**Original Investigation** / Özgün Araştırma

# Comparison of the Reliability Between Tape and Caliper in the Measurement of Distance for Nerve Conduction Study

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## ABSTRACT

**Objective:** One of the important parameters in the electrodiagnosis is the nerve conduction study (NCS) which is calculated from two other variables,i.e distance and time. Therefore, appropriate measurement of these variables which are the base of proper diagnosis is obviously very important. In this study, these was an attempt to evaluate and compare nerve conduction responses in the two methods of measuring distances with tape and caliper to show which one is more reliable than the other one.

**Methods:** This study was carried out on 100 hands of 50 appearantly healthy volunteer medical students. They were examined for the NCS of the median and ulnar nerves at the wrist using a nylon tape and a caliper. Reliability value, Cronbach`s alpha and the mean of the inter-time differences were calculated for each method.

**Results:** The means of inter-time difference, Cronbach`s alpha and reliability values for all the variables were more significant in the caliper measurement especially for nerve conduction velocity (NCV) parameter.

**Conclusion:** Caliper seems to better estimate the actual length of nerve conveying the electrical impulse and better accommodate with actual course of the nerve under the skin. Therefore, using the caliper for measuring the distance might be more reliable than the routine method of tape measurement.

**Keywords:** Median nerve, ulnar nerve, measure, nerve conduction

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## Introduction

Appropriate measurement of parameters which are the base of correct diagnosis is obviously very important, especially if these parameters are the base of other parameters, measurement. Therefore, if the first step is wrong, the others and so the results will be misleading. Normal values of nerve conduction study (NCS) parameters can be used as the reference for diagnosis of pathologic process and also as a guide for physicians to evaluate how these parameters change in the course of different disorders. Therefore, before each interpretation of the measured parameters, we should make sure that they have been measured with high reliability, validity and less error. Two of the most fundamental parameters which are necessary in order to calculate a nerve conduction velocity are the distance between stimulation sites and the onset latencies of the proximal and distal responses (1).

In this regard, two points should be taken in to account. First, in measuring the distance with tape, we should cross the tape over the anatomic curves and humps of fingers, palm, thenar, hypothenar, and the wrist region that may induce movement between the tape and skin, reducing the accuracy and reproducibility of measurement**.** Second, there is a length discrepancy in the surface compared to actual (anatomic) length in comparing the presumed course of the nerves by surface estimates versus actual anatomic course.

But if these distances are marked with caliper on the skin, there will be no movement between caliper and skin that might result in a more reliable method in the multiple measurements of distances. On the other hand, caliper might better estimate the actual length of the nerve conveying the electrical impulse and better accommodate with actual course of the nerve under the skin.

Therefore, there was an attempt in this study to evaluate and compare nerve conduction responses between the two methods of measuring distances with tape and caliper to show what differences exist between them and which one is more reliable than the other one.

## Material and Methods

This study was carried out in our physical and rehabilitation clinic on 100 hands of 50 apparently healthy volunteer medical students. They were 27males and 23 females with the mean age of 25 years (23-30 years).

For recording the evoked potentials, the participants were seated on a chair in relaxed sitting position with the elbow flexed, forearm supinated, wrist in neutral position and some abduction of digits. Skin temperature was controlled with surface thermometer.

In brief, for the median and ulnar motor study, the practitioner determined the E-1 point; then, the assistant placed the nylon tape from this point tangential to the participant's hand skin and was directed it proximally along the course of the median and ulnar nerves until a total distance of 8 centimeters was reached. Then he pointed these with a pen for cathode location. After that, the practitioner performed the CMAP (compound muscle action potential) study for each of these points. This practice was repeated three times, separately.

At the next step, a distance of 8 centimeters from the E-1 point was measured through caliper while attaching a color pen on its arm, on the participant's hands for cathode location to stimulate the median and ulnar nerves. Again, the practitioner performed the CMAP study for three times, separately.

