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Correlation Between the Modified and the Classical Methods in Carpal Tunnel Syndrome Diagnosis

Karpal Tünel Sendromu Tanısında Modifiye ve Klasik Yöntemler Arasındaki İlişki

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Abstract

Introduction: This study aimed to investigate the correlation between the modified and the classical methods in carpal tunnel syndrome (CTS) diagnosis.

Materials and Methods: The study included a total of 275 hands of 188 patients. First, the patients with CTS complaints were diagnosed according to the classical and the modified methods. Then, it was investigated whether there was a correlation between these two methods. The correlation agreement analysis between two methods was evaluated with the Kappa test.

Results: In present study, it was found that 155 hands were (80 mild + 75 moderate) diagnosed with CTS, and 137 patients were female (85.2%). Moreover, it was detected that the modified method had a sensitivity of 90% and specificity of 97% regarding the classical method. In diagnosing moderate CTS, the modified method showed a high sensitivity and specificity (98.6% – 100%, respectively).

Conclusion: In conclusion, a near-perfect agreement was found between the modified and the classical methods for the diagnosis of CTS.

Keywords: Electromyography; entrapment neuropathy; latency; median nerve; velocity.

Özet

Amaç: Bu çalışmada, karpal tünel sendromu (KTS) tanısında modifiye yöntem ile klasik yöntem arasındaki ilişkinin araştırılması amaçladı.

Gereç ve Yöntem: Çalışmaya 188 hastanın toplam 275 eli dahil edildi. Öncelikle KTS şikayeti olan hastalara klasik ve modifiye yöntemlere göre tanı konuldu. Daha sonra bu iki yöntem arasında uyum olup olmadığı Kappa testi ile değerlendirildi.

Bulgular: Bu çalışmada toplam 155 elde (80 hafif + 75 orta) KTS tanısı konuldu ve 137 hastanın (%85.2) kadın olduğu saptandı. Ayrıca modifiye yöntemin klasik yönteme göre %90 duyarlılık ve %97 özgüllüğe sahip olduğu tespit edildi. Orta dereceli KTS tanısında, modifiye yöntem yüksek bir duyarlılık ve özgüllük gösterdi (sırasıyla %98.6 - %100).

Sonuç: Sonuç olarak, KTS tanısı için modifiye ve klasik yöntemler arasında mükemmele yakın bir uyum bulundu.

Anahtar Kelimeler: Elektromiyografi; tuzak nöropatisi; latans; medyan sinir; hız.

Introduction

Carpal tunnel syndrome (CTS) is caused by compression of the median nerve under the transverse carpal ligament and is the most common entrapment neuropathy in the upper extremity (1-8). As a result of this entrapment, paresthesia along the nerve trace, weakness, and atrophy in the thenar region of the hand may occur. Broadly, the possible diagnosis of CTS can be made easily by clinical history and examination (3). However, the diagnosis of CTS is confirmed mainly by excluding other possible differential diagnoses (cervical radiculopathy, peripheral neuropathy) via electrodiagnostic tests (9, 10). Moreover, there are also patients (up to 40%) with mild CTS complaints but normal routine EMG examinations (4, 7-9, 11). Therefore, various methods have been proposed to increase the sensitivity and specificity of routine EMG study, especially in people with mild CTS symptoms (2, 4, 12). In previous studies, various methods have been used to diagnose CTS. These are median nerve motor distal latency, wrist-digit sensory latency, palm-wrist sensory conduction velocity, and median-ulnar sensory latency difference (12). Despite all these methods, there is no consensus on the diagnosis of CTS (5, 12). In addition, many researchers use the normal values of their EMG laboratories to diagnose CTS and determine its severity. These differences between the laboratories make it difficult to establish standard

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diagnostic criteria for the CTS. Therefore, we used the modified method (a new method) to diagnose CTS via determining the normal threshold value for each individual. In this study, it was aimed to examine whether there has been a correlation between the modified and the classical method in CTS diagnose.

Material and Method

In the present study, a total of 188 consecutive patients, who had complaints of CTS and applied to the EMG laboratory between August 2021 and March 2022, were recruited. The electrophysiological findings of these patients were analyzed retrospectively by both methods, mentioned before. Those patients, who had been diagnosed with normal or mild, or moderate CTS, were consecutively included in the study. However, the diagnosis of severe CTS, incomplete data and previous carpal tunnel release surgery were considered exclusion criterions.

