 0.40, indicating a moderate agreement. The computed kappa of 0.81 for duration indicates excellent agreement between the two techniques.

Conclusion

This study compared the surface electrode and the needle electrode techniques in the determination of the radial nerve latency, amplitude, duration and NCV. When all of these parameters were considered (CMAP), the study showed that the surface electrode technique had high specificity and high probability of a negative test result in an individual who is disease-free. There is fair agreement between using the surface electrode and the needle using the kappa test. When the parameters of the CMAP were taken separately, the surface electrode was comparable to the needle electrode in the determination of the latency, amplitude, duration and NCV of the radial nerve. The surface electrode had a high probability of a positive test result in people with disease and a high probability of a negative test result in people with no disease. Analysis of the NCV revealed a moderate association; substantial agreement for amplitude and latency; and high association for duration between the surface electrode and monopolar needle electrode techniques.

The results of this study indicate that the surface electrode technique is a fair to good alternative to the needle electrode technique in conducting radial motor nerve studies.

Limitations and Recommendations

The study is limited to EMG-NCV findings performed on participants using the Cadwell 6200A electrodiagnostic machine in the particular setting of the Electrodiagnostic Laboratory of the Department of Rehabilitation Medicine, Philippine General Hospital. It is recommended that further studies be conducted to determine reference values for nerve conduction studies in the healthy Filipino population. Future studies focusing on radial neuropathies using the surface electrode technique to further validate its accuracy are also recommended.

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