For the median and ulnar sensory study, the practitioner determined the E-1 point (1-2 centimeters distal to the third and fifth metacarpophalangeal joints, for the median and ulnar nerves, respectively). Then, the assistant placed the nylon tape from this point tangential to the participant's hand skin and directed it proximally along the course of the median and ulnar nerves until a total distance of 7 centimeters (for distal median sensory) and 14 centimeters (for proximal median and ulnar sensory) were reached (Figure 1). In the next stage the assistant pointed these with a color pen for cathode location. After that, the practitioner performed the SNAP (sensory nerve action potential) study for each of these three points. This practice was repeated three times, separately. Similar to the CMAP study, the sensory study was performed with caliper as well (Figure 2).

For the CNAP (Compound Nerve Action Potential) study of the median nerve, the practitioner first determined the cathode point (mid-palm along the third metacarpal bone) and then the assistant placed the nylon tape from this point tangential to the participant's hand skin and directed it proximally along the course of the median nerve until a total distance of 8 centimeters was reached. Then he pointed it with a color pen as E-1 point location. Again, the practitioner performed the CNAP study for three times, separately. This step was performed with caliper for three times as well.

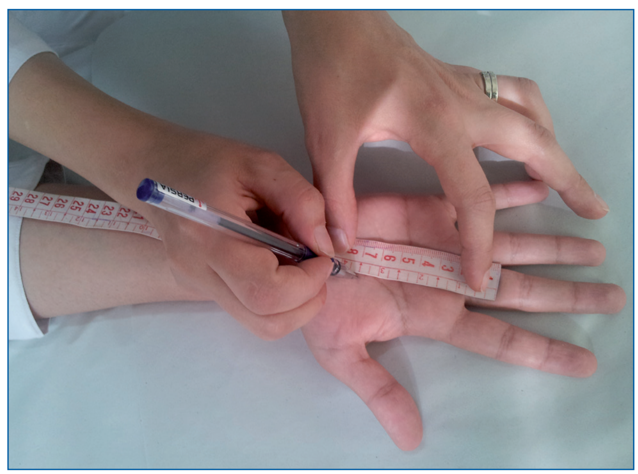

**Figure 1. Sensory study with the tape method.**

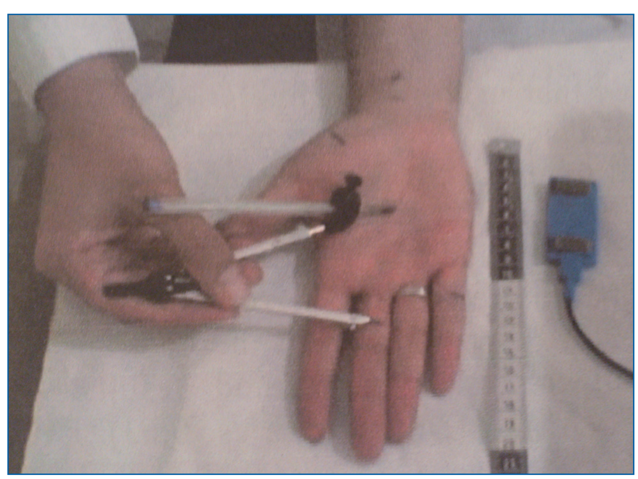

**Figure 2. Sensory study with the caliper method.**

Instrumentation parameters were as follows (with Medtronic Toennis Multiliner Version 2.0):

- **Stimulus electrode:** Surface stimulator with two steel pin attachments.
- **Recording electrode:** Bar surface electrode (saline soaked) with El-E2 distance of 40 millimeters.
- **Stimulus duration:** 0.1 millisecond.
- **Sweep speed:** 2 millisecond / division.
- **Gain:** 20 Microvolt/division for sensory and 1-5 Millivolt/division for motor.
- **Filter frequency:** 20 Hertz-2 kilohertz
- **Stimulus intensity:** Supramaximal.

Seven parameters were recorded after pertinent stimulation:

- **DMSL:** Antidromic distal sensory latency of the median nerve with stimulation at the palm.
- **PMSL:** Antidromic proximal sensory latency of the median nerve with stimulation at the wrist.
- **NCV:** Median nerve conduction velocity across the wrist.
- **CNAP:** Compound nerve action potential of the median nerve.
- **USL:** Ulnar sensory latency with stimulation at the wrist.
- **MML:** Motor distal latency of the median.
- **UML:** Motor distal latency of the ulnar nerve.