Nerve conduction studies: A 5-channel Neurosoft EMG device was performed for routine electrodiagnostic tests of the median nerve. The skin temperature was maintained above 32°C during the study. The filtering frequency range was 10 Hz-2 kHz for sensory and motor nerves conduction studies. Velcro ring electrodes were used for antidromic sensory recording. The median sensory nerve action potential was recorded at the digit II (finger)-palm and palm-wrist segments by antidromic stimulation, respectively. The onset-latency and velocity of the median sensory nerve action potential was obtained separately for each segment. The median motor compound muscle action potential (CMAP) was performed according to the belly-tendon principle, and it was recorded over the midpoint of the abductor pollicis brevis muscle. Median motor distal latency and CMAP were obtained over the wrist and elbow by electrical stimulations along the course of the median nerve.

Classical and modified methods: In this study, the classical and modified methods were applied in accordance with the criteria performed by Şahin et al. (13). In the modified method, first, the median sensorial palm-wrist conduction velocity (proximal velocity= pv), the median sensorial second digit-palm conduction velocity (distal velocity= dv), median motor distal latency (dl), and the median motor proximal-distal latency difference (pdl) were calculated. Then, the expected proximal velocity (epv) and the expected distal latency (edl) for each median nerve were calculated using the formulas "epv= dv*(1- $k_{velocity}$)" and "edl= pdl*(1- $k_{latency}$)". The cut-off values of "$k_{velocity}$" and "$k_{latency}$" were "0.236381" and "0.025016", respectively.

Diagnostic criteria of the modified method:

-Those with a pv lower than the epv were considered mild CTS,

-Those with a dl higher than the edl were diagnosed as moderate CTS.

An example of the calculation of the modified method:

- dv= 59.2cm/msec; pv= 29cm/sec; dl= 3.5msec; pdl= 4.7msec
- epv= 59.2*(1- 0.236381) = 45.2cm/msec (pv < epv)
- edl= 4.7*(1- 0.025016) = 4.6msec (dl < edl)
- the diagnose= of mild CTS

Diagnostic criteria of the classical method:

-If median nerve palm-wrist sensory conduction velocity was ≥ 50mm/ms, it was considered no CTS.

-If the velocity was < 50cm/msec, mild CTS was diagnosed.

-If the median motor distal latency was > 3.67 msec, moderate CTS was diagnosed.

-If the median nerve had a low amplitude of compound muscle action potential (<5mV), severe CTS was diagnosed.

The classical method was accepted as the gold-standard method. According to this classical method, the sensitivity and specificity of the modified method in diagnosing CTS were calculated. It was also investigated whether there was a correlation between these two methods by using the Kappa test.

Ethical approval: The study was approved by the Research Ethics Committee of the University Hospital, Faculty of Medicine, in accordance with the Declaration of Helsinki (Session No: 2022/12, Decision No: 05, Date: 05.04.2022). This study was designed retrospectively, and informed written consent was received from none of the patients.

Statistical analysis: IBM Statistical Package for the Social Sciences (SPSS) 26.0 (SPSS Inc., Chicago, IL, USA) program was used for statistical analysis. The Chi-square test was used for categorical variables, and the Mann-Whitney U test was used for continuous variables. The agreement between the modified and classical methods was evaluated with the Kappa test. The coefficients obtained as a result of the Kappa test were interpreted as perfect agreement if they were

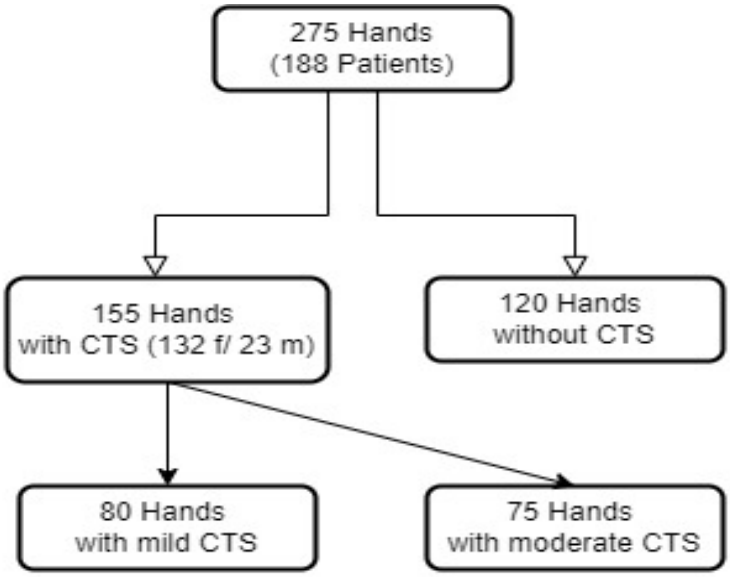

Figure 1: A flow chart of patient enrollment has been shown regarding the classical method. (CTS= carpal tunnel syndrome, f= female, m= male)

Table 1: Calculated values of the two groups according to the classical method.

	Patients with CTS	Patients without CTS
pv (cm/msec)(min-max)	35.14 ± 0.61 (13.7-49.7)	57.13 ± 0.51 (50-69.5)
dv (cm/msec)(min-max)	59.25 ± 0.44 (50-69.4)	60.59 ± 0.49 (50-69.6)
dl (msec)(min-max)	4.12 ± 0.09 (2-7.7)	2.83 ± 0.49 (0.6-3.8)
pdl (msec)(min-max)	3.91 ± 0.03 (2.2-5.2)	3.9 ± 0.03 (2.7-4.8)

CTS= carpal tunnel syndrome, **pv=** proximal velocity (the mean median sensorial palm-wrist conduction velocity), **dv=** distal velocity (the mean median sensorial second digit-palm conduction velocity), **dl=** the mean median motor distal latency, **pdl=** the mean median motor proximal-distal latency difference

1, near-perfect agreement if 0.81-1.00, substantial agreement if 0.61-0.80, moderate agreement if 0.41-0.60, fair agreement if 0.21-0.40, slight agreement if 0.10-0.20, and no agreement if 0. A value of $p < 0.05$ was assumed to be statistically significant.

Results

A total of 275 hands of 188 patients were included in this study. According to the classical method, 155 hands diagnosed with the electrophysiological CTS and 120 hands without CTS were detected. In the CTS group, 46 hands with isolated right CTS (40.4%), 27 hands with isolated left CTS (23.7%), and 41 cases (right and left 82 hands) with bilateral CTS (35.9%) were observed. The group diagnosed with CTS consisted of 80 mild CTS and 75 moderate CTS subgroups. There was 132 female (85.2%) and 23 male (14.8%) patients in the CTS group. However, there was no significant gender difference between the groups with and without CTS (X^2; p= 0.679). The mean age of the group with CTS was 50.21±12.38 years, and it was found to be significantly higher than the mean age of the group without CTS (42.22±12.61 years) (Mann-Whitney U Test; p< 0.001). A flow chart of patient enrollment has been shown regarding the classical method in the Figure 1. In the classical method, the mean velocity of the palm-wrist segment in the CTS group was 35.14 ± 0.61 cm/sec, and the mean distal latency of the median motor nerve was 4.12 ± 0.09 msec. In the Table 1, it was shown that the calculated values of the two groups regarding the mean median sensorial palm-wrist conduction velocity, the mean median sensorial second digit-palm conduction velocity, the mean median motor distal latency, and the mean median motor proximal-distal latency difference. As a result of

Table 2: The test accuracy parameters and the results of the Kappa test of the modified method.

	Total CTS (n:144)	Mild CTS (n:61)	Moderate CTS (n:83)
Sensitivity	90.3%	79.4%	98.6%
Specificity	96.6%	96.6%	100%
PPV	97.2%	93.1%	98.6%
NPV	88.5%	89.2%	100%
False negative	9.6%	20.5%	1.4%
False positive	3.3%	3.3%	0%
Kappa values	0.861	0.786	0.989

CTS= Carpal tunnel syndrome, **PPV=** Positive predictive value, **NPV=** Negative predictive value

the modified method procedure, 144 hands were diagnosed with CTS. Of these, 61 and 83 hands were divided into the mild and moderate CTS subgroups, respectively. It was found that there was a near-perfect agreement between the modified and classical methods in terms of diagnosing CTS. The modified method showed a sensitivity of 0.903, a specificity of 0.966, a positive predictive value (PPV) of 0.972, and a negative predictive value (NPV) of 0.885. However, the false-negativeness of this method was 0.096 (n= 15), and the false-positiveness was 0.033 (n=4). When examining the subgroups, a substantial agreement was observed between the two methods in terms of detecting mild CTS. In diagnosing mild CTS, the modified method showed a sensitivity of 0.794, a specificity of 0.966, a positive predictive value (PPV) of 0.931, and a negative predictive value (NPV) of 0.892. The false-negativeness and the false-positivity of this method in this subgroup were found at 0.205 (n= 14) and 0.033 (n=4), respectively. It was observed that there was a near-perfect agreement between the two methods in terms of detecting those with moderate CTS. In diagnosing moderate CTS, the modified method showed a sensitivity or PPV of 0.986 and specificity or NPV of 1. Moreover, in this subgroup, the false-negativeness and the false-positivity were observed at 0.014 (n=1) and 0 (n=0), respectively. The test accuracy parameters and the results of the Kappa test of the modified method have been shown in Table 2.