SPSS windows version 13.0 was used. Group statistics and cases processing for reliability statistics were performed. Cronbach`s alpha (a model for evaluating of internal consistency and correlation) and inter-times correlation matrix were calculated for each method. We also calculated three differences for each variable in both methods (difference between the first and second time of each test {diff. 1, 2}, difference between the first and third time of each test {diff. 1, 3} and difference between the second and third time of each test {diff. 2, 3}). The mean of these three differences (mean of differences between three times of measurement or mean of inter-times differences) for each variable in both methods. Then, independent sample test (t-test) was used to compare these means between two methods in all seven variables (DMSL/PMSL/NCV/ CNAP/MML/ UML/ USL). Another method for evaluation of reliability was carried out as: R= VARIANCE (SUBJ.)/ VARIANCE (SUBJ.) + VARIANCE (ERROR). P-value of less than 0.05 was considered significant.

## Results

One hundred hands of 27 (54%) males and 23 (46%) females were studied. There were no significant differences between males and females in methods and all variables (DMSL, PMSL, NCV, CNAP, MML, UML, USL) (P-value>0.05).

The mean of inter-time differences for variables in tape-measurement and caliper-measurement methods were as follow: DMSL (0.09 and 0.02 ms), PMSL (0.09 and 0.02 ms), NCV (2.59 and 0.86 m/s), CNAP (0.10 and 0.03ms), MML (0.08 and 0.03ms), UML (0.31 and 0.16ms), USL (0.11 and 0.04 ms), respectively. P- Value in all variables was less than 0.05.

Cronbach`s alpha for the variables in tape-measurement and caliper-measurement method were: DMSL (0.87and 0.98), PMSL (0.82 and 0.97), NCV (0.56and 0.96), CNAP (0.92and 0.97), MML (0.98 and 0.99), UML (0.78 and 0.99), USL (0.96 and 0.99), respectively.

Also, reliability value for the variables in tape-measurement and caliper-measurement method were: DMSL (0.63 and 0.92), PMSL (0.58 and 0.88), NCV (0.26and 0.88), CNAP (0.78 and 0.92), MML (0.95 and 0.98), UML (0.53 and 0.98), USL (0.92 and 0.99), respectively.

## Discussion

The validity of the calculated nerve conduction velocity depends primarily on the accuracy in determining the latencies and the conduction distances. Errors in estimating the conduction distance by surface measurement result from uncertainty as to the exact site of stimulation and the nonlinear course of the nerve segments. Surface determination of the nerve length yields particularly imprecise results when the nerve takes an angulated path, as in the brachial plexus or across the elbow or knee (1).

The experimental error of conduction velocity for various conduction velocities and distances or conduction times can be calculated, and shown in a table and family of curves (Table 1). This table and experimental curves allow us to graphically visualize the relationship of experimental error to time and distance. At any particular conduction velocity, the experimental error decreases as the conduction distance or time increases. It can be shown that the error in distance contributes only 7.7%

**Table 1. Calculated experimental error in conduction velocity for different conduction distances and conduction velocity magnitudes.**