Discussion

In this study, it was found that the classical and modified methods had 155 (80 mild + 75 moderate) and 144 (61 mild + 83 moderate) cases with CTS, respectively. The modified method had the sensitivity 90.3% and specificity 96.6% regarding the classical method in the diagnosis of the CTS. The study showed that there was a near-perfect agreement between these two methods (Kappa= 0.861). Moreover, in the moderate CTS group, it was found that the sensitivity and specificity of the modified method were 98.6% and 100%, respectively. It is reported that the incidence of CTS is significantly higher in the female population (1, 8). In the present study, it was shown that the CTS group consisted of 137 female patients (85.2%) and had older patients than the group without CTS ($p< 0.001$). Conduction abnormalities in CTS are usually limited to short segments of the carpal tunnel. Therefore, normal conduction in parts of the carpal tunnel may mask the slowdown in conduction in mild CTS (6, 9). In addition, few studies show that routine electrodiagnostic tests have limited sensitivity and specificity for mild CTS (1). According to one article, the alterations of the sensory nerve action potential in CTS were reported in 53% to 98% of cases. Another report showed that two prospective clinical studies found the sensitivity of nerve conduction testing 74% to 78%. The other articles observed that the previous studies reported a wide range of results for the sensitivity in the electrodiagnosis of CTS (2, 5, 11, 12). A 2002 literature review by the American Association of Electrodiagnostic Medicine (AAEM) showed that NCS has a sensitivity of 50% to 85% and a specificity of 95% or higher to diagnose the CTS (3, 8, 14, 15). However, various EMG clinics continue to use different reference values for the diagnosis of the CTS rather than a single set of standardized cut-offs, thereby creating the possibility of false-positive and false-negative diagnoses. Atroshi et al. found a false positive test result of 18% (4, 12). Thus, the different electrophysiologic criteria in the diagnostic tests might potentially change the management or prognosis of the patients with CTS complaints. Moreover, some patients might have an incorrect diagnosis and unnecessary surgery. Previous publications showed that

antidromic and orthodromic sensory nerve latencies are not significantly different from each other (2, 16). Nevertheless, antidromic stimulation was used in our study, as the distal segment of the median nerve was thought relatively unaffected. And the distal segment velocity was used to calculate the expected proximal segment velocity. In most studies, the onset latency of the median sensory nerve is usually involved. In contrast to that, some other studies prefer the peak latency to measure the velocity of the median sensory nerve (2). In the present study, the onset latency was used to calculate the velocity. Nevertheless, it was believed that the peak or onset latency could not affect the difference between the expected and measured velocity of the median sensory nerve regarding the new method. However, in our study, the area or duration of the sensory nerve action potential was not involved because there were conflicting results about the reliability of these parameters in the CTS evaluation (2). In most studies, the cut-off values of the distal motor latency range from 3.8 to 4.6 msec (12). In our study, the motor distal latency, calculated at more than 3.67 msec, was determined as the threshold value for the moderate CTS (13).

Study Limitations: This study had a few limitations. First, it was retrospectively designed, and second, there was only one comparison study between the modified and the other methods. However, this new method has a few advantages in that it's results might not be affected by age, height, hand temperature, and sex.

Conclusion

In the present study, it was found that there was a near-perfect agreement between the two methods in terms of diagnosing CTS. According to our results, an individual threshold value may be calculated for each patient by using the modified method. Moreover, in this method, patients serve as their controls themselves. Therefore, there may be no need to use a different standard threshold value for each laboratory.

Ethical approval: For our study, ethics committee approval was obtained with 2022/12 protocol code from Kahramanmaraş Sutçu Imam University Faculty of Medicine Non-Invasive Clinical Research Ethics Committee.

Conflict of interest: The authors declare that they have no conflict of interest.