| Conduction velocity (m/sec) | Conduction distances (mm) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 | 350 | 400 | 500 |
| 15 | 3.4 | 2.2 | 1.7 | 1.3 | 1.1 | 1.0 | 0.8 | 0.7 | 0.7 | 0.6 | 0.6 | 0.5 | 0.4 | 0.3 |
| 20 | 5.5 | 3.7 | 2.7 | 2.2 | 18 | 1.6 | 1. | 1.2 | 1.1 | 1.0 | 0.9 | 0.8 | 0.7 | 0.5 |
| 25 | 8.1 | 5.4 | 4.1 | 3.2 | 2.7 | 2.3 | 2.0 | 1.8 | 1.6 | 1.5 | 1.4 | 1.2 | 1.0 | 0.8 |
| 30 | 1.3 | 7.5 | 5.6 | 4.5 | 3.8 | 1 2 | 2.8 | 2.5 | 2.3 | 2.0 | 1.9 | 1.6 | 1.4 | 1.1 |
| 35 | 14.9 | 9.9 | 7.4 | 6.0 | 5.0 | 4.3 | 3.7 | 3.3 | 3.0 | 2.7 | 2.5 | 2.1 | 1.9 | 1.5 |
| 40 | 19.0 | 12.7 | 9.5 | 7.6 | 6.3 | 5.4 | 4.8 | 4.2 | 3.8 | 3.5 | 3.2 | 2.7 | 2.4 | 1.9 |
| 45 | 23.7 | 15.8 | 11.8 | 9.5 | 7.9 | 6.8 | 5.9 | 5.3 | 4.7 | 4.3 | 3.9 | 3.4 | 3.0 | 2.4 |
| 50 | 28.8 | 9.2 | 14.4 | 11.5 | 9.6 | 8.2 | 7.2 | 6.4 | 5.8 | 5.2 | 4.8 | 4.1 | 3.6 | 2.9 |
| 55 | 34.5 | 23.0 | 17.2 | 13.8 | 11.5 | 9.9 | 8.6 | 7.7 | 6.9 | 6.3 | 5.7 | 4.9 | 4.3 | 3.4 |
| 60 | 40.7 | 27.1 | 20.3 | 6.2 | 11.6 | 11.6 | 10.2 | 9.0 | 8.1 | 7.4 | 6.8 | 5.8 | 5.1 | 4.1 |
| 65 | 47.3 | 31.5 | 23.7 | 8.9 | 5.8 | 11.5 | 11.8 | 10.5 | 9.5 | 8.6 | 7.9 | 6.8 | 5.9 | 4.7 |
| 70 | 54.5 | 36.3 | 27.2 | 21.8 | 18.2 | 15.6 | 13.6 | 12.1 | 10.9 | 9.9 | 9.1 | 7.8 | 6.8 | 5.4 |
| 75 | 62.2 | 41.4 | 31.1 | 24.9 | 20.7 | 17.8 | 15.5 | 13.8 | 12.4 | 11.3 | 10.4 | 8.9 | 7.8 | 6.2 |
| 80 | 70.3 | 46.9 | 35.2 | 281 | 23.4 | 20.1 | 17.6 | 15.6 | 14.1 | 12.8 | 11.7 | 10.0 | 8.8 | 7.0 |

*From Maynard FM. Stolov WC: Experimental error in determination of nerve conduct.*

to the total experimental error while time assessment contributes 92.3% to the error (2). The amount of experimental error in nerve conduction studies suggests there has been a substantial improvement in the total error over the past 30 years. There has been a significant decrease in the latency measurement error, using the currently available generation of electrodiagnostic equipment (3).

This study showed that using the caliper for measuring distances was more reliable than the routine method of tape measurement. In other words, all seven variables that were evaluated with caliper in the NCS of the median and ulnar nerves at the wrist had more internal correlation and consistency with each other in comparison with tape measurement method. (We know that if reliability and Cronbach`s alpha of a method is <0.80, it could not be a reliable method in measuring). The most reliable value and the highest Cronbach`s alpha in the caliper measurement as compared to the tape measurement was NCV variable.

In this regard, obstetric calipers are recommended when attempting to measure nerve distances across a spiral pathway for example, appropriate use of obstetric calipers may be in determining the length of radial nerve traversing the spiral groove, plantar nerves from the sole of the foot to the medial malleolus, and transbrachial plexus measurements (4-6).

However, Checkles et al, in a study on the peroneal nerve conduction velocity concluded that tape and caliper measurements correlated highly with one another and with in situ lengths. Also, they concluded that difference between the tape and caliper determined velocities had a standard deviation of <1, which was not significant (7).

## Conclusions

This simple study clearly illustrates the practical utility of being aware of experimental error and the necessity of careful measurement of distances and in particular latencies. It was shown in this study that caliper might better estimate the actual length of the nerve conveying the electrical impulse and better accommodate with actual course of the nerve under skin .however, this subject requires further studies to be confirmed. It is also recommended that the normal values of the median and ulnar nerves at the wrist with caliper measurement should be gathered in normal population in another study.

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