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Author contribution: 1. Concept: HŞ; 2. Design: HŞ; 3. Control: HŞ; 4. Materials; HŞ; 5. Data Collection and Processing: HŞ; 6. Analysis and Interpretation: HŞ; 7. Literature Review: HŞ; 8. Writing-Original Draft: HŞ; 9. Writing Review and Revision: HŞ; 10. Critical Review: HŞ; 11. Software and Visualization: HŞ.

Consent to participate: This study was designed retrospectively, and informed written consent was received from none of the patients.

References

1. Alcan V, Zinnuroğlu M, Kaymak Karataş G, Bodofsky E. Comparison of Interpolation Methods in the Diagnosis of Carpal Tunnel Syndrome. Balkan Med J 2018; 35: 378-383.
2. Prakash KM, Fook-Chong S, Leoh TH, Dan YF, Nurjannah S, Tan YE, et al. Sensitivities of sensory nerve conduction study parameters in carpal tunnel syndrome. J Clin Neurophysiol 2006; 23: 565-567.
3. Demino C, Fowler JR. Comparison of Borderline Ultrasound and Nerve Conduction Studies for Carpal Tunnel Syndrome. Hand (N Y) 2020: 17: 860-864.
4. Sharma KR, Rotta F, Romano J, Ayyar DR. Early diagnosis of carpal tunnel syndrome: comparison of digit 1 with wrist and distoproximal ratio. Neurol Clin Neurophysiol 2001; 2001: 2-10.
5. Vahdatpour B, Khosrawi S, Chatraei M. The role of median nerve terminal latency index in the diagnosis of carpal tunnel syndrome in comparison with other electrodiagnostic parameters. Adv Biomed Res 2016; 5: 110.
6. Chang MH, Liu LH, Lee YC, Wei SJ, Chiang HL, Hsieh PF. Comparison of sensitivity of transcarpal median motor conduction velocity and conventional conduction techniques in electrodiagnosis of carpal tunnel syndrome. Clin Neurophysiol 2006; 117: 984-991.
7. Aktas I, Sünter G, Uluc K, Isak B, Tanridağ T, Akyüz G, et al. Does the Provocation Maneuvers Increase the Sensitivity of Sensory Nerve Conduction Studies in Diagnosis of Carpal Tunnel Syndrome? Turk J Phys Med Rehab 2012; 58: 307-311.
8. Berrin L, Mehmet A, Bagis S, Akman M. The Usefulness of Latency Difference Tests of Median-Ulnar and Median-Radial Nerves in Mild Carpal Tunnel Syndrome. Turk J Phys Med Rehab 2008; 54. 22-26.

9. Sheu JJ, Yuan RY, Chiou HY, Hu CJ, Chen WT. Segmental study of the median nerve versus comparative tests in the diagnosis of mild carpal tunnel syndrome. Clin Neurophysiol 2006; 117: 1249-1255.
10. Kasius KM, Claes F, Verhagen WI, Meulstee J. The segmental palmar test in diagnosing carpal tunnel syndrome reassessed. Clin Neurophysiol 2012; 123: 2291-2295.
11. Chang MH, Wei SJ, Chiang HL, Wang HM, Hsieh PF, Huang SY. Comparison of motor conduction techniques in the diagnosis of carpal tunnel syndrome. Neurology 2002; 58: 1603-1607.
12. Atroshi I, Gummesson C, Johnsson R, Ornstein E. Diagnostic properties of nerve conduction tests in population-based carpal tunnel syndrome. BMC Musculoskelet Disord 2003; 4: 9.
13. Şahin H, Çalışkan H, Uslusoy MY. Comparison of the modified method and the median sensory-ulnar motor latency difference in the diagnosis of carpal tunnel syndrome. J Clin Neurosci 2022; 104: 103-106.
14. Zis P, Zis V, Xirou S, Kemanetzoglou E, Zambelis T, Karandreas N. Rapid Screening for Carpal Tunnel Syndrome: A Novel Method and Comparison With Established Others. J Clin Neurophysiol 2015; 32: 375-379.
15. Emad M JN, Azadeh A, Bemana G. Is the difference between median sensory and ulnar motor latencies better than combined sensory index in carpal tunnel syndrome diagnosis? TJPMR 2016;62(3):229-233.
16. Noh JS, Park JW, Kwon HK. Palmar Digital Neuropathy With Anatomical Variation of Median Nerve: Usefulness of Orthodromic Technique: A Case Report. Ann Rehabil Med. 2019 Jun;43(3):341-346.